The Early Neolithic 'Broken World':

The role of pottery breakage in south-eastern and central Europe

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I, Bruno Vindrola-Padrós confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

For Ana and Allegra

Abstract

One of the most materially evident yet socially obscured aspects of modern consumer society has been the increasing accumulation of broken objects considered as ‘waste’ or ‘rubbish’. During the Neolithic period, central and south-eastern Europe were also to witness an unprecedented explosion of material remains, mostly pottery fragments, that would affect the social lives of local inhabitants, referred to as the *Linearbandkeramik* (LBK) and *Starčevo-Körös-Criş* (SKC) groups respectively. However, because of our modern tendency to write (pre)history in stages of technological development, the Neolithic is conventionally characterized as the moment where humans became masters over nature. Thus, it is emphasised that sedentism, agricultural production, and economic innovations like pottery were introduced. In contrast, the redefinition of the Neolithic as a 'thing-heavy world' (Robb 2013) allows envisioning the Neolithic as a world charged with broken objects. As such, this period can inform us of a unique form of knowledge on what people do when objects break. Determining how they were broken and deposited represent a fundamental way to understand this social knowledge. Through the study of the breakage and alteration of pottery fragments by a combination of wear, morphometric and failure analysis I show how breakage actions and broken objects shaped social practices in SKC sites from the Upper Tisza/Tisa Basin (NW Romania, NE Hungary and SW Ukraine), and LBK sites from the Northern Harz Foreland (northern Germany). Results indicate there was a significant variation in social responses to breakage in both regions resulting from the ubiquitous presence, continued exposure and movement of fragments through daily life, as well as from the paradoxical resilience and extensive cracking behaviour of their organic-tempered ceramics. This knowledge brought by living *with* broken objects marks a stark contrast to present lifestyles, and it becomes clear then that the modern waste crisis signals an epistemological crisis.

Impact Statement

The following thesis contributes to the modern understanding of waste and its framing as a problem. The particular way in which the thesis is framed, provides disciplines such as archaeology, with the opportunity to incorporate past knowledge into this discussion. The thesis also ventures in incorporating more critical philosophies, such as negative dialectics, which enrich debates on materiality that have become stale in the last few years. The incorporation of this 'method of thinking', provides fresh insights on a different epistemology, which is presented as the knowledge of pottery breakage. These theorisations are likely to bridge further discussions with other areas like philosophy and anthropology.

New methodologies have also been developed for studying the breakage of pottery, which is undoubtedly one of the most common materials in archaeological sites, such innovations include: the reconstruction of pottery repair techniques through the microphotogrammetric study of perforations in ceramics, the improvement of thermal shock resistance estimations through the direct measurement of cracks, the incorporation of a novel heat apparatus for standardising thermal shock tests, and the creation of scripts and macros (available online) for the automated measurement of archaeological artefacts. These are all contributions that exceed by far the discipline's boundaries.

One particularly powerful result was that organic-tempered low-fired ceramics performs admirably under thermal and bend stresses. This can provide future investigations with avenues for developing sustainable 'technologies', such as dung-tempered pottery. One of the problems of the overexploitation of cattle in modern industry is the abundance of cow dung. The results from thermal shock and strength tests show that it is feasible to produce suitable pots with this material, which can be used in a variety of modern settings.

A last strong contribution from this thesis stems from the critical appraisal of one of the most impactful periods in human history: the Neolithic. By considering waste at the so-called "dawn of European civilization", the results presented allow reinterpreting the period, and show how knowledge can be created by human interaction with what we consider today as 'waste'. In this sense, the study of the Neolithic conducted here can fuel further debate within the UK and continental Europe, but also in various other areas of the world where similar historical processes occurred.

Acknowledgements

In my still limited experience, a lot of what archaeological research (and probably all types of research) entails is learning to deal with unforeseen situations, which is the topic of my project. Unfortunately, it is always this type of knowledge that is left out of final protocols and is curiously what would make a specific protocol so unique and rich. This also obeys to the type of narratives we select to present our results, which privileges the idea of planning over execution, and with funding bodies demanding more and more to have results almost even before the actual research occurs. While I also feel I fall victim to the same procedures in my writing, I have attempted to show how these unforeseen situations were an important part of the process. It is now my responsibility and pleasure to mention all those who guided me through these (un)fortunate circumstances.

I am primarily indebted, of course, to my supervisors, Ulrike Sommer, Bill Sillar and Adam Wojcik, that have always been enthusiastic on me attempting to work on odd approaches, topics, and whatnot. While sadly becoming a rarity in academia, their enthusiasm for me has been an endless source of motivation. I believe I would not have been able to work on the topic of breakage if it were not for this motivation. I also owe my appreciation to my examiners John Robb and Mike Parker Pearson, who may well be the only other people who ever read this document, as their thoughtful comments and suggestions have improved the document and made the revision process much more enjoyable than I could have imagined. On another note, I am also extremely grateful to UCL for funding my project through the UCL Overseas Research Scholarship (UCL-ORS), and hope my work meets their expectations.

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I must give a few more mentions of people that shared their expertise and/or research with me and made large portions of my PhD possible. Firstly, I must thank Margaret Beck for

sharing the original photographs of her published tumbler experiments with organic-tempered sherds, and for her enthusiastic support on this matter. I thank Daniela Hofmann for sharing data from the pit dimensions at Niederhumel, and for her great disposition towards this request. I also wish to thank Jincheng Wang, Marcus Korb and particularly Jenny Alex for their help with interpreting results of my pXRD analysis. I must thank Sascha Szpilewski, Manou Rosenberg, Phillip Bayer and Tim Pesch for their help in translating legible and almost illegible fieldnotes from Niquet written in old German. This certainly would have been a monstrous (if not impossible) task on my own. Lastly, I wish to thank José María Vaquer, with whom I have enjoyed discussing some of the theoretical foundations of my thesis. Lastly, from my brief trip to France to view experimental reference collections of use-wear on ceramic sherds, I am extremely grateful for the hospitality and guidance of Julien Vieugué. I also thank Marine Benoit, Jacques Pelegrin and Sebastien Manem for their help with some lithics and pottery enquiries, and for their lively discussions.

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[*Din munca mea de teren în România, nimic nu m-a învățat mai multe din situații neprevăzute decât întreaga țară în general. Sunt foarte recunoscător pentru aceste surprize nesfârșite. Mai important, țin să—i mulțumesc colegului și prietenului meu Ciprian Astaloş, probabil un guru al circumstanțelor neprevăzute, pentru ajutorul lui în nenumărate situații. De asemenea mulțumesc familiei Astaloș pentru solidaritate, pentru toleranță, și pentru că au fost gazde minunate pentru mai multe luni. Sunt recunoscător personalului din Muzeului Județean Satu Mare pentru deschidere la cercetarea mea, în special lui Cristian Virag. Pe Tanti Mia și domnul Petre îi apreciez pentru toate eforturile depuse în asigurarea unui mediu de lucru foarte confortabil la Bobald. În cele din urmă, vreau să-i mulțumesc Géza Istvánfi, olarul pe care l-am vizitat periodic la Vama, pentru cunoștințele sale neprețuite cu privire la tehnicile de fabricare a ceramicii, dar, mai important, pentru împărtășirea cunoștințele sale sociale despre ruperea ceramicii.*]

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Chapter 1. Introduction

One of the most materially evident yet socially obscured aspects of modern consumer society has been the increasingly dominant presence of broken objects considered as 'waste' or 'rubbish' (Rathje and Murphy 1992; Shanks *et al.* 2004). At the dawn of the Neolithic period, an unprecedented level of material accumulation also occurred (*e.g.* Hardy-Smith and Edwards 2004). South-eastern and central Europe were also to witness an explosion of material remains, mostly pottery fragments, that would affect the social lives of local inhabitants, referred to from their pottery styles as the *Linearbandkeramik* (LBK) and *Starčevo-Körös-Criș* (SKC). However, because of our modern tendency to write (pre)history in stages defined by concepts of progress and technological development, the Neolithic period is conventionally characterized as the moment where humans became masters over nature. Thus, it is commonly emphasised that sedentary lifestyles, domestic agricultural production, and technological innovations like pottery were introduced (Alinei 2014; Fowler *et al.* 2015, 4; Shaw and Jameson 2002, 423). In contrast, the present study challenges this reductionist view, by following John Robb's (2013) redefinition of the Neolithic as a 'thing-heavy world'. In this sense, we can envision the Neolithic as a world charged with broken objects. As such, this period can inform us of a form of knowledge related to what people do when objects break, which invites reconsideration of the idea of human mastery over nature. This latent and practical knowledge on the breakage of objects has long been an undervalued element of social life, and the present study brings it forth. I aim to show how breakage actions and broken objects shaped social practices in the central and south-eastern European Neolithic. Determining how objects were broken and deposited may show a difference to our modern lifestyles and with it the opportunity to reframe what is known as the waste crisis.

1.1 A short prelude: The waste crisis and the philosophy of human control

In one of their seminars on reflexivity, Pierre Bourdieu and Loïc J.D. Wacquant stated that in every society there are officially sanctioned social problems that are considered legitimate topics for study (Bourdieu and Wacquant 1992, 236). However, as suggested by the French scholars, the crucial task for the social scientist is not to commence research by aligning towards a so-called solution of the problem at hand, but to understand why this problem has been officially considered worthy of being studied. In other words, one must first bring forth the historical conditions that enabled their authority as social problems to "avoid becoming object of the problems that you take as your object" (*Idem*, 238), *i.e*. to prevent falling prey to the same problematic preconceptions that have led us to consider the problem as such in the first place. Let us take a brief look then on the social problem in question here: the 'waste crisis', *i.e*. our inability to cope with the increasing amount of waste production.

The last two decades of ‘waste studies’ in environmental and social sciences have shed some light on the history of this crisis. The professionalization of waste disposal as we understand it today (a mechanism for keeping materials out of sight) can be seen as an 18th and 19th century construct, emanating from urbanisation, industrialisation and the intensification of the capitalist way of life (Alexander and Reno 2012, 7–8). This historical process entailed the separation between household and public management, where sanitation engineering became a recognized profession (*Ibid.*). Other ‘sanitation’ institutions also emerged at the time, such as the clinic, and with it the reconceptualisation of the human body as a locus for medical control (Foucault 1975). This also coincides with the gradual transformation of Western attitudes towards death from a highly visible public phenomenon to something regarded only in privacy and excluded from society, and with it the physical ‘disposal’ of bodies outside the public realm such that “everything in town goes on as if nobody died anymore” (Ariès 1981, 560).

Despite the ongoing changes since the 18th century, it is after the Second World War when environmentally conscious movements emerged, attempting to demonstrate the wastefulness of productive economies (Graeber 2012, 281), and fears of environmental destruction emerged (Reno 2014, 19). By the end of the 20th century, with the revitalisation of neoliberal policies and the fall of the Soviet Block, new policies emerged to confront the ‘waste crisis’, which involved the dumping of many types of toxic wastes originating in countries from the global centre in the periphery (the so-called Global South). Regardless of the international agreements created in the 1990s (Bamako and Basel Conventions), waste has legally or illegally continued to move in this direction (Alexander and Reno 2012, 18; Minter 2013; van Erp and Huisman 2010). In this sense, the waste crisis is not only about disposed objects. Instead we find that the idea of a crisis of waste accumulation, while a fairly recent phenomenon (Hawkins 2006, ix), is in fact engrained in a long history of industrial activity (mass production and technological development) and ‘destructive’ consumption (Graeber 2011, 492), the social recategorisations of dirty/clean bodies and objects, and the reconstitution of the (post)colonial world.

Currently, it is unsurprising that the highest waste production rates are found in the wealthiest and most industrialised nations (Vergara and Tchobanoglous 2012, 282). Mass waste (MW) is among the most common types of waste, of which a substantial amount is composed of broken objects. The most common way of engaging with MW are landfills (Tammemagi 1999, 4). If these structures are essentially designed to keep material away from sight (Reno 2015, 563; Reno 2011, 517), then waste management practices are concerned with making things disappear (Reno 2015, 561). This modern urge to conceal and obliviate waste builds up to the idea of the 'garbage conundrum' (Shanks *et al.* 2004, 64–66): we live in a time where garbage is produced at an unprecedented scale, yet our understanding of it is highly limited. In short, we have foregone our capacity as social agents to understand the role of 'waste'.

There is a fundamental contradiction. We are driven towards technological development and industry (a means for 'control over nature'), intending to increase utility (use-value) of things, and yet we have created more waste (an uncontrollable 'non-utility') than ever before. Even more ironic is the fact that there is a large amount of effort being put towards a 'technological solution' to waste management (see for example Vergara and Tchobanoglous 2012, 291–297), rather than, let's say for now, a sociological one. We might say then that waste in its untameable nature "signals a sense of failure" (Hawkins 2006, 1) in 'technologically advanced societies', but also expresses the limits of human knowledge (Adams 2007, 206); or, as will be argued, the limits of our ways of constructing knowledge. It is as Anna Tsing argues, it appears that "those who claim to be in touch with the universal are notoriously bad at seeing the limits and exclusions of their knowledge" (2005, 8). The waste crisis, in short, is an epistemological crisis.

This contradiction brings to mind Horkheimer and Adorno's main thesis on the "Dialectic of Enlightenment" (2002), namely the critical observation that modernity culminates in the totalising process of the philosophy of human technical mastery over nature (also discussed in Krebber 2011; Nelson 2011). Through this philosophy, human beings are driven by the calculative-rational means in which they both conceptually and physically apprehend nature to 'satisfy their needs' (Horkheimer 1947). In this reduction of human nature, thought is no longer put towards morals or ends, just on the rationalisation of means for securing self-preservation (Horkheimer 2012, vii). This process of instrumentalisation of human beings extends as well to objects. Technology becomes that which allows the subjugation of nature, and constitutes the very essence of knowledge (Horkheimer and Adorno 2002, 2). In this sense, objects become instruments: "the radio as a sublimated printing press, the dive bomber as a mere effective form of artillery, remote control as a more reliable compass" (*Ibid.*). Under this philosophy, to be knowledgeable is to be able to recognise the *usefulness* of objects. It exalts human tool-making capacities, while objects exist only as means for securing useful endeavours, *i.e*. tools.

Despite being critiqued for their overemphasis on human reason and their "distaste" for technological products (Olsen 2010, 91), in relation to the critique of human drive for control over nature, the Frankfurt School actually addresses first-hand one of the main aspects of the new materialist concern over anthropocentrism. Anthropocentrism is the contention that humans, through reason, are the only species capable of meaningfully apprehending the world, which they exploit to satisfy their needs; as such, they are the sole masters of nature, *i.e.* agents capable of willingly transforming nature (Domanska 2010, 118; Knappett and Malafouris 2008b, x; Thomas 2015c, 23). As a consequence of this philosophy of control, and perhaps a crucial distinction with the Frankfurt School, new materialists have argued that things have become of secondary importance in social theory, which has resulted in a now common realisation that things exist beyond our conceptual or utilitarian control, and can act upon us (e.g. Gosden 2005; Knappett and Malafouris 2008a; Latour 2005; Robb 2015; Webmoor and Witmore 2008). Regardless of their differences, these contemporary scholars are still highlighting the problems of a persistent humanist philosophy of control. Thus, have we really overcome the tool-centred view of humanity?

Following these reflections, in this dissertation I commence with what I consider to be a fundamental motor behind the authoritative problem of waste accumulation, *i.e*. our pervasive tool-centred philosophy of human control. Concordantly, I argue that the limits of knowledge exposed by the notion of waste merely reflect the limits of the illusory and persistent ideal that knowledge is solely constructed through the control over matter (Chapter 2). Rather than ascribing to one or another set of assumptions built by the melange of approaches to materiality and materials that have, at least *conceptually*, overcome some of these limitations, it is because of the persistence of the 'philosophy of control' that I wish to tackle it in a more radical way, through a dialectical move. This choice is also made because I fear that the 'turn to things' is dangerously close to being misinterpreted as a neo-functionalist naïve empiricism (Thomas 2015c, 11), and paradoxically may turn more towards solidifying an idea of instrumentality.

1.2 A dialectical move: Focusing on breakage

> *"…it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail"*
>
> (Maslow 1966, 15)

As somewhat explained by this quote, my critique throughout the dissertation is simple, create the idea of humans as tool-makers, and everything will be subsumed under the banner of what is ‘useful’, which is the foundational rhetoric of our stadial view of human history (see below). Rather than utilising a genealogical or even an anti-foundational approach to the question of the philosophy of control, which has been done very eloquently time and time again (e.g. Foucault 1977; Olsen 2007; Pluciennik 2001; Thomas 1999; 2004), I approach the problem of the reification of our categories of control through negative dialectics (Adorno 2004; 2017). Dialectically then, my argument moves towards the non-identical in the concept of technology, which is the recognition that what is useful is by necessity defined by what is considered non-useful, an aspect normally left out of the central ideas of human nature. For example, just as an exercise and not as a call for action, how often have we seen an inverted stadial evolution of humanity based on our history of producing waste instead of the popular one depicting our technological development (Figure 1.1)? My point is what if as an exercise we firstly invert the humanist scheme, and start our analyses on aspects of human-material relations that occur beyond human control? Following this formulation, the focus of this dissertation will be explicitly on the realm of the non-useful, namely those aspects of materials that we cannot control but impinge on social practices. Through this approach I hope to expose the fallacy of the tool imperative and present an often unseen but latent form of knowledge.

Nowhere can there be clearer evidence of this realm than in the breakage of tools. Breakage is normally seen as one of the processes through which objects are transformed into non-useful or purposeless entities; in other words, an inevitable step towards discard (Schiffer 1987, 48). However, throughout the text I will illustrate that there is more to breakage than a mere process leading to discard. As discussed by various developments in material culture theory in the last decades (Gosden 2005; Ingold 2007a; 2007b; Knappett 2007; Miller 2007; Nilsson 2007; Robb 2015; Tilley 2007), (broken) objects can be more than just useful, and through their ‘thingness’ afford different sets of human actions. In this line of thought, breakage is rather a process which, as a resistance to our will or technical control, brings forth a form of practical knowledge that is not founded on the idea of the ‘technical mastery over nature’ and is intrinsic to different social practices. This long lost, or rather latent, social knowledge of breakage, more thoroughly developed in the next chapter, shall be the focus of the dissertation.

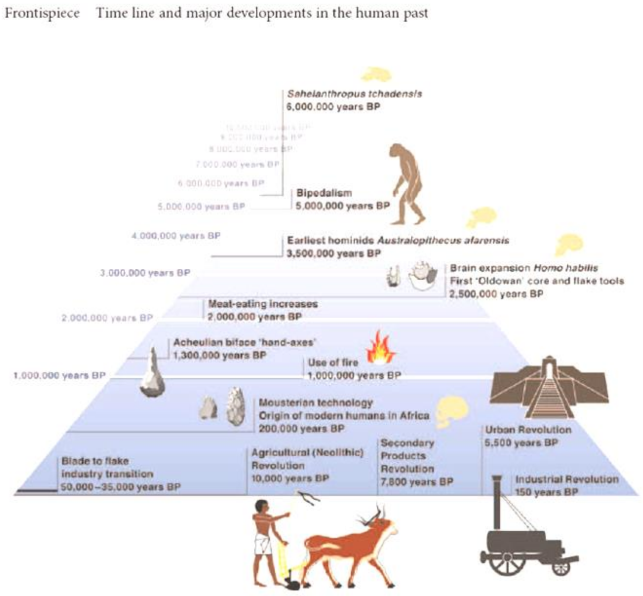


Figure 1.1: An example of the view of humanity in stages of technological development (Greene and Moore 2010, with permission by the copyright holder).

1.3 On the European Neolithic

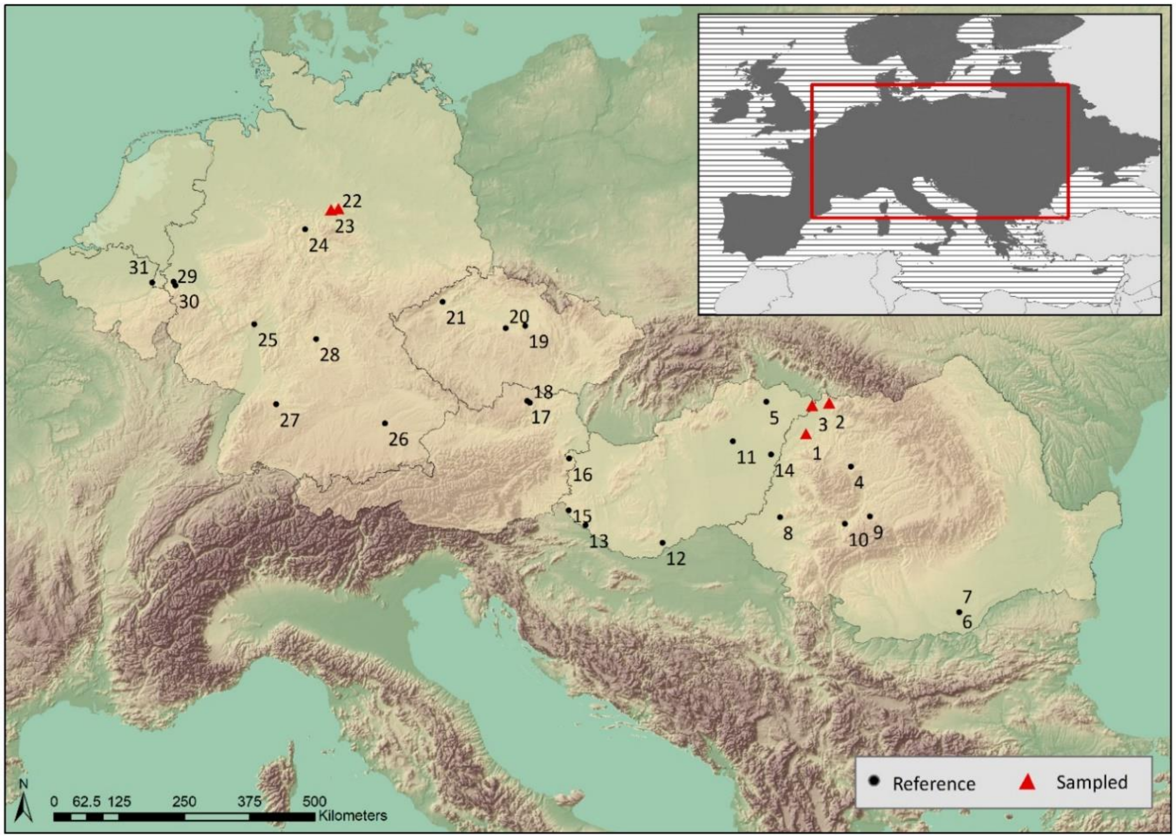
At this point, the reader must be asking, so why the Neolithic? What does the Neolithic have to do with the 'waste crisis', the 'garbage conundrum', or breakage? The Neolithic forms an interesting, if not unique, moment in history from which to view the addressed issues mainly because of two reasons: (i) it constitutes a powerful historically-constituted symbol of the European narrative of productivity and technological control, and (ii) with its recent redefinitions as a period of increasing material accumulation, grants the opportunity for understanding a different form of knowledge construction and human-material interactions that may challenge our modern conceptions of waste and (non)usefulness. From this second point stems the question: what happens when we study social groups whose history is clearly different from the foundational history of our institutions?

As arguably one of the most influential historical moments of European idealizations of the past, perhaps surpassed only by the hyper-rationalist portrayal of the Greeks (Dodds 1951) or the depiction of the imperialist Roman world as a monument of civilisation (Hoselitz 2007), the Neolithic period is portrayed as a moment of human productivity. It is seen as the crucial instance when humans gained supremacy over nature. From Adam Smith's four stages of humanity (Smith 1978 [1762-3]) to Gordon Childe's revolutions (Childe 1981 [1966]), there is a modern tendency to rewrite humanity's (pre)history in stages defined by a utilitarian model of human nature (Baudrillard 1975; Graeber and Wengrow 2018; Sahlins 1976; Scott 2017), formalised since at least the eighteenth century Enlightenment (Sherratt 1995, 6; O'Brien 1993). This characterisation of the period, of course, has not been lacking criticism. Some authors have emphasized the economic-centrism of this concept (Pluciennik 2001; Pluciennik 1999; Thomas 2015a; Thomas 1999; Sherratt 1995, 7), and others have highlighted its underlying colonialist discourse (Borič 2005a; Borič 2005b).

[redacted]

*Figure 1.2**:** A model of the 'instrumental' Neolithic (painting by Zdeněk Burian 1957).*

Of course it would be unfair and certainly untrue not to recognize that, during the last decades, the characterisation of the period has continued to grow, as we constantly attempt to rearrange it and incorporate different meanings (*e.g*. Bailey and Whittle 2005; Fowler *et al.* 2015; Hodder 1990). So, from the conventional view of the European Neolithic as a period when sedentary farming societies from the Near East spread throughout the continent with a new technological 'package' composed of a set of animal and plant domesticates, pottery and polished stone (Ammerman and Cavalli-Sforza 1979; Renfrew 1987; Zvelebil and Zvelebil 1988), we have come a long way. Yet, despite most efforts to destabilise it or even to prevent it from being a totality, the Neolithic narrative continues to be mostly about the human control over nature; whether emphasis is on domestication (Fowler *et al.* 2015, 4; Thomas 1999, 7; *e.g*. Price 2000, 20; Zvelebil 1996, 323; Zvelebil 2004, 183), pottery or polished stone tool production (Dolukhanov *et al.* 2005; Zhilin 2000). In other words, production and technology (*sensu stricto*) are still the definitional terms of the period (Sherratt 1995, 7), to which all other aspects are secondary. It seems as if "even the most apparently sophisticated contemporary scholars end up reproducing conventional wisdom as it stood in France or Scotland in, say, 1760” (Graeber and Wengrow 2018, 3).



1	Tășnad Sere	9	Ghioroc Balastiera Vest	17	Strögen	25	Bruchenbrücken
2	Călinești-Oaș-D.S.M.	10	Turdaș-Luncă	18	Mold	26	Niederhummel
3	Méhtelek-Nádas	11	Tiszaszőlős-Domaháza-puszta	19	Bylany	27	Gerlingen
4	Gura Baciului	12	Lánycsók	20	Miskovice	28	Schwanfeld
5	Ibrány-Nagyerdő	13	Becsehely	21	Březno	29	Langweiler 8
6	Boldul lui Moș Ivănuș	14	Szentpéterszeg-Körtvélyes	22	Eitzum	30	Weisweiler 111
7	Măgura Buduiasca	15	Szentgyörgyvölgy–Pityerdomb	23	Klein Denkte	31	Cannerberg
8	Ghioroc Balastiera Vest	16	Neckenmarkt	24	Einbeck		

*Figure 1.3**:** Map of the regions of interest with their sampled sites, the Upper Tisa/Tisza Basin, and the Northern Harz Foreland.*

In a recent gradualist redefinition by Robb (2013; 2014; cf. Hodder 2017), the Neolithisation of Europe is considered as a long-term history of increasing materially charged practices, *i.e.* a ‘thing-heavy world’ (2013, 665), which contrasts with the more mobile lifeways that were common at the time. Thus, it can be argued that a crucial element of the Neolithic is the set of unintended consequences brought forth by the considerable and progressive amassment of materials, which effectively changed human-material relations. Moreover, if we consider the landscapes of central and south-eastern Europe, where Neolithic sherds are the most common find (Milisauskas 2001, 193; Manson 1995, 17), *broken* pottery might have even played a dominant role in this cumulative process from where there was 'no turning back' (Robb 2013, 669). In other words, pottery might be best seen as a brittle technology which, through its breakage, could have enabled different forms of social knowledge and symbolism for human groups.

The so-called *Starčevo-Körös-Criș* groups (SKC) starting around 6200 BC in south-eastern Europe (Gheorghiu 2008:172; Manson 1995:65), and *Linearbandkeramik* groups (LBK) spread throughout central Europe at around 5500 BC (Stäuble 1995), constitute two of the most illustrious examples of the Early Neolithic in Europe. Both these groups have been conventionally portrayed according to their productive toolset (pottery, sickles, axes and adzes, among others), or their food-producing economy (Figure 1.2). Yet, commonly in sites ascribed to the LBK and in the northern area of the SKC, occupational and household surfaces are eroded, and most of the materials recovered are fragmented remains of ceramic artefacts, almost always found in pits (Stäuble 2013, 235). These features, labelled as 'waste' depositories (e.g. Makkay and Starnini 2008; Thissen 2015, 7), are frequently incorporated into models of spatial organisation, from which activity areas are reconstructed (*e.g*. Boelicke 1988; Link 2012; Rück 2007). But does this indicate pits were exclusively filled by human agents as intentional acts of disposal, or are we misguided by a sort of 'landfill analogy'?

Recent studies of pottery fragments in these areas are beginning to corroborate different behaviours that cannot be explained by the mere dumping of 'useless' remains. Firstly, while the topic is certainly obscure in the literature, some authors have recorded Neolithic mending activities on pottery (Elburg 2015; 2013, 13; Makkay and Starnini 2008; Tegel *et al.* 2012, 5), which gives us an initial cue from which to investigate the knowledge Neolithic populations had of the signs of breakage of pots. Secondly, evidence on the extended social history of fragments has become increasingly visible (Bosquet *et al.* 2010, 44; Chapman and Gaydarska 2007, 91; Classen 2009, 97; Vieugué 2015; Vuković 2015), and questions of breaking as important processes have slowly become part of the picture (Chapman 2000a, 63). Taphonomic studies (Sommer 1990; 1991; Stäuble and Wolfram 2012; Wolfram 2013), for some time now have also urged archaeologists to look beyond their assumptions, and put more efforts towards understanding how finds actually end up in these pits. In response, studies of soil micromorphology, for example, have presented evidence of the complex (re)working of pit fills, consisting mostly of broken pottery, whose formation and history are considered far from linear processes (Domboróczki and

Raczky 2010, 208; Huisman *et al.* 2014, 131; Macphail *et al.* 2008, 65). Therefore, there seems to be a complex picture of what was actually done with broken objects, which takes us beyond the idea of their immediate disposal after breakage.

In sum, it is possible that a practical knowledge in response of ceramic breakage might have been present within the cultural repertoire of south-eastern and central European populations during Neolithic times. By focusing on breakage, some assumptions on humans and objects will be challenged, which in turn will show how knowledge can be created from this unintended process (*ergo* a different epistemology is presented). By examining the uncontrolled effects of the accumulation of (broken) objects, we will come to terms with the fact that the Neolithic mastery over nature is an artifice of our making.

1.4 Research questions, aims and objectives

Following these formulations, I seek to illustrate the place of pottery breakage in social practices during the Neolithic. In this thesis, I focus on the SKC populations from the Upper Tisa Basin (Northwest Romania, Northeast Hungary and Southwest Ukraine; Figure 1.3), and on the LBK populations from Northern Harz Region. The main research questions addressed in this document are the following (see also Figure 1.4):

1. What can we learn from the Neolithic in terms of our modern ideas of waste? Was there a Neolithic social knowledge of breakage, and if so, how did this operate? How does the Neolithic knowledge of breakage contrast with modern ideas of 'waste management'?
2. How did the breakage of pottery and the resulting fragments become part of Neolithic societies? In other words, what was their place in Neolithic lifeways? In this regard, what differences can be observed between SKC and LBK groups?

According to my theoretical framework, from these main questions some derived queries include (Figure 1.4):

3. How did pottery from the regions of interest normally break? What activities can be associated with these processes?
4. What activities are carried out with pottery fragments in household spaces and pit deposits? Are they left at hand, or are they intentionally discarded as the landfill analogy suggests? Are they transported, trampled, or buried? How are deposits formed and transformed?

5. Are there any signs of pottery repair or ‘reuse’? If so, how were they repaired and reused?
6. Is there any link between how pots are broken and what occurs to them afterwards?

Materials science provides a unique format to answer these questions. In Chapter 6, my research methods will integrate: (1) failure analysis of Neolithic pots based mostly on thermal shock and strength tests of experimental samples, (2) wear analysis of Neolithic potsherds, and (3) sherd-size distribution and morphometric analysis of ceramic assemblages. These methods have the following objectives:

1. Determine the mending techniques that these populations developed
2. Identify the manner in which pots were regularly broken, the context of their demise, and interpret the social activities where breakage occurred.
3. Examine the alteration history of potsherds, their condition of deposition and the post-depositional processes affecting them.

In sum, I will explore how cracks and fractures are generated in different moments of pots’ biography, and the social knowledge developed from the perception of these features. For this reason, this approach contests the assumption that materials science is only about establishing “how potters were able to manipulate *aspects of pottery production*, including past composition and forming methods, to create vessels that served *utilitarian* (or techno-functional) purposes (Skibo *et al.* 1989, 122, my emphasis; see also Bronitsky 1986b, 212). Through this framework of pottery breakage as an uncontrolled manifestation in human-material relations, a critique to the Neolithic model of production will be construed, and in this way, we can reconsider what the waste crisis means.

Figure 1.4: Synthesis of main and derived research questions.

1.5 Structure of the dissertation

The dissertation commences with a discussion on the contradictions of the 'philosophy of control' as posited by the Frankfurt School and by more recent new materialist approaches. The questioning of the philosophy of control becomes central in my argument towards the formulation of a theory of breakage, as it is derived through a dialectical movement from this philosophy (Adorno 2004; 2017). From this discussion, I detail my main theoretical construct, the social knowledge of breakage, and propose to study this form of knowledge according to three dimensions. This is the crucial task of Chapter 2.

In Chapter 3, the influence of the philosophy of control in the definition of the Neolithic is made explicit, particularly focusing on the influential work of Sir John Lubbock, Oscar Montelius, Gordon Childe, and authors subscribing to the idea of the 'Neolithic Package'. In the chapter we follow the historical categorisation of the Neolithic as the so-called 'dawn of civilization', where humans are believed to have become masters over nature. As an attempt to overcome these tainted definitions, I introduce an alternative view derived from the recent work of John Robb and Ian Hodder, which I entitle the 'Early Neolithic Broken World'.

The next chapter (Chapter 4) goes down a more specific route and provides a brief review of the study of the *Starčevo-Körös-Criș* and the *Linearbandkeramik* phenomena of southeastern and central Europe. The focus is on problematising what I term as the 'landfill analogy' in European Neolithic studies. This analogy consists in comparing modern waste management protocols and Neolithic depositional practices. In this line of thought, it is assumed that, much like modern landfills, Neolithic pits functioned as repositories for removing material remains out of sight, and that the potsherds filling these structures were simply (useless) waste. Consequently, it is believed that the only way Neolithic inhabitants interacted with broken pottery is through a process of discard. To counter these claims, a review of more recent studies of pottery reuse, repair and deposition, as well as analyses on the soil micromorphology of Neolithic pit fills, is presented.

Following these theorisations, in Chapter 5 I provide an overview of research carried out on settlement structures and pottery technology, as well as the relevant geological and geomorphological information about my two main study areas: the Upper Tisza/Tisa Basin (UTB) and the Northern Harz Foreland (NHF). The chapter also provides a background on the excavation and finds processing methods conducted on the sites I have sampled from both regions; namely, Tășnad Sere, Călinești-Oaș and Mehtelek-Nádas from the UTB, and Eitzum and Klein Denkte from the NHF.

In Chapter 6, my sampling strategy and three main research methods are introduced, which includes: failure analysis of Neolithic cooking pots through thermal shock and standardised three-point-bend tests of experimental samples, analysis of wear traces on reused potsherds through microscopy and microphotogrammetric techniques, and the sherd-size distribution and morphometric analysis of ceramic assemblages. Each method was designed to address a different dimension of what I have defined as the social knowledge of breakage, but as shown in the final chapter of this dissertation, results obtained from each method encompass several of these dimensions.

Results are presented in three chapters (Chapters 7, 8 and 9) according to the methods selected for analysis. Chapter 7 presents the main results from first tests on sherd-size distribution and morphometric analyses. The first section synthesises the main parameters for distinguishing sherds buried right after the primary rupture of vessels from sherds that have had a prolonged exposure to the environment before their deposition. These first results set the basis for understanding the several archaeological contexts studied from the Early Neolithic sites sampled.

Chapter 8 displays results from some experimental work on microphotogrammetry of perforated sherds, which provide some parameters for identifying drilling techniques in pottery repair. These first results provide a reference for analysing Neolithic perforated sherds. The main results from the analysis of sherd wear in Early Neolithic sites are then presented, with some findings on a variety of sherds used in pottery manufacture and cooking activities. Evidence of repair on pots is also discussed by integrating the results obtained from drilling experiments.

In the last results chapter (Chapter 9), results from thermal shock and three-point bend tests are presented. For the former experiments, a preliminary study for determining the firing temperatures and the way pots were placed over the fire in cooking activities is presented. Based on this information, thermal shock tests were designed, using a heat apparatus. Results revealed the somewhat paradoxical nature of these ceramics, which can be synthesised as ‘strength through cracking’. This was corroborated with three-point-bend tests and a comparison with archaeological legacy data.

Results from these three results chapters are integrated in the final chapter (Chapter 10). Here my interpretation of the social knowledge of breakage is presented according to the Early Neolithic groups discussed (SKC and LBK). Building on this interpretation, some further generalisations are made regarding the European Neolithic in general, on the demystification of the period as a milestone in the development of human mastery over nature. Lastly, some final theorisations on the differences between the Early Neolithic and the modern waste crisis are presented as a modest attempt to help reframe this crisis.

Chapter 2. The philosophy of human control over nature and the dialectical movement to breakage

In the previous chapter a glimpse of the waste crisis and its main contradiction was presented, introducing us to the philosophy behind its justification as a social problem. This corresponds to the philosophy of human mastery over nature, and in this chapter, we shall delve into its core principles. The chapter is divided into three sections. In the first section I revise the principles of this philosophy and some of its historical roots through the work of theorists from the Frankfurt School. The second section seeks to unpack two crucial components of this philosophy, *i.e*. technology and tools, to expose the consequences this philosophy has on our view of objects. For this I draw from the work of various contemporary theorists on materiality. By following a dialectical movement, the last section seeks to confront and destabilise these principles by introducing a theory on breakage that functions as an inversion or negation of the philosophy of human control. It will be argued that: (i) the philosophy of control is based on a particular historically-constructed model of human nature, (ii) under this view, humans are reified as tool-makers and objects as tools (objects disposed towards use as indicated by its rationalised design), and (iii) by inverting the principles of this philosophy through negative dialectics and focusing on aspects of human-material relations that resist rational control, this model can be confronted.

2.1 The disenchantment of the world: The birth of the philosophy of human control

In order at arrive to premise (i), I present a brief history of the idea of reason fostered by Western philosophers mainly through the work of Theodor W. Adorno and Max Horkheimer's seminal piece "Dialectic of Enlightenment" (2002 [1944]). In this book, the authors extend the enquiry of the philosophy of human mastery over nature by embedding it within a broader history of Western thought. For them, the philosophy of control would have taken form throughout centuries of progressive exclusion of numerous parallel worldviews categorised as 'irrational'. The Enlightenment project, of which archaeology would eventually form a part of, sought to establish a unique form of knowledge divorced from what was deemed as the realm of fantasy and irrationality: a true disenchantment of the world (Horkheimer and Adorno 2002, 1). The construction of this knowledge was to be obtained through the controlled and "systematic enquiry into nature" (*Ibid.*), which was believed to improve human beings' condition. Yet, for Adorno and Horkheimer, in this demythologising process a mythology was created, and a particularly dangerous one. This corresponds to the myth of humans' technical mastery over nature, where the epistemological relation between human understanding and the nature of things is believed to be exclusively established through rational-technical control. Falling in line with the bourgeois economical thrive, an instrumental view of human nature was instituted.

The Enlightenment project could be said to commence long before modern times, with the extradition of *mythos* towards a discursive field constituted only by fantasy and irrationality, in the prevalence of *logos* as the component of truth and rationality. During the Archaic period in Greece, *mythos*/*logos* did not stand at opposite ends, but composed the field of discursive acts (Vernant 1996, 204). Myths were embellished accounts, they attracted their audience and captivated them, while at the same time, tackling “fundamental truths of existence” (*Idem*, 219). In this sense, to its audience, myths provoked an emotional drive as well as provided a framework for understanding the ‘natural’ order. In myths, nature (*phusis*) was animated by mythological figures. Myths referred constantly to the actions of anthropomorphic deities and heroes as explanatory for natural phenomena such as lightning and earthquakes (Descola 2013, 68). *Logos* had multiple meanings according to different Greek authors: word, account, opinion, among many others. For example, in Herodotus “*all reported discourse*, as well as the actual discourse of his Enquiries, falls under the head of *logos* and *legein*, whatever its degree of truthfulness" (Calame 1999, 122; my emphasis).

Some of the disbelief in mythology and questioning of divination can be said to have started taking place in 6th century Ionia with philosophers like Hecataeus, Xenophanes and Heraclitus (Dodds 1951, 180), but was still restricted to only a small group of philosophers. Several changes occurring during the following centuries, like the introduction of formal categories of thought, would eventually cause an opposition between *mythos* and *logos*. Myth was cast aside as a fantastical narration which construed a false image that captured and enchanted the audience. Explanation could no longer be sought in this narrative but was established using specific categories of thought. *Logos* now entailed a “demonstrative rationality” (Vernant 1996, 206), a truthful explanation following principles that disable ambiguity in speech, locating it in direct opposition with *mythos*, which dealt with ambiguity by linking the literal with metaphorical. In short, it all became “as if discourse could only win in the sphere of truth and intelligibility by simultaneously losing out in the sphere of what is pleasurable, moving, dramatic” (*Idem*, 208). As a consequence, nature became separated from myth and a subject for inquiry (Vernant 2006, 378).

Reason became divorced from the mythical. Nonetheless, reason was still believed to be connected to an external reality. Through reason, the eternal world became intelligible. For example, for Plato “the eternal world [was] revealed to the intellect but not to the senses” (Russell 1945, 37). Domination was about intellectual appraisal through speech, fostering a separation from matter. In other words,

> “[…] for the Greeks of the fifth century, acting did not mean making objects or transforming nature. It meant influencing men, overcoming them, dominating them. Within the framework of the city, speech was the instrument most necessary for action, and mastery of it meant power over others. The sophists' reflections on human *technē*, on the means of extending one's power and perfecting one's tools, led neither to technological thinking nor to a philosophy of technology” (Vernant 2006, 317).

Reason was also about thinking on ends, the acceptance of ideals, and ethical principles (Horkheimer 1947, 16). The domination over nature was not yet an imperative for reason. This idea of reason would become an inspiration for the Enlightenment movement.

From the 16th to the 18th century, while the focus on empirical entities had become part of a subject matter for many philosophers, there was still a concern over the moral aspects of thought. As Bertrand Russell synthesises, "in Plato, Saint Augustine, Thomas Aquinas, Descartes, Spinoza, and Kant there is an intimate blending of religion and reasoning, of moral aspiration with logical admiration of what is timeless" (Russell 1945, 37). There was a close relation between God, nature and reason. Much of the 16th and 17th century organicist/mechanistic debate on nature delved into this relation with the following question: was nature a balanced unity organised according to a (divine) plan? Regardless if philosophers at the time accepted or rejected divine intervention in the material world, most of the contenders of both sides of the debate ultimately convened in a separation of nature and humanity. This signals the historical breakpoint where the exploitation and experimentation of a now autonomous nature became a possibility and a subject of concern (Descola 2013, 69). In other words, the autonomy of thought from objects was fundamental for the total embracing of what would become industrial technology (Horkheimer and Adorno 2002, 7). However, thought was still connected to the divine in some way or another. For example, Isaac Newton’s writings shared the mechanistic view of a clock-like world set in motion and maintained by a divine force residing outside of nature (Figure 2.1), but these workings became intelligible to men through reason (Newton 1999 [1687], 393); thus there remained a connection of reason with God.

Figure 2.1: Monument at Westminster Abbey in honour of Sir Isaac Newton (picture by B. Cole, after William Kent and after Michael Rysbrack; © National Portrait Gallery, London, reproduced with permission by the copyright holder). The inscription of the actual monument also highlights the blending of reason and the divine in Newton's mathematical universe: "[...] Diligent, sagacious and faithful, in his expositions of nature, antiquity and the Holy Scriptures, he vindicated by his philosophy the majesty of God mighty and good and expressed the simplicity of the Gospel in his manners.[…]."

Eventually, both religion and metaphysics also would end up labelled as a simple non-sensical superstition (Horkheimer 1947, 18). This conceptual detriment was epitomised in the work of Auguste Comte. In the "Introduction to Positive Philosophy" ([1830-1842] 1988), Comte establishes an evolutionary scheme of mental development from a theological phase, passing through metaphysical thought, up to the maturity of positive philosophy. In the theological state, 'primitives' used a fictitious mode of thought that explained the immanence of beings and the phenomena they perceived as the result of supernatural beings (*Idem*, 2). Metaphysics is also brutally downplayed as a mode of thought whose only real use was to enable the substitution of supernatural agents with abstract forces in the explanation of 'natural' phenomena (*Idem*, 7–8).

With this transformation, the idea of reason banished its own objective presence or absolute form in the world. Objective reason, the idea of a 'great' reason capable of not only unlocking the universal truth of reality, but also of setting maxims or moral principles (Horkheimer 1947, 18), was cast away. With the dismissal of the ontological foundation of reason in an external world, and the separation of field of science from that of philosophy, the idea of reason did not collapse, but continued as a merely subjective operation. The Enlightenment project of casting aside all ambiguous subjective elements of reasoning became totalitarian (Horkheimer and

Adorno 2002, 4). In this operation, reason does not focus anymore on the construction of a 'universal' knowledge, nor on questions of morality and human nature, but in its subjective form only operates by serving the subject for the purpose of self-preservation. Through this orientation towards self-interest, reason becomes instrumental. In this hypostatisation of thought as an instrument, it is condemned to its potential for material production (*Idem*, 19), of calculating *means* to ends and not for posing questions about those ends (now deemed as 'speculation'). 'Myth' is extirpated from the world of labour, and labour is in turn reduced to a techno-extractive operation.

Therein lies its danger, as it extirpates all other forms of contemplating the world (social classificatory schemes), just as utilitarian anthropology, "it does not hesitate to destroy any other *forms of humanity*" (Sahlins 1976, 221; my emphasis). The idea of human mastery initially sought to liberate humanity from dogmatism and do justice to the empirical world that was cast aside by idealism and theology. However, in the process of subverting the otherness of the empirical world to sameness (according to principles of formal logic), reason became a dogma in itself. In other words, it became a tautology locking its tenants outside the experience of difference in the world. This leads towards the main observation I would like to point out, that the domination over nature necessarily becomes the domination over human beings: "[...] domination over nature turns against the thinking subject itself, nothing is left of it except that ever-unchanging "I think," which must accompany all my conceptions. Both subject and object are nullified" (Horkheimer and Adorno 2002, 20).

In short, the philosophy of control has profound effects on the concept of human nature, *i.e.* humans are rational beings. Yet, it is not only a confinement of human beings to reason, but their reduction to a specific model of reason, one oriented towards the adaptation of means to ends. Following these theorisations, we shall see that this process of instrumentalisation of human beings, in turn, has also affected our perception of objects, which also become reified as 'tools'. That is the scope of the next section.

2.2 The posthumanist critique of anthropocentrism

Probably the most prominent appraisal in material culture studies during the last two decades is the critique of anthropocentrism. In essence, anthropocentrism consists of "an attitude which values all things non-human – all inanimate and animate components of the environment barring other people – solely as instrumental means to the realisation of exclusively human ends" (Ingold 2000, 218). In this sense, agency as a form of rationality is considered to belong uniquely to human beings (Knappett and Malafouris 2008b, xi), for whom the world is at their mercy. Non-humans (*e.g.* material things, plants and animals), defined in contraposition to humans, in turn become passive recipients of meaning and action.

[redacted]

Figure 2.2: An example of artistic movement against anthropocentrism, the late work of William Wegman (2007). In this image there is an attempt to position animals, in this case a Weimaraner, on an equal footing to humans.

While some authors have criticised the Frankfurt School for disregarding objects and technological products (Olsen 2010, 91), it is hard to argue against the recognition that the critique of anthropocentrism mostly broadens the arguments against the philosophy of human control over nature. After all, we must not forget that the crisis of reason announced by Horkheimer and Adorno is what catalysed movements like poststructuralism, postmodernism, and subsequently some branches of posthumanism. We may say, rather superficially, that one of the differences is that while the Frankfurt School focuses on overcoming the subjugation of the human condition to the instrumental imperative and the reifications of the administered world, new materialist perspectives concentrate on reanimating the material world to decentre human beings in relation to the long-forsaken non-humans (Figure 2.2). Regardless of differences in philosophical positions between these authors (*e.g.* their position in the hermeneutic field: suspicion *versus* revelation, *sensu* Ricoeur 1970, 20–35), and even among the melange of approaches constituting this 'material turn', there is some continuity *in the critique* of the philosophy of human control over nature. Following some aspects of the 'extended' critique, this section is concerned with arriving at premise (ii) which involves answering the following question: what happens to our conception of objects under the philosophy of control? The answer will be twofold, that under this philosophy, (a) objects are reduced to an idea of tools (*i.e*. useful towards human intent), and (b) this usefulness is dictated by a rationalised production process.

2.2.1 On technology, production, and the reification of objects as tools

A first crucial consideration is the concept of technology. While the Frankfurt School brings forth the observation that in the philosophy of the mastery over nature the idea of technology occupies a central theme, as the very "essence of knowledge" (Horkheimer and Adorno 2002, 2), Tim Ingold reminds us that, as with many other domains in our modern world, the idea of technology advanced by this philosophy comes accompanied by rationalist dichotomies such as matter/mind and nature/culture. Technology is believed to be a *corpus* of knowledge which allows humans to transform "neutral objects into useful equipment" (Ingold 2000, 298). In this sense, technology is something existing in the mind of the individual (Ingold 1986, 43), and allows the subjugation of a passive nature or matter. Tools become the objectification of this form of knowledge, as objects created for an intentional project. This will be the exclusive meaning given to the word tool from now on. As the expression of the technological project, they become the sole referents of this project. For example, an axe is simply regarded as a timber acquisition tool. We can find this logic in the contemporary narrative of technology as innovation, where it is claimed technology fosters solutions to problems (Kjærsgaard *et al.* 2016, 3; Pink *et al.* 2018, 617). From this perspective, it is the 'finished' product devoid of any social relation which is *the innovation*, rather than the social transformation of objects (Ingold and Hallam 2007, 2; Pink *et al.* 2018, 617). The technological solution, such as those currently being advocated as a response to the climate and waste crises, entails the introduction of products without consideration of the creative capacities of local skills or ways of knowing. In sum, technology as innovation "celebrates the freedom of the human imagination […] to transcend the determinations of both nature and society" (Ingold and Hallam 2007, 3).

This leads us to our next observation. In the contemporary Western world, with the adoption of an instrumental view of nature (*i.e.* without agency) and the primacy of human 'mind over matter', production becomes rationalised. A division is formed between the design of objects and the actual sensuous experience of making them (Ingold 2000, 295). This process removes creativity from the process of physical engagement with the material, and restricts it to the intellectual process of design, where matter is controlled by thought. In other words, producers produce products but not the other way around (Descola 2013, 321). In Classical Greece, the artisan would shape and be shaped by the making of the object, as the artisan was tied to the unpredictable nature of the material and the dextrous activity of making would have an effect on the original design and purpose of the object (Vernant 2006, 313). In this sense, rather than controlling, human action adapted to the rhythm of the natural processes (*kairos*) involved in making objects (*Ibid*.). Today, we have established a pronounced divide between engineers/architects who design and technologists/builders who execute designs (Ingold 2000, 295). The actual 'making' of the object becomes merely the execution of a prefabricated abstract model of the object. For Ingold, "it is the *separability* of constructive work from the context of sensory experience that gives [technique] the quality of being mechanical" (2000, 296; emphasis in the original). Furthermore, as objects become conceived before practice, their *intended use*, as mandated by the rationalised process of design (see Baudrillard 1981, 186 on the Bauhaus movement for an extended critique), becomes reified.

This last point can be illustrated by Baudrillard (1975) in his critique of the Marxist notion of use-value. In Marx's Capital: A Critique of Political Economy (1906 [1987]), a duality of labour is used as an attempt to demystify the formalist notion of exchange-value. In Marx's critique, exchange-value is revealed as essentially quantified labour power, *i.e*. the amount of labour (expressed in time units) needed to produce a commodity. As such, it corresponds to an abstraction derived from the 'real' use-value of the object. This latter form of value refers to the capacity of the object to satisfy a human need based on the concrete attributes of the object. Use-value is set by the transformation of the physical properties of the object towards a useful end, which is embedded in the object. Just like the commodity, labour also possesses an exchange- and use-value. While the former corresponds to the remuneration given to the worker, the latter is not only its capacity to produce commodities but is "a necessary condition, independent of all forms of society, for the existence of the human race; it is an eternal nature-imposed necessity, without which there can be no material exchanges between man and Nature, and therefore no life" (*Idem*, 50). For Marx, under the capitalist system of exchange value, the concrete reality of the relation between 'Man' and Nature (*i.e.* useful labour) becomes obscured, and labourers, already alienated from the production process, cannot recognize the value of their own work but must accept the one given to them. However, as Baudrillard notes, in the dialectical movement established by Marx between exchange- and use-value, human nature was already being reduced. It is not enough to counterpose the qualitative nature of use-value to the quantitative one of exchange-value, but also to reveal the condition that enables this relationship: the presence of a reduced idea of labour force according to a principle of production (Baudrillard 1975, 25). This is hidden in the idea of use-value. The definition of objects as ‘useful’ already condemns them to an abstraction: it represents the *intended use* (*i.e.* predetermined use) as determined by the production process, and not its *actual* use. Thus, the notion of use-value, which seemingly opposes abstract value with an apparent concrete attribute, actually functions as an alibi to exchange-value, as an abstraction that guarantees the reduction of human beings and objects to their productive capacity (also argued by Descola 2013, 322).

These considerations lead us to the following crucial argument: with the totalisation of the philosophy of human mastery over nature, there is alternative existence for objects other than in their tool status. This means that objects are reduced to things put to use as devised by the rational human actor during the design of the object. In other words, if agency exclusively belongs to humans, based on the criteria of consciousness and intentionality, then objects are just passive recipients that are put towards the intent of humans. The philosophy of control reifies subjects as toolmakers and objects as tools. This is partly why Ingold states "it is decidedly odd that the term ‘anthropocentrism’ should have been adopted to denote an attitude that, more than any other, withdraws human life from active participation in the environment" (Ingold 2000, 218). Without the Frankfurt School’s reminder that for the technocratic philosophy of control to have become so dominant it required the historical exclusion of all other forms of being, I consider that focusing *solely* on material agency might forfeit our ability to confront this philosophy.

A clear example of this is Symmetrical Archaeology’s disguised idealism. Continuing the critique of anthropocentrism, and as an attempt to decentre human beings, the contenders of this approach state we must first and foremost put humans and things on the same ontological footing, a principle of symmetry. Hence, human beings are claimed to be just things amongst other things (Olsen and Witmore 2015, 191). Symmetrics further state that things, such as abandoned houses, centrifuges, walls, penguins, etc., are entities irreducible to representations or relations, as they *essentially* exist beyond these. Archaeologists’ gaze should then not only be put towards human-thing relations, but beyond to thing-thing relations. This is how their object-centred metaphysics (*e.g* Harman 2010) claims to have overcome the subject-object dichotomy by moving beyond the perceptual subject and reformatting essentialism. Yet, despite efforts to differentiate themselves from Kantian metaphysics (Olsen *et al.* 2012, 19–20), the proposal brings back the Kantian *noumenon* (Wolfendale 2014). The means to access the essence of things (*i.e*. the thing-in-itself) is to speculate through thought and a sort of non-Geertzian ‘thick’ description[1]. In this

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[1] This descriptive method has also been denounced as a type of antiquarianism (Barrett 2016, 1685).

operation, symmetrical archaeology not only reverts to idealism[2], by positioning human thought over matter, it also creates for itself a 'materialist' cloak or alibi with which to disguise this idealism (see also Vatsvåg Nielsen 2019). In this, the project sets itself to fail. There is an aprioristic assumption of human nature, beyond the highly problematic 'thing' category. Instrumentalised ideas of humans and objects continue to be reified. This aspect has already left some authors worried about leaving humans aside and depoliticising the discipline (Fowles 2010, 23; Hodder 2014, 229; Lucas 2015, 191). For this reason, I claimed in the previous chapter that rather than confronting, symmetric archaeology overdetermines the philosophy of the human mastery over nature.

My point is that the critique of the philosophy of control should not be about just thinking about things, but about tearing down our instrumental model of (human) nature, which has been persistently centralised in contemporary Western philosophy. For this reason, instead of attempting to exhaust all aspects of 'things' through intellectual description (as symmetric archaeologists advocate), I wish to focus on a singular aspect of material agency: the capacity of objects to resist our control. I hope that through a dialectical movement to the uncontrollable or untameable, we shed light on a different version of human nature as well as on objects. In other words, "to invent and to make is human. To break, to curse, to despair, repair and mend, perhaps all the more so" (Laviolette 2019, 322).

2.3 A dialectical movement: The focus on breakage

This section is probably the most important of the whole dissertation, as it sets the basis of my theories on the role of breakage in Neolithic societies. As stated above, I have decided to tackle the all-permeating persistent philosophy of control through its own fissures, by establishing a dialectical movement. This movement is what then leads me to formulate a rough guide on its negation. To do so, I am firstly required to provide the reader with a brief background on what I mean by dialectics, which is carried out in the next section.

2.3.1 A brief note on negative dialectics

Dialectics can be initially considered as a 'method of thought' that strives to recognize the limitations of thought as it encapsulates or apprehends matter. While the origins of dialectics may

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[2] A similar argument has been forwarded by Peter Wolfendale on Harman's object-oriented philosophy. The author claims that rather than an metaphysics of objects what is brought forth is an *introspective* metaphysics, so "far from challenging the retreat of philosophers from the world into the bastion of consciousness, he has simply extended the domain of consciousness into the world" (Wolfendale 2014, 365).

be traced to Aristotle, it has been transformed by prominent modern philosophers, namely Hegel, Marx and Adorno. Through these authors we come to recognize that dialectics are not only a method but is also a specific way of viewing reality. In this view, objects are viewed as "dynamic and contradictory in themselves" (Adorno 2017, 103). Our concepts, which are historically mediated, tend to become rigid, and to do justice to the matter they attempt to apprehend, they must become dynamic once more. In other words, there is an inevitable gap between our conceptualisations of matter and matter itself, *i.e*. concepts cannot fully grasp objects. In this sense, dialectics work through epistemological concerns, and not with ontological formulations, which is already a fundamental difference with many of the approaches to material agency outlined above.

Both Hegelian 'idealist' and Marxist materialist dialectics have been endlessly praised and criticised by social theorists and philosophers, and it is not the intent of this section to delve into their failures, successes or transcending insights. I intend only to emphasise one fundamental difference of these previous formulations with negative dialectics, which are the dialectics I intend in following here. This is contention that rather than a search for synthesis, which for Adorno reverts the totalisation of the identity principle (2019, 241, 249), negative dialectics are considered open or fractured (Adorno 2017, 95). Fragmentation stems from the fact that objects cannot be exhausted by thought, and thus the search for synthesis, as in Hegelian dialectics, would only be immanent to the subject, reverting to a principle of identity. Thus, negative dialectics entail the search for the resistance otherness offers to identity (Adorno 2004, 160–161), and not a search for identity or sameness. This would seem similar to claims given by symmetric archaeology on the irreducibility of things. However, negative dialectics are not an essentialist position, as it presupposes objects are always in a process of becoming. Furthermore, contrary to the speculative principles of symmetrics, dialectical thought does not "start from any rigid concepts, from a rigid system, from any rigid givens, but is eminently required to abandon itself to the matter itself […]" (Adorno 2017, 157). This surrendering to matter is not achieved by thought alone, but also by experience, as "experience forbids the resolution in the unity of consciousness of whatever appears contradictory" (Adorno 2004, 152).

At this point, negative dialectics can be viewed as a way of combating the reification of concepts in our modern administered world, and of recalling the inadequacy of our inherited concepts. This fight is of course approached by means of contradiction or negation. Contradiction has to be understood in contrast to principles of formal logic, mainly the principles of identity and non-contradiction. Put rather briefly, these principles are considered the axiomatic basis of logical reason, and state that each entity is: identical with itself, or as Bertrand Russel puts it “whatever is, is” (Russell 2014, 68), and cannot be both be and not be (Swabey 1923, 212). Thus, the non-contradiction principle would indicate that propositions like “A is B” and “A is not B” cannot coexist. For dialectics, however, the identity of the object is inextricably linked to its non-identity. Hence, there is an unavoidable failure of apprehending objects with concepts. So, as mentioned by Adorno in one of his lectures (2017, 214), in the proposition “A is B”, which is presented as a judgement of truth, there is also some sort of slippage or untruth; namely, the proposition also states that A is not identical to B, if not, it would state “A is A”. Secondly, the proposition also supposes that B is a larger concept from which A is simply a representative. As such, B would encapsulate everything conceivable of what A is not. Thus, the identical is unavoidably flawed in terms of apprehending the object.

Dialectical thinking tries to reconcile the identical (concept) with the non-identical (object), but this reconcilement does not mean achieving synthesis or returning to a concept where non-identity is incorporated. Reconcilement would ultimately entail a moment when difference is no longer coerced into sameness or the identical (Adorno 2004, 6). In other words, “by inscribing the concept’s limitation into classificatory structures, it becomes possible to keep the process of cognition open and historically evolving alongside objects […]” (Krebber 2017, 208). By working through the cracks and fractures of our flawed conceptual frameworks, *i.e.* force the concept to “criticise itself” (Adorno 2017, 50), we open ourselves to the non-identical, to difference. Nonetheless, contradiction or negation is not, in this sense, an end product to debunk a theory, but a starting point in which to start our enquiries. It represents a first movement that has to be derived from the initial proposition, and not by contraposition through an external force (Adorno 2017, 38). This derivation is what I attempt to establish in the next section.

2.3.2 A first movement

At the start of this dissertation I commenced by highlighting a fundamental contradiction with the philosophy of technological control regarding waste, namely, that technology is the panacea of the contemporary world turning everything useful. However, in the supposed era of technological advancement, waste as a non-useful entity is ever more present. The untameability of waste signals the limits of this (technological) knowledge. This is the point of departure for our dialectical argument. If under the technocratic gaze objects are seen as tools (*i.e.* things put to use according to a plan set by the human agent in the phase of production), following principles of non-identity and contradiction, this necessarily implies that objects are also not tools. So, what would the non-tool state of objects really mean? This would entail looking at objects when they are either: not put towards use and yet are still somehow present or put towards uses that were not part of their rational design, such as improvised uses influenced by an unforeseen circumstance or unintended process. In other words, “where there is no prior representation of an end, there can be no instrumental means, no tools” (Ingold 1986, 47). As an antithesis to the realm of rationalised production, this involves aspects of human-material relations that occur through a process which is uncontrollable or unintended by the human agent.

Martin Heidegger’s description of the ‘unusable’ (1962, 95–107) provides a precedent from which to start this exploration. In Being and Time (1962), the author distinguishes between two modes of being for the things that surround *Dasein*, those are: ‘ready-to-hand’ and ‘present-at-hand’. When *Dasein* is immersed in a task, the things in use for that task become invisible; they are ready-to-hand. For example, in hammering a nail, the hammer is used without any explicit theorisation of it; it becomes an implicit thing as the task is performed. However, a lot can go wrong. When this happens, things become present-at-hand, and it is here when assertions can be made about the thing. Heidegger distinguishes three scenarios in which there is a transition between ready-to-hand and present-at-hand. In a first scenario, an object cannot be used to fulfil its function because of its damage, or its unfitness for the task. In this process, it becomes conspicuous. The interesting element from Heidegger’s observations is that the transformation of these objects into a state of un-ready-to-hand does not mean that the object is experienced purely as present-at-hand (*Idem*, 103), but there is some ready-to-handness that is retained. For example, there is a possibility of repairing or of reusing. A second situation is when a tool is absent from the subject’s grasp. In this situation, the present absence of the object changes the experience of those articles that are ready-to-hand (*i.e*. the ones not missing), which become obtrusive. But the missing object becomes purely present-at-hand. Lastly, for Heidegger, there is a third situation where ready-to-hand articles are perceived as a hindrance to perform a specific task, as something that ‘gets in the way’. The valuable contribution of these scenarios is that they lead us towards viewing objects beyond their tool status, which provides “an invitation to a different form of understanding" (Wolfendale 2014, 319).

The non-useful state of things reminds us that our experience of objects exists beyond functional endeavours. However, where we part ways with these propositions is that, rather than following Heidegger’s ontological concerns, our interests are epistemological, namely that it is our reproduction of contemporary Western categories of control that tends to obscure any non-technological form of knowledge. One might even say that Heidegger's views are rather ethnocentric in that he assumes conspicuousness, obtrusiveness, and obstinacy are a sort of universal 'natural' human perception of the un-ready-to-hand, but for the moment this is certainly not the matter of concern. Strictly epistemologically speaking we might state alongside Ingold that:

> "If we were to *subtract the technological project that assigns to every object its particular function*, in terms of which each becomes useful for one purpose or another, these erstwhile instruments would revert, alongside all other environmental objects, to their primordial status as things in a landscape, confronting the organizing subject rather than extending its organized activity" (1986, 7; my emphasis).

Secondly, while Heidegger has certainly shown various ways in which objects transcend their tool status, with the purpose of keeping the dialectical argument alive, my efforts will be oriented towards human-material relations that do not arise from human control, but from the resistance of materials. One way of approaching this is the study of the breakage of objects.

2.3.3 Focusing on breakage: A rough guide

With the exception of studies on the intentional breakage of objects (Chapman 2000), the notion of breakage remains a deeply undertheorised aspect of human-material relations. Part of this is related to the consensual preconception of breakage solely as a "process leading to discard" (Schiffer 1987, 48). Apart from this teleological categorisation of the process, there is normally no further effort to understand it. This becomes beneficial, as "[…]those things that have not yet been saturated by the official categories of thought" (Adorno 2017, 149) are the things that can be most revealing. It is because of the non-exhausting attempts to understand breakage that its question forms part of a 'subject of study' that can take us beyond the instrumental.

To guide our exploration, breakage is considered here as a type of resistance, *i.e.* something that "stands in the way of the will" (Sennett 2008, 215). It is that which *resists* the control or mastery over nature. In this sense, nature becomes active. To describe it from a praxeological point of view, it is a non-intended phenomenon in the sense of that which the human agent is *not* disposed towards doing (see intentionality in Reckwitz 2002; cf. Ingold 2000, 415), and for that reason it feeds a certain *contingency* in practice. In the rationale exposed in the introduction chapter, objects are considered instruments towards a rational purpose, *e.g.* a hammer is a percussion tool. But when the object breaks, it impedes the subject from fulfilling that function. Broken, the object ceases to be an instrument, and becomes something else. In other words, it resists our technical control over it. The study of breakage escapes the technological project in its strictly utilitarian sense[3]. In this sense, we could say that cracking and fracturing of materials remind us that objects are more than their particularistic reduction of what they afford as tools, just as much as we are more than toolmakers. Thus, "[…] materials do not just disappear in the fabrication of the object, indeed their properties and capacities continue to mingle and react as they have always done, forever threatening the things they comprise with dissolution or even de-materialisation" (Ingold 2007a, 9).

In recognising that breakage occurs mostly as an unintended development, the second point I wish to highlight is that, rather than viewing breakage as a single moment before discard, breakage is a process actually occurring all the time (Figure 2.3; see Drazin 2019). In other words, it is not merely a single event, as for example we might say of intentional breaking of objects, but there is a history to its formation. This is a history of the object's relation to other agents, and it is what may mark the crucial difference, for example, between a pot completely fracturing when dropped or not. As is mentioned in failure analyses, "[…] a material's failure is never an instantaneous event but is always one which has a beginning, a more or less complicated history of development, and an end" (Fréchette 1990, 5). For these reasons, we might say that breakage is always latent and threatening to occur. Let us take an example given by Lévi-Strauss on the decorated Pomo baskets:

> "The basket spirits, they claimed, live within the decorative coils; it is their village. And within the latter there must be a 'door', that is, an intentionally created defect, that, often scarcely visible, breaks the continuity of the design and allows the basket spirits, when they die, to escape and ascend to their sky home. One woman who failed to make a 'door' on her basket, was condemned to death by the imprisoned spirit" (Lévi-Strauss 1997, 170).

Thus, it appears that some elements of the design of the object, in this case the interrupted coils, are tailored to the spirits liberation from the object. In other words, knowledge of the object's breakage influences how the object is designed. It is not that the object is designed to break, like some cheap modern products, but that in the moment that it inevitably does break, certain mechanisms have already been put into place to deal with it. Furthermore, the myths certainly add to that knowledge through tales of unfortunate events, which gives words of caution should individuals forget to add these 'doors'.

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[3] Here I am making reference exclusively to the definitions of technology as detailed above.

Approaches to object biographies have long stressed the fact that objects constantly transform and their historical relations with people have a say in what happens to them (Gosden and Marshall 1999, 170). Against the production-centric study of material culture, Kopytoff (1986) argues that the meaning and value of things are transient. Objects, more specifically commodities, are charged with culturally specific meanings that can be reclassified when moving in different contexts or ‘spheres of exchange’. For instance, a cherished work of art, like a Picasso, can have a specific monetary value (say $690,000) in one sphere but can be considered priceless in another (Kopytoff 1986, 82). This same object can be stationed in a museum for exhibition at one point of its life, and then sold to a private collector at a later stage, where its value and meaning shifts. Thus, object biographies are far from being lineal, and are rather always in a state of becoming. There can be entirely different outcomes when the same type of pot breaks during production or consumption stages of its social life, particularly in societies where there is a division of labour and fields of production and consumption are kept decidedly separate. Yet, the consideration of breakage as a resistance and a process rather than an event invites caution with the sequential or staged approach to the study of objects, which so often convert ‘stages’ into dogmatic, rather than ‘real’, boundaries. It forces us to consider that actions are not only sequential but also have a duration in human temporal experience with objects (more clearly seen in section 2.3.4.2 and 10.1.4; Robb 2020, 128).This links with the third and more crucial aspect I wish to highlight, that breakage can be seen a set of generative actions. In this sense, breakage does not occur as an isolated phenomenon, it happens within a social and natural context (Sennett 2008, 226–227; see also Drazin 2019, 310). Following this, we can argue that when the object breaks or is (perceived as) breaking, it links to another set of actions. This means that it *generates* a response, informing us of a particular type of knowledge. This knowledge, formed as the result of the encounter with these resistances (Sennett 2008, 222), is what I refer to in the next section as the social knowledge of breakage. Thus, *intent can be triggered from an unintended action*, and broken or breaking objects can invite purpose. More importantly, it is through the study of the social frame surrounding the phenomenon of breakage that we can visualise a form of knowledge that is not created by the control over nature.

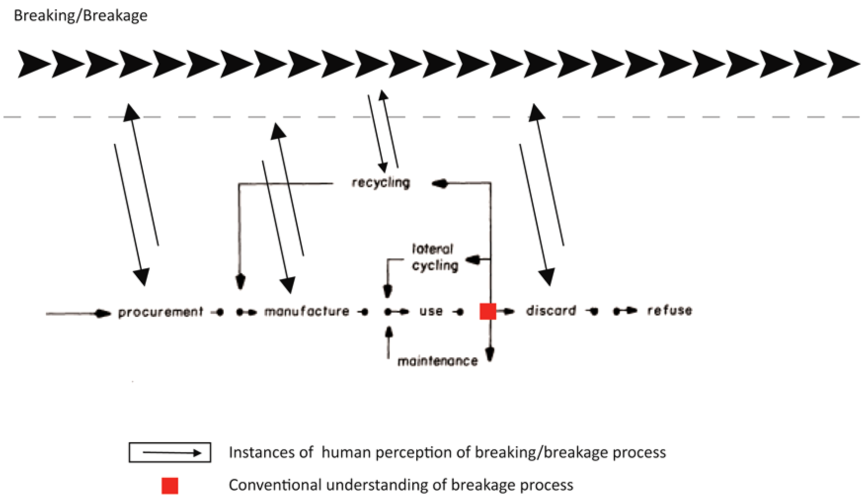

Figure 2.3: Reviewing breakage as a historical process rather than an episode leading to discard (flux model after Schiffer 1972, with permission by copyright holder).

2.3.4 The social knowledge of breakage

I argue that this constitutes a non-technological form of knowledge. On the one hand, the social knowledge of breakage is not about transforming raw materials into useful equipment, as is the case of technology, it is about objects that have already been transformed and do not follow their intended function. On the other hand, the social knowledge of breakage is dependent on how practices unfold, and, in this sense, it cannot be planned entirely ahead. In contraposition to technology, this is a form of knowledge that is not planned *a priori* but something that takes shape in practice, when the cards are on the table, so to speak. It is about recognizing that "people construct culture as they go along and as they respond to life's contingencies" (Bruner 1993, 326).

Drawing on the Theory of Practice, I consider the social knowledge of breakage to be an embodied or incorporated form of knowledge, which is acquired and expressed practically (Bourdieu 1990, 74; Connerton 1989, 102). Thus, as a practical form of knowledge it allows agents to decipher perceived signs (*e.g.* cracks or fractures), and orients them towards further action (Bourdieu 1977, 10–11), while it is reproduced in this same performance. This form of practical knowledge is unique, as while it cannot be constructed through instrumentality or the agent's domination over the object, it remains an informative part of social practices. In other words, it is a non-intended yet still very present form of knowledge. One does not plan to learn how an object will break while making or using it, but one still does, and it can be crucial for the continuation of the practices where the object performs. As Robb states, "both intentional and unintentional action are part of the larger process of social reproduction" (Robb 2010, 498). For example, the cook, an agent often missing in archaeological investigations, does not only learn the careful processing of the food, but also learns when the equipment at hand is damaged or unfit and knows how to react to this (Sutton 2006, 105). It is articulated by Amanda Hesser in the following passage on bone-handled forks:

> "Cleaning one requires the same attention as when washing a well-seasoned iron pan. Bone-handle forks should never be put in the dishwasher. Instead, rinse them quickly in hot sudsy water, and dry immediately. [...] My grandmother's fork is just barely surviving. Having lifted and turned soft-shell crabs and having pierced a lifetime of steamed cauliflower, it has been rendered frail by its journeys from hot stove to soapy water. The slivers of bone have pulled away from the slender steel base. She now uses a pink rubber band to hold it together. Mine are comparatively polished -- intact, untarnished and ready to age along with me" (Hesser 2003, 18).

In short, there is "an entire relationship to objects that the recipe does not codify and hardly clarifies" (De Certeau *et al.* 1998, 201). Although I am focusing on the non-linguistic aspect, which archaeology strongly encourages, it is important to recognize that it can also be transformed in linguistic expressions, for example in oral traditions (see Appendix 1).

Ingold's action-perception theory gives us some insights into how people might incorporate knowledge and create new meanings from their material world, particularly when considering what happens when things break. In a world of becoming, the way humans and nonhumans perceive the world involves "moving around in it, attending to it, and discovering […] what it has to offer" (Ingold 2018, 39). Perceiving and acting are one and the same (*Ibid.*). Practitioners are participant observers of what their environment affords, and while certain relational forces are presented in their active engagement with this environment, such as the attrition produced by sand as pots are being cleaned at a river, it is the attentiveness and experience of the practitioner that will determine if this affordance is acknowledged. This recognition also means that agency (be it human or nonhuman) is inextricably linked to a "multitude of structures, arrangements and conditions which must be true, or provided, or in conformity with a norm, for the action both to exist as a possibility and then be brought to pass" (Robb 2010, 498). Skill is, thus, relational. It is about the body's inextricable link to an environment of relations (Ingold 2000, 353), such that thinking and feeling (or as Ingold phrases it: care, judgement and dexterity) are synchronous. Dexterity implies not repetition nor replication, but live sensory corrections in the practitioner's movements adjusting to changes in the task at hand (Ingold 2000, 353; Reed and Bril 1996, 436), which lets us understand the effect materials can have on bodily knowledge. When forming pots on the wheel, skilled potters continually move their fingers according to where they feel the pot needs to be thinned. These skills are learned not as a conscious act of imitation, but as part of a practical *mimesis* (to borrow a term by Bourdieu 1990, 73), where the apprentice moves and simultaneously attends to what others do (Ingold 2000, 353). In this sense, we can say that the social knowledge of breakage is predominantly transmitted by the immersion of practitioners in a 'shared environment' (Ingold 1993, 222-223). It is knowledge that is always left out of protocols, recipes, manuals, textbooks. Lastly, the concept of dexterity also leaves room for the acceptance of the fact that even the most skilled of practitioners can mishandle and break objects.

The knowledge of breakage from a practice point of view can be studied in three dimensions: (i) the knowledge of what is to be done when the object is perceived as breaking (anticipation), (ii) the knowledge of how it breaks (*e.g.* as one is making the object or cooking), and (iii) the knowledge of what must be done after the object is broken. These dimensions are strictly separated for analytical purposes, but they certainly overlap in many ways. From now on most of these theorisations are made mostly for brittle materials, and examples given will be mostly about pottery, as it is the material being studied in this document.

2.3.4.1 The first dimension: The signs of breaking

The first dimension considers that breakage can be anticipated. By this I refer to the reactions or attitudes that arise from recognising various *signs of breaking*. This links to the idea that there is a history involved in the breakage of objects, and I would further add that it is the attentive, and sometimes trained, hand that can perceive it. In short, the first dimension is not about what to do when objects are broken (as that is the third dimension), but what the reaction is when it is perceived to be breaking. Among the communities in Pumpuri (Bolivia), when pots that are used for *chicha* brewing develop even a mild crack, they are considered unfit and their use for this purpose is mostly avoided (Sillar 2000a, 108). As the author mentions, it is because of the great value and effort in acquiring maize to produce *chicha* that the use of a cracked vessel for brewing is considered "risky" (*Ibid.*). In short, there is a sense of what should be done with those features (*e.g*. cracks, fractures, chips) that can be *considered to be* conducive to a broken pot.

Another common reaction apart from letting breakage happen, as was the case with the Kalinga cooking pots, or of removing the object from the practice to prevent it from happening, as with the *chicha* vessels, is mending or repairing the pot. Repair has attracted most attention lately, as a counterargument to the technological agenda, which I certainly adhere to here. However, for me the interesting thing about repair is not only these “subtle acts of care” (Jackson 2011, 222) that reconcile the subject’s moral relation to the object, but that it signals the manner in which people strategically read (so to say) the breaking object according to their embodied history. That is why I consider repair to be of great value archaeologically, as it a feasible way of informing on the person’s knowledge about the signs that the object is breaking and what must be done. Another interesting point is that if we consider repair as a response that arises from an unintended set of actions (such as breakage), in other words as a cultural improvisation rather than the result of a schematic rational design, can this knowledge be systematic?

2.3.4.2 The second dimension: Object breakage

With reference to the second dimension, as pots get increasingly involved in human practices, so does our sense of their demise. In this developed sense, there is a latent knowledge that is always, so to say, in the back of our heads during practice and which shapes practice in various ways. This is the knowledge of how an object can break in different scenarios. Colloquially, we encounter this constantly and quite unconsciously: if I put a glass near the edge of the table it will fall and break, if I pour boiling water into a glass with cool liquid it will crack or burst, if I play football near my mother’s vases I will knock them down.

It is ever more present to experienced tutors when they observe inexperienced hands grasp the object. For example, during pottery manufacturing, the potter knows the movements that must be avoided by his/her apprentice when a pot begins to bend inappropriately on the wheel and how to carefully remedy this. The potter also knows that making bases too thick or leaving too much liquid accumulated in the base while throwing can lead to the pot cracking during the drying stages. There is not a single potter I have met that does not know what can go wrong at every moment of fabrication and what course of action can be taken. In short, there is knowledge of that persistent threat of breakage. But also, if things like cracks appear, the causes are immediately recognized (see Appendix 1), which is why it is commonly outlined in craft books (Fraser 1986). This refers to a much more *concrete* aspect of this dimension.

Cautionary measures even in case there are no signs of breaking can reflect this second dimension. A clear example is the untameable firing process. Among the Azande, experienced potters take caution during the manufacturing of vessels to prevent their breakage during firing,

> "On the night before digging out his clay [the potter] abstains from sexual intercourse. So he should have nothing to fear. Yet pots sometimes break, even when they are the handiwork of

> expert potters, and this can only be accounted for by witchcraft. 'It is broken-there is witchcraft', says the potter simply" (Evans-Pritchard 1937, 67).

Similarly, potters near Skopska Crna Gora in Macedonia, create a figurine called the master or landlord of pans and place it on the first finished clay pan to protect other pans from bewitchment (Filipović 1951, 169). It might be that the ultimate breakage of the object does not occur daily, although ethnoarchaeological surveys highlight that it happens often enough (Shott 1996; Shott and Sillitoe 2001; 2004; Shott and Williams 2006), but this does not mean that there is not a daily reproduction of an embodied knowledge of the breaking of the object. Unfortunately, the second dimension is probably the most challenging to study archaeologically. While details of how this was done are described in Chapter 6, I advance the fact that efforts are mostly put towards understanding the more concrete aspect of it, by examining how pots break in specific scenarios. In sum, the purpose of studying this dimension is to explore the idea that there is a latent knowledge of how the object will break as it performs in different social practices.

2.3.4.3 The third dimension: The broken pieces

In contrast, the third dimension is probably the easiest to describe, as it is subject of many archaeological investigations. This dimension relates to the 'aftermath' of the breakage and involves the sense of what to do when pots are ultimately broken. For example, the case of the ceramic reuse of in Tzetzal communities in México is remarkable. Broken pots act as collection devices, flowerpots, feeding dishes, storage containers, pottery manufacturing implements, and placenta receptacles for afterbirth activities, among many others (Deal and Hagstrum 1995, 115–118). The attitudes towards broken pots can depend very much on how the vessel breaks (in terms of its context of breakage but also the 'shape' of fragments formed; Figure 2.4), the type of vessel, and its context of use. This is not a merely functional endeavour. Object biographies have shown for instance that reuse and curation of objects are not entirely tied to the scarcity of resources but to the historical relation of humans with objects (Swift 2012, 168). Thus, reuse also is a form of citing or referencing the object's past meanings into a new form. In Roman Britain, for example, some heirlooms like adult-size metal bracelets were repurposed as rings or smaller bracelets for children, carrying the mark of the family lineage with them (Swift 2012, 193-194).

But responses to broken objects do not solely imply their reuse, sometimes things are left as they are. For example, in Tzetzal and Wanka communities, it is not uncommon that carrying jars (*kib*) are dropped while obtaining water from wells (Deal 1985, 264). The frequent breakage by dropping this specific type of vessels along these areas constructs a practical knowledge of how the pots break, and the unfortunate carrier knows that it is pertinent that some fragments be taken for storage while others are just set aside on the path (*Ibid.*). So broken objects are not always put to use after they are broken, neither are they discarded, but they can be left right then and there.

As exposed by depositional studies, however, where materials are deposited have a strong link to how they are perceived and categorised (Hodder 1987; Moore 1986). For the Maya at Chunchucmil, broken pottery was deemed dirty, and so they were easily removed from domestic spaces. However, these are not placed randomly, but to the west of their habitation structures, which is considered the “direction of decay” (Hutson and Stanton 2007, 141). In contrast, for the Dogon (Mali) certain types of rubbish like *bìnugu* (a mixture of manure, straw and ‘dirty’ liquids; Douny 2007, 317) are viewed through a positive lens, so the accumulation of these materials in domestic spaces is welcomed. It is a sign of prosperity. For example, “may God make your house dirty” (Douny 2007, 314) is a common saying. Other materials like broken pottery and plastic bottles are dumped outside, yet the ‘outside’ materials are always potential resources. Domestic waste is always in transformation (Douny 2007, 313). John Chapman’s (2000) view on fragmentation provides another example of the creative role of broken materials. Chapman considers that during Neolithic times in south-eastern Europe, just like gift-economies in Polynesia (Mauss 1966; Strathern 1988; Weiner 1992), fragments were considered extensions of persons. It follows that the abundant accumulation of these fragments, as attested consistently throughout the European Neolithic, does not respond simply to the dumping of ‘rubbish’ but as a strategy to augment the status of the owner (Chapman and Gaydarska 2007, 197).

Accumulation of (broken) objects has been also associated with memorialisation of ancestors, events, buildings and places (Cameron 2002; Cruz 2006; Gordillo 2007; Mills 2008, 106-107; Thomas 1999, 70-71), and have an "active role in shaping social processes" (Pollard 2008, 45). In agreement with practice theory, deposited materials can act as mnemonic aids in the reproduction of social practices, i.e. what people leave behind is highly influential in the structuring of further practices (Gillespie 2001; Lucero 2008, 201; McNiven 2013). Middens, such as the ones registered at Goemu village (Australia; McNiven 2013; McNiven and Wright 2008), are continually renewed, and it is the "structured and formalised processes of their construction" (McNiven and Wright 2008, 144) and not their final form, that is of importance. These heaps of fragmented materials associated to houses served as reminders of everyday activities, *e.g*. what was being consumed and discarded (McNiven and Wright 2008, 145), but also delineated domestic spaces (a 'living architecture'; McNiven 2013, 576). Thus, deposits of broken materials do not only act as a hinderance that demands cleaning (Binford 1978, 339; Schiffer 1972, 161-162) nor are they a collection of items that no longer form part of social life (Schiffer 1972, 157), but they are also dependent on how they are categorised and what role they have in daily practice. In short, there is a culturally specific repertoire of what should be done and not done with fragments.

[redacted]

Figure 2.4: Example of fragment reuse according to breakage pattern and fragment size/shape from a Tzetzal vessel (after Deal and Hagstrum 1995).

2.3.4.3.1 A precaution on some archaeological categories

As is widely known, there are various sets of categories created mostly by behaviouralists to designate broken objects, such as primary, secondary or even tertiary refuse. While I would not object to these categories *per se*, there is a teleological assumption engrained in these concepts that I find particularly problematic for the objectives set out in this dissertation. Namely, the assumption that broken objects are simply deposited with the intent of eventually discarding them, as these objects are said not to comply with any (symbolic or utilitarian) function (Schiffer 1987, 47). In other words, there is a certain universalised directionality of the deposition act, whether artefacts are discarded in place of use (primary) or taken to a separate location (secondary and tertiary) for that purpose (Schiffer 1972; Kuna 2015). In this way, these categories close the possibility of any alternative interpretation. However, I do not reject these concepts altogether, as I believe that broken objects can indeed go through some of these states. What I propose is rather than determining depositional practices with the use of these categories *apriori*, I prefer to put them momentarily in brackets until that *telos*, in this case discard, is actually revealed through my analysis.

Another commonly used concept to designate what happens to broken objects is ‘structured deposition’. While initially defined as a “formalised, repetitive behaviour” in reference to rituals or ceremonial events (Richards and Thomas 1984, 191), it has since acquired many meanings (see Garrow 2012 for a review). Other reformulations have posted this concept as a continuum between deposits that seem ‘odd’ for their relation to some ceremony or outstanding event, and patterned deposits resulting from everyday life (Garrow 2012, 95). By reference to Bourdieu and Giddens, Thomas himself has urged to shift attention towards the practical (or non-discursive) dimension of ‘structured deposition’ (2012), which encapsulates both symbolic and functional aspects of depositional practices. As such, structured deposition would entail a type of deposition “where people have placed or dropped particular classes of material in particular locations […] simply because ‘that is how it is done’” (Thomas 2012, 126). *Partly* in line with this last reformulation of the concept, I will use the concept from now on to describe the act of ‘careful’ placing of objects according to the social categories of space.

2.4 Concluding remarks

Throughout this chapter, I have outlined three central concepts of the philosophy of control — technology as an essential body of knowledge on the means to turn objects useful, the central role of a rationalised process of production for dictating what is useful about the object, and the hypostatisation of objects as tools. In the last section, as a dialectical movement, I have inverted these concepts and presented my own theoretical concepts —a latent (non-rationalised) bodily knowledge, that is triggered by unintended phenomena (breakage), and which addresses objects as both tools and non-tools. This was then divided for analytical purposes into three dimensions, which serve as the foundations to study the archaeological expression of this form of knowledge. Rather than go in too much detail on dialectics and how it has been philosophised by Adorno (2004; 2017), I opted to directly work with negative dialectics on the specific topic at hand. Nonetheless, I provided a brief overview to guide the reader.

It is important to clarify that the purpose of this movement is not to overcome the contradictions of the philosophy of control, but to explore its negation to its ultimate consequences. Thus, in a way this theoretical construction is but a first movement to approach the archaeological investigation of Early Neolithic lifeways through a different angle, which will be termed in the next chapter as a ‘broken world’. Through this lens, in the next chapter I will briefly explore the conventional image of the Neolithic period, and advance through to more recent redefinitions of it as a ‘thing-heavy world’. It will be this redefinition that enables us to study the role of broken objects in Neolithic times.

Chapter 3. The instrumental Neolithic

Humans are considered beings solely driven by their tool-wielding capacity. This captures some of the main principles of the philosophy of human technical mastery over nature mentioned in the previous chapter. In this chapter, we shall explore how under this gaze (pre)history becomes rewritten under the premise of tool development and production. Particularly, we shall focus on the influence of this philosophy on the narrative about the Neolithic. I will argue that: (i) this narrative is both the result and (a particularly powerful) medium for the reproduction of the philosophy of human mastery over nature, as it is believed to mark the crucial moment in which humans gained supremacy over nature through a specific toolset; and, (ii) to confront the philosophy of control we need to view this period from a perspective that places the resisting capabilities of the material world into its central considerations. In sum, if we are to venture into epistemes that are not based on an idea of human control, such as the social knowledge of breakage, we must firstly open up the concept of the Neolithic to this possibility.

As a first clarification, this line of argumentation does not contemplate "the Neolithic" as a static concept, as different definitions have been made throughout more than a century (Thomas 1993, 362). Instead, it contends that there has been a long historical tendency to subvert definitions towards a same underlying modernist philosophy. With the purpose of exposing this tendency, this chapter revolves around some of the key definitional moments of the Neolithic and the philosophies championed by their authors. These moments include: John Lubbock's expansion of Christian J. Thomsen and Jens J.A. Worsaae's Three Age System, Oscar Montelius' addition of a Near Eastern origin, Gordon Childe's Neolithic Revolution, and the development of the idea of the 'Neolithic Package'. The last section ponders on the recent reformulation of the Neolithic as a thing-heavy world and emphasises how it confronts the philosophy of control, enabling the study of the social knowledge of breakage.

3.1 The birth of the Neolithic

3.1.1 The tool-centred schema

The Three Age System had already been created in Scandinavia by Thomsen's work on museum collections and Worsaae's investigations in shell middens and burial mounds, and it was gradually accepted in different parts of Europe at different times (Rowley-Conwy 2007, 1–2). While allegedly not part of an evolutionary model (Gräslund 1981, 22–29), this aspect of the Three Age System would soon change. In Victorian Britain, where the term Neolithic would be actually coined, the acceptance of this chronology was particularly measured, appearing in the work of social evolutionists like Sir John Lubbock, Herbert Spencer, and Sir Edward Tylor, in contraposition to the Bible's short chronology.

Though often only seen as a development from biological Darwinian evolution and the growing concept of race (Stocking 1968), social Darwinism was also installed in Britain by the convergence of Comtean positivism and British liberalist political economy, which was founded by anachronistic utilitarian principles of human nature inspired by figures like David Hume, Adam Smith, and Jeremy Bentham. In other words, "[…] the Comtean impulses had been domesticated to the dominant English utilitarian tradition […]" (Stocking 1987, 41). Among the utilitarian tradition, the human mind was considered having an inbuilt impulse of 'necessity', ultimately reduced in John Stuart Mill's (2004 [1848]) political economy to the desire of acquiring wealth[1]. To achieve progress, this impulse needed to be controlled by reason.

The nineteenth century social evolutionary classification and unification of human history escalated bottom-up from what was considered the most fundamental state of human nature: savagery. This served as a basis to distinguish between the natural state of the savage — whom cannot but live through instinct alone and is incapable of sacrificing his immediate desire for a greater future benefit (Mill 2004, 184–185) —, and that of the rational civilised man — whom satisfied his basic needs through intellect (*i.e*. rational calculation)[2]. Lubbock described the 'savage' in similar way, as a "slave to his own wants, his own passions" (1865, 484), while the "civilised man questions nature […], he *forces nature* to throw light upon herself, discovers *hidden uses* and unsuspected beauties […]" (*Idem*, 487; my emphasis)[3]. This progression of humankind towards civilisation envisioned so-called 'modern savages' as a survival from a distant past. For the Victorian scholar, as a prehistorian one had but to study these vestiges to understand ancestral European customs (Lubbock 1870, v, 1).

Apart from the study of languages, kinship or religion, social Darwinists like Lubbock examined the material culture used by these 'savage' human groups in order to observe the unilineal technological progression of humankind. In this scale of technological development "[...] no one would go back from letter-writing to the use of the quippu or hieroglyphics; no one would

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[1] Wealth here of course is defined not only in terms of money but in terms of useful objects (Mill 2004 [1848], 170)

[2] The derogatory language is from the provided sources.

[3] The connection between John Stuart Mill and John Lubbock also delved into politics. Through Herbert Spencer, Lubbock's political career was much aided by Mill (Clark 2014, 71).

abandon the fire-drill and obtain fire by hand-friction" (Lubbock 1870, 341). Whereas Montelius also considered decadence or degeneration (as mentioned below), which was common in earlier theories of history from Hesiod to Giambattista Vico and Jean-Jacques Rousseau. In addition, tool complexity was a reflection of human intellectual development. For example, Lubbock describes how so-called ‘primitive cultures’ were unable to control the natural world through their less developed tools (Trigger 2006, 174–176), and repeatedly compared their intellect to that of children (Lubbock 1882, 9, 516, 517) or even, as in his entomological work, to insects that can barely attain communication amongst themselves (Lubbock in Clark 2014, 77).

Following this chilling line of thought, in 1865 Lubbock introduced the term Neolithic as a stage of savagery, which implied Neolithic populations were not considered in control over nature. While not the only one to subdivide the Three Age System (Lartet 1861; Mortillet 1883), which was already done by Worsaae early on (Gräslund 1987, 38), in Lubbock’s scheme the Three Age System involved four stages: the Palaeolithic, the Neolithic, the Bronze Age and the Iron Age. While the author was interested in the Bronze Age, probably due to the ongoing debates at the time (Rowley-Conwy 2007, 257–268), the Neolithic was essentially created as a period where instruments and weapons of flint and other types of stone were manufactured with a higher degree of skill, with polished stonework serving as a sort of *fossile directeur* (Lubbock 1865, 2–3, 60; Figure 3.1). This was later expanded to include other aspects like agriculture, domestication of animals (ox, sheep, goat, pig and dog), weaving with flax, pottery manufacture, and the presence of several longstanding features (tumuli, burial and shell mounds, and lake dwellings; Lubbock 1868, xxiii–xxiv), but the defining marker of the period was still the appearance of polished stone tools. John Lubbock’s scheme is explicitly about the technological advancement of humankind (Thomas 1999, 7). Behind the concept of ‘technology’— objects put towards purpose—, and ‘humankind’—beings driven towards the satisfaction of material wants and desires— where one finds the foundational principles of liberalist economy in his scheme.

Within the social evolutionary approach in archaeology, the term *Neolithic* advances us towards a period of savagery where men barely had the *means* to satisfy their own desires through more embellished yet still rudimentary tools. Moreover, it installs the universality of the human natural tendency towards the satisfaction of wants and desires. While Lubbock and many of his social evolutionist contemporaries did not build this periodisation in terms of ‘subsistence strategies’ (Pluciennik 2001, 744, 745), as many eighteenth and nineteenth century thinkers did (*e.g.* Nilsson 1868, Ch. VII; Smith [1763] 1978, 14), there was undoubtedly a concept of human nature that was essentially instrumental. Just like in the work of Gabriel de Mortillet (Richard 2012, 17), this emphasis on tools would become much more accentuated later in Gordon Childe's Neolithic revolution.

[redacted]

Figure 3.1: Some of the Neolithic polished stone tools (1, 2, and 5) described by Lubbock (after Lubbock 1865).

3.1.2 *Ex oriente lux*

Towards the end of the nineteenth and the start of the twentieth century, dying hopes of progress and improvement were changing ideas of the human capacity for innovation (Trigger 2006, 229). It became popular to adopt diffusionism as a universal panacea for explaining the origins of things. The concept of culture became increasingly popular, such as in the German *Kulturkreise* school of anthropology. It is within this context that Oscar Montelius' prehistoric research would introduce another important element to the idea of the Neolithic.

Montelius was a supporter of biological Darwinism and the teleological view of human prehistory (Montelius 1899; 1903), but mostly followed the Enlightenment tradition in Scandinavian archaeology (Gräslund 1974, 83; Trigger 2006, 225). As such, his assumptions about technology were very much the same as those of his predecessors. Technology was seen as achieved through reason, and an effective means of dealing with nature (Trigger 2006, 225–227). Based on principles from biological Darwinism, his typology outlined the evolution of objects from simple to complex forms (Klindt-Jensen 1975, 89). Like organs in a body, some parts of the object were considered functional, while others were merely survivals or (non-functional) vestiges from an earlier time (Montelius 1903, 17). By tracing the part of the objects that remained functional at a specific point in time and their relation to other objects in closed or 'safe' archaeological contexts (like graves or hoards), a typological series could be constructed tracing the development and contemporaneity of types (Figure 3.2). Thus, objects whose parts were all functional could be attributed to a greater age than those whose parts were vestiges. Furthermore, this method also allowed to distinguish progress from degeneration, which was often discussed by typologists at the time (Johnsen 1976, 106).

[redacted]

Figure 3.2: Example of Montelius' typological method (Montelius 1903).

Through this detailed examination of finds and assemblages, Montelius could subdivide Thomsen's periods. For example, he divided the Scandinavian Neolithic into phases I-IV. However, what would become the major addition to the concept of the Neolithic was the diffusionist idea that agriculture had originated in the Middle East and made its way through south-east Europe onwards into the west of the continent (Montelius 1899). Of course, it is important to clarify that Montelius was not the first scholar to grant importance to the Near East in the so-called origins of civilisation, such was common for example in bible-inspired interpretations (Rudebeck 2000, 161). While his work was deeply influential in most of continental Europe (*e.g*. Childe 1939), this particular aspect was somewhat challenged by some authors (Trigger 2006, 228–229), most notably by Matthäus Much (1907) and Salomon Reinach (1893). Regardless of the impact of diffusionism, the idea of the Neolithic did mostly retain its evolutionary and technological components, *i.e*. as a stage characterised by polished and 'ornamented' stone work (Montelius 1920), but slightly more effort was given to accentuate the period as something more than a stage of savagery. For example:

> "The Northmen of the later Stone Age had raised themselves so much above the state of savages, that they not only made such objects [flint implements] as were indispensable for the necessaries of life, but took no little pains to have them as ornamental as possible" (Montelius 1888, 17).

In sum, from Lubbock's initial formulation of the Neolithic, not much had changed by the start of the 20th century. Montelius had drawn directly from an organicist analogy, where objects continued to be characterised in terms of their 'useful' traits in humanity's evolutionary progression by means of technological development. The Neolithic was not yet considered *per se* a moment of human mastery, although some of these traits were starting to emerge, but it had started to contrast with the preceding Palaeolithic period.

3.1.3 The Neolithic Revolution

Although the social evolutionary scheme of progression of humankind had been replaced with diffusionist explanations accounting for developments and regional variations, by the time Gordon Childe was writing the Neolithic had not changed its utilitarian dye. Like many contemporary and preceding authors, Childe built his scheme on the well-established Three Age System. In this sense, he was already inheriting some inbuilt elements of the instrumentality of subjects and objects. Another important influence in Childe's periodisation of prehistory was Lewis H. Morgan's (1878) evolutionist scheme: savagery, barbarism and civilisation. However, he should be most notoriously recognised for introducing a new perspective on the Neolithic, one stemming from Karl Marx's radicalisation of the concept of production to define human existence[4].

It is certainly not hard to find the idea of humans as producers (*sensu* Baudrillard 1975, 31) in Childe's work, nor the idea of humanity driven towards civilisation. Childe was a contender of the philosophy of human technical mastery over nature and the notion of progress, which was atypical during one of the most economically unstable and politically belligerent moments in modern times: the interwar period and the Second World War (cf. Spengler 1918). Archaeology had a role in vindicating "the idea of progress against sentimentalists and mystics" (Childe 1981 [1936], 36), by presenting evidence of this process through the classification of tools (*Idem*, 45). History was extended to prehistory and aimed to examine the production systems of the past, which made prehistoric archaeology "concerned about what men made [produced]" (*Idem*, 33). We could say that just like Marx mostly did with historical periods[5], Childe rewrote prehistory in light of production.

Following this philosophy, he described historical changes through what he believed to be essential economical changes and, as economy for him was the "means whereby survival is secure" (1981, 34), this involved changes that fundamentally helped the survival of our species. It is through these terms that he described his inheritance, the Three Age System:

> "The archaeologists divisions of the prehistoric period into Stone Age, Bronze, and Iron Ages are not altogether arbitrary. They are based upon the materials used for cutting implements, especially axes, and such implements are among the most important *tools of production* […] Realistic history insists upon their significance in moulding and *determining social systems and economic organisations*" (Childe 1981 [1936], 32, my emphasis).

Tools of production, *i.e. useful* objects, equipped humans in (pre)history with the means to secure the fundamental resources for survival; thus, not only moulding but determining their socioeconomic systems. In accordance to this formulation, he distinguished between primary tools, those that allow the immediate satisfaction of needs (Childe 1944, 25), and secondary ones,

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[4] This part of Marx's monumental oeuvre is somewhat victim of the modern instrumental times. In other words, the reduction of human nature to a utilitarian principle cannot be uniquely attributed to his philosophy, as it is shared among many contemporary thinkers, nor can his philosophy be reduced to this idea of labour.

[5] Marx also speculated on the modes of production during prehistoric times with the popularized notion of primitive communism (Marx 1967 [1894], 831), and was influenced by evolutionary ethnologists such as Lewis H. Morgan (Marx 1972 [1880-1882]). However, unlike other historical periods like feudalism and mercantilism, this was not a really detailed part of his work. It is with the later work from Frederick Engels that this was more thoroughly examined (1902; 1976 [1925]).

which are tools used to manufacture other tools that improve the satisfaction of those primary needs (*Idem*, 28). In his evolutionary scheme the more we advanced from the rudimentary Palaeolithic Acheulian and Clactonian tools, the better confectioned our primary tools became.

Childe synthesised two major economic revolutions: the Neolithic and Urban revolutions. These revolutions were mostly fuelled by environmental changes and caused fundamental demographic fluctuations, taking the Industrial Revolution as inspiration (Renfrew 2009, 381). Here we shall only focus on the Neolithic Revolution. According to his oasis model (Childe 1929), increase in aridity in the Fertile Crescent would have led to congregations of resources in oases, which gave way to demographic growth and a closer relationship with plants and animals. In this sense, without rejecting the importance of polished stone in Lubbock's scheme and certainly accepting the Near Eastern origins (Childe 1939; *contra* Kossinna 1911), Childe anchored the Neolithic on plant cultivation and animal domestication (*Idem*, 30), which created a fundamental change in how the Neolithic was perceived. While polished stones and other inventions attributed to the period were of importance, such as pottery and textile production, they could not compare with the "indispensable condition for human progress" (*Idem*, 12): the production of food and with it the "real control over nature" (Childe 1985 [1942], 72). Childe highlights two crucial elements from this stage. First of all, food production granted the potential for accumulation of surplus, which would have permitted humans to fulfil their immediate needs, and which formed the basis for further developments. Secondly, he highlights the self-sufficiency of household production, where trade was not necessary to ensure the survival of these collectives (Childe 1985 [1942], 67–69). Both of these defining elements highlight the Neolithic as a world of productivity and, inspired in Morgan's classification system, led to Childe's consideration of the period as a stage of barbarism (Childe 1985 [1942], 30).

In sum, in the Childean scheme (inspired by Marx and Morgan), where human means of production are considered their means for existence, human (pre)history is defined by the *means* through which survival was ensured. Following this instrumental depiction of human groups (a commonality with his predecessors), on the one hand, food production (mainly agriculture) becomes the central feature in the definition of the Neolithic; on the other hand, tools, such as axes, hoes, sickles, and querns, are the element to study them. In other words, Neolithic objects in their reduction as tools become valuable mainly as the referents of production. While similar to the previous scheme advanced by evolutionists and utilitarian liberalists, the Neolithic was now considered 'barbarism' (1985, 55), and as such, a fundamental *revolution* towards civilisation. With these changes the Neolithic was transformed into a powerful symbol of human transcendence over nature (Ingold 2000, 78).

3.2 The Neolithic package and onwards

From the mid-1960's onwards, the "Neolithic package" became a popular term in British Archaeology, while a major shift in archaeological method and theory was already underway. Behavioural-processual approaches had become the dominant theoretical trend in archaeology (Binford 1962; Clarke 1968; Renfrew 1982; Schiffer 1972). These approaches were heavily influenced by the unilineal evolutionism of Leslie White, the multilineal evolutionism of Julian Steward, and/or systems theory. One common (either explicit or implicit) contention was that culture involved an adaptation to an external (mostly 'natural') environment. For example, for the members of the New Archaeology culture functions as an extrasomatic adaptive mechanism that guaranteed the survival of the species (also see Binford 1962, 218; Renfrew 1972, 486), and technology was seen as a way to improve "man's ability to control and adjust to environments" (Steward 1977, 44). An extreme position was White's consideration of technology as the 'determinant factor' in shaping social institutions, in other words:

> "[…] the social organization of a people is not only dependent upon their technology but is determined to a great extent, if not wholly, by it, both for in form and content. As a matter of fact, a social system might well be defined as the way in which a society makes use of its particular technology in the various life-sustaining processes […]" (White 1959, 19).

It would be highly repetitive to include all depictions of the Neolithic in the post-Childe era, but it is safe to say that the continuity of the Neolithic as a monument of human control is evident in numerous works published at the time (Figure 3.3). The Neolithic was promoted as: a new stage where there was a "development of an efficient primary control over food supply" (Braidwood 1962, 5); a period where the subsistential basis of what would later become 'civilisation' was firstly established (Renfrew 1972); a revolution of man's cultural (technological) control over animal and plant growth (White 1959, 284–290); "a way of life in which man has discovered means of controlling his environment" (Kenyon 1969, 145); among other similar definitions. The approach surrounding these definitions also consummated the stigmatisation of hunter-gatherers as people 'dominated by nature' (Van der Leeuw 1993).

Under this influence, the slippery concept of the 'Neolithic package' ended up assembling the Childean scope on subsistence strategies (mainly food production), the toolkit already signalled by Lubbock, and the near eastern origins of these elements. In this vein, Mesolithic lifestyles seem to have been abruptly replaced in the Neolithic east-to-west 'wave of advance', *i.e.* a process referred to as acculturation[6] (Ammerman and Cavalli-Sforza 1979; 1984). All in all, it can be stated that, under this model, the Neolithic comprised a universal techno-economic package that originated from the Near East and advanced throughout Europe until reaching the British Isles. Once again, it would seem food-producing technologies were envisioned as finished problem-solving products ensuring human survival.

[redacted]

Figure 3.3: Buchanan's (1992) diagram of technological development, synthesising part of the rationale behind the instrumental version of the Neolithic.

3.2.1 The critiques of the Neolithic package and the 'cultural and hermeneutic turn'

It is crucial now to consider the critiques of the 'Neolithic Package' during the late 1980s and early 1990s, because they arguably represent the first attempts to confront the philosophical basis of the Neolithic, which had been persistent for more than a century[7]. This rupture was partly triggered by the post-processualist focus on multivocality, decentering the author, and voicing the 'other', which converged against totalising and colonialist narratives (Shanks and Tilley 1987; 1992), as well as attempts to shift archaeologists' attention from technological functionalism to symbolic action (Hodder 1982; 1990). In addition, during these times the concept of technology had also been redefined by an anthropology of techniques (Lemonnier 1986; Van der Leeuw 1993).

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[6] While the authors propose other scenarios like warfare, mutualism and disease (Ammerman and Cavalli-Sforza 1984, 116–119), the actual simulation of their wave of advance model is simply based on the idea of acculturation (*Idem*, 118).

[7] That is, if we do not consider eighteenth century precursory formulations of such a period.

Consequently, critiques of the Neolithic package, and thus the model of human control over nature, were not lacking in the upcoming years in Europe and are synthesized (rather expediently) in two overlapping trends. Firstly, there are those following archaeological evidence that argue the implausibility of the model. In various regions of Europe, different elements of the package do not appear at the same time. For example, ceramics are found associated with foraging in the whole of northern Eurasia, from eastern Siberia to the Netherlands (Jordan and Zvelebil 2010; Piezonka *et al.* 2020), while in the Near East there is a well-known Pre-Pottery Neolithic (Kenyon 1954). Ertebølle groups in south Scandinavia become more sedentary, intensified their exploitation of maritime resources, but remained foragers for a long part of the Neolithic (Bogucki 1988, 129). Furthermore, the economic benefits and advantages of agriculture have also come into question (Scott 2017, 97), as some evidence has started to appear of the various illnesses arising from the overreliance on agriculture and more sedentary lifestyles (Freeman 2013; Larsen 2006; Lucejko *et al.* 2018; Molleson 1994; Nicklisch *et al.* 2012; Rascovan *et al.* 2018; Wolfe *et al.* 2007). In part, it would seem that the so-called 'transition' towards the Neolithic Package in Europe was more characteristic of the whole period (Robb 2013, 667).

The other strand of critiques stemmed from more meta-theoretical considerations of the model. For example, Dusan Borič critiques the construct of the Neolithic as a colonialist discourse, where Neolithic populations are seen as the ones overpowering Mesolithic groups; thus, creating a dichotomy between foragers and farmers (2005, 88). Similarly in social anthropology, the Neolithic has been associated with European ethnocentrism (Descola 2013, 51; Sahlins 1972, 2, 5), as hunter-gatherer lifestyles are portrayed as living in a state of 'nature' and barely surviving (as criticized Lee 1968), contrasting with 'encultured' Neolithic populations. For their part, Thomas (1999, 33; 2015a, 1073) and Mark Pluciennik (1998, 77) shed light on the use of subsistence strategies, and particularly agriculture as a hegemonic category to define the period. The former also exposes the attempts of scholars to create the Neolithic as a totalising discourse (Thomas 1993, 389), attempting to show that it is in fact a historically-construed category. More recently, James Scott (2017, 8–9) has emphasised the continuity of a 'civilizational narrative' that the Neolithic begets, considered as a milestone of human progress.

From these critiques, various other types of approaches have started to develop. Investigations of the Neolithic have now come a long way to inquire on: the cosmological transformation of human practices (Hodder 1990), the household as a fundamental axis of social organisation (Borič 2008; Thomas 2015b; Hofmann and Smyth 2013), the mortuary domain

(Chapman 1994; 1983; Chapman 1981; Hofmann 2015a), kinship relations (Bentley *et al.* 2012; Claßen 2009), conflict (Golitko and Keeley 2007; Kaufmann 1997; Meyer *et al.* 2018; Petrasch 1999), and many more aspects (see Fowler *et al.* 2015 for a more thorough description). Models considering the role of local histories, rather than a top-down acculturation process, have also become common (*e.g.* Bánffy 2006; Chapman 2003; Thomas 1999; Tresset and Vigne 2007; Whittle 1996; 2004; Zvelebil 1995), as they blur the essentialist divide between the 'Mesolithic' and 'Neolithic' categories. Nonetheless, there are some notorious problems that remain untouched, and consequently this has led to a revitalisation of the philosophy of human control we are attempting to confront. These are summarised next.

3.2.2 The problems of the hermeneutic turn and the return to the Neolithic package

A few critiques have arisen in recent times. First of all, currently there is recognition that only looking towards local histories might be obviating the effects of the longer or deeper history these communities shared throughout the millennia (Hodder 2017; 2018; Robb 2013). This is part of the problem with the postmodernist agenda, which seeks to bring down hegemonic models by deconstructing their totalising narratives, and in turn shift towards 'the local', but falls short when the same old narratives continue to flow downstream. On the one hand, simply deconstructing universals leaves no room for shared history, *e.g.* between Neolithic/Mesolithic or different Neolithic groups, as argued by Tsing:

> "Universals are indeed local knowledge in the sense that they cannot be understood without the benefit of historically specific cultural assumptions. But to stop here makes dialogue impossible. Furthermore, it misses the point. To turn to universals is to identify knowledge that moves—mobile and mobilizing—across localities and cultures. Whether it is seen as underlying or transcending cultural difference, the mission of the universal is to form bridges, roads, and channels of circulation'" (2005, 7).

Universals are also a necessity of systematic research, used even by the most hermeneutic approaches, but these must be kept at bay by considering their history, *i.e.* not taking them as absolute realities (Sommer 1990, 57).

On the other hand, with the hermeneutic turn Mesolithic or Neolithic lifestyles are automatically characterised by what is considered to be 'non-modern'. In this way, if Modernity can be characterised by dichotomous categories such as nature/culture or mind/matter, then the Mesolithic/Neolithic past cannot; if Modernity is pervaded by universals, then the

Mesolithic/Neolithic was not. Following Vaquer (2013, 162–163), we can say these strategies resort to a "negative essentialism", as they define populations by what they cannot be.

We could also consider the critique championed by Olsen *et al*. (2012), namely that the philosophy of control also pervades postprocessualist symbolic approaches. In this view, the postprocessualist movement downplays things by reducing them to mere referents of human meaning (Webmoor 2007, 568). For example, this could be the case in Lévi-Strauss' structuralism, where, in a sort of Neo-Kantian rationalism, human thought signals 'Man's' control over Nature:

> "[…] man's relations with his natural environment remain objects of thought: man never perceives them passively; having reduced them to concepts, he compounds them in order to arrive at a system which is never determined in advance : the same situation can always be systematized in various ways" (1966, 95).

This is certainly visible in archaeological approaches inspired in this strand of philosophical and anthropological thought. For instance, a clear example is Ian Hodder's *The Domestication of Europe*, where we still manage to find elements of the philosophy of control:

> "The origins of agriculture refer to a long period in the Near East and Europe (from the tenth to the fourth millennia bc) in which certain plants and animals were increasingly brought under human control" (1990, 16).

However, we should not take Olsen's critique so lightly, as it can be an oversimplification of the huge array of approaches that fall under the umbrella of 'symbolic archaeology'. For example, practice theory could easily fall into this category, and it has been an approach that explicitly discusses how bodies, symbols and things work beyond human intent (here I refer to intent as the result of human consciousness) to make practices reproducible and, therefore, durable.

Nevertheless, the point I wish to make is that we still tend to subvert back to the totalising narrative of the Neolithic package, either through its explicit embrace or its implicit negation, which once more allows the narrative of human mastery to linger on. A clear example is the recent revival by geneticists of the idea that Mesolithic populations were either replaced or displaced by incoming farming populations (Bramanti *et al.* 2009; Haak *et al.* 2010), sometimes with the use of problematic terms such as acculturation and colonisation (Battaglia *et al.* 2009; Mirabal *et al.* 2010; Richards 2003; 2003). While migration of Near Eastern populations is difficult to argue against, this is once more professed as a one-dimensional process and forces a return to the clear-cut dichotomous division between Mesolithic (hunter-gathering) and Neolithic (farming) populations (as criticised by Hofmann 2015b, 461). Therefore, despite most efforts to melt down the hegemonic narrative of the European Neolithic, it continues to be structured by eighteenth and nineteenth century ideas about human nature exposed above (see also Graeber and Wengrow 2018); whether emphasis is put on Neolithic populations' capacity to *produce* their own food (Fowler *et al.* 2015, 4; Thomas 2015a, 1088; 1999, 7; *e.g*. Ammerman 2003; Cavalli-Sforza 2003; Price 2000, 20; Zvelebil 1996, 323; 2004, 183), or to manufacture pottery or polished stone tools (Barker 2006; Dolukhanov *et al.* 2005; Kunst 2010; Zhilin 2000). In spite of critiques, the Neolithic is still regarded by most scholars as a package (Çilingiroğlu 2005; Verhoeven 2011), and we continue struggling to understand it as a process (Jones and Sibbesson 2013, 167). Thus, the image that persists is that the Neolithic period marks the start of human domination over nature.

Throughout the previous chapter, we have seen how — in tandem with other historical processes like industrialisation, the expansion of market economies and the bureaucratisation of society — the construction of the Western idea of human nature has centred on a gradually reduced notion of 'reason', ultimately reducing human-material interactions to a purely instrumental relation. Thus, questions over objects remain questions about how they can become useful for a particular endeavour, while the non-useful (such as the broken object) is rarely conceived *within* social structure. In this chapter we have seen how the Neolithic, a historical category, becomes victim of the same philosophy of control and a symbol of productivity, construed as *the* period where human beings finally started mastering their control over nature. I now move towards a recent redefinition of the period, which I consider challenges the philosophy of control at its core. This redefinition is fundamental, as the liberation of the concept of the Neolithic from its connotations of human mastery or control over nature, is what enables the study of the Neolithic social knowledge of breakage (a form of knowledge stemming from an uncontrollable force).

3.3 The Neolithic as a thing-heavy world

As the theoretical tide shifts once more, the last ten years of research into the European Neolithic has brought an array of different approaches (Fowler *et al.* 2015; Jones and Sibbesson 2013; Thomas 2015a). Amongst the more recent, and more promising for forwarding our approach here, is John Robb's (2013) emergent causation model and his interpretation of the Neolithic as a *thing-heavy world*.

The author introduces a multi-scalar approach that attempts to understand both the locality of human action and broader regional patterns that arose during the European Neolithic.

For this reason, he conceives the Neolithisation of Europe occurring as a process of emergent causation. Rather than a linear view of causality, emergent causality involves circuits where both cause and effect have interchangeable positions and bounce back to affect each other (Bennet 2005, 445). It forwards, in other words, a step beyond the proverbial chicken and egg scenario. More importantly, through this concept Robb takes into consideration the weight technological choices and social practices had on the structuring of further choices and practices.

As Holocene foragers across Europe picked and chose various types of Neolithic things or techniques (*e.g*. pottery, axes and farming) for different reasons and motivations, these would have been incorporated according to their own cultural logic, such as 'local histories' models suggest. However, once choices were made, there were certain mutually reinforcing unintended consequences that made it more difficult to divert from these original choices (Robb 2014, 33). For Robb, one of the clearest cases was the reinforcement between farming, sedentism and increased accumulation of materials (2013, 665). While Robb does not elaborate on this particular relation, one might guess it goes as follows: an increase in the intensity of labour with farming activities would have generated certain dependency to the land, and thus less movement; at the same time, both farming and sedentism enabled material accumulation, which in turn would have made movement more difficult and provided access to materials (tools and non-tools) that could have benefited agricultural work. This would have eventually made it difficult for populations to return to mobile foraging lifestyles (*Idem*, 667). So, rather than a quick colonising process introduced as a package from the Near East, the European Neolithic would have been a several millennia long, *gradual* and *irreversible* process. In short, human action becomes shaped by the deep history of social practices and their material consequences (see for example Hodder 2006).

Particularly important in this model, is the consideration of material accumulation as one of the main unintended consequences of social life in the European Neolithic. As mentioned by Robb, new material relationships were forged in this lengthy period, where a more thing-light and mobile hunter-gatherer lifestyle shifted towards a Neolithic *thing-heavy world* where there was an increasingly localised and larger range of objects (Robb 2013, 665). Of course, this does not discard the contention that Late Mesolithic populations were actually not as mobile as normally presumed (Holt 2003), as the emergent causation model does not consider the Neolithic as a package, but as a long gradual historical process where humans left a stronger imprint in the landscape. The central concern lies in the 'social implications' of this process, as we are called to put our attention towards the "materiality of social practices" (Robb 2014, 35). In this sense, for Robb pottery would have posed itself as an important material for structuring the Neolithic social landscape. On the one hand, its surface decoration and design provided a place for potting skills and framed the local communities of practice (Robb 2015, 174). On the other hand, its heaviness and fragility required recurrent places for food consumption and stable seasonal potting areas (Robb 2013, 665).

Moving beyond a Victorian narrative of linear progression from savagery to modern industrialised European lifestyles or a degenerationist view of a 'fall from grace' from hunter-gathering (Robb 2013, 680), the emergent causation model puts emphasis on the reinforcement of institutions and their unintended material consequences as the main triggers of the Neolithisation of Europe, while at the same time considering the role of local histories in this process. It is about quite simply the interplay of human agents' historically constituted material choices and the weight of that history (*i.e*. deep time). In this sense, the trend of ever-increasing material accumulation is restricted to a very particular historical process occurring in Europe and not an innate universal human condition (*contra* Schiffer and Miller 1999, 2). It also means that what happened in the European Neolithic did not necessarily happen in the same ways in other regions of the world. For example, in several regions of Mesoamerica and South America domesticates occur and expanded long before pottery or sedentism (see for a synthesis of some of these regions Pearsall 2008; Pickersgill 2016; Raymond 2008), which does not sit well with an emergent causation model between sedentism, farming and pottery accumulation.

In short, rather than a moment of human control, this redefinition of the European Neolithic introduces the possibility of examining the material consequences of past human agency, and how materials acted back. This aspect is essential for studying the social knowledge of breakage. For this reason, stemming from this model I introduce some further considerations under the term 'broken world'.

3.3.1 An Early Neolithic Broken World

With the concept of the thing-heavy world, the idea is fostered that people started living more intensely with their accumulated objects and built environment. Building from this model, this dissertation is focused on understanding the effects of the unintended material accumulation in the Neolithic. For this, I have tried very hard not to fall prey to the modernist projection that the subject of material accumulation and broken objects means this is a dissertation about waste management, this would be "unwarranted" considering waste management is a development of our recent history (Illich 1992, 80). Instead, I have proposed my own theoretical construct, *i.e.* the social knowledge of breakage. Through this concept we can see that material accumulation is not necessarily related to discard of material but triggers a whole range of human social-material interactions.

For the construct of the social knowledge of breakage to work, emphasis must not be on a world of objects or tools, but on broken objects, ergo a broken world emerges. Several Heideggerian sympathisers would directly denominate broken objects as '*things*' (e.g. Olsen 2010; Olsen *et al.* 2012). The first reason for my preference of the former term is that it emphasises the object's condition or state as a non-tool. It is in this state that we can understand human material relations beyond the scope of a philosophy of control, which can be easily lost with the ongoing abuse of the term '*thing*' (*e.g.* Witmore 2014). For example, frequently the term thing is used to designate an object like a pot, but also a fragment of the pot. This obscures the crucial difference between the object put towards purpose according to its rationalised design (*i.e*. tool) and the material resisting human intent (*i.e*. the breaking/broken object) that I am attempting to understand. It is undoubtedly one of the many problems of essentialising 'things'.

Secondly, the idea of a broken world is not just about saying the European Neolithic encloses all human groups that cohabited with broken materials, the term 'broken' also signals the inversion of categories I am trying to make with the philosophy of control. By evoking an aspect of the Neolithic that is seemingly 'useless', it challenges it as a world of productivity. Therefore, rather than a moment of human mastery over nature, of finished products and technologies, is it possible to envision the Neolithic as something different? For instance, could we study it as a moment of human creative (and potentially improvised) interaction with the unintended broken bits and pieces of their social practices? In short, the idea of a broken world entails a different perception of the residual and fragmented environment, which constantly resists human populations and, in this process, generates intent.

Amongst the elements of a broken world, pottery provides a unique opportunity. In Neolithic times, broken pottery could have been an important contributor to this materially imprinted landscape, as it is undoubtedly the most ubiquitous and abundant find in open air and tell sites (although in the latter clay and mudbricks are also common). In some SKC sites pottery can constitute around 95% of the archaeological assemblage (Manson 1995, 71). Of course, this is partly due to the fact that it is a material with the capacity to withstand wear and decay (which is a point frequently raised), but it is also due to one of the most deeply undervalued properties of ceramics: its brittleness. Essentially, ceramic materials, when submitted to different critical stresses, tend to break rather than deform (Quinn 2007, 1–1; Roesler *et al.* 2007, 71). Hence, it is a material that enables breakage and accumulation (Barley 1994, 73; Blanco-González 2015, 19; Chapman 2000, 43–44). So, while Robb (2015, 174) makes more explicit emphasis on the design features of pottery and what it enables, I wish to focus on pottery as a *brittle material,* and how it disrupts and shapes human intent. This does not mean that pottery was the only material contributing to accumulation and its effects, as once again we are partly biased by what is preserved in archaeological sites, but that it is probably our best chance to study this phenomenon in detail.

Within this scheme of the Neolithic, I shall attempt to understand the social order that arises from the unintended material accumulation of broken objects. More accurately expressed, by focusing on the effect of pottery breakage I will ultimately aim to grasp the social knowledge that was constructed from these resistances. This includes the consideration of mending and reuse, which of course are topics that form a substantial part of this dissertation, but also of learning something that might appear useless to us: how did past people actually break their pottery? In short, one of the main questions addressed in this document is: how did the breakage of objects help structure the social life of people during Early Neolithic times? More specifically, two different human groups are of interest, as they are often portrayed as the ‘best example’ of the spread of the Neolithic package into Europe, which are often referred to according to their ceramic styles: *Starčevo-Körös-Criș* (SKC) and *Linearbandkeramik* (LBK; Linear Pottery Culture) located in south-eastern and central Europe respectively. Yet, much like the concept of the Neolithic, the categorisation of these groups is also tainted by the philosophy of human mastery over nature, as will be shown with the overuse of what I term the ‘landfill analogy’ to explain human relations with broken objects. Therefore, the task of the next chapter is to provide a detailed account of how these groups have been categorised.

Chapter 4. The south-eastern and central European Neolithic

Considering the theorisations in Chapter 3, on the consolidation of the Neolithic as a period of human mastery over nature, we can now move on towards more specific problems arising from this depiction. In this regard, south-eastern and central Europe have been essential areas for construing the Neolithic narrative of control or domination over nature, where it is argued that the package of production flourished within the continent (*e.g*. Childe 1964, 106) from the end of the seventh millennium cal BC in the central Balkans (Biagi and Spataro 2005) and from around 5500/5400 cal BC in central Europe (Stäuble 1995). The original designation of the Neolithic populations in these regions were tied to the distribution of very particular ceramic styles, such as *Starčevo* (Bosnia, Croatia, Macedonia and Serbia), *Körös* (Hungary), and *Criș* (NE Hungary, Bánffy 2006; Moldova, Romania, and Transcarpathian Ukraine) groups in south-eastern Europe (in conjunction abbreviated as SKC from now on), and *Linearbandkeramik* groups (LBK from now on) in central Europe. In most sites in central Europe, the land cover has been affected by erosion produced by millennia of land clearing and deforestation. Therefore, most of this fragmented material has been preserved in pits, leaving little evidence of occupation surfaces. By treating pit fills as 'secure assemblages' in the Montelian sense (1903), models of activity areas and household reconstructions have been created based on the distribution of finds in pits (*e.g*. Boelicke 1988a; Bogaard 2011; Hachem 2000; Hachem and Hamon 2014; Lazarovici and Maxim 1995; Link 2012; Rück 2007), and more importantly, chronologies and histories of site use (Boelicke 1982; Bogaard *et al.* 2011; Lüning and Stehli 1992; Stehli 1994; Strien 2012; Zimmermann 1988). Without problematising the origin of these pit deposits or the extended life of pottery fragments, most of these models have become the portrait of Neolithic lifestyles in Europe. Broken pots are assumed to have been discarded just after breakage, thus at the same time breakage becomes a mere *sign of uselessness*. By singularising breakage as a meaningless process there can be no understanding of the variation of responses to pots breaking, as these responses are reduced to the activity of dumping. In other words, there can be no such thing as an Early Neolithic 'knowledge of breakage', only a depiction of modern disposal activities. In turn, the locations of deposition, *i.e*. pits, are commonly portrayed as waste management units, which would have effectively removed broken materials or waste from sight, or rather from practice. These assumptions about pottery breakage and pit deposition encapsulate what I denominate as the 'landfill analogy'. My main argument in this chapter is that the Philosophy of Control is partly translated into the southeast and central European Neolithic by use of this analogy. In other words, the landfill analogy is merely the projection of modern waste management practices into the Neolithic. In line with the early critiques of these models by taphonomic studies, as well as recent evidence on depositional processes and potsherd use-life, some revision on the role of pottery breakage is warranted.

Following these concerns, the chapter is structured in two main sections. In the first section I present a brief overview of the dominant models explaining the role of pits and pottery in SKC and LBK social life. This will provide the reader with an idea of how the landfill analogy is (re)produced, but also with a summary of the main results of the extensive work done on these Neolithic groups. The second section of the chapter attempts to destabilise the landfill analogy by highlighting some early critiques, and more recent evidence that seems to indicate variation of pit depositional processes and some activities possibly shaped by broken pottery. Lastly, the review of this literature allows me to narrow down the broad research questions presented in Chapter 1: “how were Neolithic pots broken?” and “what happened to broken pots?”.

4.1 The Early Neolithic in south-eastern and central Europe

4.1.1 The *Starčevo-Körös-Criș* (SKC)

"*Lux Balcanica est umbra Orientis*" (Todorova 2009, 15)

The SKC pottery style was distributed along the heart of the Balkan Peninsula during Early Neolithic times, and currently their extent includes the modern countries Bosnia Hercegovina, Croatia, Hungary, North Macedonia, Moldova, Romania, Serbia, Slovenia, and the Ukraine. Due to a certain degree of Balkanism (Maran 2017, 17; Todorova 2009, 16) of Western academia, these Neolithic groups have been historically represented as a sort of migratory bridge between the Near East and northern Europe (Maran 2017, 18). Gordon Childe summed this up when stating the uniform nature of the Neolithic from "the Drave to the Baltic and from the Vistula to the Meuse” (Childe 1985, 61). Consequently, much of the characterisations of these groups has been weighed against the Near Eastern Neolithic package, which has obscured some unique elements of these groups (as discussed below).

Much like any defined Neolithic ‘culture’ in Europe, categorisations have been at least initially based on ceramic typologies, with variations recorded according to region. National boundaries were often used as limits of cultural groups, and led to designation of *Starčevo* in former Yugoslavia, *Körös* in Hungary, and *Criș* in Romania, which were then turned into cultural differences. Despite said variation, pottery styles and decorations are mostly similar, and most scholars now conceive it as the same broad phenomenon (*e.g*. Borič 2008, 122; Gheorghiu 2008;

Tringham 1971, 73; Šošić Klindžić and Hršak 2014). The SKC phenomenon is also now believed to have been *partly* descendent from Karanovo I/II, associated with populations moving northwards from western Bulgaria and North Macedonia (Whittle 1996, 40–41) and then along the 'Danube axis' (Silva and Vander Linden 2017, 5). Few absolute dates exist, but these place the southern SKC at the end of the 7th millennium cal BC (Biagi and Spataro 2005; Manson 1995, 69; Silva and Vander Linden 2017, 6).

4.1.1.1 Models of SKC lifestyles

There is hardly any consensus on models of SKC site structure and daily life activities. House remains are sometimes retrieved and living surfaces preserved. A first crucial distinction has been made between Neolithic tell and non-tell or flat open-air settlements (Raczky 2015), which marks a contrast, for example, with Karanovo sites in the south of the Balkan Peninsula. This means that rather than long sequences of rebuilding and stacking of houses, SKC settlements are short-lived. Nonetheless, numerous flat Neolithic settlements in Greece have also appeared (Souvatzi 2008), which indicates this division might be partly biased, as tells are generally more visible.

Depending on preservation, in flat settlements remains of rectangular wattle-and-daub houses are found (Dizdar and Krznarić Škrivanko 2001; Kalicz and Raczky 1980; Mantu 1991; Oross *et al.* 2016; see also Bánffy 2013) often containing hearths (Lazarovici and Lazarovici 2011; Tringham 1971, 86) and possibly clay floors (Carneiro and Mateiciucová 2007, 259; Tringham 1971, 87). Thus, it is stated that in the SKC "the basic architectural unit was the single-roomed four-walled building" (Whittle 1985: 50), which occasionally are burnt down (*e.g*. Kalicz 1998; Kalicz and Raczky 1980, 15–16; Carneiro and Mateiciucová 2007, 279). Clay models of four-walled houses have been found throughout the Early Neolithic Balkans (Trogmayer 1966), sometimes with a vent in the roof (Jovanović 1991; Theocharis 1973), which could suggests hearths were used inside houses. However, it is also claimed that pit-houses (*i.e.* semi-subterranean houses) were present in the early SKC phases, and only in late SKC phases do the aforementioned surface buildings emerge (Bogdanović 1988; Garašanin 1983; Lazarovici and Maxim 1995; Luca *et al.* 2008; Maxim 1999; Manson 1995, 86). However, while some consider that these small pits with roofs in-between wattle and daub houses were simply used for activities such as "cooking or tool manufacture" (Bánffy 2013, 128), other authors have rejected the pit-house interpretation altogether (Ehrich 1977; Tringham 1971, 86). An alternative explanation has considered mobility patterns, and interpreted huts and pit-houses as less permanent structures (Borič 2008, 122; Greenfield and Jongsma Greenfield 2014; Whittle 1996, 52).

[redacted]

Figure 4.1: SKC wattle and daub houses (A; after Carneiro and Mateiciucová 2007), and three Early Neolithic clay models found at: Porodin, Macedonia (B; after Borič 2008), Thessaly, Greece (C; after Whittle 1996), and Röszke-Ludvár, Hungary (D; after Trogmayer 1966)

[redacted]

Figure 4.2: Reconstructions of SKC pit-houses (left, Bogdanović 1988; right, Minichreiter 2001).

However, the debate is not yet over. Part of the problem lies in the similarity of pit-houses with irregularly shaped pit complexes. Pit complexes are a series of dugout features, presumably made for extracting clay for building or pottery manufacture, and then joined by erosion (Figure 4.3). These pits are normally found with large numbers of sherds, chipped and ground stones, daub, bone fragments, among others. Due to the heterogeneity of materials within these features and their irregular shape, once dug out the ‘functions’ of pits appear to be an enigma. The only criteria used for distinguishing these features from pit-houses are the presence of postholes or hearths, which are not exactly common, and of daub fragments, which can enter pits in various ways. Furthermore, there is also an ongoing interpretation of pit complexes as dwellings, even when none of these features are found (Minichreiter 2001, 207). The explanation for the pit filling, however, is normally reduced to disposal (*e.g*. Bogucki 1996, 246).

[redacted]

Figure 4.3: Plans and profiles of some pit types in SKC sites. These include examples of a pit complex from Gura Baciului (Lazarovici and Maxim 1995) and a pit with oven from Zadubravlje (Minichreiter 2001).

Another type of pit encountered occasionally is the storage pit (Figure 4.3). These pits are believed to be smaller in diameter (*ca*. 3m) than pit complexes, and contrary to pit-complexes these have a regular oval form and appear to be a single pit dug sometimes immediately outside houses (Greenfield and Lawson 2020, 26; Minichreiter 2001, 202). Pits with ovens are also found in SKC sites (Bánffy *et al.* 2010, 41; Makkay 1992, 123; Virag *et al.* 2006; Figure 4.3). Most ovens are oval either with a dome or two chimneys, but some are found with cylindrical shapes (Bánffy *et al.* 2010, 41; Minichreiter 2001, 206). Ovens have been expediently interpreted as being used either for baking (Bánffy *et al.* 2010, 41; Minichreiter 1992) or even as pottery kilns (Minichreiter 2001, 203). Alternatively, these pits are interpreted as 'working' areas (Minichreiter 2001), such as pottery manufacture, stone working and cereal processing.

The efforts to understand all these pit features, often neglect pit filling processes, partly due to the excavation methods used and the fact that finds inside pits can later become mixed. Consequently, there is very little we actually know about domestic life in SKC sites, nor what was done with broken pottery.

4.1.1.2 SKC pottery

Studies of Neolithic pottery in southeast Europe are predominantly typological to this day (Amicone 2019, 1). The purpose of these studies has been to classify pottery vessels according to their decoration and morphology and equate these with ethnic/cultural groups or chronological changes. Thus, it is the stylistic design of pottery which has been the focus of these studies. Considering that typological research in south-eastern European countries has normally been characterised by 'splitting' rather than 'lumping' of pottery styles (Chapman 2000a, 2), in *very* general terms we can stress some important similarities. For instance, SKC pottery commonly consists of a range of biconical, globular, carinated and V-shaped vessels. Smaller vessels are usually open bowls, sometimes carinated, with either flat, ring, or pedestalled bases (Figure 4.4). Medium-sized vessels are usually globular or biconical with flat or footed bases. As shown in SKC sites from the Körös valley, the number of feet in vessels can range from four to thirteen (Makkay and Starnini 2008, 7). There are also large shouldered vessels with cylindrical necks (Figure 4.4; Manson 1995, 71). Handles also usually appear on medium and large-sized vessels in the form of protuberances or sometimes perforated lugs, which suggests vessels were hung. In terms of decorations, SKC typologies coincide in that the first phases consisted of burnished or white painted 'finer' wares with some barbotine-coated coarse wares. In later phases, black painted fine wares with spiralled motifs become prevalent, and on coarse vessels impressed decorations are predominant (Arandjelović-Garašanin 1954; Lazarovici 1979; 1984; Lazarovici and Maxim 1995; Makkay 2007; Maxim 1999; Plates). More detail is provided in the next chapter on the specific stylistic variations of pots from the study area, *i.e.* the Upper Tisza/Tisa Basin.

[redacted]

Figure 4.4: Morphology (left) and decoration (right) of SKC pottery vessels at Gura Baciului (after Maxim 1999). Examples of Early (IB-IIA; top right) and Late (IIIB-IVA; bottom right) SKC phases according to painted wares.

Technological approaches to pottery analysis have become abundant in the last two decades of research. Clay used in SKC pottery manufacture appears to be local (Spataro 2006, 70; 2007, 153; Szilágyi and Szakmány 2007, 45) and tempered with organic matter, but occasionally are also found with mineral grains added (Bánffy 2004; Ciută 2005; Gâţă 1994; 1998; Kreiter 2010; Kreiter and Szakmány 2011, 115; Moskal-del Hoyo *et al.* 2017; Kadrow and Rauba-Bukowska 2017b; Saridaki *et al.* 2019; Sommer *et al.* 2019, 7; Spataro 2006; 2008; 2011; Szakmány and Starnini 2007; Szilágyi and Szakmány 2007; Virag 2008a; 2015b, 99). Yet, the exact nature of these organic fibres has not been determined yet. Some scholars have identified phytolith remains from the *Triticum* genus (Kreiter *et al.* 2013, 133; Moskal-del Hoyo *et al.* 2017, 339), but research into other Early Neolithic sites across Europe have provided some evidence of cow dung being used as temper (Tsetlin 2003, 291; 2010, 71–72; Franklin 1998, 6; Neumannová *et al.* 2017, 182). Thus, it may be possible that the consistent and widespread use of organic matter to manufacture pottery presents some regional variation. At a much lower quantity, there have also been few examples of untempered pots (Seidler and Amicone 2017). While there is mention of untempered pots found in the earliest levels of Gura Baciului (Lazarovici and Maxim 1995), these are from a very limited number of sherds. Firing temperatures have also been estimated between 700-870° from sherds of sites like Tășnad-Sere, Homorod and Călinești-Oaș-D.S.M (Kadrow and Rauba-Bukowska 2017b, 424; Kreiter and Szakmány 2011, 114; Maniatis and Tite 1981; Spataro 2014, 185, 187; Szilágyi and Szakmány 2007, 40).

Forming techniques used for pottery manufacture are less well-known. Coiling has usually been assumed (cf. Makkay and Starnini 2008, 77–78), and recent investigations have confirmed that this technique was used for building vessel walls (Commenge 2009; Gomart 2016; Saridaki *et al.* 2019, 135; Thissen 2015, 11; Thissen 2012, 9). Through the study of macrotraces of forming techniques, another documented technique complementing coiling is paddle and anvil, recorded at Vörs-Máriaasszony-sziget (Gomart 2016, 157). In this particular case, coils were formed and then became elongated through repeated beating of the pot with a paddle. The manufacture of vessel bases is also varied. Some bases are produced by forming single or even double flattened clay discs, as seen in Vörs-Máriaasszony-sziget (*Ibid*.). Other bases are formed with coils, either by manufacturing the vessel upside-down until reaching the end of the base or with coiled spirals, such as the bases documented in Nagykörű Tsz. Gyümölcsös (Upper Tisza Valley, *Ibid*.; Gomart *et al.* 2020, 58) and in several SKC sites in Serbia (Sebastien Manem 2017, personal communication). Interestingly, these vessel forming techniques can also be linked to Early Neolithic sites in the Struma Valley (Bulgaria) around the start of the 6th millennium (Vieugué *et al.* 2010, 718–720).

The identification of vessel uses remains a profoundly understudied phenomenon, and most interpretations of function are based on vessel form (Spataro 2014, 194). Furthermore, some authors even remain sceptical about the use of SKC pots over fire, arguing significant traces of fire exposure like soot are absent (Kreiter 2010, 277; Starnini 2008, 106). Laurens Thissen (2005) suggests that cooking could have been done with heated clay objects. Unfortunately, this line of argumentation remains mostly hypothetical. In addition, taphonomic processes could be responsible for the disappearance of some surface traits on vessels (see section 5.1.4.1.1). In contrast, recent studies on use-alteration of Early Neolithic pots from Blagotin (Serbia), where soot clouds, oxidised patches and carbonised remains inside pottery were found, showed mainly bowls of various dimensions were used over the fire (Vuković 2011, 206; 2019, 179). The latter studies also confirmed that there were different ways of positioning vessels when cooking, either directly on or over the fire (Vuković 2011, 206–207, 210 respectively). In recent organic residue analysis, beeswax was identified in bowls and globular vessels from Măgura (south Romania; Roffet-Salque *et al.* 2015, 228) and Tomašanci-Palača (eastern Croatia; Miloglav and Balen 2019, 82), which has been interpreted as a coating applied to reduce vessel permeability (*Ibid*.). In a lipid residue analysis on potsherds from Ecsegfalva 23 ruminant animal fats were identified, and mid-chain ketones indicate vessels were heated for cooking (Craig *et al.* 2007, 357). Animal fats have also been identified in Early Karanovo vessels from Kovačevo (Vieugué *et al.* 2009). However, there have been no large-scale systematic studies carried out so far to clarify our knowledge of SKC pottery use.

4.1.2 The *Linearbandkeramik* (LBK)

Like the SKC in southeast Europe, the *Linearbandkeramik* (LBK from now on) has been taken as the central model for the Neolithic package in central Europe, as all the elements are present, including long-term houses, farming, ground stone tools, and the ubiquitous presence of pottery. The LBK makes reference to a unique style of pottery consisting of banded incised patterns originating somewhere north of lake Balaton in Transdanubia (Bánffy 2004, 66; Pavúk 2004, 74; Zvelebil *et al.* 2010, 304). This ceramic style is considered to have been a derivation from SKC pottery (Kaczanowska and Kozlowski 1994, 51; Pavúk 2004, 76; Spataro 2010, 102)**.** In addition, recent studies suggest central European populations associated to the LBK are genetically linked to populations from the northern Balkans, which is an area associated to SKC and the later Alföld LBK (Keerl 2015; Olalde *et al.* 2015; Szécsényi-Nagy *et al.* 2015). The first LBK ceramic styles quickly became widespread in central Europe, reaching the Northern Harz Foreland to the north, the Rhineland to the west, and north-western Hungary to the east. With the exception of the so-called phase 0 (Stadler and Kotova 2010), in Germany and Austria the LBK is generally considered to have commenced around 5500/5400 cal BC (Stäuble 1995; 2005; Whittle 1990) with the oldest or *älteste Bandkeramik* phase (Quitta 1960; Tichý 1960; äLBK from now on).

4.1.2.1 Models of LBK households

Partly due to the lack of preserved occupation surfaces in most of central Europe and the limited scale of archaeological excavations, until the Second World War Early Neolithic pits in central Europe were often interpreted as pit-houses. These were considered pits containing hearths and postholes (Radig 1930), and the finds retrieved from them believed to be the result of either the remnants of activities or the post-abandonment flow of nearby rubbish inside the dwellings. Since the excavation of Köln-Lindenthal by Buttler and Haberey (1936) with large-scale excavations and the use of ethnographic comparisons, in Germany it became apparent that the dark-coloured features on loessic soils were in fact long rectilinear buildings erected from large posts and flanked by longpits. Thus, contrary to SKC groups, the pit-house interpretation was eventually disproven (Paret 1948). Yet, at the time the buildings themselves were not considered houses, but barns. More importantly, with these studies some first questions of how finds ended up in pits were established (as synthesised by Stäuble and Wolfram 2012, 36). Thus, in the first systematic models of LBK buildings there was a shift in perspectives of settlement arrangement from pit-houses to long barns, and pit deposits were interpreted as the product of many outcomes, including refuse disposal from activities carried out in adjacent buildings.

These interpretations set the basis for a series of models of LBK settlement reconstructions, such as the house complex and the *Hofplatz* model. The house complex was first applied to sites in Czech Republic (Soudský 1966; Soudský and Pavlů 1972), while the *Hofplatz* model was created from research on sites in Rhineland (Boelicke 1982; Kuper *et al.* 1974). The models basically divide sites into (private) domestic units composed of a longhouse, yard and adjacent pits within a certain radius from the house (Figure 4.5). The generally reproduced assumption is that houses and pit features were contemporary, and that the material remains within the latter directly reflect the activities that were performed within the former (Modderman 1970, 35; Soudský 1966, 30). The basic assumption on pit fills had passed from reflecting refuse activities of pit-dwellings, to those of barns, and eventually longhouses (summarised by Stäuble 2013, 232). Pit filling processes were heavily simplified (Rück 2013, 209), and since then, these assumptions have rarely been questioned (Bickle 2020, 184).

[redacted]

Figure 4.5: Hofplatz and associated artefact discard model for longhouses at Langweiler 8 (after Boelicke 1988a).

[redacted]

Figure 4.6: LBK longhouse plan (after Stäuble 2005) and reconstruction (after Stäuble 1997).

[redacted]

Figure 4.7: LBK pits according to description given in the texts. Examples of longpits, outer trenches, pit complexes, and pits with ovens are from Langweiler 8 features (Boelicke 1988b), and a single example of a storage pit from Hienheim (Modderman 1977).

There is some consensus on the reconstruction of early LBK longhouses, namely their rectilinear plan, a regionally-specific orientation, the segmentation of internal areas of the house by rows of posts, and associated pits along the long ends of the houses, which are sometimes merged with trenches (Last 2015, 294; Stäuble 2005, 12–20). LBK houses have been described as possessing a tripartite division into north-western, central and south-eastern areas (Modderman 1988, 90; Pavlů 2000, 198; Soudský 1966, 36; Stäuble 2005, Figure 2; Waterbolk and Modderman 1959, 168), and adjacent pits outside each section were associated with activities being performed in each sector of the house. The northwest sector is seen as sleeping quarters (Coudart 1998, 105), although Modderman (1988, 96) suggested north-western sectors could work as stables, which has so far been unsubstantiated by phosphate analyses (Lienemann 1998; Stäuble and Lüning 1999). The central area of the house are considered to be working/living areas with potentially a hearth (Modderman 1988, 96), which was also suggested in a study on the distribution of burnt clay (Lüning 1986), while the southeast sector is associated with grain storage, because of the indication of double posts and a presumed second floor (Bradley 2001, 52; Lüning 2000, 158; Modderman 1988, 96). However, there is hardly any consensus on the types of activities performed in each sector.

Pit typologies according to function have also been proposed in several regions, but there are some pan-regional commonalities in äLBK settlements. Longpits (*Längsgruben*) are the most common and widespread pit type, although they are also present in the later LBK phases (Figure 4.7). These pits normally flank the long sides of houses and are believed to have been dug with the intent of extracting loam for building houses or other structures (Modderman 1988, 104). Longpits are generally assumed to have been filled by ‘rubbish’ from the house, an interpretation partly based on the accumulation of relatively large quantities of potsherds, lithic artefacts, bones, and some botanical remains, most predominantly emmer and einkorn grains (Kreuz 1990). Outer trenches (*Außengräben*), which are found adjacent to longpits, are considered to support the eaves of the roofs (Figure 4.6 and 4.7; Lüning 1988), and thus are apparently not associated to any drainage function. Longpits and trenches are sometimes difficult to discern in the sections, partly because they are joined by erosive processes (Figure 4.7). More enigmatic are pit complexes (*Grubenkomplexe*). Like their SKC equivalent, their shapes show several episodes of digging (Figure 4.7; Stäuble 1997, 74), but there is no clear idea of how they have been filled. Presumably for this reason, the interpretation that they were filled by refuse is commonly adopted (*e.g.* Bánffy 2013, 129). Other types of pit contain ovens (Figure 4.7; Bernhardt 1986; Boelicke 1988b, 428–434; Lenneis 1995, 18; Modderman 1988, 104), which are generally considered as activity areas outside houses. Storage or “cauldron-shaped” pits (*Kesselgruben*) are small oval features with bell-shaped sections (Figure 4.7; *e.g*. Fansa and Thieme 1985; Lüning 1977, 66–67; Tischendorf and Girardelli 2016, 30; Zápotocká 1989), but the main diagnostic criterion is their flat bottoms or ‘floors’ (Boelicke 1988b, 323). These pits are also sometimes found with grain kernels (Van de Velde 2008, 78). Yet, even with storage pits, the common is that these features are eventually infilled by discard of refuse.

In sum, there is a general assumption of the passivity of deposits, and the all-encompassing refuse pit explanation observed for the SKC is also commonly implemented in LBK studies. However, this explanation has become criticised in the last two decades (see section 4.2.1), which enable a deeper examination of the depositional processes involved in the formation of pit fills.

4.1.2.2 LBK pottery

Pottery has been the most widely studied *Linearbandkeramik* object, mostly because of its use as a chronological marker, which is a dominant approach in central European archaeology (Bailey 2000, 76; Sommer and Gramsch 2011, 25; Trigger 2006, 490; cf. Bertemes 2002; 2011). Thus, descriptive records of the slight morphological variation of biconical and globular LBK pottery, as well as the range of incised curvilinear motifs represented on these vessels, are abundant in various sites (Figure 4.8; *e.g*. Cladders 2001; Kloos 1990; Quitta 1960; Siegmund and Hainski 1992a). Originally formulated by Hans Quitta (1960; 1964; cf. Tichý 1960), the main typological classification of the LBK divides this ‘culture’ into phases, such as earliest or oldest (*älteste*; äLBK), early or older (*ältester*), middle (*mittlere*) and later or younger (*jüngere*), according to mostly stylistic (*i.e.* morphology and decoration) but also compositional attributes of pottery vessels.

In the äLBK phase, a key morphological trait is the fabrication of flat-bottomed vessels (Quitta 1960, 9–11), such as bowls (*Schalen*), carinated globular vessels (*Kümpfe*), and spherical flasks (*Flaschen*) with cylindrical necks. Nonetheless, there are also examples of pedestalled bowls, which become less frequent through time (Cladders 2001, 100). Globular vessels are sometimes accompanied with small handle protuberances or lugs at their maximum diameter. Generally, in this phase, bowls are also more frequent than globular vessels (*Idem*, 99). The decoration in the äLBK phase consists of curved, spiral, and linear motifs incised in broad and separated lines often distributed throughout the whole vessel (*Idem*, 98), and finger impressions only occur occasionally (*Idem*, 44). Much like the preceding SKC pottery, this phase is also associated to the widespread use of organic temper in pots (Quitta 1960, 8). In the later phases (oldest to youngest), vessel bases become more rounded. *Kümpfe* vessels become predominant, their shape becomes more spherical, and rims become less pronounced. Incised lines become narrower, occupy different areas of vessels (including rims), and are increasingly ornamented (Pechtl 2015, 558). There is also a much larger variation of motifs used. Thus, similar central motifs to the äLBK like spirals and meandered lines are used, but these are complemented with hooks, short lines, nets, among others (*Ibid.*). There is also a shift from the use of organic temper to one of mineral or grog temper (Claßen 2010, 120; Engelbrecht and Lüning 2005, 170; Quitta 1964, 17). Despite these small differences between phases, the outstanding homogeneity of pots in terms of their morphology and decoration has been commonly recognized (*e.g.* Cladders 2001; Cladders and Stäuble 2003; Sommer 2001).

Figure 4.8: Examples of 'typical' äLBK vessels from Schwanfeld (1-4) and Bruchenbrücken (5-12) (after Cladders 2001).

A far more restricted group of studies have focused on pottery technology, mostly composition, firing and forming techniques. Studies of äLBK pottery composition through petrographic or macroscopic methods have determined that these ceramics were mostly manufactured with locally acquired clays mixed with organic temper (Cladders 2001, 39; Kreiter *et al.* 2017, 128; Mecking *et al.* 2012, Table 1; Modderman 1988, 111; Riederer 1985). However, the specific source of organic temper can be varied and is more difficult to ascertain, which has hardly been problematised. Some possibilities include: wheat chaff, grass or animal dung (Cladders 2001, 40; Neumannová *et al.* 2017, 182). In rare occasions, these are accompanied by some mineral component, commonly sand (Riederer 1985, 35–36; Siegmund and Hainski 1992, 21), but their addition is generally deemed to be unintended (Cladders 2001, 40). Firing temperatures, as determined from X-ray diffraction analyses of archaeological samples (Thér *et al.* 2019; cf. Slager *et al.* 1978, 198) and the use of a dilatometer (Riederer 1985, 30), did not exceed 800°C.

Manufacturing methods appear to vary across regions. For instance, in the Rheinland (Germany), hammer and anvil technique has been advocated (Modderman 1988, 111–112), while evidence of coiling has been identified at Bylany (Czech Republic; Neumannová *et al.* 2017) and at Cuiry-lès-Chaudardes (Gomart 2014). In the latter, coiling occurs in various ways, either forming S, Z or O patterns (*Idem.*, Table 5). In various large LBK sites throughout Germany and in the Balaton region (Hungary), both coiling and paddle and anvil techniques have been identified, while single flat discs are commonly used as bases (Cladders 2001, 43–44; Kreiter *et al.* 2017, 128). Furthermore, much like evidence of spiral coiling of bases observed at Cuiry-lès-Chaudardes (Gomart *et al.* 2015, Table 2; Gomart and Ilett 2017, 213), in my examination of LBK ceramics from the Northern Harz Foreland I have also detected this technique (Appendix 2). However, analyses of forming techniques are still in their infancy for LBK ceramics, and much variation in forming techniques, as well as their anthropological implications, are still to be properly understood.

Even less common are studies of the uses of LBK pots. As expected, form/function analyses prevail. Animal fats have been identified in potsherds from Bylany, Zwenkau, Eythra, Brodau, Wang and Niederhummel (Matlova *et al.* 2017, 272; Salque *et al.* 2012, 58). Residue extracted from sherds found at Bylany, Eythra and Zwenkau showed the predominant use of globular vessels and bowls in serving and food processing activities (Matlova *et al.* 2017, 269; Salque *et al.* 2012, 56). In a few cases, presence of long-chain ketones indicated pots were exposed to high temperatures during use (Matlova *et al.* 2017, 265; Salque *et al.* 2012, 56), suggesting most likely cooking was performed. At Wang and Niederhummel porcine adipose fats were dominant, which indicates a higher reliance on pigs and/or wild boars (Salque *et al.* 2012, 56). More recently, beeswax has been identified in potsherds from Brunn am Gebirge and

Niederhummel (Roffet-Salque *et al.* 2015, 228). Lastly, also at Brunn am Gebirge remnants of birch bark pitch has been detected (Puchinger *et al.* 2019), suggesting the use of pots for manufacturing adhesives.

Despite extensive studies of LBK pottery, there is still very little we know about human-material relations, other than how pots were designed in terms of their style (decoration and morphology), composition and *intended* uses.

4.1.3 Summary: The instrumental Neolithic and the 'landfill analogy' in south-eastern and central Europe

Several aspects must be highlighted from the observed instrumental models of Early Neolithic lifestyles in both LBK and SKC groups, which build up to what I denominate as the landfill analogy. Just to remind the reader of observations made in Chapter 1, modern landfills can be seen as structures, mostly already dugout areas or abandoned mines, used to contain and to remove all materials deposited there from sight, ensuring no obstacles are in the way of industrial production. In other words, landfills are a sort of 'necessary evil' that enable production, the most praised element of modernity, to continue working at maximum capacity. In the dominant models of Neolithic lifestyles exposed so far, the elements of an instrumental view of objects (as detailed in the previous chapter) prevails by establishing an analogical relationship between modern waste disposal mechanisms and past Neolithic discard behaviour; in other words, by creating a 'landfill analogy'.

Neolithic pottery is mostly studied as a referent or sign of Neolithic production and design. Whether it is because of typological or technological questions, this material is studied for its capacity to reflect the intended and rationalised design of the human agent. This paradigm is also reflected in the very limited number of studies focusing on determining the actual uses of pots. Because of the instrumental model, when breakage is addressed, it tends to be considered as an event leading to discard (Figure 4.9), which resembles the Schifferian flux model discussed in Chapter 2 (Figure 2.3). However, even though Schiffer accounts for recycling, reuse and maintenance of objects, these are not really accommodated in the Neolithic depictions given above.

In the research of SKC and LBK, once pots are broken, the common contention is that they were dumped into pits initially created for other purposes (Figure 4.9), of which the most preferred explanation is the extraction of loam for walls and floors. These pits, whatever their topography, are often designated innocuously as waste, garbage or rubbish pits (*e.g*. Andreescu and Mirea 2008, 59; Kreuz 2007, 261–263; Kreuz and Schäfer 2011, 335; Luca and Suciu 2008, 42), as is often done for other periods as well. Pottery fragments in these features are often referred to as rubbish, implying broken pottery did not have a large role in social practices (as criticised by Chapman 2000a, 4; 2000b, 62) and are associated with *modern* categories of dirt (Sommer 1990, 49). Another example is the presence of urine and manure in pits, which is hardly ever considered, even though there is some evidence to suggest these were part of these deposits (Macphail *et al.* 2008, 63; Sommer *et al.* 2019, 5; Stäuble and Lüning 1999). The designation of pits as refuse-filled structures has become widespread, but no clear explanation is given on what exactly this entails. It would seem that, just as modern landfills, Neolithic pits were waste management structures (Bosquet *et al.* 2010, 40).

[redacted]

Figure 4.9: The Schifferian flux model applied to LBK pottery (after Keefer 1993). Text translation on bottom left corner: "stages of Linear Pottery vessels".

In summary, there seems to be a projection of our urban modern social knowledge of breakage, namely the immediate disposal of seemingly useless objects, into interpretations of Neolithic human-material relations. In the next section, the main critiques of these models are outlined, and results from the last two decades of research on extended lives of broken pots and the variation of depositional processes in pits are presented.

4.2 Looking past the instrumental Neolithic and the landfill analogy

Considering the abovementioned models of SKC and LBK lifestyles that reproduce the landfill analogy, I now present the published evidence that may destabilise these models. This evidence is summarised according to the two main components of this analogy: the formation of pit deposits and what is done with broken objects. Given the limited amount of studies questioning these SKC and LBK models, I review this information for both SKC and LBK together. Lastly, I also show that despite the growing evidence on the variation of depositional processes responsible for filling pits and the extensive history of potsherds, unfortunately more work is needed.

4.2.1 Neolithic houses and pits: Critiques and different interpretations

The first critiques of these house and activity area models were articulated from a taphonomic point of view. In this sense, the focus was on questioning the assumption that pit fills are the result of activities carried out in *contemporary* adjacent houses. Site formation processes were stressed as crucial for unravelling the sequences of pit formation and infill (Lüning 1973; 1977). Various authors expanded and intensified this study since (Květina 2010; Sommer 1991; Stäuble and Wolfram 2012; Wolfram 2013), and for some time now have put efforts on figuring out how finds end up in these pits in the first place. At Bylany, finds distributions revealed that refuse in pits cannot be directly linked to particular households (Květina and Hrnčiř 2013, 343; Květina and Končelová 2013, 6). Distribution studies of pottery refits at Early Neolithic SKC and LBK sites arrive at a similar conclusion (Allard *et al.* 2013, 22; Bosquet 2013, 34; Bosquet *et al.* 2010, 44; Claßen 2005, 115; 2009, 97; Kowarik 2010, 94; Domboróczki and Raczky 2010, 208).

Other studies have debunked the assumption that pits fills are mainly the result of refuse disposal and stress the variation of pit infill mechanisms. Stäuble (1997) has shown that at Bruchenbrücken some pit deposits may be linked to the quick backfilling process essential for the building of the houses. In contrast, recent published overviews of LBK settlement structures and depositional practices both conclude that LBK pits are generally presumed to have been filled gradually (Bickle 2020, 186; Last 2015, 280). Once more at Bylany, finds distribution studies show that different types of pits were deposited in different ways, but predominantly by 'natural' processes (Končelová *et al.* 2019; Pavlů 2013). Concordantly, soil micromorphology studies at the LBK site of Elsloo-Riviusstraat (Netherlands), and at the SKC site of Măgura (south Romania) highlight that pits were not simple dumping areas but had different uses, as evidenced by re-excavating/backfilling activities (Huisman *et al.* 2014, 131; Macphail *et al.* 2008, 65). Recent reviews of structured deposits (in the ritual sense) on various pits in LBK sites such as: inverted vessels, deliberately placed artefacts at the bottom of pits, 'suspiciously rich' deposits of decorated pots, deposits with complete pots, among many others, have begun to cast doubt on simplified interpretations of pit deposit formation (Elburg 2013; Hofmann 2020; Ritter-Burkert 2020). Therefore, there is evidence that pit filling was probably more varied than assumed.

4.2.2 What about broken pottery?

The last two decades of studies from both SKC and LBK groups are beginning to suggest different human-(broken)material relations that cannot be explained by a modern analogy of dumping 'useless' remains. Firstly, while the topic is certainly obscure, Neolithic mending or repair activities on pottery have been documented, which gives us an initial cue from which to investigate the knowledge these populations had of the signs of potential breakage of pots. Repair holes on sherds from SKC sites are widespread (Karmanski 2005, Plate CX, 1-4; Lazarovici and Maxim 1995, Figure 31; Makkay and Starnini 2008, Figures 65, 5; 197, 7; 221, 9; 256, 6; 360, 8), and less documented in LBK sites (Cladders 2001, Plate 48, 3-5). Generally, as indicated by their biconical section, fired ceramic sherds during Early Neolithic times were drilled until halfway through and then worked from the opposite surface until a hole was created. It has also been suggested that some fibre was used to tie both sherds together (Makkay and Starnini 2008, Figure 65, 5). Repair holes are often difficult to differentiate from perforations created for other purposes (*e.g.* Băcueț-Crișan 2008, Plate 15, 1-4; Cladders 2001, Plate 25, 2), and there has not been much effort to obtain more information. One might assume that a preliminary way of distinguishing them is by their proximity to the fragment edge, as holes in spindle whorls tend to be at the centre of a fragment. Another type of repair technique has been the application of wet clay on cracks formed during drying stages of pottery manufacture (Cladders 2001, 44; Makkay 1992, Plates 17 and 25; Makkay 2007, 167–173). At the sites of Altscherbitz and Eythra there is evidence that repair might have been more common than expected (Elburg 2013, 13; 2015; Tegel *et al.* 2012, 5). Well-preserved cracked vessels decorated in younger LBK style were found inside wells with evidence of being glued with birch bark tar. Straps were also joining vessel fragments through two holes drilled at both sides of cracks. Lastly, there is also evidence of the complete redesign of repaired vessels (Elburg 2015, 240), which is a practice that extends to other LBK sites (see for a review Einicke 2014).

Secondly, evidence of the extended social history of fragments has become increasingly visible. The use of potsherds has not been thoroughly analysed in SKC and LBK sites, but it has been indirectly addressed, as many refitting studies conclude fragments from same vessels have been deposited in pits at different times (Allard *et al.* 2013, 22; Bosquet 2013, 34; Bosquet *et al.* 2010, 44; Classen 2009, 97; Chapman 2000a, 63; Chapman and Gaydarska 2007, 91; Kowarik 2010, 94; Domboróczki and Raczky 2010, 208). At Miskovice and Bylany (Czech Republic; Květina and Končelová 2011, 62; Last 1998, 28), as well as in Buduiasca–Boldul lui Moș Ivănuș (Romania; Thissen 2015), ceramic fragments with different degrees of abrasion were deposited within different pit features, suggesting a prolonged history of fragments after pottery breakage.

Despite the rather low importance given to these repurposed objects, direct evidence of fragment reuse as spindle whorls (Kalicz 1990, Plate 17, 4,7, Plate 45, 1; Karmanski 2005, Plates CVI-CIX, CX, 5-10; Lazarovici and Maxim 1995, Figure 30 and 31; Makkay 1997), sherd discs (Cladders 2001, Plate 18, 15; Kalicz 1990, Plate 17 2-6, 8, 11; Karmanski 2005, Plates CII-CV; Makkay and Starnini 2008, Figure 18, 10; Minichreiter 2012, Figure 5), and a ceramic polisher (Makkay and Starnini 2008, Figure 172, 5) have been documented. However, most detailed research on pot and potsherd reuse is attested in other regions or periods. The novel use-wear analysis conducted at the Early Neolithic site of Kovačevo (6100-5600 cal. BC; southwest Bulgaria) has shed light on the reuse of potsherds for pottery manufacture and hide processing (Vieugué 2014; 2015). This behaviour is also observed in later Neolithic sites such as Vinča Belo Brdo (Serbia), where a varied set of uses for fragments has been recognized (Vuković 2013; 2015). The addition of grog temper became also a common practice in Vinča groups (Spataro 2014b, 194), as well as in older, middle and younger LBK groups at Königshoven (Classen 2010, 120), which could be highlighting the increasing importance of fragments in everyday practices. There is also an example documented of a broken pedestal base that was abraded for an unknown purpose at Szarvas 8/23 (Makkay and Starnini 2008, Figure 18, 113).

In sum, what I wish to highlight from these examples is that a practical knowledge of ceramic breakage could have been present within the Early Neolithic cultural repertoire in central and south-eastern Europe, which is a form of knowledge pointing towards a very different engagement with fragments than what we would normally practice in a modern urban setting.

4.3 Conclusion

The study of *Starčevo-Körös-Criș* and *Linearbandkeramik* groups has increased significantly in the last decades. While there are many studies using a landfill analogy, furthering the idea of the Neolithic as the birth of human control over nature, recent studies on pits and potsherds have started to destabilise this narrative. As shown in section 4.2.1, there is recognition on the need to understand the variety of ways materials can end up in pits. However, it appears we are barely scratching the surface. For example, intense and widespread fragment reuse is mostly hypothetical. Similarly, our knowledge of pottery repair during the Neolithic is highly limited, and there does not seem to be the slightest concern with understanding of how pottery might have broken.

More importantly, having detailed some background on the central and south-eastern European Neolithic, my research questions can be put more precisely. Considering a crucial aspect of the broad question of 'what happens to broken pots?' is determining: how were Early Neolithic pits filled? Similarly, we can narrow down the question 'how were Neolithic pots broken?', towards how did organic-tempered pottery break during use, like cooking? Lastly, our question on the signs of breakage can certainly include, how were Early Neolithic pots repaired?

Before continuing, a clarification must be made, as in archaeology there is a tendency to 'throw the baby with the bathwater'. I do not argue that dumping pottery in pits never occurred in the European Early Neolithic, indeed it will be shown that this happened in multiple occasions, but that the (structured) principles of this practice need to be teased out of the actual investigation of material remains. Having clarified this, we move on to the next chapter, where I provide detailed information on the specific regions and sites that I have chosen for studying pottery breakage.

Chapter 5. The study areas: The Upper Tisza/Tisa Basin and the Northern Harz Foreland

This chapter provides a general description of the two regions I have chosen for my analysis. I have selected these regions primarily because to-date they both represent supposed 'Neolithic boundaries' with local Mesolithic populations, and it is on these boundaries where the 'cultural essence' of the Neolithic package tends to be highlighted by researchers. As my intent of viewing the Neolithic as a thing-heavy world (or in our case a 'Broken World') is to try to flip the page from production-based definitions of Neolithic groups, these regions are of great interest. In other words, it is because of their allusion to some Neolithic 'purity' that these boundary regions are pertinent for analysing them under a different gaze. Both areas also represent geomorphological boundaries between lowlands or plains and more mountainous terrains. Nonetheless, there are geomorphological differences between these regions that must be taken into account, namely the fact that the Upper Tisza/Tisa Basin has been mostly shaped by fluvial agents, while the Northern Harz Foreland has been moulded by glacial movement since at least the start of the Pleistocene. The clayey substrate in the former region contrasts with the loessic cover of the latter.

I have selected sites from both study areas that have been extensively excavated, but also possess fine-grained information on ceramic finds, which can be represented by Tășnad Sere in the UTB and Eitzum in the NHF. In addition, I have complemented this selection with a few smaller sites, such as Méhtelek-Nádas, Călinești-Oaș-Dâmbul Sfintei Mării and Klein Denkte. There is variation regarding excavation units, and thus the level of fine-grained information obtained from said fieldwork varies between sites. The extreme cases are, on the one hand, Méhtelek-Nádas -where the spatial information of finds is limited to their location in features-, and on the other hand Tășnad-Sere -where there is a three-dimensional record of the position of every find encountered. Despite these differences, there is cohesion in the final data created, as different analytical scales were used to compare all these sites to each other (see Chapter 6). In this chapter, I present all relevant information of each site with regards to excavation and find processing methods, as well as the main features and finds discovered. At some of the sites, too many features were uncovered to be described in detail, and for this reason descriptions centred only on those features that were part of my analysis.

5.1 The Upper Tisza/Tisa Basin

The Upper Tisza/Tisa Basin (UTB from now on) is a network of floodplains in northwest Romania, northeast Hungary and southwest Ukraine (Figure 5.1). The basin is shaped by two large water bodies that flow down from the Carpathian Mountains, *i.e.* the Tisza/Tisa and the Szamos/Someș Rivers, and their tributaries. Together these waterways have been central in the formation of alluvial fans and marshes that characterise this intensely irrigated area (Sümegi 1999, 174). The region has also been continually affected by floods in (pre)historical and modern times (Kiss 2009; Nagy *et al.* 2010). Since the 19th century, work to improve drainage and prevent floods has been carried out (Szabó *et al.* 2012, 242), which has significantly reduced the marshes in the area.

5.1.1 Geology and geomorphology

The UTB can be geologically circumscribed to the west and northwest by the volcanic Tokaj or Zemplén Mountains– a primary and secondary source of Carpathian II black obsidian (Biró 2018; Szepesi *et al.* 2018), and limnic quartzite[1] (Szekszárdi 2005)– the southeast by the Apuseni Mountains– rich in crystalline schist and limnic quartzite (Crandell 2014b)-, and towards the east by the Oaș-Gutâi Mountains – also abundant in limnic quartzite (Crandell 2014a, 75).

From its crystalline schist basement (Mutihac and Mutihac 2010, 633), marine deposits such as limestones, marls and evaporates were formed during the Miocene. This was a consequence of the formation of the Great Pannonian Sea, when the Carpathian Mountains and Alps were uplifted (Sherratt 1982, 289). Since the Miocene, rivers have arguably become the main geomorphological agent in the region, eroding and accumulating alluvium in small basins. The tectonic subsidence and uplifting of basins and mountains throughout the Pleistocene and at the Pleistocene/Holocene border have shifted the causeways of some of the main rivers in the region. With the warmer and more humid Holocene conditions (Kiss *et al.* 2015, 145–146), the directional change of river flow has been central in the formation of the poorly drained soils of marshes and swamps. For example, the Tisza/Tisa River originally flowed down to the Ér/Ier Valley, and around 20-14kya shifted westwards to a subsiding Bodrogköz region, leaving behind abandoned alluvial fans and meanders (Kiss *et al.* 2015, 146–147; Sherratt 1982, 292; Szabó *et al.* 2012, 242; Figure 5.1). One of the effects of this landscape modification was the formation of the Ecsed/Ecedea marsh (Pécsi and Sárfalvi

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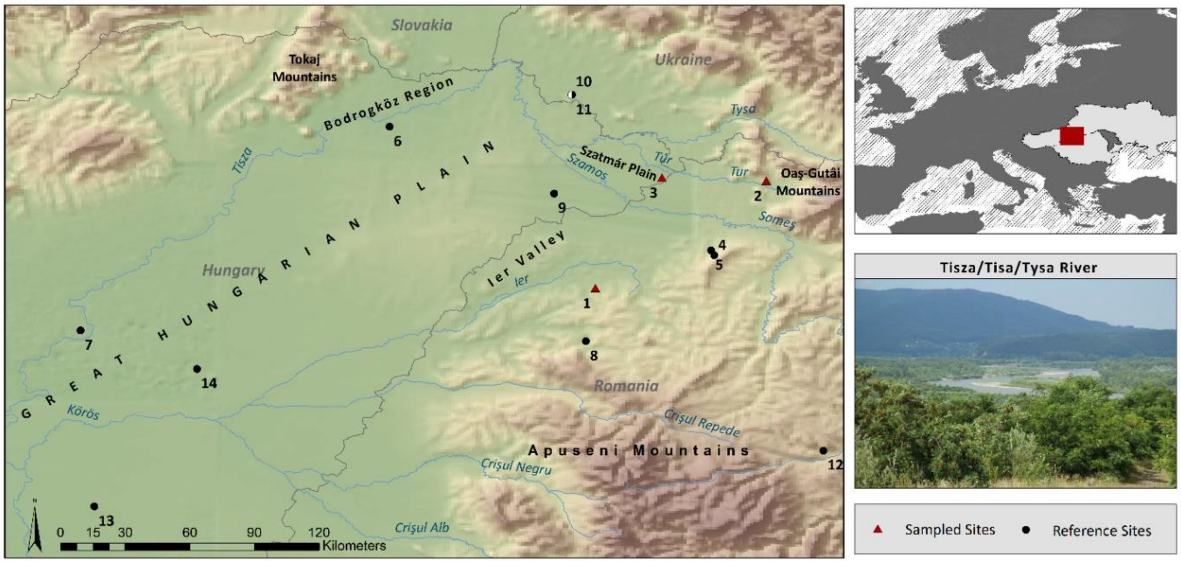
[1] Is a type of chert found throughout NW Romania; however, it has also been called Jasper, Opal or Sinter by some authors (see Crandell 2014a).

1964, 54; Török 2002, 164). Other examples of these fluvial landforms can be observed in the Bereg or Szatmár Plain and the west Romanian Plain (Figure 5.1).



1	Tășnad Sere	5	Homorodul Vechi	9	Nagyecsed	13	Endrőd-Öregszőlők 119
2	Călinești-Oaș-Dâmbul Sfintei Mării	6	Ibrány-Nagyerdő	10	Zastavne-Mala Hora	14	Ecsegfalva 23
3	Méhtelek-Nádas	7	Nagykörű	11	Zápszony-Kishegy		
4	Homorodu de Sus	8	Suplacu de Barcău	12	Gura Baciului		

Figure 5.1: The Upper Tisza Basin with sampled and reference sites.

5.1.2 The Early Neolithic in the UTB

The Early Neolithic occupation in this region corresponds to the settlement of later SKC groups, in their northernmost distribution. While the Neolithic in nearby regions like Transylvania, the Banat, and the Körös Valley started from 6200 cal BC (Biagi *et al.* 2005, 44; Bronk *et al.* 2007, 184; Hertelendi *et al.* 1995, 242; Spataro 2010, 97; Whittle *et al.* 2002, 93), in the UTB the phenomenon only began after in the 58th century BC (Kalicz 2011, 44; Kalicz and Makkay 1976; Oross and Siklósi 2012, 153). Radiocarbon dates as well as archaeological finds suggest Neolithic populations in the region migrated northward from either along the Tisza, the Ér/Ier Valley, or Central Transylvania (Domboróczki 2010a, 184; Kalicz 2011, 45; Lazarovici 1998; Raczky 1983; 1988, 27–32; Virag 2008b).

There is a particularly heated debate about the influence of Mesolithic people reflected in the SKC assemblages in the region (Borič 2005a; Chapman 2003; Domboróczki 2010a; Raczky *et al.* 2010; Kertész and Sümegi 2001; Whittle 1998). In this respect, the UTB is not only considered part of the northern boundary zone of SKC groups, but also an environment that was rather different from drier plains in south-eastern Europe (Kertész and Sümegi 2001; Raczky *et al.* 2010, 160; Sümegi *et al.* 2013). Some differences to the lithic and ceramic assemblages from the Great Hungarian Plain have also been highlighted (Chmielewski and Astaloș 2015; Kalicz 2011; Starnini 2001), and has even led some authors to propose that a variant of the Körös group was inhabiting the UTB, *i.e.* the Méhtelek group (Kalicz 2011, 11; Kalicz and Makkay 1976, 22–23). Other authors explain these differences in terms of adaptation of migrating SKC populations to different wetland environments, where other procurement strategies were chosen (Raczky *et al.* 2010). Rather than falling prey to dichotomous interpretations, I will shift focus from this lengthy debate towards the cumulative effect of material culture in the region.

5.1.3 Chronological schemes and pottery in the UTB

The pottery from the Upper Tisza/Tisa Basin corresponds to the later SKC in Lazarovici's (1984) typology, *i.e.* phases IIIB and IVA. Ceramic material from the UTB shows a resemblance in morphology and style in NE Hungary – such as in Méhtelek-Nádas (Kalicz 2011)**,** Ibrány–Nagyerdő (Domboróczki and Raczky 2010), and Nagyecsed (Kalicz and Makkay 1976)–, NW Romania – like Călinești-Oaș-Dâmbul Sfintei Mării (Virag 2008a)**,** Suplacu de Barcău/Porț (Băcueț-Crișan 2008; Ignat 1998), Homorodu de Sus (Bader 1968), and Tășnad Sere (Iercoşan 1994; Virag 2015b)-, and SW Ukraine- for example in Zastavne-Mala Hora and Zápszony-Kishegy (Potushniak 1996; 2004). Vessels are usually carinated, globular, or V-shaped (Maxim 1999). Bowls can be carinated or straight-walled (V-shape in profile), while large jars are solely globular. Pottery bases can be flat, footed (from four to thirteen legs) or hollow pedestals subdivided into high and low (Figure; Makkay and Starnini 2008; Virag 2015b, 104; cf. Oross 2007, 496). Some common pottery surface decorations include barbotine, incised motifs, and fingernail impressions (Astaloș *et al.* 2013, 49–50). Despite similarities, some stylistic variation has been noted at the site of Méhtelek-Nádas, which is described in section 5.1.4.3.

With regards to sampled sites, at Tășnad Sere and Călinești-Oaș-D.S.M., small bowls are troncoconical, carinated or semispherical (Figure 5.2, 1-3; Plate I, 1,3; the latter two sometimes occuring with a lobed rim, Virag 2015b, 103). Some of these bowls have short and high pedestals (Figure 5.2, 7-8; Plate I, 7-8), the latter sometimes with two or more perforations on its sides (Figure 5.2, 8). There are also deep bowls with V-shaped sections and straight rims (Figure 5.2, 4-5). Globular medium-sized pots have cylindrical necks (Figure 5.2, 9, 11; Plate I, 2) or end directly at the rim (Figure 5.2, 12), and are sometimes made with ring bases or short pedestals (Figure 5.2, 10; Plate I, 5). Less frequent are large globular jars with thick and flat bases (Figure 5.2, 15). In contrast, at Méhtelek-Nádas large jars appear to be most common (Figure 5.3, 13-14), and footed bases seem to be preferred over pedestals (Figure 5.3, 3-7, 10-11, 14; Kalicz 2012, 114). In sum, while some caution is warranted given the lack of use-wear studies and the suggestions from studies in adjacent regions, which show vessel functions do not seem to necessarily follow vessel forms (Vieugué et al. 2008; Vuković 2019, 179), vessel shapes from Tășnad Sere and Călinești-Oaș-D.S.M. could suggest serving bowls and cooking pots were most common, and only a small amount of large thick-based vessels were perhaps used for storage. This is also consistent with the ethnographic literature suggesting cooking and serving pots are the most broken vessels, due to the extensive use given to them (Shott 1996, 471; Stanislawski 1978, 223; Varien and Mills 1997, 148). At Méhtelek-Nádas, however, storage seems to be the most frequent type of vessel function in the pits excavated so far, which makes the site a useful comparison.

[redacted]

Figure 5.2: Most common vessel shapes represented at Tășnad Sere. Contexts include: S1/1989 (2; after Iercoșan 1989), C2/2005 (8), C216 (1-4, 7, 9-12, 14-15; after Virag 2015b), and UCLT1 (5, 6, 13).

Compositional analyses at some sites in NE Hungary, like Méhtelek-Nádas, Ibrány–Nagyerdő-dűlő, and Nagykörű-Gyümölcsös (Kreiter 2010; Kreiter and Szakmány 2011), and in NW Romania, like Tășnad-Sere, Călinești-Oaș-Dâmbul Sfintei Mării, and Homorodul Vechi (Kadrow and

Rauba-Bukowska 2017b; Seidler and Amicone 2017; Sommer *et al.* 2019), confirm vessels were manufactured with local fine-grained raw materials. They were predominantly tempered with organic matter and occasionally with some locally available minerals (*e.g*. sandstone, schist, limestone, volcanic rocks). Only small variations exist in terms of composition, most noticeable in the site of Méhtelek-Nádas where there is a preference for larger grains (Kreiter 2010, 273). Some studies have mentioned grog in fabrics (Kalicz and Makkay 1976, 15; Virag 2008a; 2015b), but more in-depth examinations seem to indicate that the argillaceous formations frequently interpreted as grog are most likely to have been natural clay pellets (Kadrow and Rauba-Bukowska 2017b, 423; Sommer *et al.* 2019, 7). X-Ray Diffraction and petrographic analyses confirmed that fabrics were also commonly fired at low temperatures, ranging from 600-850°C (Kadrow and Rauba-Bukowska 2017b, 424; Kreiter 2010, 271). Overall, populations in the UTB during the Early Neolithic seem to have manufactured pottery uniformly and following SKC recipes observed in other regions. However, despite the overall similarity of pottery style and composition, the site of Méhtelek-Nádas, possesses some stylistic and compositional variation discussed below.

[redacted]

Figure 5.3: Some reconstructed vessels from Méhtelek-Nádas.

5.1.4 The Early Neolithic sites sampled

As mentioned in the introduction of this chapter, three sites were selected from the UTB region. Of these sites, Tășnad Sere was central in my analysis. This site was selected due to: (i) the excellent preservation of finds, occupation layer and house remains, (ii) the detailed recording of finds, and (iii) the fact that excavations were ongoing at the time of my analysis. The latter provided me with great opportunity to understand postdepositional processes, as well as form part of the recording of features and finds. Călinești-Oaș-Dâmbul Sfintei Mării (Călinești-Oaș-D.S.M. from now on) and Méhtelek-Nádas were later additions to my sample, and selected to complement this site, as they represented 'typical' SKC sites mostly characterised by pit complexes. The archaeological record from Călinești-Oaș-D.S.M. is well-documented, and most of the spatial information of finds and profile sections of features are available, which made it a suitable site for my study. Méhtelek-Nádas was particularly attractive due to its rich assemblage of perforated sherds, which was important for analysing pottery repair. Furthermore, all three sites had formed part of petrographic analyses, which provided important information on the microstructure of the ceramic material. Table 5.1 summarises the sites and features sampled from the UTB.

Site	Zone/ Trench	Feature	Type	House	Segmented**	Other Samples	Post-depositional
Tășnad Sere	Su IV/2005	C2/2005	Pit with oven	H1/2005			
	UCLT1	4	Posthole	H1/UCLT1	Yes	MM, BSS, BT	
		5	Posthole	H1/UCLT1	Yes	MM, BSS, BT	
		7	Pit Fill		Yes	MM, BSS, BT	
		8	Posthole	H1/UCLT1	Yes	MM, BSS, BT	
		10	Posthole	H1/UCLT1	Yes	MM, BSS, BT	
		11	Posthole?	H1/UCLT1	Yes	MM, BSS, BT	
		12	Posthole	H1/UCLT1	Yes	BSS, BT	
		13	Posthole	H1/UCLT1	Yes	BSS, BT	
		14	Posthole?	H1/UCLT1 Annex?	Yes	BSS, BT	
		15	Posthole	H1/UCLT1	Yes	BSS, BT	
		16	Posthole	H1/UCLT1	Yes	BSS, BT	
		17	Posthole	H1/UCLT1	Yes	BSS, BT	
		18	Posthole	H1/UCLT1 Annex?	Yes	BSS, BT	
		19	Posthole	H1/UCLT1	Yes	BSS, BT	
		20	Posthole	H1/UCLT1	Yes	BSS, BT	
		21	Posthole	H1/UCLT1	Yes	MM, BSS, BT	
		22	Linear Feature/Ditch	Unknown	Yes	MM, BSS, BT	
		23	Posthole	H1/UCLT1	Yes	BSS, BT	
		25	Posthole	H1/UCLT1 Annex?	Yes	BSS, BT	
		26	Posthole	H1/UCLT1	Yes	BSS, BT	
		27	Posthole	H1/UCLT1 Annex?	Yes	BSS, BT	
		28	Posthole	H1/UCLT1 Annex?	Yes	BSS, BT	
Călinești-Oaș	S1/2000	CC1	Semi-sunken house?	H1/2000?	Yes	BSS	Ploughed
	Sp.1/2000	CC2	Pit		Yes	BSS	Ploughed
	Sp.1/2001, S1/2001, S2/2001	CC3	Pit			BSS	Ploughed
Méhtelek-Nádas	1-3	1-3/α	Pit				
	III	III	Pit				Embankment Construction

*Table 5.1: Sites and features sampled from the UTB region. MM = Micromorphology, BSS = Bulk Soil Sample, BT = Botanical Sample, MB = Microbiological Sample. *Refers to further divisions of features to retrieve spatial information of finds.*

5.1.4.1 Tășnad Sere (Satu Mare Province, Romania)

The site is an open settlement buried nearly two metres under the alluvial deposits of the Cehal, a tributary to the Ér/Ier River within the Satu Mare Province (Figure 5.1 and 5.4). Before the 1970s the river ran along the eastern flanks of this Neolithic settlement, but channel work redirected the river towards more central areas of the site. During historic and prehistoric times, the area bordered the Ecedea Marsh (Virag 2015b, 97), and is considered a boundary between the Great Hungarian plains towards the west and the Carpathian and Apuseni Mountains to the east and southeast respectively.

Researchers have dated the occupations of the site in various periods: Criș IIIB-IVA (Early Neolithic; according to Lazarovici's 1984 typology), Pișcolt (Middle Neolithic), Coţofeni (Late Copper Age), Cehăluţ-Hajdúbagos (Bronze Age), La Tène C, Przeworsk (Roman Period), and Early Slavic (6th-7th century AD; Astaloş 2005; Astaloş *et al.* 2013; Stanciu and Virag 2013; Virag 2015b). The late SKC phases of the site were determined from compositional evidence (Seidler and Amicone 2017; Sommer *et al.* 2019, 7), and the characteristic incised decorations found below the rims of vessels (Astaloș *et al.* 2013, 49). Semi-fine ceramics from context 216 have well burnished surfaces and appear painted (when preservation is good), which can be associated with phases IVA and IVB (Virag 2015b, 99). In the ceramic material retrieved by recent excavations at UCL Trench 1, the decoration is almost exclusively impressed or incised, such as pinched fingernail impressions (Plates IV, 4-6; Plates VI 4-5, 7) and linear incisions (Plates II, 3; III, 2-4; IV, 1). Some vessel shapes include open vessels with pedestals (Plate I, 5, 8), globular flat-based vessels (Plate I, 4, 6), and carinated bowls (Plate I, 1, 3).

5.1.4.1.1 Site stratigraphy

Five layers have been distinguished. The top layer (Unit 1) can be interpreted as the spoil produced from the channelling work carried out at the adjacent Cehal River, from which vegetation now grows. Underneath there are two alluvium layers composed of silty clay sediment (Units 2 and 3). Unit 3 also contained a few sherds that could correspond to an "eroded archaeological horizon" (Sommer *et al.* 2019, 2). Below Unit 3, an anthropogenic layer in a silty clay substrate becomes visible (Table 5.2). The substrate is partly mottled with iron oxide stains and manganese concretions at lower depths. Fe-Mn mottles are generally suggestive of poor drainage conditions (Macphail 2007, 214), which is common of pseudo-gley soils. The stains and concretions increase substantially below the occupation layer and into the 'natural' or archaeologically sterile layer. Worm casts filled with fine clay are found throughout the anthropogenic and 'natural' layers. Soils are generally slightly acidic towards the occupation layer (Appendix 4), which could explain the fact that no seeds and only few fragments of bones have been found until now.

Unit	Depth	Colour	Description
Alluvium I (Unit 1)	Surface to 0.27-0.40m	Very Dark Greyish Brown (10YR 3/2)	Unit 1 consists of a continuous layer of alluvial clayey silt sediment. It shares with Unit 2 a gradual boundary (6-13cm) with few irregularities (*i.e.* smooth). Soil structure corresponds to subangular block (30-50mm) and possesses a high amount of porosity due to its facility to crack both horizontally and vertically, forming polygons.
Alluvium II (Unit 2)	0.27-0.40m to 0.65-0.80m	Very Dark Greyish Brown (10YR 3/2)	This unit possesses the same attributes as Unit 1 and was barely distinguishable. The boundary with Unit 3 is diffuse (>13cm) and possessing few irregularities. The unit is the original soil before the deposition of the spoil heap from channel work at the adjacent Cehal River. Polygonal cracks are visible.
Alluvium III (Unit 3)	0.65-0.80m to 1.24-1.37m	Brown (10YR 4/3)	Unit 3 is composed of slightly finer sediments with lighter colouration. It also mottled with strong brown (7.5YR 4/6) iron oxide stains (<1cm) uniformly distributed throughout the unit. The boundary with Unit 4 is clear (2.5-6cm) with few irregularities. Polygonal cracks are visible.
Anthropogenic (Unit 4)	From 1.24-1.37m	Dark Grey (10YR 4/1)	This anthropogenic unit is characterised by a firm silty clay sediment with a darker colouration and mottled with manganese and iron oxide stains (<1cm). Worm casts filled with fine clay are also commonly found. The boundary with Unit 5 seems clear (2.5-6cm) and with few irregularities. Polygonal cracks are visible.
Natural (Unit 5)*	N/A*	Dark Brown (7.5YR 3/2)	Unit 5 is composed of a sticky clayey clay sediment. The unit is even more abundantly stained with manganese and iron oxide than the previous unit (stains are <1cm). Worm casts are also visible. Polygonal cracks are visible.

*Table 5.2: Stratigraphic description of southern profile of UCL Trench 1. Soil description was made following Courty et al.'s (1989) criteria. *Unit was added from excavation plan, as at this depth the southern UCLT1 profile has not yet been entirely excavated.*

Apart from worm activity and the channel work in the area, another postdepositional process identified on site has been argilliturbation (*sensu* Waters 1992). This process can be described as the vertical migration of archaeological finds through cracks formed by the shrinking of clay substrates and can sometimes be detected by the vertical (90°) inclination of potsherds, lithic tools or bones[2]. The clayey substrate has also affected preservation of the surface of potsherds.

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[2] However, literature seems to be ambiguous on this indicator (Domínguez-Solera 2010).

Sherd surfaces are corroded by the sticky clay soil, which removes traces of surface finishing techniques. This is a pattern observed throughout the Szamos region (Kalicz and Makkay 1976, 15).

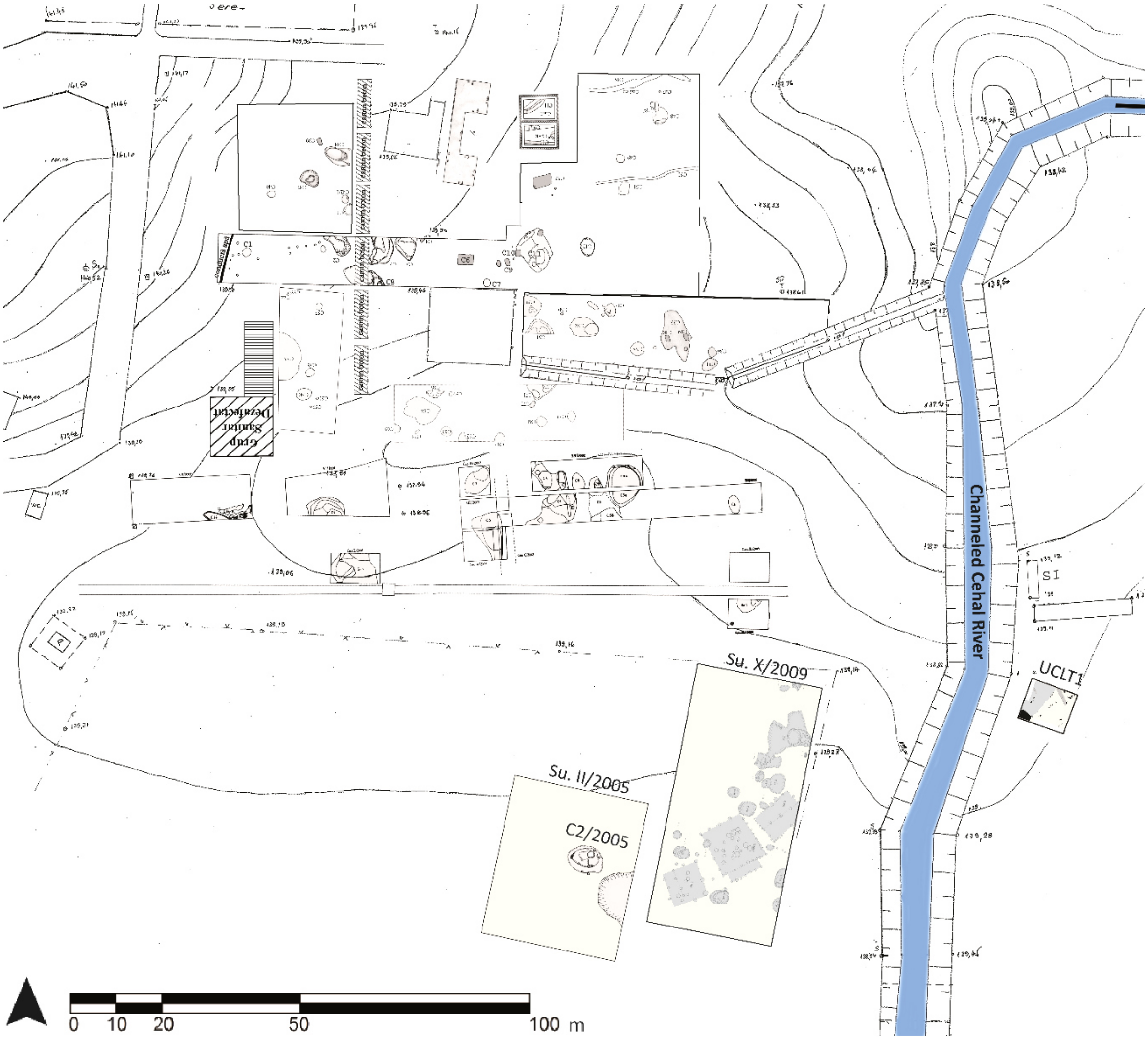

Figure 5.4: A sketch of Tășnad Sere excavation plans (with permission by Astaloș).

5.1.4.1.2 The features and finds

The site has been excavated in numerous campaigns since its discovery over three decades ago (Appendix 3). Descriptions are limited to those sampled for this thesis: Context 2 excavated in Trench Su. IV/2005, and all of the features analysed from UCL Trench 1 (UCLT1 from now on) in the 2012-2018 excavations (Table 5.1). Following the continental system, the excavation of Trench Su. IV/2005 was performed according to feature, such as: pits, ovens, post-holed houses, and graves. However, stratigraphic information of finds was often not recorded or the labels containing this information was lost, which created problems in the understanding of deposit formation (as stressed by Sommer and Astaloș 2015, 82). In contrast, the excavation of UCLT1 was performed according to a grid system with 1x1m squares and 5cm spits. For each spit, detailed 3D recording of features and finds larger than one centimetre was carried out by coupling photogrammetry, planning and total station information. Samples for other analyses have been taken and are synthesised in Table 5.1. In the following two subsections, features sampled from these two trenches are described, and a summary of their finds is provided.

5.1.4.1.2.1 Trench Su. IV/2005

Trench Su. IV/2005 was located just a few metres off the western bank of the Cehal. Two large pits were uncovered from this trench during the 2005 excavations, *i.e.* C1 and C2. The former was only partially excavated and was not sampled. C2/2005 is a pit 7m long and 5.10m wide with an oval-shaped dugout oven to the west (Figures 5.4 and 5.5) and was situated adjacent to the larger pit C1/2005. During the excavation, C2/2005 was catalogued as a semi-sunken house, according to the several post-holes identified (Virag *et al.* 2006; Figure 5.5). The ceramic material excavated from C2/2005 was mostly unprocessed, as only a portion of the assemblage had been washed. The washing performed on sherds hindered but did not impede use-wear analysis, as many of the traces left by brushes could be identified. However, due to the limited stratigraphic and spatial information of finds, distributional analyses were not possible.

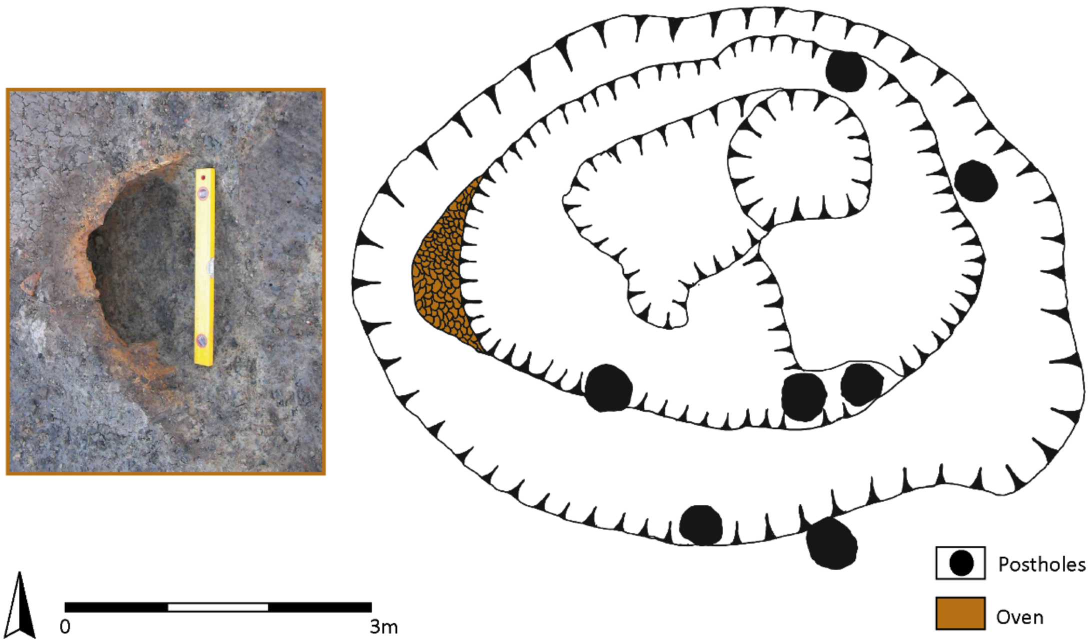

Figure 5.5: Plan view of Context 2 (after Virag 2016) and Photograph of the 'oven' taken during the 2005 excavations (redrawn from Virag et al. 2006).

Apart from the substantial number of potsherds, materials found include 33 clay weights, two spindle whorls, nine miniature vessels, burnt bone, burnt daub, lithics, and some hearth or oven fragments. The bones (n=158) recovered have been attributed to both domesticates (50%) – primarily cattle (90.9%) – and wild fauna from steppe and hill areas (50%) – including aurochs (21.2%), red deer (27.3%), roe deer (14.6%), wild boar (12.7%), European ass (12.7%), wild horse (2%), and brown bear (2%; El Susi 2018). These finds fit into the broader regional pattern, which shows a large variation in the exploitation of wild animals and plants for the Pannonian region (Gaastra *et al.* 2019, 9).

5.1.4.1.2.2 UCLTrench 1 (2012-2017)

Various features have been identified in UCL Trench 1 (UCLT1 from now on), which include 27 postholes, two linear features, and a single pit (7/UCLT1). The alignment of a clear line of some of these postholes running west-east has allowed the identification of a house (H1/UCLT1 from now on; Figure 5.7). Some postholes from H1/UCLT1 appear too small to be considered the main posts for this building, but if one compares the results from excavations carried out in 2009 (Figure 5.4 and 5.6), just on the opposite bank of the narrow Cehal channel, the picture becomes clearer. The wattle and daub houses identified in Su X/2009 are defined by large postholes in every corner, but immediately adjacent to these houses there are several small postholes. Figure 5.4 shows Virag's reconstruction of these houses, and what he interprets as an annex. In UCLT1, some small postholes appear to be arranged in a similar way (Figure 5.7). This remains a possibility until further excavations reveal more information. Until then, the two portions of the occupation surface studied include the house (H1/UCLT1) and its exterior (Out/UCLT1). This division explains the distribution of finds (Figure 5.8; see also Chapter 7), as most are observed in the central areas of the house and decrease substantially toward the east or exterior of the house.

Feature 7 is an oval pit with an estimated radius of 2.5m and is currently the only feature of this kind found in UCLT1. Until 2017, around half of the feature had been excavated, and a large number of pottery fragments retrieved, including the bottom half of a pedestalled vessel found *in situ* (Plate VIII, 2). Stone tools found so far include mostly small obsidian blades and fragments of schist, possibly from a grinding stone. In comparison to the other features in the site, pH values are significantly lower (Appendix 4), and there is higher amount of inorganic phosphorous, sulphur and carbon (Paraskova 2018; Sommer *et al.* 2019, 4). Moreover, microbiological analysis of soil from this feature revealed the clustering of lypolithic microorganisms, among them thermophilic bacteria. These bacteria develop at relatively high temperatures (60-70°C) during composting, and thus are associated with decaying of organic remains (Chernysheva *et al.* 2017, 495). In sum, the results from the geochemical and microbiological analyses suggest the pit partly acted as a deposit for organic refuse (Sommer *et al.* 2019, 5).

[redacted]

Figure 5.6: Plan of trench Su X/2009 and its reconstruction (after Virag 2015a). Red box highlights the annex.

In general, finds from UCLT1 have consisted mainly of pottery. Finds from the excavation at UCLT1 were washed carefully by hand and only minimally using sponges, no refitting of sherds was performed, and every find was bagged with its own label, containing their 3D spatial reference number. In a few occasions, labels have become destroyed and some finds have repeated numbers, but in most of these situations the square and spit numbers are available to provide some spatial reference. Other finds include fragments of (burnt) daub and hearths, spindle whorls (Plate VII, 2-3), ground stone (mainly schist), a few animal bones, and chipped stones (limnic quartzite, Hungarian obsidian, and Balkan flint) have also been discovered. Despite complications during recording of the orientation of potsherds, results have ruled out fluvial action as responsible for the deposition of finds in the occupation layer (Sommer *et al.* 2019, 2).

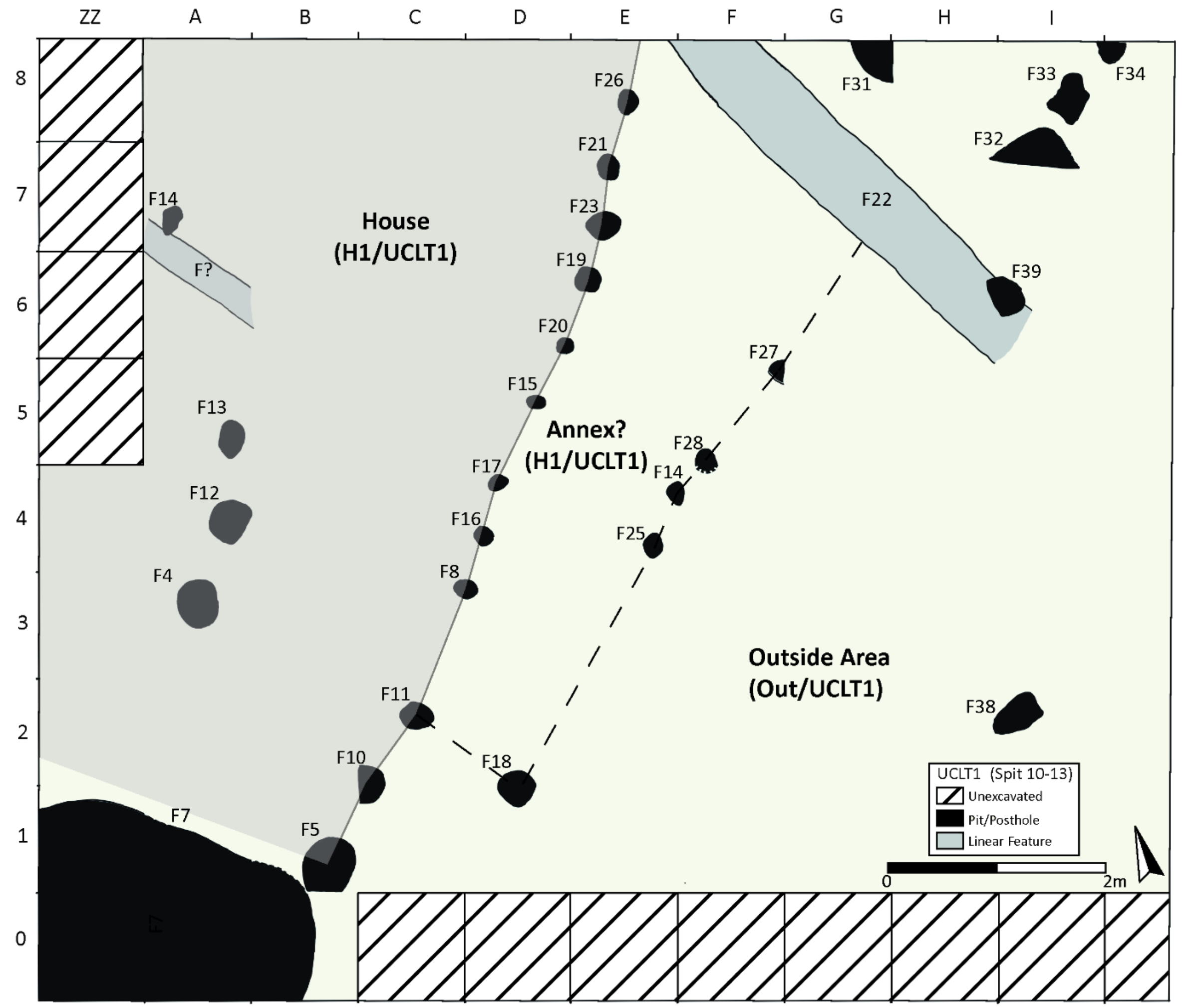

Figure 5.7: Plan of features from UCLT1.

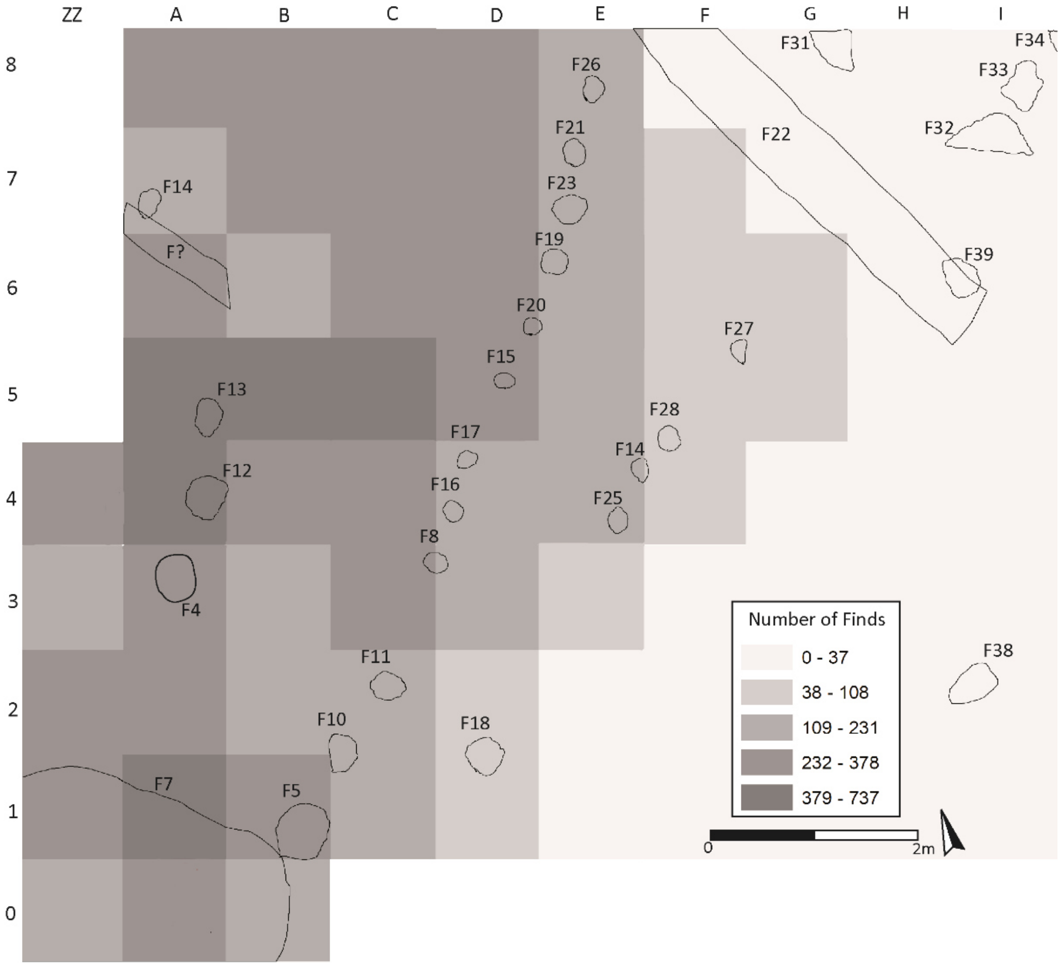

Figure 5.8: Finds density distribution in UCLT1.

5.1.4.2 Călinești-Oaș-Dâmbul Sfintei Mării (Satu Mare Province, Romania)

Călinești-Oaș-D.S.M. is located in a depression surrounded by the Oaș Mountains, and near the alluvial deposits of the Tur River in north-western Romania (Figure 5.1). The site is specifically located on the gentle foot slopes of Saint Mary's Hill (around 300 m.a.s.l.), an abundant source of limnosilicates (Chmielewski and Astaloș 2015, 31). The area now comprises a modern farmland that has been worked by locals for several generations and, thus, ploughing has been an ongoing activity for more than a century.

The Early Neolithic occupation at the site represents the northernmost SKC settlement in Romania. The pottery from pit Sp.1/C1 belongs to Lazarovici's (1984) phases IIIB-IVA (Németi and Astaloș 2001, 61; Németi *et al.* 2002, 93; Virag 2008a, 42). Similar to pottery from Tășnad Sere, the ceramic is predominantly tempered with organic matter; however, volcanic rather than clastic minerals are the common inclusions (Kadrow and Rauba-Bukowska 2017a, 272). The occupation at Călinești-Oaș-D.S.M. has been described as seasonal, and the site is considered to be a small camp (around 50m^2), possibly used for obtaining raw material from the nearby mountains (Chmielewski and Astaloș 2015, 31).

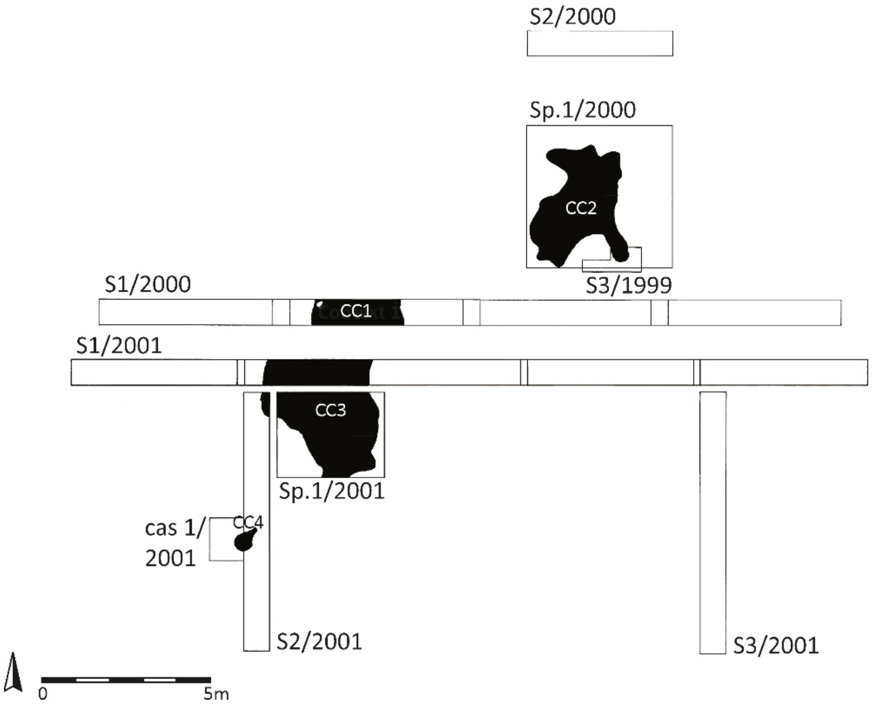

Figure 5.9: Plan of Călinești-Oaș-D.S.M (redrawn from Chmielewski and Astaloș 2015).

5.1.4.2.1 Site stratigraphy

The site stratigraphy consists of: (i) a layer of ploughed topsoil down to a depth of around 0.30m directly over (ii) the archaeologically rich dark clay substrate from the pit features, and lastly (iii) a yellowish silty sterile layer found below these features. The topsoil of the site has been affected by ploughing, which can be clearly observed from the surface material recovered from the site.

5.1.4.2.2 The features and finds

Various trenches have been dug at the site, of which S3/1999, Sp.1/2000, S1/2000, S1/2001, Sp.1/2001 and S2/2001 revealed pits with pottery finds. Of the four features excavated from the site (CC1, CC2, CC3, CC4; Figure 5.9), the first three pits were sampled, as they were recorded with more detail (see below). Once more, following the continental system, these trenches were excavated by feature, and the ceramic material from these excavations were washed with cleaning brushes.

5.1.4.2.2.1 Trenches S3/1999 and Sp.1/2000

In 1999, test trench S3 uncovered a pit complex (CC2), and the complete feature was excavated the next year in trench Sp.1/2000. The latter trench was subdivided into 4x4m squares labelled as A, B, C and D. Two smaller pits were detected within CC2, one within square C (Unit 2) and another in square D (Unit 1a; Figure 5.10). Finds retrieved from CC2 include: 1457 chipped stones, a few ground stones, two female figurines and a large amount of 'corroded' fragments (Németi and Astaloș 2001). The most common types of vessels found in this feature were large closed globular pots (n=18) followed by some open bowls (n=4; Virag 2008a, 40). These ceramic finds are mainly composed of organic matter in combination with mineral inclusions (Virag 2008a, 36) (*Idem*, 36). The study of the chipped stone assemblage showed that the abundance of *débitage* scattered across this feature in comparison to the low amount of blade tools, and the high percent (84.8%) of local limnic quartzite suggests knapping was performed in this location (Chmielewski and Astaloș 2015, 62–63).

5.1.4.2.2.2 Trench S1/2000

A complete west to east profile of feature CC1 was documented in the year 2000 (Németi and Astaloș 2001) in trench S1/2000, and three stratigraphic units were separated: the ploughsoil (up to 0.30m deep), and two artificial spits. The latter consisted of an upper (from 0.30 to 0.60m) and a lower spit (from 0.60m to end of feature). CC1 was also subdivided horizontally according to units measuring 1x1.5m. In a west to east direction, the upper spit consisted of units 1-2, 2-3, 3-4, 4-5, 5-6 and 6-7, and the lower spit was divided into units 2-3, 4-5 and 5-6 (Figure 5.11). Two postholes were identified in the feature, giving some suggestion of a roof above the pit. However, excavators were doubtful of these postholes, and a big question mark is left on the nature of feature CC1 (Németi *et al.* 2002, 92). Other non-ceramic finds from the feature include burnt bone, a large ground stone and some blades made from limnic quartzite. Magnetic susceptibility analysis of bulk soil samples from CC1 was conducted by the author and is presented in Appendix 4. Results show a small increase in values according to spit, suggesting a stronger imprint of human activities in the later stages of filling of the pit.

5.1.4.2.2.3 Trenches S1/2001, Sp.1/2001 and S2/2001

Trenches S1/2001, Sp.1/2001 and S2/2001 were excavated in 2001 and revealed feature CC3 (Figure 5.9 and 5.12). This feature is a partially excavated shallow pit complex approximately 10m long and 6m wide. Trench Sp.1/2001 was subdivided into units A, B, C and D. The depth of the trench was around 0.7m, which in some areas did not reach the bottom of the pit (Németi *et al.* 2002, 92). Due to its proximity, CC3 and CC1 could potentially be the same feature, even though no postholes were identified in the former. Only a few finds were discovered in feature CC3, these include polished stone axes and eroded potsherds, some of which had impressed decorations (*Ibid*.).

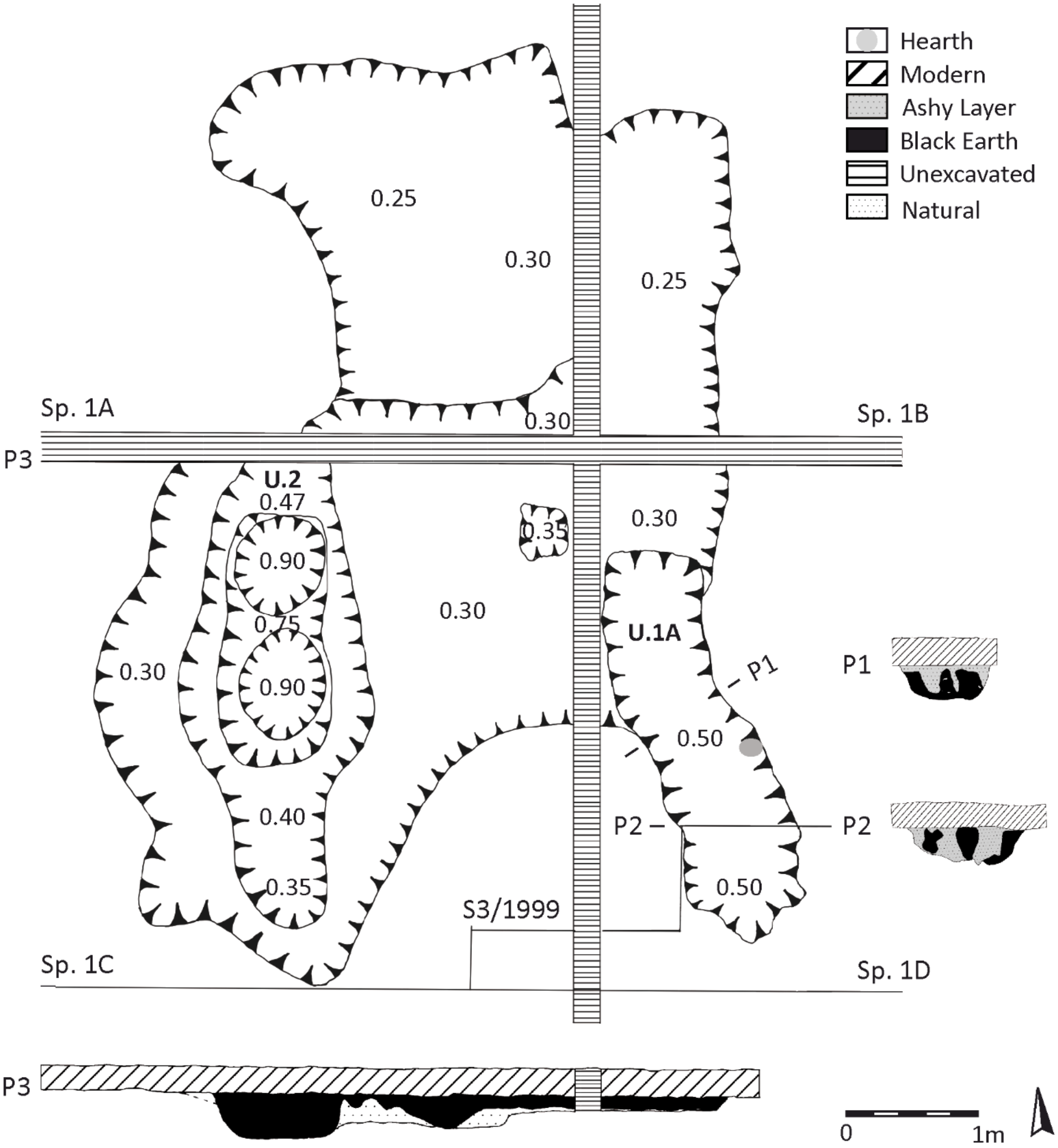

Figure 5.10: Plan and Profile of feature CC2 (with permission by Astaloș).

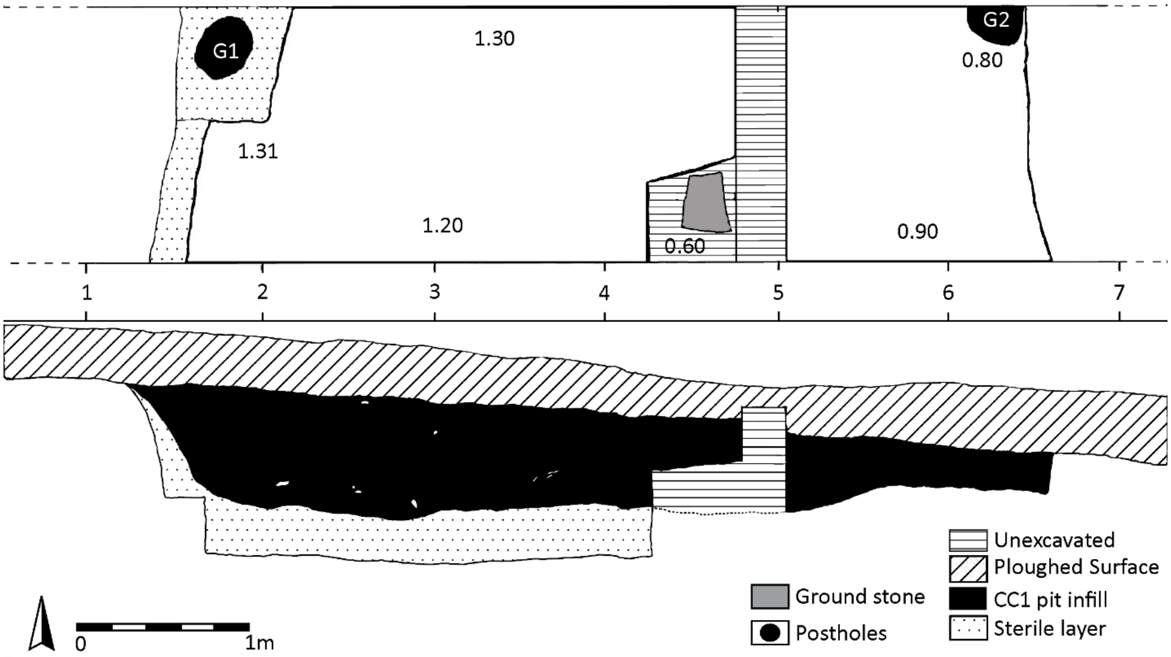

Figure 5.11: Plan and Profile of feature CC1 (after Vindrola-Padrós et al. 2019).

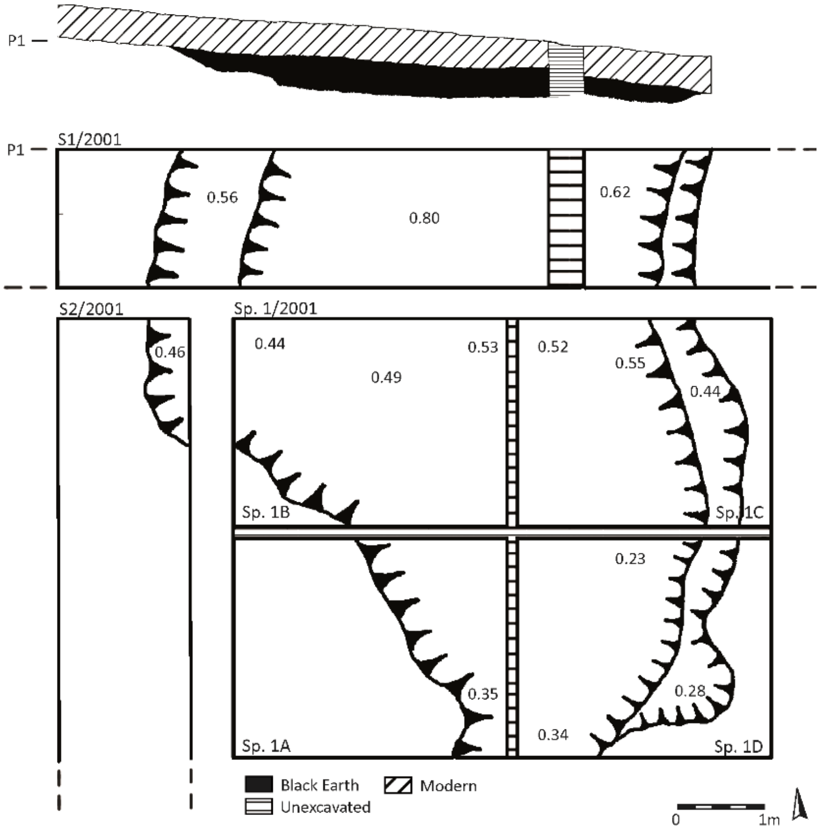

Figure 5.12: Plan and Profile of feature CC3 (with permission by Astaloș).

5.1.4.3 Méhtelek-Nádas (Szabolcs-Szatmár-Bereg County, Hungary)

The site of Méhtelek-Nádas is located in northeast Hungary, near the Romanian and Ukranian borders. The site is positioned on the left bank of the Túr River, a tributary of the Tisza, and a nearby meander cutoff named Nádas (meaning 'reeds' in Hungarian; Makkay 2007, 199). After a large flood in 1970, the site of Méhtelek-Nádas was discovered during the building operations of an embankment (Makkay 2007, 199; Figure 5.13).

Méhtelek-Nádas occupies a special place in Hungarian and south-eastern European archaeology, as one of the first sites to be discovered beyond the Szolnok area (originally considered to be the 'Körös northern border'; Kalicz 1965, 28), and is currently among the northernmost Körös sites in Hungary (Kalicz and Makkay 1976; cf. Makkay 1996). Radiocarbon dates from three charcoal samples, two from a pit hearth in pit 4-5/α (Bln-1332, GrN-6897) and one sample from pit 1-3/α (Bln-1331), date the Early Neolithic occupation of the site between 5780-5480 cal BC (Kalicz 2011, 44; Kalicz and Makkay 1976). Unlike other settlements in the Hungarian Plain, *e.g.* the Körös Valley, the location of the site differs from common settlement patterns of SKC groups. On the one hand, the clayey soils are highly acidic and are considered less than optimal for agriculture (Makkay 2007, 231). On the other hand, the settlement area was well placed for obtaining Tokaj obsidian (Biró 2018; Kalicz 2011, 11; Makkay 2000, 28). This is abundant in most features excavated at the site, and it is also widely distributed in central and south-eastern Europe (Biagi 2011; Biró 2018, 218; Kaczanowska and Kozlowski 2012, 162; Sherratt 1982, 298).

The site is also considered as the type-site of a Körös 'variant' (Kalicz 2011, 11) that would also include most sites in the UTB (see Kalicz 2012, 113). Although there are some differences in the lithic assemblages to other Körös sites in the south of Hungary, such as its obsidian rich assemblage (Chmielewski and Astaloș 2015; Starnini 1993), the distinctive elements of the so-called Méhtelek group are mostly attributed to morphological-stylistic elements from the pottery. Large jars are typical and, while pedestals are rare, footed vessels with four to ten feet are extremely common at Méhtelek (Kalicz 2012, 114). In terms of decoration, there is a preference for "impressed dots and wedge-shaped impressions" (Kalicz 2011, 21), as well as schematic flat human figures (Makkay 2007, 199). There is also a remarkable diversity of anthropomorphic figurines, including a particularly high number of oblong slab figurines (Kalicz 2012, 115). Nonetheless, the question of whether Méhtelek can be considered a variant SKC group is beyond the scope of this dissertation.

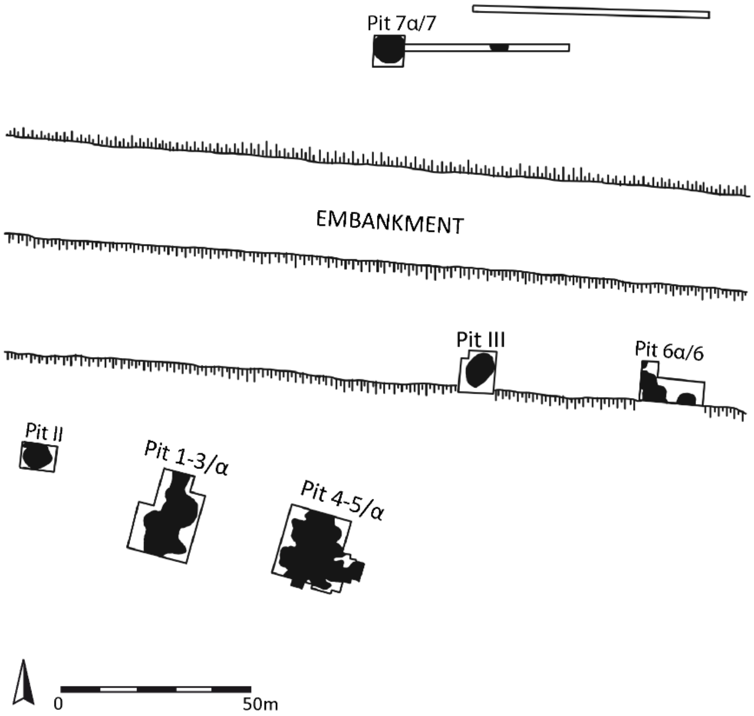

Figure 5.13: Plan of Méhtelek-Nádas (redrawn from Kalicz 2011).

5.1.4.3.1 Site stratigraphy

The site stratigraphy was not, to my knowledge, performed at this site. Thus, only feature-specific stratigraphic descriptions are made below.

5.1.4.3.2 The features and finds

Trenches 1-3 and III were selected for my analysis, mostly because they constituted the few completely excavated features at the site, and because of the extraordinary number of sherds with repair holes found. Similar to the traditional excavation methods mentioned above, excavations were made by feature. The amount of ceramic and lithic finds retrieved from these contexts is extraordinary, considering the small number of features completely excavated at the site. More important for my investigation, and which made the site particularly attractive, was the high number of ceramic fragments found with perforations (Figure 8.26). Unfortunately, finds processing methods at this site have limited some parts of my analysis. Pottery sherds were severely brushed, which left little scope for the study of use-wear traces. Since several vessels were reconstructed from sherds, the archaeometric and morhpometric analysis of finds was impaired. Furthermore, stratigraphic information of finds appeared to have been misplaced or the labels mixed, as only a few inventoried finds still have this information.

5.1.4.3.2.1 Trenches 1-3

Trenches 1-3 uncovered a pit complex, *i.e.* pit 1-3/α, measuring over 11m long, 5m wide and a maximum depth of 1.2m (Figure 5.14). Unfortunately, no thorough description of the stratigraphy of the pit is available in any of the publications of the site. The radiocarbon dates from this feature were 5850-5620 cal BC, which is the oldest date obtained from the site. Apart from the perforated potsherds, excavators found burnt daub remains, a bone spoon, 415 chipped stones (70% obsidian), 19 cores, and 24 figurine fragments. The pit has also been described as containing an "enormous number of pottery fragments" (Kalicz 2011, 15) with at least 2020 fragments[3], from which 17 vessels were reconstructed.

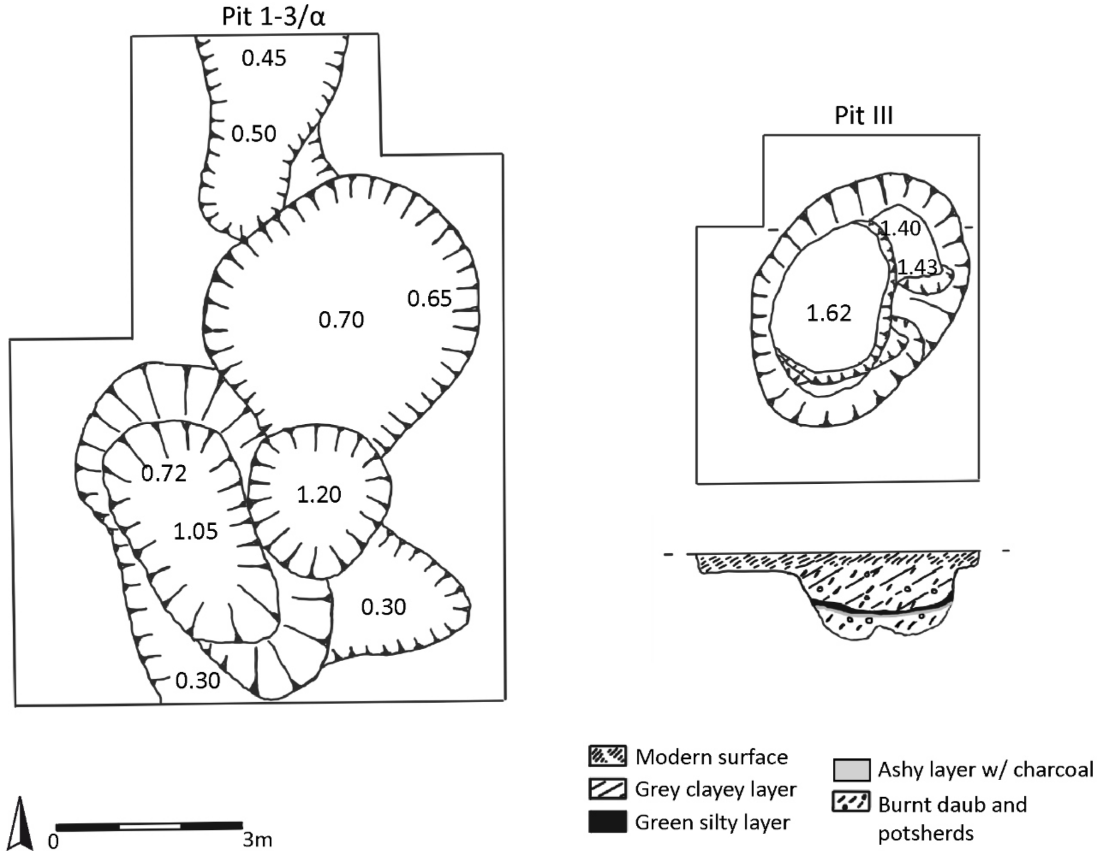

Figure 5.14: The two sampled features from Méhtelek-Nádas: Pit 1-3/α and Pit III (redrawn from Makkay 2007).

5.1.4.3.2.2 Trench III

Near the embankment, Trench III revealed a small pit, *i.e.* Pit III, measuring around 4.5m long, 3m wide and reaching a maximum depth of 1.62m (Figure 5.13 and 5.14). The feature was

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[3] This number consists of fragments that have been inventoried; thus, the total number of fragments found from this feature is missing.

sampled based on the fact it was fully excavated and its ceramic finds had been all inventoried. The upper layer of the pit had been partly destroyed by machines from the dam construction. According to Kalicz (2011, 16), the pit infill was composed of an upper 'yellow loamy mud' layer followed by an 'organic blackish fill'. However, at 1-1.2m depth a thin greenish-brown layer appeared, which was also described by Makkay (2007, Figure 127) as a "hard green silty deposit". Lastly, the pit's bottom at around 1.62m was composed of a thick layer of charcoal. In total, around 580 pottery sherds (from which twelve vessels were restored), 651 chipped stones (50% obsidian), 39 cores, 22 stone tools, some large antler axes, several unworked pieces of antler, and two clay figurines were retrieved and inventoried from this context (Kalicz 2011, 16).

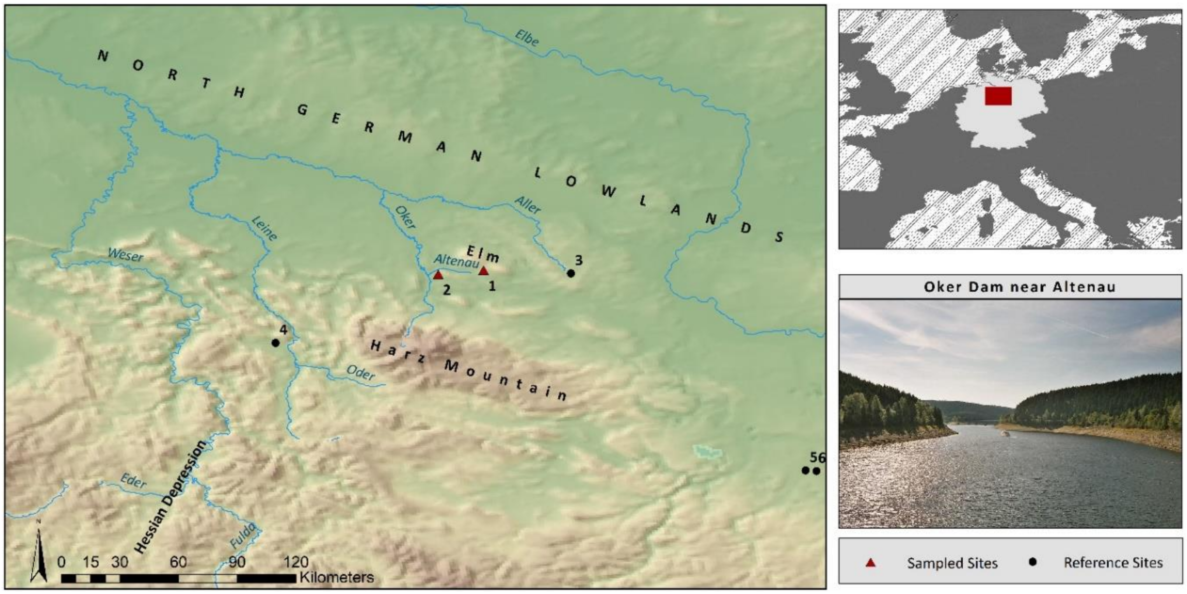
The research conducted on the lithic assemblage confirmed the prevalence of obsidian artefacts, most likely of the Carpathian 2 type from the Tokaj Mountains (Chmielewski and Astaloș 2015; Starnini 1993). The presence of large amounts of cores, blanks and tools suggests knapping for tool preparation and maintenance was performed in close proximity (Starnini 1993, 82–83). A large amount of tools originated from the rather small Pit III, this includes all of the borers found at the site, which were atypically manufactured by simple retouch (Starnini 1993, 38).

5.2 The Northern Harz Foreland

The Northern Harz Foreland (NHF) comprises the area between the north German Lowlands and the undulating landscape of the Harz Mountains. In terms of hydrology, this region corresponds to the Oker River catchment area (Kreuz 1990, 45). Both sites selected from this area are 16km apart and located near the Altenau River, which rises at the Elm ridge and flows westward into the Oker (Figure 5.15).

5.2.1 Geology and geomorphology

Geologically, the area constitutes part of the northern boundary of the Weichselian Loessic belt, deposited after the retraction of the Fenno-Scandian Ice Sheet during the Late Pleistocene. Loessic cover is thinner in the NHF than in other areas in Central Europe, as much of the pre-Weichselian Loess has been eroded by ice advancement during the Saalian glaciation (Lehmkuhl *et al.* 2016, 25). Apart from the strong input of Weichselian aeolian loess (Krauß *et al.* 2016), Late Pleistocene deposits in the northern Harz Region were also formed by fluvial action and slope formation processes, which, considering the geomorphological setting at the foot of the Harz slope, were important contributors to sedimentation in the area (Reinecke 2006; Lehmkuhl *et al.* 2016, 26). During the Holocene, a second wave of erosive processes took place, mostly attributed to human clearing of vegetation cover (Bode *et al.* 2003; Dreibrodt *et al.* 2010). As a consequence of deforestation, slope wash and mass movements were facilitated in the NHF, which left thinner soil profiles and accumulated dark-brown fine material in some areas (Bode *et al.* 2003, 88; Niquet 1963, 47).



1 Eitzum 2 Klein Denkte 3 Eilsleben 4 Einbeck 5 Eythra 6 Zwenkau-Nord

Figure 5.15: The Northern Harz Foreland (Oker photograph by Markus Schweiß, license permission GFDL) with sampled and reference sites.

5.2.2 The Early Neolithic in the NHF

Early Neolithic occupation in the NHF is associated with LBK populations, believed to be accessing the region either from the east through the Central German Loessic landscapes or from the south through the *Leinegraben* lowland and the Hessian Depression (Saile 2010, 439). The region represents the northern border of the äLBK, which only expanded in middle Neolithic times around 50km to the north. Due to the thin soil profiles, and the erosive processes described, LBK sites from the NHF follow the general trend of poorly preserved occupation layers (e.g. Stäuble 2005, 25–26). Thus, contrary to some sites in the UTB, finds are mostly restricted to the better-preserved pit infills.

At the moment, the evidence of contact with Mesolithic populations in the NHF is still limited (Saile 2010, 445). Late Mesolithic sites are hardly preserved, due to the extensive use of loessic soils for agricultural activities, and the dates obtained from Late Mesolithic surface sites are often contested (Rost 1992; Saile 2010, 443). Moreover, the distribution of Mesolithic sites does not coincide with Early Neolithic settlements (Saile 2010, 442). An adze fragment has been found at the Late Mesolithic site Laubach 7 (Grote 1998), and there is an example of a Mesolithic flake axe at Eitzum (discussed below), but all these finds are controversial (as synthesised by Saile 2010).

5.2.3 Chronology schemes and pottery

The chronological scheme commonly used in this region corresponds to the one initially formulated by Quitta (1960; section 4.1.2.2). In the NHF, there is much similarity in the style and morphology äLBK pottery, as shown in the assemblages from Einbeck, Eitzum, Esbeck, Eilsleben, and Klein Denkte (Kaufmann 1983; Quitta 1960; Schwarz-Mackensen 1985; Siegmund and Hainski 1992). Eleven vessel shapes have been identified, which include mostly small bowls and biconic and/or globular vessels. Several vessels with hollow pedestals have been identified, but are uncommon (Cladders 2001, 52; Schwarz-Mackensen 1985, 21). Stylistically, curvilinear motifs dominate, with open rather than closed shapes being more common (Niquet in Quitta 1960, 29; Schwarz-Mackensen 1985, 25).

At the sampled sites of Eitzum and Klein Denkte, highly frequent are small conical (Figure 5.16, 1, 5) and convex bowls with flat bases (Figure 5.16, 3-4; Cladders 2001, 50-53; Schwarz-Mackensen 1985, 21). Also found are medium-sized biconic vessels sometimes occurring with a protruding lip (Figure 5.16, 6) and globular pots (Figure 5.16, 7) with flat bases. From the larger sized vessels, barrel-shaped 'storage' pots with flat and thick bases are common (Figure 5.16, 8, 10), and long-necked flasks (Figure 5.16, 11) are a rare occurrence (Schwarz-Mackensen 1985, 21). Therefore, at the sampled LBK sites the predominance of small and medium-sized bowls and globular vessels indicate serving, food preparation and cooking were likely the most common uses given to pots, while storage and transportation of water seems to be a secondary role for pottery at the site, as shown by the less frequent use of large pots and flasks.

Petrographic analysis of potsherds from Eitzum, Klein Denkte and Eilsleben revealed the predominance of plant temper used with local micaceous clays (Riederer 1985, 35; Schwarz-Mackensen 1983, 216). Some mineral inclusions, such as quartz, plagioclase, microcline, hornblende, muscovite and biotite were commonly identified, but most are likely to have been part of the clay. The only exception are ceramics that contain sand, which have been recorded in at Eitzum and Einbeck (Riederer 1985, 35–36; Siegmund and Hainski 1992, 21). Firing temperatures of ceramics from Eitzum and Eilsleben were estimated between 700°C and 850°C according to measurements with a dilatometer (Riederer 1985, 30) and by refiring ceramics in a furnace (Kaufmann 1983, 182). Therefore, äLBK pottery from the NHF region seems to fall in line with recipes identified in other regions from Central Europe.

[redacted]

Figure 5.16: Most common vessel shapes represented at Eitzum and Klein Denkte (after Schwarz-Mackensen 1985).

5.2.4 Early Neolithic sites sampled

As mentioned above, two sites were sampled from the Northern Harz Foreland. Eitzum was firstly selected due to the detail-rich recording of finds and features and the well-preserved house remains (particularly H4/1987, see below). To complement my analysis from this site, Klein Denkte was added to my study. While house remains in this site are not well preserved, pit fills were in excellent condition and, like Eitzum, the spatial location of finds was well-recorded, which allowed me to unravel the depositional processes in pits. Both sites were also part of a petrographic study, providing rich descriptions of the microstructure of the ceramic material. Table 5.3 summarises the information on features sampled from these two sites.

Site	Zone	Feature	Type	House	Segmented*	Other Samples	Post-depositional
Eitzum	A	WLH1 (2-4)	Longpit	H1/1956-1958			
		5	Longpit?	H1/1956-1958			
		6	Longpit?	H1/1956-1958			
		ELH1 (7-8)	Longpit	H1/1956-1958			
		9	Pit				
	B	13	Pit	H3/1957-1958?			Drainage
		14	Longpit	H2/1957-1958?, H3/1957-1958?	Yes	BSS, BT	Drainage
		15	Longpit	H2/1957-1958?			
		2/Pf.2	Posthole	H2/1957-1958?			
		2/Pf.5	Posthole	H2/1957-1958?			
		16	Pit		Yes		
		17	Pit				
	D	3	Posthole?	H5/1987		P	
		5	Posthole?	H5/1987		P	
		7	Longpit	H5/1987		P	Drainage
		10	Colluvial? Surface				Drainage
		11	Longpit	H4/1987	Yes	P	Drainage
		15	Posthole	H4/1987		P	
		16	Posthole	H4/1987		P	
		22	Longpit	H4/1987	Yes	P	Drainage
		23	Longpit	H4/1987	Yes	BSS, P	Drainage
		24	Trench?		Yes	P	
		25	Colluvial? Surface			P	
		26	Longpit	H4/1987	Yes	BSS, P	Drainage
		29	Posthole?	H5/1987		P	
		36	Longpit	H5/1987		P	
		81	Colluvial? Surface	H4/1987	Yes	BSS, P	
		108	Pit	H4/1987			
		114	Posthole	H4/1987			
		119	Posthole?	H4/1987			
Klein Denkte	4	59	Longpit	H1/1987	Yes		
		67	Longpit	H1/1987	Yes		

71	Longpit, Outer Trench	H2/1987	Yes
72	Pit?		
74	Longpit	H3/1987?	Yes
101	Longpit	H2/1987	Yes

*Table 5.3: List of analysed features from Eitzum zones a, b, and d, and Klein Denkte zone 4. BSS = Bulk Soil Sample, BT = Botanical Sample, P = Phosphate Sample. *Refers to further divisions of features to retrieve spatial information of finds.*

5.2.1.1 Eitzum (Lower Saxony, Germany)

The site is located on a gentle southwest facing slope near the Schöppenstedt Depression, just two kilometres from the Altenau River (Figure 5.15). This small tributary to the Oker, together with the various streams that were around 500m of the site in historical times (Stäuble 2005, 30), made Eitzum a well-irrigated area. Soil formation from the 0.5/2m thick Weichselian Loess cover began from the Late Pleistocene and Early Holocene, creating the 'black earth' or humus-rich soils (Kreuz 1990, 13; Stäuble 2005, 30). Consequences from Holocene deforestation have been observed from the shallow soil profiles, as slopes become unstable, surfaces erode, and colluvium is formed. At Eitzum to this day the black soil is decalcified and in certain areas covered by colluvium (Stäuble 2005, 31, 36).

There have been several occupations recorded at the site, spanning from Early to Middle Neolithic, according to earliest LBK, Stichbandkeramik and Rössen pottery recovered. Later occupations are evidenced by burials, two of them from Late Neolithic/Early Bronze Age (Schwarz-Mackensen 1985, 28), and three from the Iron Age (Stäuble 2005, 29). While there are some features with mixed finds from several periods (*e.g*. features 1, 17, 81), most Early Neolithic features do not seem to have been reused.

Three radiocarbon dates from charcoal and organic content in ceramics found in feature 14 were obtained from two separate laboratories (H 1487/985 in Cologne and Bln. 51 in Berlin) and the results have been calibrated by several authors (Behrens and Rüster 1981; Cahen and Gilot 1983). Chronological estimations from charcoal have been criticized (Modderman 1982), as charcoal can be affected by old-wood effect or its anthropogenic origin can be dubious. With some reservations, the organic material obtained from crushed ceramic should prove more reliable (Stäuble 1995, 229). Under this consideration, a final calibration of dates from the crushed ceramics in feature 14 was carried out by Stäuble (2005, 222) using OxCal, and estimates the date of feature 14 between 5473-5303 cal BC. With some reservations, a last set of dates was obtained from charcoal from an oak found in posthole 16 of House 4, with a calibrated date of 5623-5347 BC (Ki-3370, Ki-3371). Thus, the oldest LBK occupation of the site can be located reliably around the 55th to 54th century BC (Stäuble 2005, 239).

5.2.1.1.1 Site stratigraphy

Three layers were identified at the site. The first layer identified is a 0.3 to 0.5 m thick Ap-horizon colluvial surface layer of moved black decalcified earth (J. Schalich in Stäuble 2005, 30). Often relocated archaeological materials were found in this layer. This layer is followed by a dark 'lime-free' B-horizon between 0.25 to 35m deep (*Parabraunerde*; Niquet 1963, 70; Schwarz-Mackensen 1983, 210–211). In comparison, in the eastern area of zone D another 10cm stratum of the Ap horizon can be dug. Below these layers, features such as postholes and pits were filled with black degraded and decalcified soils developed from Loess, usually appearing at shallow depths ca. 0.40-0.50m from the surface (Niquet 1963, 48; Schwarz-Mackensen 1983, 214; 1985, 14). As mentioned above, two phases of erosion can be said to be responsible for these shallow depths: Late Pleistocene glacial erosion and vegetation clearing throughout the Holocene (J. Schalich in Stäuble 2005, 30). However, the archaeological features were observed to be well-preserved, in stark contrast to the erosion and colluvial surfaces observed in the Ap-Horizon.

5.2.1.1.2 The features and finds

Excavations of three zones (A-C; Figure 5.17) were performed from 1956-1958 by Franz Niquet and was reinvestigated by Gesine Schwarz-Mackensen (1983; 1985). Features were excavated leaving baulks at intervals for section drawings, and the finds between the baulks were kept separate. For my analysis, zone C was excluded because of the small number of finds. The area just 15m north of Niquet's zone B is designated here as zone D (Figure 5.17) and was excavated in 1987 by Jens Lüning. While field methods were mostly similar to Niquet's, there were some crucial differences, which allowed here a more detailed study on the deposition and distribution of ceramic finds. Firstly, rather than using just profiles, some longpits in Lüning's excavations were segmented with a numerical grid system, and only half of these segmented longpits were excavated (Stäuble 1990, 331; 2005, 29). This was accomplished through systematic sampling, *i.e*. selecting every other square in the grid like a chequerboard (Figure 5.19). Secondly, these longpits were excavated in 10cm spits, providing crucial stratigraphical positioning of finds. Other samples retrieved from zone D are presented in Table 5.3. The effects of washing fragments with brushes from similar finds processing methodologies complicated the interpretation of use-wear, and the consequences of refitting/gluing fragments into vessels, which reduced the sample size for morphometric analysis and on occasions even damaged the edges of some of the fragments.

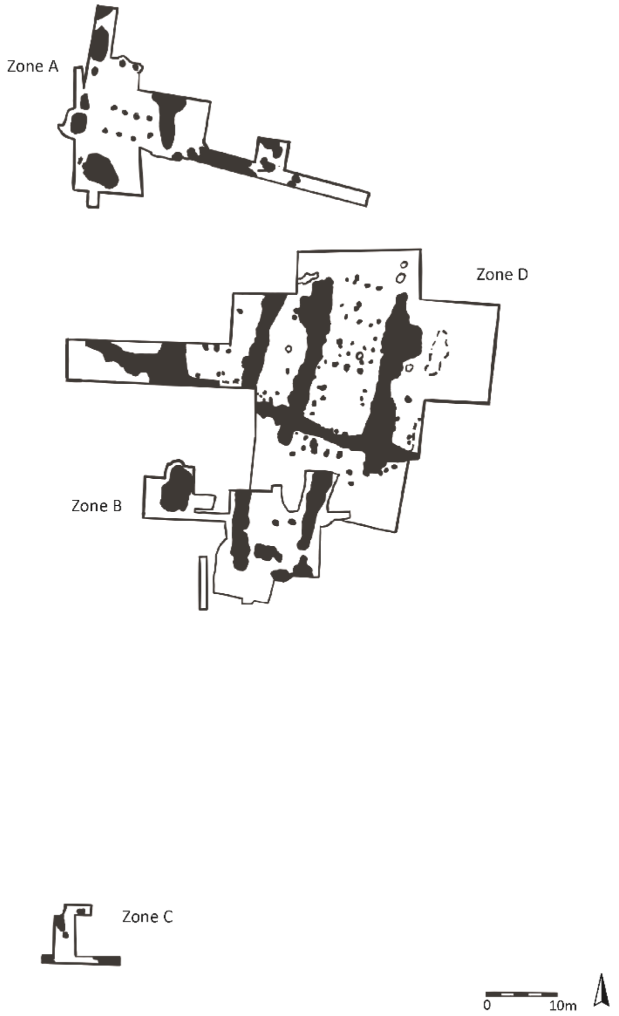


Figure 5.17: Plan of the 1956-1958 and 1987 excavations at Eitzum (redrawn from Stäuble 1990).

5.2.1.1.2.1 Zone A

Two houses with longpits (labelled here as H1/1956-58 and H2/1957-58) and several rows of postholes were originally interpreted by Niquet in zones A and B. Unfortunately, some of these longpits and postholes were dissected by drainage work (Table 5.3), which was also observed in later excavations. During the first three field seasons, Niquet uncovered twelve pits, and around ten postholes. However, only eight pits contained äLBK ceramics, and these are the only features listed in Table 5.3. Some of these features include part of a 'typical' LBK longhouse, *i.e.* H1/1956-58. In fact, this house is probably the most easily recognisable LBK longhouse from Niquet's excavations at Eitzum (Stäuble 2005, 32). However, we must also remember about the problems of assuming contemporaneity between pit formation, pit infilling and the activities performed in longhouses (see also Sommer 1991; Stäuble 2013; Wolfram 2013). Thus, to properly understand processes of pit deposition, interpretations of houses are taken with caution.

Figure 5.18: Detail of excavated features in Zone A at Eitzum (redrawn from Schwarz-Mackensen 1985)

The H1/1956-58 house consists of western and eastern longpits with two rows of postholes in-between. The western longpit is composed of features 2 and 3 (Table 5.3), and can be potentially associated to features 4, 5 and 6. While these units were recorded separately in the course of three field seasons, at the time of my recording of the material there was significant loss of spatial information on most of the potsherds from this area. Despite this limitation, there is enough information available to consider features 2 and 3 as part of a single longpit (labelled here as WLH1) measuring around 6m long x 3m wide and up to 0.5m deep. The feature was rich in ceramic finds, especially towards the shallow southern end of the pit, containing over a thousand fragments. Interestingly though, in these features most finds came from a depth between 0.2-0.4m, where the pits were not yet visible (Schwarz-Mackensen 1985, 41). This gives some indication that the upper layer of the pit was affected by erosion. In contrast to the richness of finds in WLH1, the eastern long pit of H1/1956-58 (ELH1 from now on) had a small number of sherds. While the longpit was differentiated by the excavator of the site into features 7 and 8, based on later reinterpretations (Schwarz-Mackensen 1985) they can also be interpreted as a single longpit (ELH1; Figure 5.18). Towards the southeast end of zone A, the irregularly-shaped pit feature 9 was uncovered containing only a few ceramic sherds. The pit's relation to H1/1956-1958 remains unclear.

5.2.1.1.2.2 Zone B

Excavations in zone B uncovered yet another set of LBK longhouse features, according to Niquet (1963) and Schwarz-Mackensen (1985; Figure 5.19). Feature 14 and 15 were believed to be the western and eastern longpits of this hypothetical house with pit 16 representing its south end. However, this is debated by Stäuble (2005, 32) who claims the distance between postholes and longpits (*i.e*. <1m) is too close to be considered part of the same house. For this reason, House H2/1957-1958 is considered doubtful and features were analysed as separate units. Feature 14, around 11m long and 3m wide, was subdivided according to profile sections: E-F, E_2-F_2, G-H, J-K, L-M, N-O, P-Q, and N_2-O_2, and was abundant in äLBK potsherds (Figure 5.20). In addition, 14 grains of barley and emmer were found in this context, suggesting some form of grain processing activities in the vicinity. Feature 16 measures around 3m long and 2m wide and was also subdivided according to two sections; however, the number of finds was too low to establish any intra-feature analysis of potsherds (see discussion in section 7.3). Lastly, three rows of postholes between features 14 and 15 were originally recorded by Niquet. Spatial information of potsherds in postholes were only available for 2/Pf.2 and 2/Pf.5. Reinterpretation of the profile section of these features has cast doubt on their interpretation as postholes (Schwarz-Mackensen 1985, 44), and for that reason caution is taken here when interpreting our results from these features.

A diverse set of pits were also found in zone B. At the western end of this zone lies feature 13, a pit 7.5m long and 4.5m wide. While Niquet initially interpreted this pit as a separate unit from H2/1957-1958, Stäuble has reinterpreted this feature as the western longpit of a third house (2005, 33). Aside from this debate, according to Niquet's field diary numerous sherds, flint tools, flakes and some fired clay were found in this feature in the 1958 excavation. The most (in)famous find in this feature was a flake axe, which is a common tool commonly in the Late Mesolithic (Price 1991, 219). This find led to suggestions of contact between LBK and Late Mesolithic groups (Niquet 1963, 73), but there have even been doubts about the correct interpretation of the tool as a flake axe (Schwarz-Mackensen 1985, 17). Lastly, Feature 17 is an irregular-shaped pit located to the south of feature 15, and also has an unclear relation with any house structure (Schwarz-Mackensen 1985, 16).

Figure 5.19: Detail of features in Zone B at Eitzum (redrawn from Schwarz-Mackensen 1985).

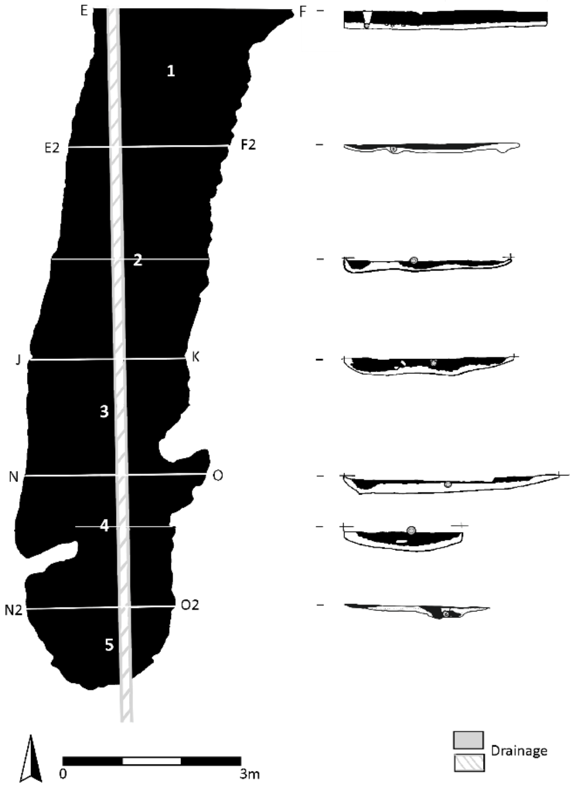


Figure 5.20: Zone B feature 14 at Eitzum with profile drawings and internal segmentation (redrawn from Schwarz-Mackensen 1985).

5.2.1.1.2.3 Zone D

Zone D corresponds to a 1100m^2 trench excavated in 1987 that uncovered houses H4/1987 and H5/1987. The former corresponds to a 25m long and 10m wide house composed of two longitudinal pits with outer trenches (*Außengräben*), six to seven rows of postholes, and two outer walls (Figure 5.21; Stäuble 1990, 331; 2005, 33). Features 11 and 22 form the western longpit of H4/1987, while features 23 and 26 constitute its eastern counterpart. The longpits are once again quite shallow, with maximum depths of 0.5m for the western and 0.6m for the eastern longpit. The two longpits are connected by a trench (features 23 and 24). According to Stäuble (1990, 335) there are a number of indications that the longitudinal pits and their infilling might actually pre-date the longhouse. The most remarkable indication is the fact that the sediment found filling posthole 85, which contains red clay fragments, contrasts with the infilling of the trench composed of features 23 and 24. Another indication comes from phosphate analysis carried out throughout Zone D, where there is no recognisable difference in values from the trench/longpit intersection in the southeast corner of H4/1987 (Stäuble and Lüning 1999, 181). Most of the finds from zone D consisted of potsherds and were mostly retrieved from the longpits and this trench. The western wall of the house can be identified through postholes 56, 57 and 73, while the opposite wall is potentially identifiable through posthole 77 (Stäuble 2005, 33). Lastly, features 10, 25, and 81 represent areas immediately adjacent to either ditches or longpits and could represent colluvial surfaces with some scattered potsherds (Figure 5.21). The latter was divided into 2x2m squares across the eastern portion of zone D and allows understanding the distribution of surface material at Eitzum.

Immediately west of house H4/1987 is H5/1987, containing two longitudinal pits with outer trenches (features 7 and 36). In terms of house reconstruction, the postholes can be linked to adjacent longpits, but the identification of transverse rows of postholes is difficult (Stäuble 2005, 34). The notable exception is the row of postholes 8, 9, and 32. A limited number of finds was retrieved from this house.

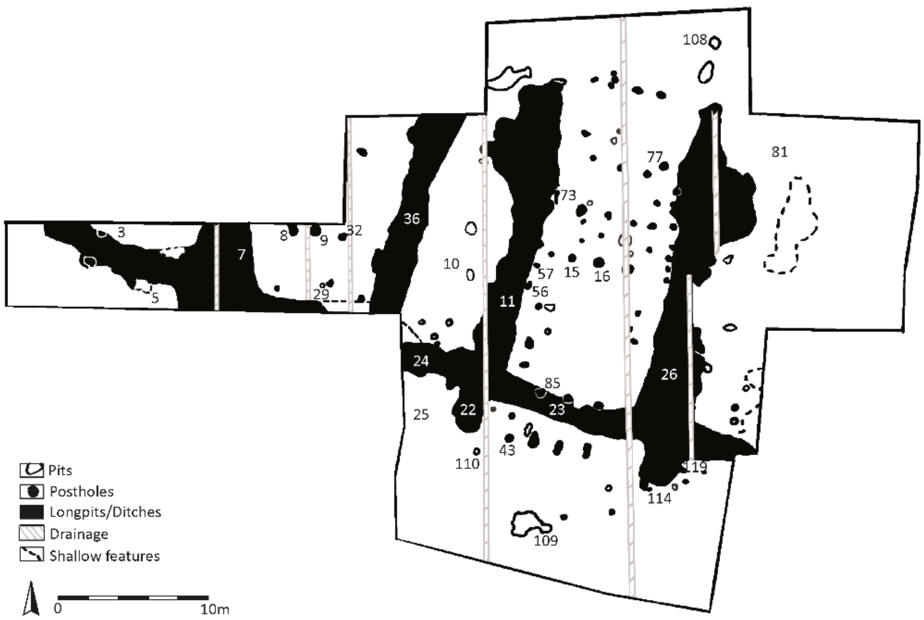


Figure 5.21: Features from Zone D at Eitzum (redrawn from Stäuble 1990).

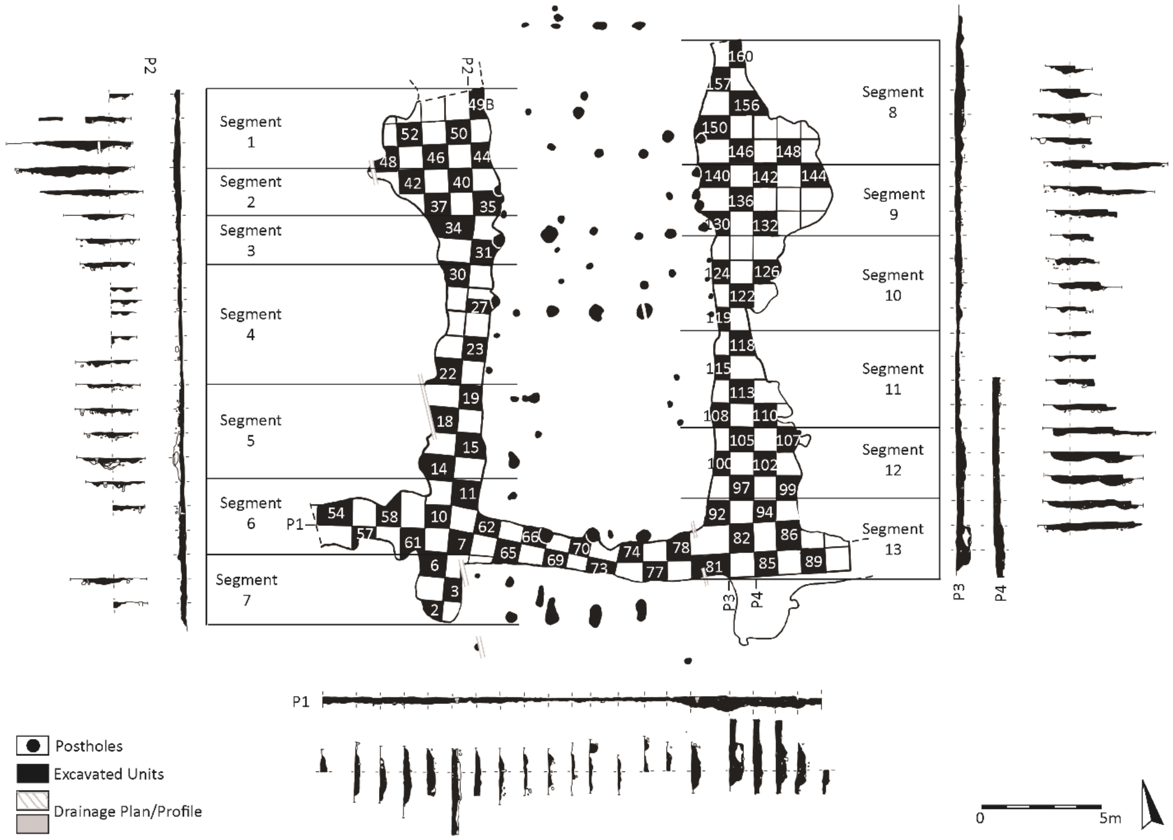


Figure 5.22: Grid system created for features 11, 22, 23, 24, and 26 in Zone D at Eitzum (redrawn from Stäuble 2005).

5.2.1.2 Klein Denkte (Lower Saxony, Germany)

Klein Denkte is located in a large flat area west of the Altenau just north of the Rothebach (Figure 5.15). The area is a transition zone to the glacial moraines characteristic of the north German lowlands (Kreuz 1990, 44; Stäuble 2005, 21). While the site has been described as ‘poorly preserved’ and affected by modern ploughing activities (Stäuble 2005, 25–26), this is relative, as some deep features are well preserved.

Klein Denkte is a multi-period site. The part of the site corresponding to the oldest LBK has been AMS dated from the organic component of a crushed äLBK potsherd at 6050±110 years BP (UtC-1835; Stäuble 1995, 234; Stäuble 2005, 231). This date was thought to have been obtained from the alkaline soluble fraction of the organic matter in the potsherd, so amino acids from cooking processes were initially thought to have been dated (Stäuble 2005, 231). However, this hypothesis was rejected after further comparative tests with other äLBK sites, namely Enkingen and Schwanfeld (*Idem*, 232). Thus, the chronology of the Early Neolithic occupation of the site was established through relative dating of ceramic sherds. Evidence of occupations from other periods at the site were found in pits and postholes from the 7th and 10th century AD (Stäuble 2005, 21).

5.2.1.2.1 Site stratigraphy

Given the closeness of this site to Eitzum, the same layering can be observed. However, in the case of Klein Denkte, in some areas the ploughing was so intense that the Ap horizon meets the gravel ice age deposits below the Loess, and where some features, like postholes, were eroded (Stäuble 2005, 21).

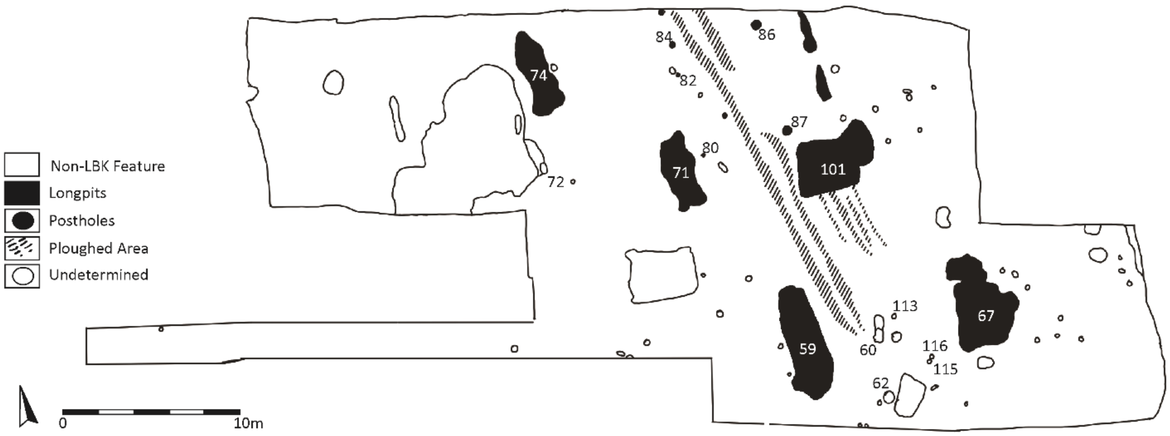


Figure 5.23: Plan of Zone 4 at Klein Denkte (redrawn from Stäuble 2005).

5.2.1.2.2 The features and finds

Excavation methods at Klein Denkte followed the same procedure as the 1987 excavations in Eitzum, with two notable exceptions. First of all, while longpits were segmented in squares, as in the Eitzum excavations, at Klein Denkte all the squares in the grid were excavated and all of the archaeological material retrieved. Five zones were selected at Klein Denkte, but only zone 4 revealed longitudinal pits and potsherds attributable to an äLBK house (Figure 5.23). Finds have also been processed in similar ways to the Eitzum material from the 1987 excavations, with some of the ceramics being refitted but most of the spatial information held intact (see above).

5.2.1.2.2.1 Zone 4

In the 1987 excavations, three potential non-contemporaneous LBK longhouses and associated pit features were identified in Zone 4 at Klein Denkte. While material from other periods was retrieved from this zone as well, none of the materials and contexts appear to be mixed with äLBK ceramics. This includes feature 101, which appears superimposed by the mediaeval feature 76 in the original site plan (Stäuble 2005, 23). Following descriptions from Stäuble (2005, 23-25), the first house (H1/1987) identified was accompanied by a western longpit (feature 59) without a clear external ditch and reaching a maximum depth of 0.6m, and its much wider and shallower (ca. 0.2m deep) eastern counterpart (feature 67; Figure 5.25). Outer walls and inner postholes have been difficult to interpret, which leaves the possibility that features 60, 62, 113, 115 and 116 could have been part of the internal workings of the building. It is important to clarify that the only reliable date mentioned above was obtained from feature 59.

Continuing with Stäuble's (*Ibid.*) accounts, the second house (H2/1987) was interpreted through features 71 and 101 (Figures 5.24 and 5.25), the western and eastern longpits respectively. Feature 71 was 4m long, 1.5m wide, and with a maximum depth of 0.75m. This deepest point of the feature might correspond to the outer trench of the house (Figure 5.24) but remains unclear. Posts of the western wall of the house would presumably be associated to postholes 80, 82 and 84, and internal posts of the northern part of the house with postholes 86 and 87. Lastly, H3/1987 is a potential house marked by feature 74, a 5m long and 2m wide western longpit. However, as this feature is lacking an eastern counterpart there is also the possibility it might just be part of H2/1987 (*Idem*, 25).

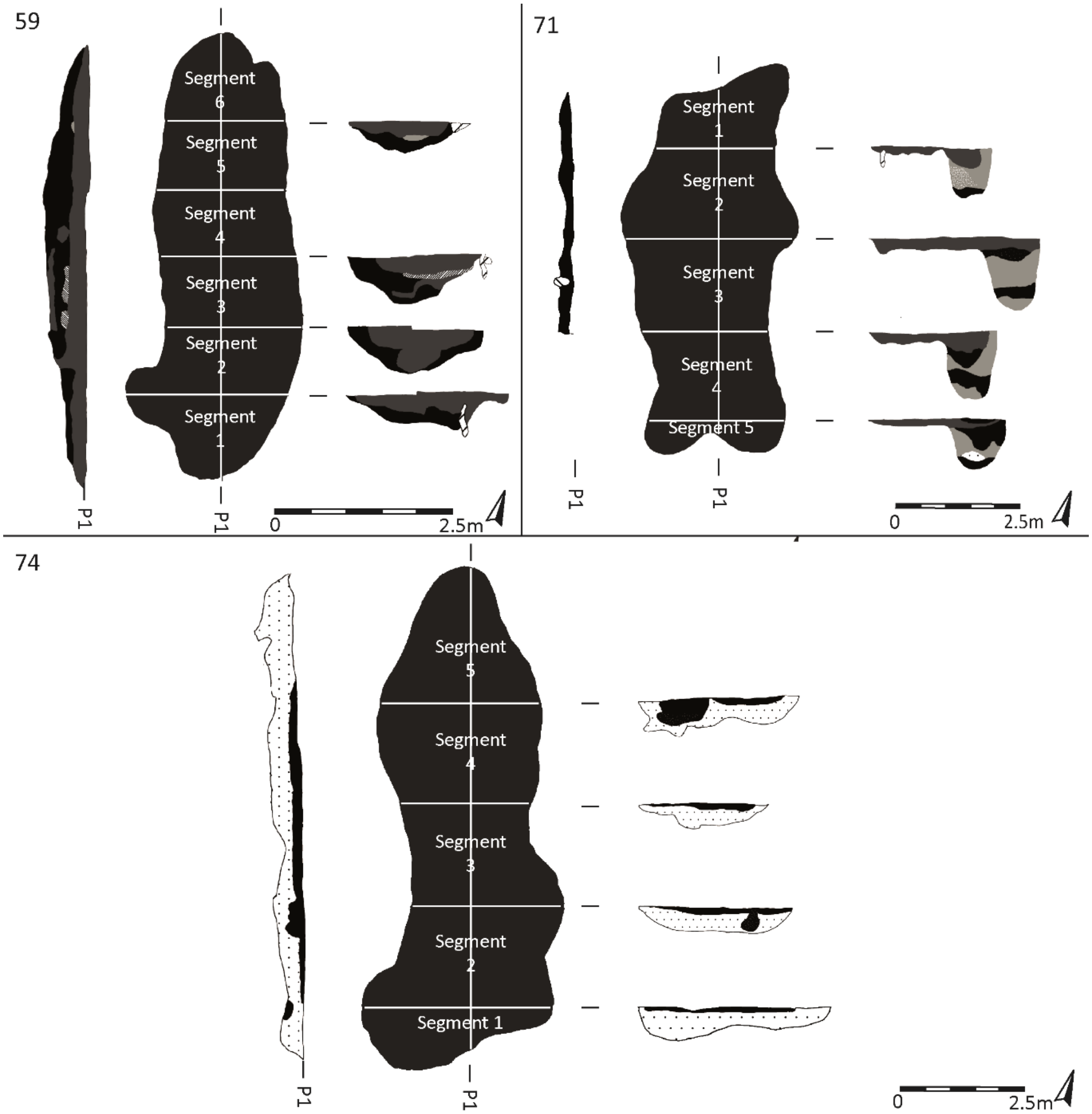


Figure 5.24: Plan and profiles features 59, 71 and 74 from Zone 4 at Klein Denkte (redrawn from Stäuble 2005).

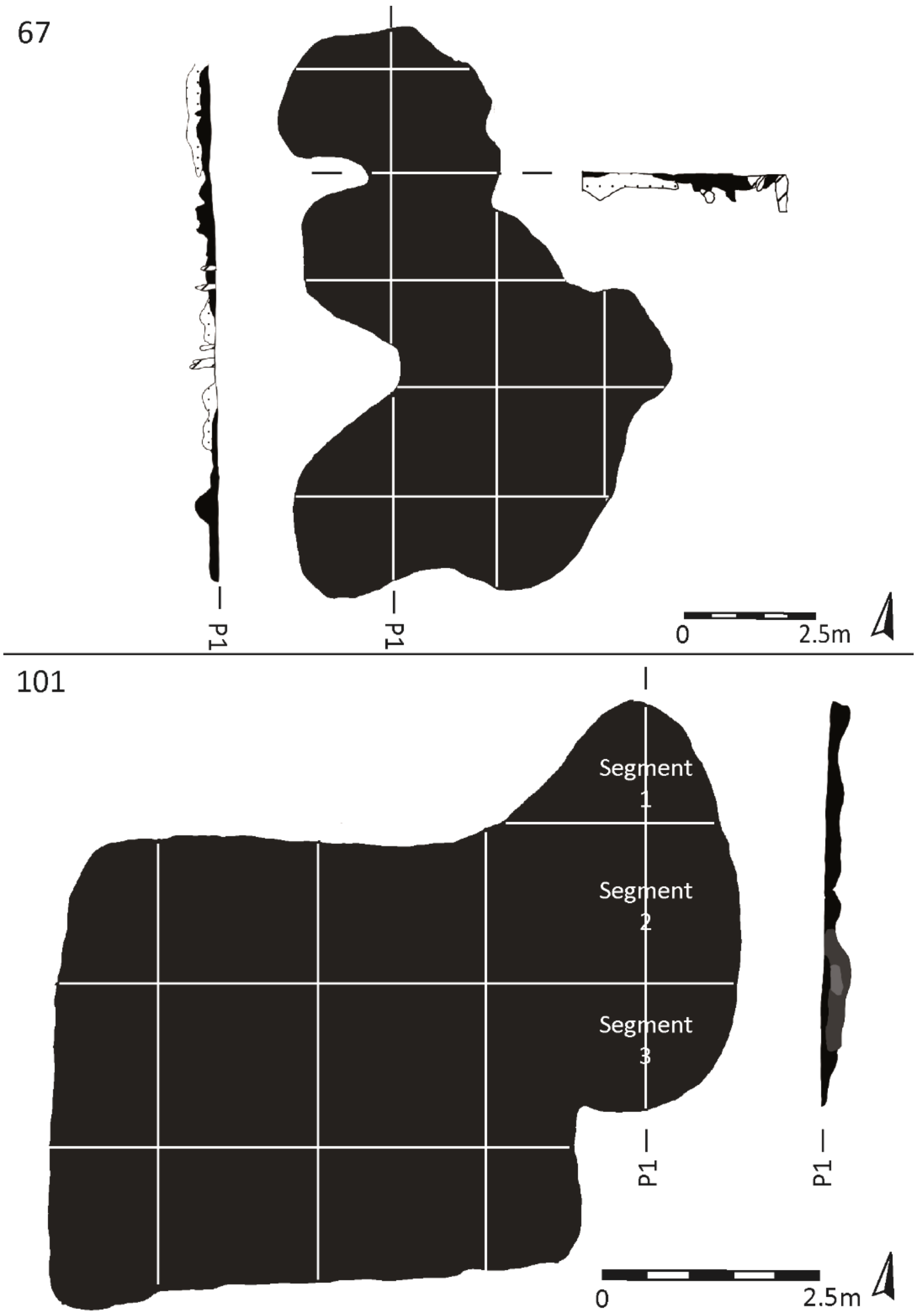


Figure 5.25: Plan and profiles of features 67 and 101 from Zone 4 at Klein Denkte (redrawn from Stäuble 2005).

Chapter 6. Principles and methods for inferring the social responses to pottery breakage

My methods are developed in two parts, each one addressing a different dimension of the social knowledge of breakage (section 2.3.4), which are: (1) how do social groups identify the potential signs of breakage, (2) what do they know about how pots break, and (3) what is to be done to the broken pots. As most of the archaeological process ideally works in an inverted way, that is we start by analysing the final resting place of fragmented material remains and then we work towards determining the objects they once belonged to, the methods selected for answering these questions are presented in this same fashion. In other words, I start by presenting methods focused on determining the (post)depositional processes affecting potsherds, then those related to the use of fragments and pottery repair, and finally on the techniques for determining how pots would have broken (Table 6.1).

Therefore, the first part of this chapter presents a set of methods focused on the third dimension of the knowledge of breakage, *i.e.* what happens to broken pots. To answer this question, a method was devised to understand the deposition of potsherds, as well as post-depositional processes affecting the deposits where pottery is found. This method corresponds to sherd-size distribution and morphometric analysis of potsherds through computational techniques and image analysis (Vindrola-Padrós *et al.* 2019). Some questions that are derived for this analysis include: how are potsherds being deposited? Are they transported before deposition? Are they readily visible/'ready-at-hand' or immediately buried/hidden? In short, these questions refer to the degree of exposure that pottery fragments had. In very general terms, this method provides information on what was done with fragments once formed, which serves to test the landfill analogy (section 4.1.3). Lastly, wear analysis of potsherds was used to deal with a different aspect of the question of what occurred to pots once broken (3), namely: how were broken pots incorporated in human practices? How were potsherds used and pots repaired? The investigation of wear traces was conducted through microscopic examination and the use of microphotogrammetric techniques.

The last section of the chapter is centred on how breakage is likely to occur when performing specific day-to-day practices. In other words, this study concerns the first and second dimensions of breakage. For this purpose, failure analysis of Early Neolithic pots was conducted. This method consists in determining the causes why a component or object fails to fulfil its intended function(s) (Becker and Shipley 2002, 5). To carry out this study, an activity where vessels could have been commonly broken in Neolithic times was simulated: cooking. For this purpose, a series of materials science tests, *i.e.* thermal shock and three-point-bend tests were designed for experimental specimens.

Dimension	Methods	Techniques	Sample	Sample Size*
First: what was done when pots were considered 'breaking'?	Analysis of wear traces on pottery repair holes (complemented with drilling experiments)	Microphotogrammetry and microscopy	All sherds with repair holes in sampled contexts and experimental ceramic discs for drilling experiments (Bore shape parameters: types A-D; bore composition parameters: obsidian, limnic quartzite, flint, and steel; Drilling parameters: hand-drilled and rod-drilled)	TS: 1 MN: 12 Ei: 1 Total: 14 sherds
				Experiments: one disc per parameter
Second: how did pots break?	Failure analysis	Flexural strength tests with three-point-bend	Experimental ceramic discs (Forming parameters: coiled and pinched; composition parameters: dung-, chaff- and un-tempered	Three ceramic discs per parameter
		Thermal shock cycling experiments with heat apparatus		One ceramic disc per parameter
Third: what was done with broken pottery?	Sherd-size distribution and morphometric analysis (complemented with tests)	Image segmentation and analysis	Sherd-size distribution: all fragments (>1cm) without fresh fractures in sampled contexts	TS: 9657 CO: 1064 MN: 1712 Ei: 3247 KD: 364 Total: 16,044 sherds
			Morphometrics: all body sherds (>1cm) without fresh fractures in sampled contexts	TS: 8035 CO: 788 MN: 345 Ei: 2353 KD: 295 Total: 11,816 body sherds
	Analysis of sherd wear traces (complemented with drilling experiments and reference collection)	Microscopy and microphotogrammetry	All well-preserved fragments with wear traces	TS: 20 MN: 12 Ei: 17 Total: 49 sherds

*Table 6.1: Summary of methods and sample selection for studying each dimension of the social knowledge of breakage. TS = Tășnad Sere, CO = Călinești-Oaș-D.S.M., MN = Méhtelek-Nádas, Ei = Eitzum, KD = Klein Denkte. *Information of sample size for each site and context is given in the next two chapters.*

6.1 Sherd-size distribution and morphometric analysis

The objective of this method is determining if potsherds were left accessible or exposed, or if they were hidden or out-of-sight (*e.g.* buried) during Early Neolithic times. The study of size distributions and morphometry of fragments can be beneficial for providing information on the movement of materials through different contexts, the degree of exposure before they become buried, and if they are exhumed and incorporated in other contexts. This information allows inferring how human relationships with broken materials unfold in different past settings, and how these materials influenced further social behaviour. Considering the particularities of the study area described in the previous chapters questions to answer are: how did potsherds end up in pits? What do these depositional processes tell us about human interaction with broken pots (*i.e*. the third dimension of the social knowledge of breakage)?

6.1.1 Some principles from earth and materials sciences

As mentioned before, potsherds are the most ubiquitous and abundant find in Neolithic sites. They provide information not only about their interaction with human and non-human agents, but also on the deposits where they are found. For this reason, an earth science approach to the study of potsherd size and shape is presented, which includes soil sciences and sedimentology. One of the main foci of the latter lies in understanding the main mechanisms and processes of different depositional environments. This is partly accomplished by studying the size and shape of the grains that comprise a deposit. Size is considered a physical property of grains, and the distribution and sorting of grain sizes in a particular sediment can reflect depositional mechanisms and conditions (Boggs 2011, 54). Shape is a scalar phenomenon (Mitchell and Soga 2005, 87; Figure 6.1), where each scale or order of shape can be modified according to specific depositional but also post-burial processes. At the largest scale we can describe the particle or grain’s form, at the mid-scale the shape of the grain’s corners, and at the small scale the surface texture (Figure 6.1). Apart from depositional and transportation processes, the material properties of grains must also be taken into account, as size and shape will be modified differently. A core principle of conventional sedimentological approaches is that the size and shape of a particle is ultimately dependent on its microstructure and its subsequent history (Selley 2000, 42).

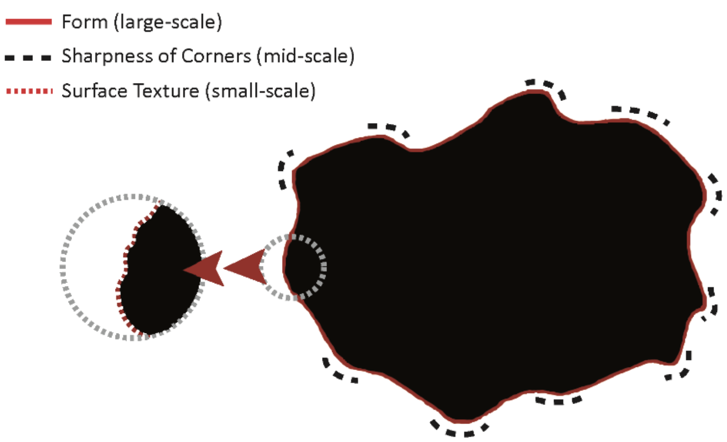


Figure 6.1: Different scales of shape of a particle (redrawn from Mitchell and Soga 2005).

While potsherds can be considered rocks in terms of composition, they are also materials derived from vessels or containers. Their microstructure and most of their material properties originate from the manufacture, use and breakage of pottery vessels. This statement brings us closer to the domain of materials sciences, which are concerned with the "generation and application of knowledge relating the composition, structure and processing of materials to their properties and uses" (Cohen 1980, xii). Following these considerations, in the next subsections I advance some principles from earth and materials sciences applied to the analysis of potsherd size and shape.

6.1.1.1 Effects of microstructure and material properties on the size and shape of potsherds

Before considering (post)depositional processes, one must firstly consider the microstructure of the ceramics studied, as it governs its material properties (such as its strength/toughness, hardness, and thermal shock resistance) and thus on how a potsherd’s size and shape will be modified during these processes. The microstructure of a material can be considered as a combination of its composition, texture, structure, and surface treatment (Rice 1987, 348). The ceramics studied in this dissertation either have had no surface treatment or their surface has been severely affected by postdepositional processes (see Chapter 5), I have decided not to include a description on the effects of surface treatment on potsherd geometry.

Unlike most commonly used modern ceramics, prehistoric ceramics are considered multiphased[1] or composites (Rice 1987, 348), as they are composed of various bounded constituents like inclusions, pores, fibres, among others, and are predominantly low-fired. Thus, their composition (*i.e*. type of clays, temper or inclusions) is a fundamental contributor to the

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[1] A phase is considered as "any part of the system which is physically homogeneous and bounded by a surface so that it is mechanically separable from other parts of the system" (Kingery *et al.* 1976, 270)

microstructure of the ceramic (*Ibid.*), and consequently to the shaping of the ceramic fragment. Since ceramics are brittle materials, they tend to break rather than deform when stresses are applied (Roesler *et al.* 2007, 71). Fractures formed during this process behave differently according to the ceramic's constituents, which results in the formation of potsherds with different shapes. Thus, sherds of ceramics with mineral inclusions will have different shape attributes than fibre-reinforced ceramics, as minerals tend to arrest cracks through deflection (Tite *et al.* 2001, 304) while fibres can arrest crack propagation through crack-bridging mechanisms, which involves fibres acting as a connector between two surfaces divided by a crack (Becher 1991, 257). For these reasons, the composition of ceramic specimens should be monitored in any archaeometric or morphometric study (Vindrola-Padrós *et al.* 2019, 20).

The microstructure of the ceramic material is also characterised by its texture, *i.e*. the form, configuration and size distribution of its constituents (*e.g.* temper, pores, clay minerals, any other additive), and structure, which refers to the arrangement of phases between each other (Bronitsky 1986b, 223; Rice 1987, 348). The amount and size of inclusions influence how the material is fractured. Coarse-grained pots are more likely to contain flaws, which are locations where cracks initiate. However, coarse grains can also create effective energy dissipation mechanisms that arrest or deflect cracks that propagate (Rice 1987, 362). In other words, large amounts of coarse inclusions in the ceramic fabric results in high fracture energy (Müller *et al.* 2015, 842). Consequently, ceramic vessels characterised by high fracture energy can potentially produce small sherds with rough fracture surfaces. However, in case of sherd size these observations remain theoretical, since coarse inclusions are commonly used by potters to make large vessels, and here fragment size would be subject to other variables like the thickness of the specimen. On the opposite end, fine-grained pottery is considered more resilient to crack initiation than propagation, thus once cracked the specimen is more likely to break because of the lack of energy dissipation mechanisms. As a result, finer ceramics tend to form highly angular sherds and with smooth surface textures, as cracks can travel through less torturous paths and meet at sharper angles (Vindrola-Padrós *et al.* 2019, 27).

In terms of the structure of the ceramic paste, the effects of the orientation and arrangement of particles in prehistoric ceramics are better known. The orientation of inclusions is highly dependent on the pottery manufacturing techniques used (Courty and Roux 1995; Rye 1981). For instance, thrown pots possess a diagonal alignment of inclusions and voids (Rye 1981, 80; cf. Berg 2008, 1180), while coiling techniques orient the different phases of the material horizontally, following the direction of the coil (Carr 1990, 15; Rye 1977, 207). Since cracks propagate following paths of least resistance, the different weakness zones left by different forming techniques will ultimately influence the size and shape of sherds. For example, step-like cracks commonly formed along the poorly joined coils of a pot result in rectangular sherd shapes (Rye 1981, 68). In this scenario, the size of the sherd can also partly be determined by the size of the coil. The firing process is another important contributing factor, including the soak time and temperatures reached (Gosselain 1992; Livingstone Smith 2001). Firing partly contributes to the strength of the bonds between different phases of the ceramic. With increasing temperature, the boundaries between grains and the clay matrix begin to dissipate, as grains undergo sintering and vitrification. In low-fired pottery, bonds between phases tend to be weak (Müller *et al.* 2015, 836), which can produce a higher amount of fragmentation (section 7.1), and thus a reduction of the mean size of sherds in an assemblage (see for example Figures 6.3 and 6.4).

As mentioned, ceramic microstructure influences the material properties of pots. In taphonomic studies, two material properties are of particular importance: strength/toughness and surface hardness. The former refers to the resilience of a material to crack initiation/propagation (respectively strength/toughness; Müller 2016, 610). In relation to the shape and size of potsherds, with an increase in strength or toughness, the likelihood of geometric transformation by breakage processes is reduced (Vindrola-Padrós *et al.* 2019, 20). For example, weak sherds subjected to trampling are likely to be less elongated than stronger ones. As we are dealing mainly with organic- and/or mineral-tempered ceramics in this dissertation, it is important to note that impact experiments show the latter are usually stronger than the former (Skibo *et al.* 1989, 125; although compare with results in Chapter 9). When potsherds are submitted to abrasive stresses, surface hardness becomes a central property, influencing changes in size and shape of specimens. Fragments submitted to abrasive processes decrease in size and their corners are rounded. Therefore, surface hardness has an impact on the "rate of deterioration of the abrasive and thus on abrasive particle geometry and contact" (Moore and King 1980, 137). Harder materials will be more resilient to morphological alteration than softer ones. When considering prehistoric pottery, firing conditions are the main determinant of this material property (Rice 1987, 354). For this reason, hardness tests, such as ones forwarded by Orton and Hughes (2013), are normally designed to provide some information on the firing process.

The last factor to discuss is parent vessel size. Research by Chase (1985) has shown that vessel thickness, rather than vessel form, is the major contributor to fragment sizes. This parameter has also been used to explain the selective preservation of thick sherds in ceramic assemblages (Chapman 2000a, 65–68; Rye 1981, 59). Furthermore, it is also hard to argue that the size of the vessel (in terms of volume or surface area) ultimately conditions how large a sherd can be. A quick way to monitor vessel sizes is through estimated vessel-equivalents or EVEs (detailed in section 6.1.2.3.1).

6.1.1.2 Common types of (post)depositional processes affecting the size and shape of sherds

Having considered the effects microstructure and material properties on potsherd size and shape, we now consider the effects of (post)depositional processes. Following Vindrola *et al.* (2019), three types of processes are taken into account: breakage, abrasion and weathering.

As I have utilised breakage as a broader theoretical term, I utilise rupture to designate the narrower term specified next. Here, rupture is considered the fracturing of the ceramic material usually by stresses like impact or bending (Sanhueza Riquelme 1988, 75). As an analytical strategy, rupture can be divided into primary and secondary (Lindauer 1992, 211). Primary rupture concerns the initial breaking of the pot and the formation of potsherds, while secondary rupture consists of the successive fracturing of fragments. While often disregarded, primary breakage can actually occur during or after deposition. For example, sherds from dropped pots can be left where they lie, *i.e.* primary refuse (*e.g*. DeBoer and Lathrap 1979, 129; Longacre 1981, 64), and buried pots may theoretically fragment by the weight of the soil compacting over it (see McGowan and Prangnell 2015 for an example on human burials). Secondary rupture is an exponential phenomenon, meaning that for every broken pot, subsequent fragmentation will increase sherd numbers exponentially (Byrd and Owens 1997, 316; Gordillo and Vindrola-Padrós 2017, 161) until a stable sherd size is reached where fragmentation no longer occurs (Nielsen 1991, 493). Some common human and/or non-human activities associated to secondary rupture are ploughing (Ammerman 1985; Dunnell and Simek 1995; Reynolds 1988; Reynolds 1982), animal burrowing (Blackham 2000), or trampling (Nielsen 1991).

Abrasion consists of the "removal or deformation of material on a ceramic's surface by mechanical contact, specifically, the sliding, scraping, or, in some cases, striking action of an abrader" (Schiffer and Skibo 1989, 101). In terms of (post)depositional action, abrasion is usually associated with processes like river flow, wind erosion and slope movements (Balista *et al.* 1991; Kirkby and Kirkby 1974; Rick 1976; Skibo 1987), but can also be the product of human activities (Dunnell and Simek 1995; López Varela *et al.* 2002). For example, an intended human abrasive action is the reshaping of potsherds for various purposes (Gijn and Hofman 2008; López Varela *et al.* 2002; Vieugué 2010; 2015).

Weathering can be a chemical –erosion through the dissolution of particles - or mechanical process by which a specimen is worn down below or at the Earth's surface (Allaby 2013, 629). Examples of chemical weathering include the degradation of potsherds under high soil acidity, which has been documented in some of the sites sampled for this dissertation (see Chapter 5). Mechanical weathering involves the breakdown of buried materials, and is associated with disruptive mechanisms like salt crystalisation, freeze-thaw action, and surface removal by clay soils (Noghani *et al.* 2018; O'Brien 1990; Reid 1984). The latter process has also been recorded in several sites in the UTB region. While Skibo (2013, 119) has utilised the concept of attrition in his use-alteration study of ceramic vessels to encompass both abrasion and non-abrasive processes that erode ceramic surfaces, I prefer to use the concept of weathering from earth sciences, as it makes a distinction from rupture and abrasion in regards to (post)depositional processes.

6.1.1.3 Depositional processes affecting spatial and stratigraphic distribution of fragment sizes and shapes

Other important depositional processes are not so much related to the alteration of fragment size and shape but are responsible for sorting sherds according to these attributes. These processes are presented according to the depositional environments of interest in this thesis, which are pits and houses.

Pits, ditches and other dugout features are depositional environments where downslope movement processes can occur (Figure 6.2). Experimental work shows that the edges of ditches quickly erode and sediments fall along slopes until the angle of repose is between 30-40° (Fowler and Swanton 1996, 8; Jewell and Dimbleby 1966, 318; Lüning 1981, 278). Slope stability is affected by the amount of vegetation, which is removed when pits are dug. However, as time passes slopes stabilise because of vegetation growth, which also acts as obstacles for the movement of material inside pits (Lüning 1981, 279). Scree slope rockfall models provide an explanation of how individual rocks are sorted by size and shape along the surfaces of slopes (Kirkby and Statham 1975; Statham 1976). As slow and gradual processes, movement of rocks downslope are mandated by the contact between the surfaces of rocks and the slope. Large rocks possess more kinetic energy and thus are not detained by irregularities of the surfaces of slopes, while smaller rocks are easily stopped by these irregularities (Dorren 2003, 73). As a consequence, large rocks travel further downslope. Spherical and round objects move further downslope as well, as friction is decreased between the surface of the rock and that of the slope. Hence, when there is sorting by shape, rolling mechanisms are said to have occurred, while sorting of rocks by size relates to sliding mechanisms (Statham 1976, 54–55). Much like sediments and rocks, potsherds are affected by slope processes. Some studies have shown how spatial sorting of ceramic fragments by size occurs along slopes, with larger fragments moving longer distances downslope (Kirkby and Kirkby 1976; Rick 1976). In a recent study, spatial sorting of fragments by size (surface area) and shape (sphericity and roundness) has also been identified in an Early Neolithic pit (Vindrola-Padrós *et al.* 2019), which was attributed to the slow and gradual downslope movement of fragments.

Květina and Končelová (2011) have modelled another process linked to pits, which is human dumping or throwing of potsherds inside pits. As pits are gradually filled by dumping potsherds in the middle portion of pits, a depositional cone would be formed, and in subsequent dumping events larger fragments roll down the sides forming a ring-like pattern (Květina and Končelová 2011, 58; Figure 6.2). However, dumping can also occur from the edges of pits, in which case this periodical activity would result in stratification of deposits and finds within pits (Stäuble 1997, 22; Figure 6.2). Quick processes like backfilling have been theorised as an alternative explanation of sherd deposition in pits related to human activity. In this scenario, the fill of the pit would be homogenous (unstratified) and refits between sherds would occur at different strata or spits within the pit (*Idem*, 25). Assuming that sherds were not abraded or severely fragmented before deposition, we can only speculate that in this scenario there would be no clear spatial sorting of sherd sizes and shapes unless slope processes are also in effect.

[redacted]

Figure 6.2: Some depositional processes involved in pit filling (after Květina and Končelová 2011).

Human activities within or near houses can also be responsible for distinctive arrangement of sherds according to their size or shape. Processes termed “provisional discard” (Deal 1985, 253–259) and “structured deposition” (as broadly defined in section 2.3.4.3.1) commonly occur inside houses or in their immediate vicinity. During these processes large fragments or vessel portions are generally arranged in specific locations before or not long after their primary rupture (Deal 1985, 253–254; Hayden and Cannon 1983, 131). The process would also result in the spatial sorting of angular fragments with rough surface textures, as freshly broken pots display such characteristic shapes (Vindrola-Padrós *et al.* 2019; section 7.1). Another process linked to house “maintenance” (Deal 1985, 259) is sweeping. This process commonly occurs in houses and results in small fragments being displaced (Deal 1985, 260; Hayden and Cannon 1983, 126), and can be considered a high energy process, compared to the gradual downslope movement of sherds.

6.1.1.4 Size and shape descriptors as indicators of (post)depositional processes

Two independent sets of descriptors are useful for unravelling (post)depositional processes: those belonging to size – dimensions of the particle – and others concerning shape of potsherds. In sedimentology, the grain size of sediments is reflective of “the energy of the depositing medium and the energy of the basin of deposition” (Reineck and Singh 1980, 132), *i.e*. the agents and modes of transportation/deposition of sediments. In archaeological assemblages, among the processes mentioned before, rupture is certainly the most aggressive process affecting sherd size. A clear effect of secondary rupture processes is the significant reduction of sherd size until a ‘stable’ size is attained (Kirkby and Kirkby 1976, 237; Nielsen 1991, 493). Nonetheless, depending on the microstructure of a material, certain types of high energy primary rupture can also significantly produce a substantial number of small fragments (Vindrola-Padrós 2015). For example, the top left plot in Figure 6.3 and 6.4 shows how low-fired pots dropped from different heights can become severely fragmented from a single impact episode.

In soil science, the analysis of grain-size distributions is a powerful tool for determining depositional environments (Krumbein and Sloss 1963; Visher 1969). However, the distribution is also limited by the availability of certain grain sizes (Reineck and Singh 1980, 132). For example, while eolian action can affect the sorting of grain sizes in sand dunes, it is also true that mainly sand-sized grains are available in these environments. Several studies of archaeological ceramics have shown that fragment size distributions can work as indicators of specific secondary rupture processes (Blackham 2000; Bradley and Fulford 1980; Kirkby and Kirkby 1976; Nielsen 1991; Reynolds 1982). As shown in Figure 6.3, sherd size distributions of assemblages affected by secondary rupture, such as ploughing or trampling, tend towards a certain degree of size sorting in contrast to assemblages formed by primary rupture (*e.g.* in Figure 6.3 this refers to pendulum impacted, dropped pots and vessels found *in situ*). However, when comparing some of these results (Figure 6.3), we find a problem of equifinality; namely, these distributions on their own can produce ambiguous results when attempting to pinpoint *specific human or nonhuman activities*. In sum, fragment size distributions can be useful indicators of fragmentation or secondary rupture but are troublesome if attempting to identify specific activities responsible for this fragmentation. To achieve the latter, shape parameters must be considered as well.

As mentioned before, the morphometric approach advanced here considers shape as a scalar phenomenon. An often-used scalar classification of shape by earth scientists consists of a tripartite division, *i.e*. large, medium and small scales (Figure 6.1). According to this classification, I have selected four parameters, which allow unpacking the processes by which pottery fragments are transformed. These parameters are sorted next according to scalar representation, as these are used for determining the shape alteration of fragments by (post)depositional processes. A summary of the relation between these shape descriptors and (post)depositional processes is presented in Chapter 7, but here I discuss the methodology.

In large-scale shape description, *i.e.* form of a particle, two shape parameters can be considered: sphericity and length-to-thickness ratio (S/W from now on). The former details the relation between length, breadth and height of a grain or rock (Cho *et al.* 2006, 591). Tumbling experiments of limestone rock fragments in sedimentological studies have shown that the sphericity of a specimen rapidly increases because of rupture processes and less by abrasion (Krumbein 1941b, 503). A similar experiment on potsherds has shown the same conclusion (Skibo 1987, 136). An archaeological study of ploughing of potsherds demonstrated that fragment sphericity is significantly increased during rupture (Dunnell and Simek 1995, 309). A second large-scale descriptor is the S/W ratio (Kuna 2015; Květina and Končelová 2011; Řídký *et al.* 2014), and is based on the assumption that fragments continually break until they reach a certain degree of ‘compactness’.

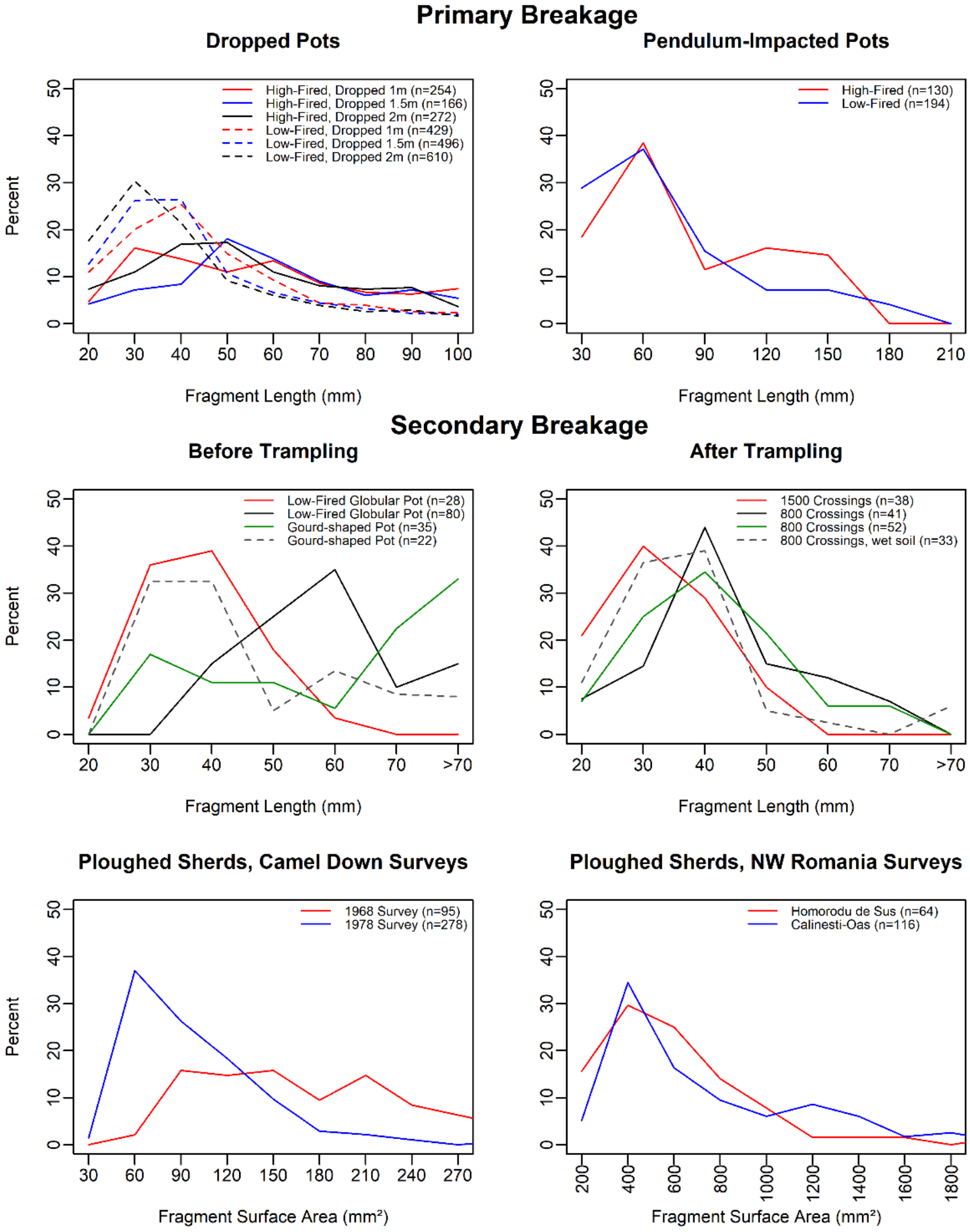

Figure 6.3: Synthesis of different (post)depositional processes and their effect on fragment size. Primary rupture is represented by drop experiments performed on two types of mineral-tempered flowerpots: high-fired are fine-grained (<500µm), and low-fired pots are medium-grained (<1mm). Secondary rupture processes are represented firstly by a trampled assemblage of compositionally varied fragments (after Nielsen 1991). The bottom plots represent ploughed assemblages: Camel Down surveys (after Reynolds 1982), and surveys of Early Neolithic sites in northwest Romania (after Vindrola-Padrós et al. 2019).

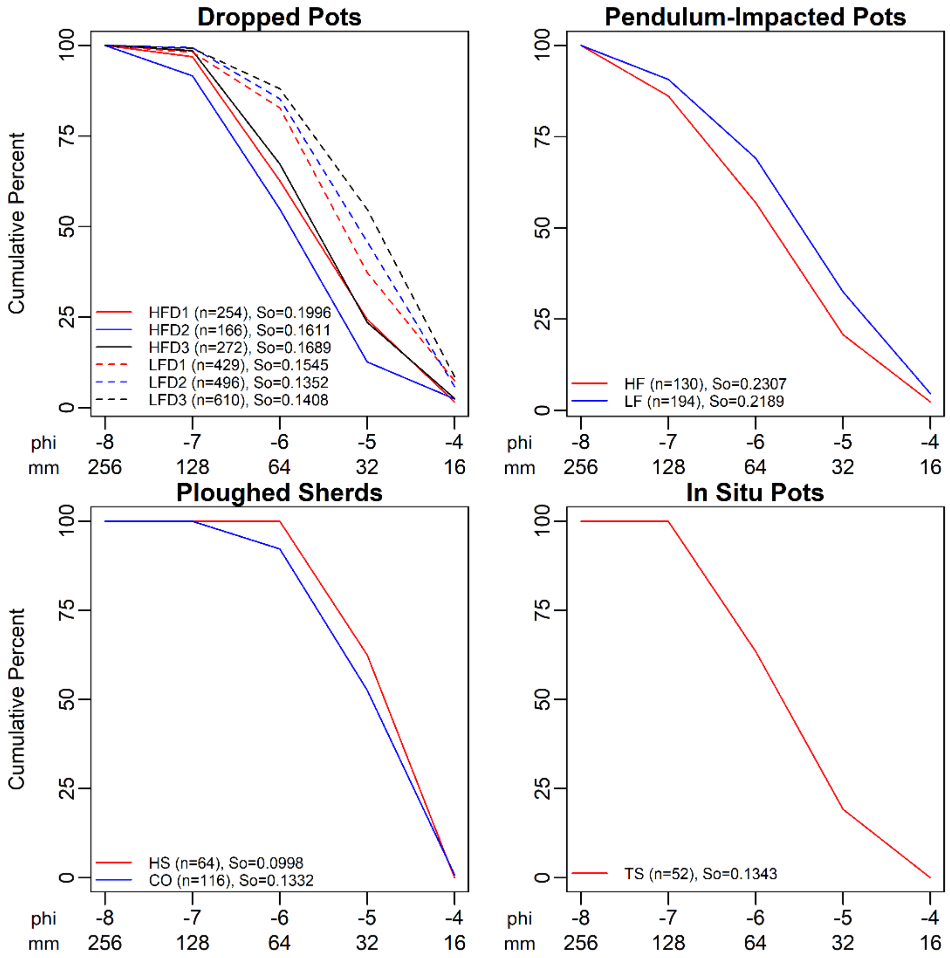

Figure 6.4: Relative cumulative frequency of potsherds from different contexts showing different degrees of size sorting.

With regards to medium scale parameters, roundness is considered the "overall degree of curvature of the edges and corners of a particle" (Allen 1989, 144). Once again, experiments on rock and mineral fragments demonstrate that the roundness of a particle's corners is mostly the product of wear or abrasion (Krumbein 1941a, 70; Wadell 1935, 250). These abrasion conditions are commonly associated with the mode of transportation of a grain (Stein 1987, 362) by wind, fluvial or surf actions (Kuenen 1959; 1960; 1964; Wadell 1935, 251; Wentworth 1919). Another important consideration from sedimentological studies is that the corners of large grains round faster than those of smaller ones; thus, the presence of small rounded fragments is reflective of prolonged exposure to abrasion (Krumbein 1941b, 512). In the taphonomical study of archaeological ceramic fragments, roundness has also been shown to be a strong indicative of abrasive processes (Skibo 1987; Skibo and Schiffer 1987). These studies also show that under wet conditions, the rounding of fragments is significantly increased (Skibo and Schiffer 1987, 87), and affects organic-tempered ceramics more than mineral- or grog-tempered ones (Vaz Pinto *et al.*

1987, 128). While the paper does not delve into any explanation of why organic-tempered pots are less resistant to abrasion, it is likely linked to the higher porosity of these materials.

A third-order shape property is surface roughness or texture (Campaña *et al.* 2016, 75; Kuo and Freeman 2000, 60). Surface roughness can be used as an indicator of the 'textural maturity' of particles (Campaña *et al.* 2016, 75), but can also help identify postdepositional weathering processes (Barrett 1980, 293; Krumbein and Sloss 1963, 113). The same principles can be applied to the (post)depositional study of ceramic fragments. After the primary rupture of a composite ceramic, fragments possess jagged edges that are the product of cracks moving around or through the ceramic's different phases. While abrasive processes will smooth these irregularities, post-burial mechanical weathering will produce a higher degree of surface roughness on the edges of fragments, *e.g*. fragments discovered *in situ* (Vindrola-Padrós *et al.* 2019, 28).

Lastly, the spatial sorting of fragment sizes and shapes can also be analysed in archaeological contexts, which provide cues on certain depositional processes (as discussed in section 6.1.1.3).

6.1.2 Image analysis and computational techniques for the study of size and shape of potsherds

Having considered the main principles of the study of size and shape of potsherds, I now move on to explain the computational techniques I have developed for my study. Computational techniques in morphometric and archaeometric analyses consist of converting objects of interest into 2D projections through digital photographs and using these projections to quantify different parameters of size and shape. Digital photographs convert images to numerical data in the form of pixel values. Image analysis consists of developing algorithms to use these values for various purposes like quantifying size and shape. In sedimentological studies, these techniques are praised for their speed, accuracy and reproducibility (Altuhafi *et al.* 2013, 1291; Lira and Pina 2009, 1529; Rodriguez *et al.* 2013, 194), which are enhanced through the automation of measurements. Even more valuable is the fact that a large range of parameters are made available, including some that allow conceptualising different scales of shape.

6.1.2.1 Sampling strategy

All of the contexts and features listed in Tables 5.1 and 5.3 were sampled for sherd-size distribution and morphometric analyses. From these samples, a strategy was devised with several exclusion criteria that addressed limitations of the computational techniques, the nature of the assemblages studied, and the post-excavation processing methods used at each site. Firstly, potsherds with fresh breaks on any of their fracture surfaces were discarded from the analysis. In situations where the amount of freshly fractured fragments was perceived to be large, I weighed the excluded sample to ensure a representative amount had been selected for analysis.

Secondly, taking into account arguments posed by Allen (1989, 145), only body sherds were used for morphometric study. The reason for this exclusion criterion is that fragments like rims possess convexities that are vulnerable to abrasion (Schiffer and Skibo 1989, 108), and therefore have an effect on fragment morphology as an indicator of (post)depositional processes. Nonetheless, the analysis of size distribution of fragments included all fragments regardless of the vessel portion they represent.

Thirdly, as detailed in the previous chapter, there were several restrictions imposed by the finds processing methods used on some of the sites, such as refitting or gluing fragments. Depending on the state of the fragments' edges, some of the glued or refitted fragments had to be taken out of the sample. In the sites from Lower Saxony, it is important to remember that most vessel units were just composed of a few fragments and were not reconstructed as in Méhtelek-Nádas and Călineşti-Oaş; thus, the number of fragments excluded through this criterion was very low.

Lastly, fragments under 1000-pixel area were discarded from the sample. Following test results from recent papers (Sun *et al.* 2019, 5; Takashimizu and Iiyoshi 2016, 9), size and shape measurements of objects below 250 pixel length can show considerable errors, particularly so when using middle- and small-scale shape parameters. Taking into account the image resolution obtained for my study (see section 6.2.2.3), the 1000-pixel threshold is equivalent to fragment lengths below 10mm.

6.1.2.2 Software

ImageJ/Fiji and Matlab were the selected software for my study. The former is freely available and funded through the National Institute of Health (NIH), USA (Ferreira and Rasband 2012). ImageJ/Fiji was selected as it is open-source and possesses a large variety of continually updating plugins designed 'by scientists for scientists'. More importantly, the software contains a series of inbuilt algorithms that were easily adapted to quantify different shape attributes of sherds. The 'Analyze particles…' function was the most important feature used from this software. Through this function, objects in binary images are selected as Regions of Interest (ROIs) and measured according to specified parameters. Matlab is commercial software developed by

Mathworks. The software also contains tool packages for image analysis and object shape description in 2D and 3D form. In terms of our two-dimensional approach to sherd shape, the software was used for measuring roundness of particles according to a recently developed algorithm (Zheng and Hryciw 2015). The software was also used for obtaining measurements from 3D photogrammetric models of repair holes (specified in section 6.2.3.2).

6.1.2.3 Data collection

6.1.2.3.1 Basic recording strategy

Before I collected and analysed images of sherds, I recorded some basic information on the materials' condition, the make-up of the assemblage, the fabric composition of the pottery fragments as well as other visible properties and features. Much of this information was considered essential to assess laboratory experiment designs, the sherd-size distributions and morphometric analyses of fragments and assess potential selection of fragments for wear analysis. For the latter, the information helped in the sorting of potsherd assemblages to rule out microstructural causes of assemblage variation (see section 6.1.1.1).

Following Orton and Hughes (2013, 215), estimated vessel-equivalents (EVEs from now on) were calculated in each assemblage for measuring fragmentation through a brokenness ratio. A second reason for calculating EVEs was to assess the size of vessels that are most represented in a given assemblage, which is an important factor to address when studying fragment sizes (section 6.1.1.1). Using a rim chart, base fragments were used for calculating EVEs, as they were the most frequent diagnostic portion of pots in the Early Neolithic sites analysed (Chapter 7). Vessel sizes were determined according to the projected vessel diameter determined with the rim chart, and a classification of vessel sizes was made as follows: Very Small (<6cm), Small (6-10cm), Medium (11-15cm), Large (16-20cm), and Very Large (>20cm). EVEs were then grouped into these size groups to determine the most common vessel sizes. In addition, a brokenness ratio was obtained for each excavated feature by dividing the number of fragments over the EVEs. The higher the values for the ratio are an indication that there is a higher variation of stresses applied to pots after primary rupture (Orton and Hughes 2013, 215–216).

A recording system was created, once more inspired by Orton and Hughes (2013), in order to record basic information on the composition of the potsherds. The results were compared to petrographic analyses performed on each of the sites studied (Kreiter and Szakmány 2011; Riederer 1985; Seidler and Amicone 2017; Sommer *et al.* 2019). The following variables were recorded:

- *Composition and granulometry*: these variables were determined macroscopically, and occasionally aided by a digital microscope. Three size categories were used: fine (<1mm), semi-fine (1-2mm), and coarse (>2mm). The amount of inclusions was not considered for two reasons: (i) the visual inspection by naked eye can easily confuse some pores with voids from organic remains, and (ii) petrographic studies on ceramics from sampled sites address this issue more accurately (Kadrow and Rauba-Bukowska 2017b; Kreiter 2010; Kreiter and Szakmány 2011; Riederer 1985; Seidler and Amicone 2017).
- *Hardness*: This category was used as an indicator of firing temperatures, and to obtain further information on the effect of abrasive processes on the ceramic assemblage (see section 6.2.1.4). Hardness was measured according to Orton and Hughes' (2013) modified version of the Mohs hardness scale. Fragments are scratched with a fingernail and a piece of steel. If the fingernail produces a scratch on the surface of the specimen it is categorized as 'soft' fragment; if it was affected by the piece of steel but not by the fingernail, it was recorded as 'hard'; and finally, if no mark is produced by either of the materials, the fragment is 'very hard'.

The basic recording also included information on the preservation, such as registering if any of the fragments' fracture surfaces were 'fresh', and if so, were they refitted or missing, and some post-depositional marks (*e.g.* striation marks due to washing with brushes, traces of being struck by a trowel or spade, and the presence of calcite formation). Lastly, the thickness of sherds was also measured. Thickness was measured to calculate one of the shape descriptors mentioned in section 6.1.2.5.

6.1.2.3.2 Image collection and processing

The photographic layout consisted of sequentially positioning fragments with their concave face up on an LED pad. The white background enabled a quicker identification of objects in ImageJ and left fewer margins for error during the automation process. The software would then identify objects from top to bottom, correlating the ROI number given to the sample number recorded in my database. The camera used for most pictures was a Canon E0S 40D camera with a 17-85mm lens. Photographs were obtained in raw format (CR2), converted to tiff, and finally into 8-bit binary images. This ensured high resolution of images, which on average was around 120 pixels per mm. Both image processing and analysis was automated, and the macro is available in the supplementary information of a recent paper (Vindrola-Padrós *et al.* 2019).

6.1.2.4 Measuring and analysing size

There are many ways of measuring fragment size in two- and three-dimension. The challenge is to find a unique or absolute numerical parameter that best accommodates the size of the object of interest. For example, in soil science the three-dimensional size of a grain can be defined by “the volume of the sphere that holds the same volume as the grain” (Heilbronner and Barrett 2014, 188), but volume may not be the best parameter to measure anisometric or concave-convex grains (*Idem*, 189). In our case, as potsherds are in principle plate-shaped, because one of their dimensions is severely restricted by the thickness of the parent vessel’s wall, 2D representations will be in principle relatively accurate. In the archaeological literature, length or weight have been most commonly utilised as a size parameter of sherds (*e.g.* Chase 1985; Last 1998; Nielsen 1991), mostly because of convenience (*e.g*. less time-consuming to measure, more practical, standardised, etc.). However, considering the platy form of sherds, surface area is certainly a better-fitting two-dimensional descriptor of potsherd size. Furthermore, in order to compare the sampled assemblages with previous work done, I have also taken measurements like length (Feret diameter) and width (Minimum Feret) with ImageJ/Fiji, and manually recorded sherd weight and thickness.

The distribution and sorting of sherd sizes are then analysed by different methods. Box and density plots of sherd surface area are used to visualise the distribution of the samples. For this I firstly apply a modified version of the Udden-Wentworth phi scale, which better distinguishes coarser sediments (Blair and McPherson 1999). This phi scale is convenient because measurements can be organised in same ordinal size categories, and thus compare different assemblages. Sherd sizes are usually between -4 and -8 ϕ, which corresponds to the gravel fraction (Table 6.2). In order to transform my data into this phi scale, the following formula is used:

$$\varphi = -\log_2(\text{Feret})$$

To visualise the degree of sorting of an assemblage, a common method consists in plotting cumulative frequency percentages again using phi values as size categories. Once plotted, the more vertical the curves, the greater degree of sorting of a given sample (Figure 6.4). In order to corroborate the observed datum, a sorting coefficient (So) is applied (Folk and Ward 1957, 13). The coefficient, a.k.a. inclusive graphic standard deviation, is calculated as follows:

$$\text{So} = \frac{\varphi_{84} - \varphi_{16}}{4} + \frac{\varphi_{95} - \varphi_{5}}{6.6}$$

In sedimentology, the closer values approach 0.1-0.3 the sample is considered to be very well-sorted, while values closer to 2 are said to be very poorly sorted (Folk 1966, Table 3). However, these values differ when considering sherds instead of sediment grains, and that is why sherd-size distribution tests as specified in section 6.1.2.6 had to be performed.

Particle Length		Grade	Class	Fraction	
mm	Phi (ϕ)			Unlithified	Lithified
4096	-12	Very coarse	Boulder	Gravel	Conglomerate
2048	-11	Coarse			
1024	-10	Medium			
512	-9	Fine			
256	-8	Coarse	Cobble		
128	-7	Fine			
64	-6	Very coarse	Pebble		
32	-5	Coarse			
16	-4	Medium			
8	-3	Fine			
4	-2	Granule	Granule		
2	-1				

Table 6.2: Gravel fraction from the modified Udden-Wentworth scale (after Blair and McPherson 1999).

6.1.2.5 Measuring and analysing shape

Two-dimensional morphometrics through image analysis is a widely known method in several disciplines (Campaña *et al.* 2016; Cox and Budhu 2008; Eramo *et al.* 2014; García-Granero *et al.* 2016; Kuo and Freeman 2000; Ros *et al.* 2014). However, there is little agreement on the best or most accurate representation of an object's shape (Rodriguez *et al.* 2012), as this partly depends on the type of object and context being studied (Rodriguez *et al.* 2013, 194). Based on morphometric tests performed previously (Vindrola-Padrós *et al.* 2019), I have selected three shape descriptors: sphericity, roundness and convexity, as they represent independent parameters (Barrett 1980, 292). I have also added the length-to-thickness ratio (S/W) as a fourth shape descriptor, which is a parameter not independent from size. By using fragment thickness, this parameter takes into account that potsherds have a platy form, and thus is a useful complement for sphericity (Vindrola-Padrós *et al.* 2019, 27).

According to Cho et al.'s (2006, 591) formulations, sphericity can be calculated as "the diameter of the largest inscribed sphere relative to the diameter of the smallest circumscribed sphere" (Figure 6.5). Using ImageJ/Fiji software, this required the use of the Maximum Inscribed Circle plugin (Burri and Guiet 2016) and Smallest Enclosing Circle macro (Schmid 2009). Hence, the final equation used was the following:

$$\text{Sphericity} = \frac{\text{Diameter of Maximum Inscribed Circle}}{\text{Diameter of Smallest Enclosing Circle}}$$

With sphericity, values close to 1 describe compact or equant objects. Also, within the description of fragment form, the S/W ratio was calculated. This corresponds to a simple division between fragment length over thickness (Kuna 2015; Květina and Končelová 2011; Řídký *et al.* 2014). In case of S/W, higher values represent more elongated shapes.

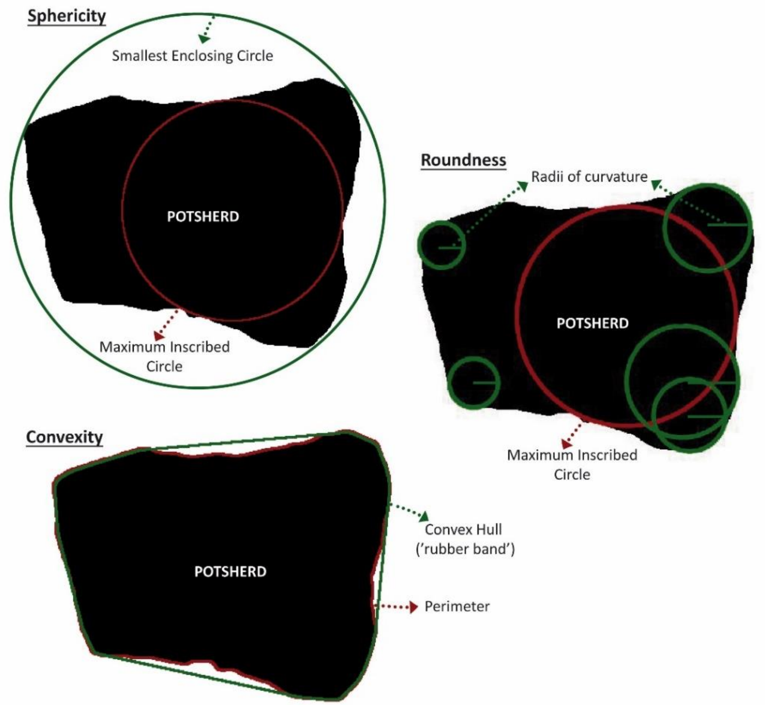

Figure 6.5: Software shape parameters (after Vindrola-Padrós et al. 2019[2]).

Roundness calculations followed Waddell's (1932) formula:

$$\text{Roundness} = \frac{\sum \frac{r}{R}}{N}$$

where *R* corresponds to the radius of the maximum inscribed circle in the object, *r* is the radii of curvature of corners and N the total amount of corners (Figure 6.5). In this way, the closer values are to 1, the rounder are the corners of the object. Problems with the use of this formula can be mostly attributed to manual or non-automated computational techniques, as measuring corners of every specimen can be a lengthy and time-consuming process (Krumbein 1941a, 65; Powers 1953, 117). Moreover, the selection of corners for calculating the radii of curvature ultimately depends on the eye of the beholder (MacLeod 2002, 32; Zheng and Hryciw 2015, 499). Nonetheless, its

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[2] Reprinted from Journal of Archaeological Science, 104, Bruno Vindrola-Padrós et al., Working with broken agents: Exploring computational 2D morphometrics for studying the (post)depositional history of potsherds, 19-33, Copyright (2019), with permission from Elsevier

accuracy usually remains unquestioned. In this dissertation I use a recently developed script in Matlab (Zheng and Hryciw 2015) to overcome these limitations. The code fully automates measurements of object roundness according to Waddell's formula, including the corner selection process, and significantly reduces time spent in obtaining measurements. The algorithm was tested against manual measurement of potsherds performed by Allen (1989), and these results are available in the supplementary material of Vindrola-Padrós *et al.* (2019).

Lastly, convexity was used as a descriptor of surface roughness of an object. The parameter is an inbuilt descriptor in ImageJ/Fiji software. Measurement is done through convex hull that surrounds the ROI and the outline length or perimeter of the object (Figure 6.5). The equation for convexity is formulated as follows:

$$\text{Convexity} = \frac{\text{Perimeter of the Object}}{\text{Perimeter of the Convex Hull}}$$

Smooth fragment edges are represented by high values, while lower ones correspond to more rough edges.

6.1.2.6 Sherd-size distribution and morphometric tests

A series of tests were created to monitor the reliability of the computational techniques and parameters used for distinguishing different (post)depositional processes. Samples consisted of potsherds from contexts where (post)depositional processes were known or could be determined, such as: different ploughzones (Cpl, Hpl), found *in situ* during excavations (Tsi), or broken in drop experiments (Vindrola-Padrós 2015; Table 6.3). In addition, data from tumbling experiments performed on organic-tempered fragments were also included in morphometric experiments (Beck *et al.* 2002). The data were obtained by processing and analysing figures from the publication. However, since this publication only included a representative from each abrasive stage, these are added to plots merely as a reference and not as a dataset (section 7.1.2). The expectation was that sherd-size distributions and morphometric values would show a high contrast between ploughed fragments, which are prone to secondary rupture and abrasion, and pots from primary rupture contexts.

With emerging trends on some of the sampled features, a series of statistical tests were performed to ensure their significance. Since the assumption in t-tests is that distribution is normal, data had to be normalised first by transforming it to $\log_2$ or $\log_{10}$. If distributions were normal, pairwise t-tests with Bonferroni adjustment (p=0.05) were undertaken. If data were still not normalised, a non-parametric test had to be performed, *i.e*. Mann-Whitney U test (p=0.05).

ID	Context	Site	Period	n1	n2	Fabric Type*	Grain Size	Hardness **
Cpl	Ploughzone	Călineşti-Oaş-D.S.M.	Neolithic	116	97	Organic temper (37.07%) Organic with mineral inclusions (51.72%) Mineral Inclusions (6.03%) Untempered (5.17%)	1-2mm	Soft
Hpl	Ploughzone	Homorodu de Sus	Neolithic	64	64	Mineral inclusions (10.94%) Organic temper (89.06%)	1-2mm	Soft
Tsi	Buried *in situ*	Tăşnad Sere	Neolithic	52	41	Organic temper (73.08%) Organic with mineral inclusions (26.92%)	1-2mm	Soft
Ep1	Drop experiment	IoA (UCL)	Modern	252	146	Mineral inclusions	<1mm	Soft
Ep2	Drop experiment	IoA (UCL)	Modern	49	17	Mineral Inclusions	<500µm	Hard

*Table 6.3: Samples used for sherd-size distribution and morphometric tests. n1=sample size for sherd-size distribution tests, n2=sample size for morphometric tests. *Percentages are given for the larger data set, i.e. n1. **Hardness was established qualitatively through Mohs' hardness scale and sorted into categories defined by Orton and Hughes (2013). These categories are described below.*

6.1.2.7 Analysing the spatial distribution of sherds

A spatial distribution analysis of fragments according to their sizes and shapes was also conducted. This analysis provides supplementary information on how fragments are deposited inside specific depositional environments, such as houses and/or pits (as discussed in section 6.1.1.3). In order to make a distinction with the term "sorting" as defined in section 6.1.2.4, I will refer to patterns where fragments are arranged by their size or shape within different areas of a depositional environment (such as inside houses or pits) as "spatial sorting" of fragments. Data from measurements of sherd surface area, sphericity, S/W, roundness and convexity were plotted according to horizontal and vertical units subdividing pits and occupation layers. This analysis was limited by the spatial resolution of excavation methods presented in Chapter 5.

6.2 Analysis of potsherd wear

Considering how pots might have been reused and repaired in Neolithic times (discussed in Chapter 4), the study of these practices is inextricably linked to the analysis of wear. Thus, wear traces were studied to establish the main uses of pottery fragments found in the contexts analysed, which would inform on the possibility of fragments being incorporated in other practices. These traces were also studied to obtain information on how vessels were perforated as a part of repair strategies.

6.2.1 Principles of wear applied to the study of repair and reuse of pottery

Wear can be defined as the "removal of material from surfaces in relative motion by mechanical and/or chemical processes" (Tabor 1977, 387). A first important implication of this definition is that the characteristics of the surfaces that are in contact with each other (such as topographical features, microstructural composition and texture, etc) and the nature of the interaction are what produce the loss of material. This loss can occur by microfracture, chemical dissolution, but also melting at the interface between two or more surfaces (Kato and Adachi 2001, 273). In this sense, wear should not be confused with abrasion as defined in section 6.1.1.2, as abrasion is only one of the mechanisms by which wear is produced (see below). It is also important to view wear as a reductive or subtractive process.

The study of wear involves the examination of surface topography (Adams 2002, 28–29). The surface topography is dependent on the microstructure and the surface treatment of the vessel. As with ground stones, in the surface of the ceramic specimen, areas of higher elevation are the first to come into contact with another surface, and they represent areas most prone to wear (Adams 2014, 130). In prehistoric ceramics, these elevation areas are more easily observed macroscopically on the fracture surfaces of sherds, but they can also occur in exterior and interior surfaces of vessels or fragments.

6.2.1.1 Wear modes and some common traces of repair and reuse of pots

In the tribological literature, classifications of wear involve four modes: adhesive, abrasive, fatigue, and corrosive (Kato and Adachi 2001, 273; Figure 6.6). As this last wear mode most commonly occurs in metals, and we are solely interested in ceramic materials, it is not considered any further. The other three wear modes are inextricably linked and on occasion difficult to separate, but they give us a framework and terminology to commence an assessment of wear traces on potsherds. Similarly, it is often the case that not one, but several wear mechanisms develop at the interface between surfaces.

In ceramics, adhesive wear characterises the fracturing produced by a strong adhesion at the point of contact between two surfaces (Buckley and Miyoshi 1984, 336; Kato and Adachi 2001, 277). Similar to ground stones (Adams 2014, 132), adhesive wear in prehistoric potsherds are more easily seen when loose grains are dislodged and attach to hands or sticky surfaces like wet clay. These dislodged grains can then act as abrasive agents. Abrasive wear involves the contact between hard and soft surfaces with the former penetrating the latter (Buckley and Miyoshi 1984, 337). Since in most prehistoric pottery the clay matrix is soft, abrasive wear is extremely common in repair and reuse activities (see below). Lastly, the continual friction at the contact interface between surfaces can generate fatigue fractures, and the resultant wear is termed fatigue wear (Kato and Adachi 2001, 278). For example, as in prehistoric ceramics and ground stones areas of elevation support most of the load when in contact with another surface, these are often crushed as the result of fatigue, generating "cracks, step fractures, and pits" (Adams 2014, 133).

[redacted]

Figure 6.6: Examples of the three wear modes described (after Kato and Adachi 2001).

These modes of wear are active in some common mechanisms involved in the (re)use of sherds and the repair of pottery, such as sliding (*e.g.* scraping or smoothing), incising or cutting, and drilling. Sherds utilised for scraping, smoothing or burnishing pots in a leather-hard or even completely dry state commonly show abrasive wear traces from hard inclusions in the pot (Binder *et al.* 1994; Godon and Lepere 2006; Hauzeur 1991; Magrill and Middleton 1997). Striations, *i.e.* shallow scratches (Adams 2014, 133), following the direction of movement are a common trace observed. In this regard, as ceramics are anisotropic, when the direction of wear follow the crystallographic plane, friction decreases and there is greater resistance to abrasion (Buckley and

Miyoshi 1984, 349). This can be a reason why striations are easily formed on potsherd scrapers (*e.g*. Van Gijn and Hofman 2008, 29), generally because the direction of wear runs perpendicular to grain or fibre orientation in the ceramic (see for example Figure 6.7d), which for coiled pottery is usually parallel to the vessel wall. Furthermore, if the abrading particle is smaller than the distance between the inclusions in the potsherd, the soft clay matrix of the fragment is eroded away and the hard particles on the potsherd's surface become elevated features, which has been termed pedestalled-tempering (Skibo 2013, 127). Grain pullouts as the result of both adhesive and abrasive wear are another trace commonly observed on sliding and grinding mechanisms (Cho *et al.* 1994), usually because of the poor bonding between grains and the clay matrix (Kovaříková *et al.* 2009, 7).

Commonly, the smoothness of exterior, interior or fracture surfaces of sherd tools can also be an indication of sliding mechanisms. If the surface of the potsherd is put in contact with a harder surface, for example large granite rocks that can be used for reshaping potsherds, then elevated topographical features (such as mineral inclusions and clay matrix of the sherd) are quickly levelled and smoothened through use. If the potsherd is used for scraping soft surfaces, such as hide, plants or wet clay, the surface topography is smoothened differently. These soft surfaces not only come into contact with elevations, but also touch the interstices and topographical depressions of the ceramic. In these interstices, soft materials act as cushions, and surface fatigue and abrasion are less severe. As a consequence, both elevations and depressions are slowly smoothened but not levelled (Adams 2014, 134). With some soft materials, a polish or sheen is also formed (Shamanaev 2001, 145; Vieugué 2015, Table 3; Figure 6.7b). Bright gloss is argued to be distinctive of hide processing, while dull sheen is observed on sherds used for working with plant stems and wood (Anderson-Gerfaud 1983; Vieugué 2015, Table 3).

Potsherds are also used for cutting or incising. These processes involve the application of a sharp particle against a softer surface at shallow angles (Bitter 1963, 9). In brittle materials, wear debris can be formed from cracking of surfaces when cutting or incising (Kovaříková *et al.* 2009, 7; Kato and Adachi 2001, 288–289). A clear example of incision are the potsherd tools used for decorating the surface of pots, where faceting, fine striations and rounding of the worked edge are the common traces (López Varela *et al.* 2002, 1143). In contrast, grooves, *i.e.* deep scratches (Adams 2014, 133), appear as the result of using potsherds as 'supports' for cutting or shaping bone or shell objects (Vieugué 2014, 105–106). Thus, in archaeological scenarios cutting and incising should be differentiated as they can be indicative of very different practices.

The use of potsherds for drilling is also often described. This entails a rotary motion with a sharp perforator. During drilling, several mechanisms occur at different contact points between surfaces. For example, in ceramics at the tip of the borer indentation and compression can occur, while cutting is prevalent in peripheral areas, where the cutting speed is higher (Heinemann 2014, 416). Indentation tests on industrial ceramics show that if the perforator is blunt, plastic deformation is the first result, followed by radial and circular cracking, but if it is sharp, radial cracking becomes the prevalent trace (Buckley and Miyoshi 1984, 337). Thus, indentation cracks are useful for identifying drilling mechanisms. Potsherd boring tools for perforating pots at leather-hard or dry stages acquire circular striations, rounded edges and even dents at the active surface (López Varela *et al.* 2002, 1141). The drilling of potsherds also happens as part of bead manufacture, or the perforation of spindle whorls or loom weights (e.g. Médard 2006; Torchy and Gassin 2010, 733; Vieugué 2014, 89–94, 98–100). During pottery repair, drilling is also commonly practiced (*e.g*. Cleal 1988; Dooijes and Nieuwenhuyse 2009; Guldager Bilde and Handberg 2012; Madsen 2009; Torcică 2010; White *et al.* 2009). Unfortunately, few use-wear studies have to my knowledge been performed on low-fired ceramics (*e.g*. Balesta and Zagorodny 2002; Girardet 1993). Thus, much of the evidence comes from engineering and lithic studies. A common set of traces recorded on drilled stone, bone and shell artefacts are rotational striations (Gurova and Bonsall 2017a, 163; Vargiolu *et al.* 2007a, 54). These striations are dependent on the raw material of the perforator and the material being perforated. For example, copper implements do not leave striations on marble (Gwinnett and Gorelick 1987, 20). Another important wear trace distinction can be made between through holes – perforations made by piercing through the workpiece entirely –, and blind holes – those that do not perforate the whole piece (Heinemann 2014, 416). Many Early Neolithic sherds possess one or both of these types of holes (Madsen 2009, 84; Vieugué 2014). The presence of both these types of perforations on single sherds can be the result of different types of uses given to potsherds or of the different choices made by the craftsman when drilling, such as deciding to drill at a different location halfway through making the first hole.

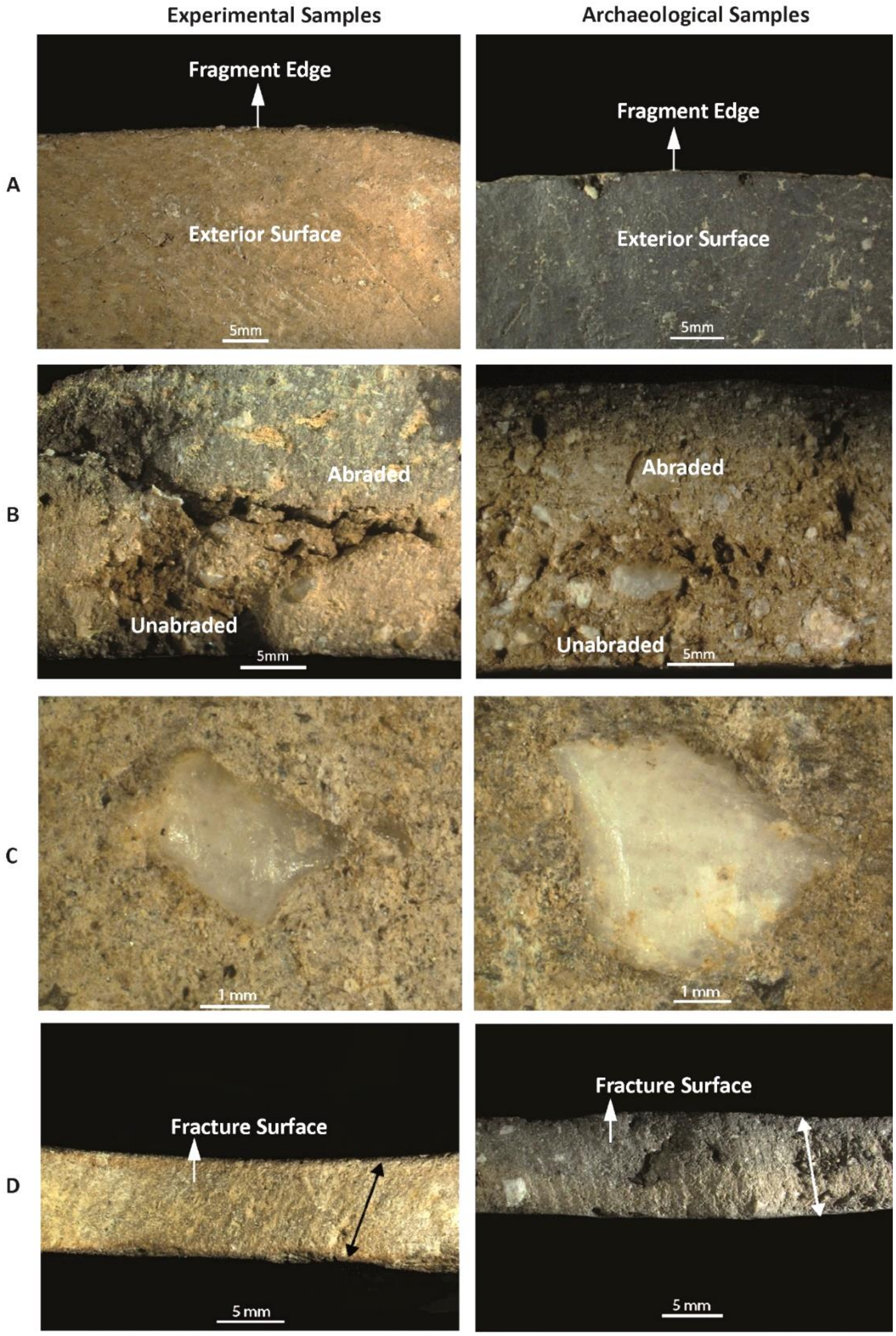

Figure 6.7: Common wear traces identified on archaeological and experimental potsherds used for working clays (after Vieugué 2015)[2]: regular worked edge as seen from exterior surface of fragment (A), clear boundary between abraded and unabraded areas on fracture surface (B), polish on mineral inclusion (C), and striations running perpendicular to vessel wall (D).

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[2] Reprinted from Journal of Archaeological Science, 58, Julien Vieugué, What were the recycled potsherds used for? Use-wear analysis of Early Neolithic ceramic tools from Bulgaria (6100–5600 cal. BC), 89-102, Copyright (2015), with permission from Elsevier

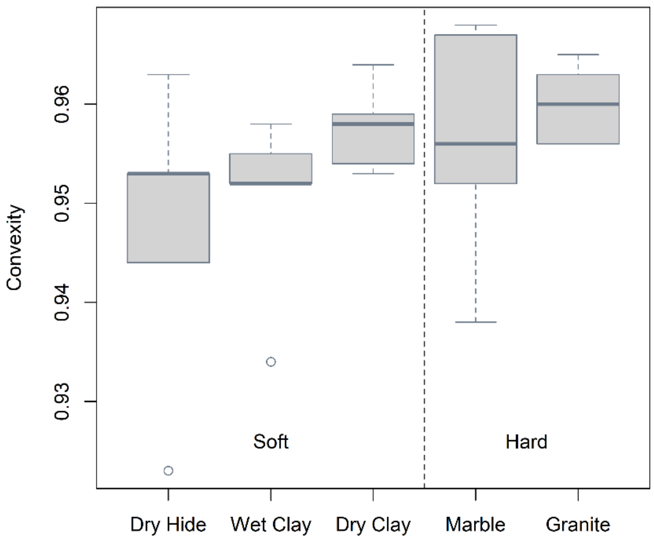


Figure 6.8: Edge roughness ('convexity', as defined in section 6.1.2.5) of sherds used to scrape different types of materials for up to 30 minutes (with permission by Julien Vieugué). N = 5 for each category.

Mechanisms less strictly related to wear, are percussion and thermal alteration of potsherds. Direct percussion is a reductive process recorded on pottery or glass sherds during processes of tool manufacture, such as Kimberley spear points (Harrison 2003), awls (Kehrberg 1992, 458), or cutting implements (Wilkie 1996, 44). Knapped sherds show conchoidal fracturing along their edges and on occasions, just like chipped stones, the direction and angle of the blow can be determined. Another, often overlooked, wear mechanism of potsherds is heating. Thermally induced fractures and plastic deformation are commonly developed during these mechanisms due to the differential expansion of surfaces in contact with the remaining body of the object. Traces that cannot strictly speaking be related to wear (*i.e.* they do not imply removal of material) but are common on reused fragments submitted to heating processes include sooting and recolouration. Despite their common occurrence in the ethnographic record, very few archaeological studies have addressed thermal-alteration as the result of potsherd reuse (Sullivan 1988; Sullivan *et al.* 1992; Van Buren *et al.* 1992). The potential uses associated with these traces can be varied including: heat retainers in hearths or ovens (Duričić 2014; Vuković 2015, 119), covers or supports for separating coals from food (Castetter and Underhill 1935, 25; Sullivan *et al.* 1992, 248–251), windbreakers and/or covers in pottery firing (Sillar 2000, 47; Stanislawski 1978, 221; Sullivan 1988, 27), or scoops for removing ashes or coals in fires (Van Buren *et al.* 1992, 96).

6.2.2 Terminology and diagnostic criteria

The following criteria were selected by the author according to results from several experimental and ethnographic studies on potsherd reuse, but also on some of the extensive use-wear literature on ground stones (Adams 2002; 2014; Dubreuil and Savage 2014). In the case of the use of sherds, most of the conclusive research done so far has been prolific on the traces produced by potting (Gosselain 2010; López Varela *et al.* 2002; Mayor 2010; van Gijn and Hofman 2008; van Gijn and Lammers-Keijsers 2010; Vieugué 2015; among many others) and hide processing (Shamanaev 2001; Vieugué 2015; cf. van Gijn and Hofman 2008, 32). Experimental research on wood and bone processing using sherds have ambiguous findings (Shamanaev 2001, 145–146; cf. Vieugué 2015).

A series of systematic studies on well-preserved potsherds in Neolithic sites, such as Vinča Belo Brdo (Vuković 2013; 2015) and Kovačevo (Vieugué 2014; 2015), provide a thorough description of the common diagnostic traces found in some European Neolithic assemblages. Hence, I have tailored some of the diagnostic criteria according to results from these studies. The wear criteria could be used for describing either fragment remanufacturing, as well as (re)use or repair related processes.

Before moving on to the criteria selected, first it is appropriate to clarify a few terms that will be used henceforth. The exterior and interior surfaces of the sherd are homologous with those of pottery vessels, while "fracture surface" consists of the area of the fragment created by the rupturing of the parent vessel or fragment (Figure 6.7d). I use the term "active surface" to indicate the area of the fragment that has been *worn by use*, which can be the exterior, interior and/or fracture surface of the fragment.

The following diagnostic criteria were used for recording wear from smoothing, sliding and scraping mechanisms:

- *Regularity of the worked edge or edge roughness*: This criterion refers to the surface roughness of the worked edge as seen in plan view (Figure 6.7a). Although relative to the hardness of the raw material being worked (Figure 6.8), the increase in use-time of the potsherd eventually generates smoother or more regular edges (Figure 6.7a).
- *Presence of striations and grain pullouts*: Striations are defined above as shallow scratches and provide information of the hand gestures, movements and the preferred direction of use for the utensil/tool. The latter is also indicated by grain pullouts, which are commonly dislodged in sliding mechanisms.

- *Wear traces on inclusions:* when inclusions are present in the ceramic material, the wear traces, like striations, chipping or of their smoothing, are an indication of the type of material being worked. This information can help identify the activities in which sherds performed. Striations on inclusions are also great indicators of the preferred direction of fragment use.

- *Extent of wear*: Refers to the worn area and can be an indication of the use-time of the fragment. It can be localised, partial or entirely covering the active surface. Nonetheless, the extent of the wear is relative to the hardness of the ceramic and topography of the sherd's active surface before use. Since ceramics analysed in this study are all mostly composed of organic temper (Chapter 7) and these ceramics are quickly affected by abrasion, the extent of wear was only significant in cases where very little amount of wear could be observed.

- *Outline of wear*: Refers exclusively to the boundary between worn and unworn areas as seen on the fracture surface of the fragment. As mentioned before, soft materials can smooth elevations, interstices and depressions on tools. Thus, boundaries between worn and unworn areas are diffuse and difficult to discern. In contrast, when working harder materials, these boundaries on the sherd's fracture surface are clear, as elevated areas are the only point of contact.

Less commonly found traces of percussion, cutting and thermal alteration were monitored using different parameters. In regard to percussion mechanisms, diagnostic criteria include the position, *i.e*. on which surface the potsherd could have been struck, and the direction of the blow as seen by the negative scars left on the fragment. Cutting mechanisms were deduced from the location, extension and distribution of grooves on the potsherds. Since most of the materials analysed were organic-tempered, and therefore porous, these parameters were important to differentiate grooves from naturally occurring opened concavities of the fabric. Thermal alteration was identified by the colouration changes, thermally induced fractures, and textures (*e.g*. pumiceous or bloated).

Lastly, in order to develop diagnostic criteria for assessing drilling mechanisms, a series of experiments were designed. These experiments were used to understand repairing practices and are presented next.

6.2.3 Experiment design of drilling mechanisms on potsherds

Given that experimental research on pottery repair holes has been lacking, and repair links to an important part of my theorised understanding of the social knowledge of breakage, a simple set of experiments were conducted to understand the conditions in which these traces were formed in the past and to what extent they reflect repairing or 'caring' strategies. Due to the fact that almost the entire number of perforated fragments studied in this dissertation came from the UTB (with the exception of one fragment from Eitzum) I decided to tailor the experiments according to information from this region. The research questions for these experiments included:

- Can we detect differences between perforator shapes and composition by studying the size, shape and surface texture of ceramic perforations?
- What hand gesture or manufacturing techniques can be identified?

Concordantly, two objectives were set for these experiments: through the analysis of blind holes in ceramics, (i) to detect differences of borer composition and shape, and (ii) to identify different manufacturing techniques. To accomplish the first objective, two procedures were designed: time-limited drilling and depth-limited drilling. A variable compared in both these experiments was the type of raw material of perforator. Both procedures were carried out with perforators manufactured with five types of raw materials: flint, limnic quartzite, obsidian, antler and stainless steel. The first three were materials commonly used in Early Neolilthic sites in the UTB and adjacent areas to manufacture perforators (Chmielewski 2012; Chmielewski and Astaloş 2015; Starnini 1993). Antler, particularly from deer, was not common in SKC sites (Tóth 2012, 176; Beldiman and Sztancs 2011), and there does not seem to be any direct evidence of use as perforators. However, this material was added to the tests as it has been found at two of the sites sampled for this dissertation, *i.e.* Méhtelek-Nádas and Tăşnad Sere, and while a distant possibility, it provides a good comparison with the other materials tested. Lastly, steel was used as a control. These perforators were used for drilling pinched ceramic discs manufactured from northwest Romanian clays, and the details of their manufacture are specified in section 6.3.2.1.

The first procedure consisted of hand-drilling ceramic discs in 30 second intervals with a type A perforator (Figure 6.9), without resharpening or retouching the tool. This provided a record of the evolution of the perforation and perforator through time. The second procedure involved hand-drilling the ceramic specimens until reaching at least half of the disc's thickness without resharpening the perforator. Furthermore, as lithic perforators in the UTB have been classified as mostly non-standardised tools made on either flakes or blades (Chmielewski 2012, 120), in this second procedure another variable was the shape of the perforator. Based on published literature (Chmielewski 2009; 2012; Mateiciucová 2007; Starnini 1993; Starnini and Szakmány 1998), four types of lithic perforator shapes (types A-D) were manufactured (Figure 6.9).

[redacted]

Figure 6.9: Types of lithic perforator shapes from Early to Middle Neolithic Sites in the Upper Tisza Basin and adjacent areas. The perforators are from Călineşti-Oaş-D.S.M. (11), Ecsegfalva 23 (5, 6, and 7), Endrőd 119 (3, 4, and 16), Méhtelek-Nádas (9, 14, and 15), Oros-Homokbánya (2, 12, and 13), Seini Dagas (1), Szarvas 23 (10), and Zăuan-Dîmbul Cimitirului (8). Image references: 1 (after Chmielewski 2009); 2, 8, 11, 12 and 13 (after Chmielewski 2012, Figure 73); 5, 6 and 7 (after Mateiciucová 2007, Figure 31.16); 4, 10 and 16 (after Starnini and Szakmány 1998, Figure 2 and 20); and 9, 14 and 15 (after Starnini 1993, Figure 30).

The second objective was identifying traces of different manufacturing techniques or gestures during drilling of ceramic discs. Two drilling techniques were used: hand-drilling and rod-drilling. Both techniques solely used flint perforators from types A to D. During hand-drilling the lithic artefact was held by hand and a rotary wrist motion was applied (a.k.a. thumb drill; Gurova and Bonsall 2017, 162; Figure 6.10), while rod-drilling involved hafting the lithic tool on a wooden shaft and rotating the composite tool with the palms of the hands (Figure 6.10). While other types of drills are sometimes mentioned in the literature, such as bow- or pump-drills (Gurova *et al.* 2014; McGuire 1896), it was assumed that the rotary motion and inclination of the tool created by these composite artefacts would not diverge substantially as compared to hand-drilling.

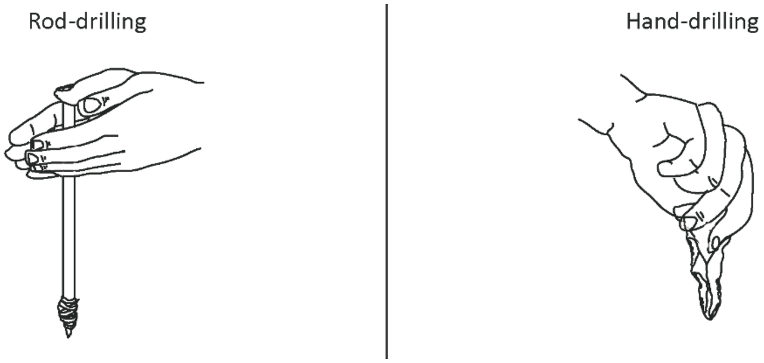


Figure 6.10: Example of hand and rod-drilling techniques tested.

6.2.3.1 Perforator manufacture

To manufacture the lithic perforators, common types of raw materials used in the UTB and adjacent areas during Early Neolithic times include: obsidian, flint and limnic quartzite (Chmielewski and Astaloş 2015, Tables 3-6; Mateiciucová 2007, 694; Starnini 1993; Starnini and Szakmány 1998). While limnic quartzite is a raw material commonly found throughout the broader Carpathian basin (Crandell 2014a; Szekszárdi 2005), it is the most compositionally variable of the raw materials mentioned. Consequently, it was obtained locally from an outcrop at Racşa in Oaş country (NW Romania). Since in the UTB lithic perforators were generally *ad hoc* tools or non-standardised tools (Chmielewski 2012, 120), different types of perforators had to be made according to the different shapes represented in the archaeological assemblages. While the variations in perforator shapes in the archaeological record are very likely to be the result of use rather than the manufacture, it was deemed important to monitor the geometry of the perforator's tip in the drilling procedure.

From every lithic raw material used in this experiment four types of perforators were made: A, B, C, and D (Figure 6.9; Appendix 6). Type A represents the *mèche de fôret* type perforators (Heinen 1998), and were here manufactured exclusively from blades. Types B, C and D are all manufactured from flakes, and their sole difference is the shape of the tip of the perforator that range from bottle-shaped to triangular. The flakes and blades were made by experienced knappers, one of which was familiar with Early Neolithic techniques in the Balkans and were retouched and shaped by the author using both hard and soft hammers. Retouching was performed by pressure and by direct percussion only on limnic quartzite, which was a harder material to work. For hand-drilling, the perforators had to possess a wider and longer proximal end than usual, and a thicker tip to withstand the pressure exerted by hand over the contact surface (Gurova and Bonsall 2017a, 162). The antler was sourced from an already deer. Since it is claimed that in SKC sites antler was mostly worked by scraping and abrading the material with rocks (Tóth 2012, 177), the tip of the antler was simply shaped into a sharp edge with a coarse sandpaper.

Lastly, for the second set of experiments, a simple rod-drill was manufactured using a wooden pine shaft and a leather strap to haft the perforator (Figure 6.11). The leather strap was tied in a wet state so that it would tighten when dried. For this experiment only flint perforators types A to D were used.

Figure 6.11: The rod-drill used for perforations, with a type A flint perforator hafted.

6.2.3.2 Recording methods and parameters measured

Due to the difficulties of obtaining measurements and generally examining perforations, microphotogrammetry was selected as a recording technique for both experimental and archaeological samples. The protocol was developed in conjunction with Vladimir Vilde (PhD student from the History of Art Department, UCL). The perforated discs and sherds were painted with two black dots (for calibration) and positioned on a rotating stand, and photographs were taken with a Dinolite microscope every ten degrees from two different angles for every hole (through or blind) on the sherd (Figure 6.12).

After image extraction, the three-dimensional shape of the perforations was created through a dense point cloud model. To construct this point cloud, the camera positions first need to be computed according to a structure from motion approach. This task was accomplished through the open-source software OpenMVG with the Akaze FLOAT setting set for feature detection. The data obtained were later converted to PMVS, which generated the point cloud. The model was calibrated, and its orientation adjusted. For the former process, the two painted black dots near the edge of the perforation were measured using the same recognition algorithm in the image and point cloud based on colour clustering.

The measurements detailed below were obtained from these point cloud models using Matlab, and a code was written to automate the process. This code worked well for the experimental samples, but more work will be needed to adjust the algorithm for archaeological samples. This adjustment is necessary because each archaeological object (in this case sherd perforations) had unique characteristics, due to the different preservation state and colours from the firing of the pots.

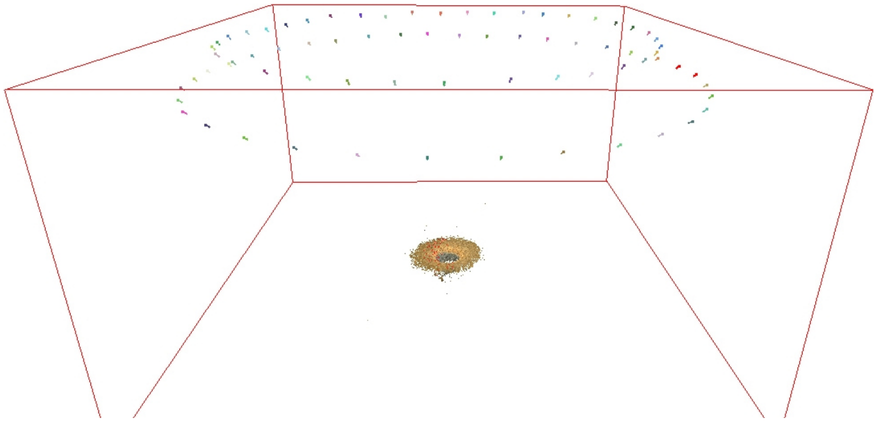


Figure 6.12: Positioning of cameras in pictures taken for micro-photogrammetry.

Once the 3D model was rendered and calibrated, a number of parameters were recorded to obtain information on the type of tool used. Using samples from the first procedure, *i.e*. the time-limited perforation, a parameter was calculated for each raw material to consider the *degree of effort* required to perforate the ceramic. The first one was simply the work-time compared to the depth of the perforation. This parameter is highly dependent on the hardness of the perforator, as the assumption is that harder materials tend to perforate the ceramics faster than softer materials.

The *topography of perforations* was analysed in order to distinguish borers of different composition. The assumption is that the roughness of the perforator is partly dependent on its composition and material properties, and that these differences are visible on the traces left on the wall of the perforation, such as the so-called ‘rotational striations’ mentioned in archaeological drilling experiments (Gurova *et al.* 2014, 49; Gurova and Bonsall 2017, 163; Vargiolu *et al.* 2007, 50). The parameter is calculated by the changes in the angles on the perforation’s surface. The angles are obtained by comparison with a reference vector, which in our case corresponds to the ‘flat’ surface of the fragment or disc where the perforation started. The angle distribution of the perforation wall is represented in a 3D normals figure and the distribution of angles is presented in a histogram (section 8.1.1 and 8.1.2; Figures 8.3 and 8.6). In the former figure, blue colours are indication of flatness or 0° angle, while red signals a completely vertical or 90° angle. The expectation was that the more brittle the perforator, the more frequently it would chip during drilling process, creating more ‘jagged’ perforation profiles. Therefore, antler or steel would leave smoother profiles in contrast to lithic perforators that would leave a rougher topography. Another plot used for visualizing the topography of the perforation wall was through a heat map signaling the variation of depth. This plot allowed visualising the consistency of rotational striations.

Two parameters, *i.e.* centre of ellipses and aspect ratio per depth, were used to obtain information on the gestural differences between hand-drilling and rod-drilling at different angles. The reasoning behind the selection of these parameters was that the differences in techniques would be mostly related to how the perforators are moved during the drilling process. In this way, hand-drilled specimens would show a lot more changes in the direction and angle of perforation, whilst rod-drill or hafted perforators would restrict this movement considerably.

Centre of ellipses per depth of perforation was chosen to detect the inclination of the perforator during the drilling operation. To calculate this parameter, the 3D model of the perforation is sectioned into slices, and an ellipse is fitted to each of them. The centre of the ellipse is then estimated and plotted. The expectation was that, due to the restriction of movement, the blind holes in rod-drilled specimens would have all the centres of the slices aligned. In contrast, hand-drilled perforations would show substantial deviation between centres, as the perforator would move from the constant repositioning of the perforator inside the blind-hole (Figure 6.13).

Lastly, the aspect ratio per depth of the perforation, as seen in plan, provides information on the manner in which the rotation of the perforator took place. Similar to the centre of ellipse, the three-dimensional perforation is firstly divided into slices, and an ellipse is fitted onto the outline of each slice in plan view. The aspect ratio of the ellipse, that is the difference between the long (a) and short (b) axis, was then calculated (Figure 6.13). The expectation was that rod-drills would create circular-shaped perforations, therefore an aspect ratio closer to one, while hand-drilled perforations would show a diverse range of values. Similarly, the diameter of the perforation by depth was also included in the discussion, to view similarities between perforator shapes used to drill the specimens.

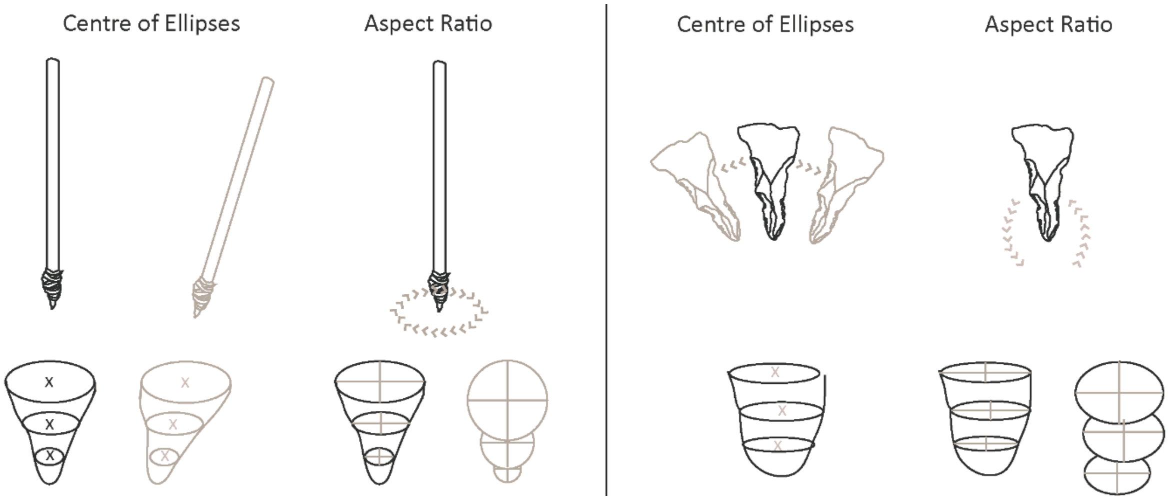


Figure 6.13: An idealised view of centre of ellipses and aspect ratio per depth according to drilling technique.

6.2.4 Sampling strategy

Samples selected for analysis were based on a criterion of preservation, *i.e.* potsherds with preserved traces that were unequivocally related to the reuse of fragments. Two sets of postdepositional processes affected the assemblages analysed. Firstly, in contrast to the sites analysed by Julien Vieugué (2010; 2015), many of the fragments from the SKC assemblages analysed had eroded surfaces due to specific soil conditions outlined in the previous chapter. Secondly, as finds processing at the sampled sites included brushing or gluing fragments together, in many occasions it was difficult to assess if traces were in fact related to (re)use of fragments. Furthermore, since Early Neolithic pottery from the UTB and NHF is low-fired and mostly contains organic matter, these materials are more sensitive to (post)depositional abrasive processes than the mineral tempered pots (Beck *et al.* 2002; Skibo *et al.* 1989; Vindrola-Padrós *et al.* 2019). Nonetheless, unlike postdepositional traces (Beck *et al.* 2002, 6–13), reuse and use-wear alterations are not extensive and are usually localised in specific areas of fragments (Vieugué 2015, 92). For this reason, worn and intact surfaces of the same fragment were systematically compared to assess the causes of wear.

Selected fragments were classified into types according to their use, repair or reuse trace and subdivided into categories consistent with Vieugué's (2014) typology (Table 6.4). Category U was added to include the possible use of refired fragments, for example in cooking or pottery firing practices. This classification of potsherds was needed to assess the appropriate techniques for examining specific use-wear or reuse traces (*e.g*. the use of microphotogrammetric techniques for studying perforations.

Category	Description
A	Fragment with intact exterior and interior surfaces, but with abraded fracture surface
C	Fragment with blind hole(s), but intact fracture surface
D	Fragment with through hole(s), but intact fracture surface
E	Fragment with both blind and through holes
H	Fragment with abraded exterior or interior surface(s) and intact fracture surface
J	Fragment with grooved interior or exterior surface and intact fracture surface
K	Rounded fragment with unmodified knapped edges
L	Rounded fragment with intact exterior and interior surfaces, and abraded fracture surface
U	Fragment with signs of refiring

Table 6.4: A revised version of Vieugue's (2014; my translation) ceramic tool typology.

6.2.5 Data collection and analysis

Examinations were performed macroscopically and microscopically under different magnifications (2x, 50x, and 200x), focusing on traces in the clay matrix of the fragment and some mineral inclusions found on the active surfaces of the sherds. It is important to note that since most fabrics were exclusively organic-tempered, only a few occasional inclusions were present for inspection. In order to differentiate use-wear traces from other abrasive processes, the active surfaces were always compared with the other unworn surfaces of the fragments (Vieugué 2015, 93). The differentiation thermal alteration from cooking from that of potsherd use was established by examining the location of the traces of refiring and in some cases by the contrast with contiguous refitted fragments (see for example Gordillo and Vindrola-Padrós 2017, 161). Following Vieugué (2014, 69), recording was tailored to the specific traces of shaping or use of potsherds encountered (Table 6.5; see section 6.2.2 for a thorough description). Polish could not be recorded, due to the postdepositional alterations of fragment surfaces in the sampled sites. For the study of perforations, micro-photogrammetric technique and parameters were used as detailed in section 6.2.3.2 and Table 6.5.

Lastly, the list of traces was assessed for each fragment to infer the processes that generated them and/or interpret how fragments were used. For example, some common fragment uses included scraping and smoothing of wet or dry clays in pottery forming activities.

Mechanism	Repair/Reuse Trace	Parameters Recorded
Smoothing, scraping or sliding	Smoothened and leveled surfaces	Regularity of worn edge, outlines of use-wear, traces of wear on mineral inclusions, and traces of chipping
Percussion	Negative scars	Position and inclination of knapping
Cutting	Grooves/cutmarks	Location, extension, and distribution
Heating or Refiring	Signs of refiring (colouration changes, deformation, bloating, thermally induced fractures)	Colour, texture, and presence of fractures
Drilling	Perforations	Topography of perforation wall, and the centre of ellipses and aspect ratio of perforation

Table 6.5: Summary of recording strategy of archaeological samples according to specific traces.

6.3 Failure analysis

This section completes the list of aims outlined in Chapter 1. Failure analysis was selected to determine how pots from the Upper Tisa Basin and the Northern Harz Foreland were normally broken, as this provides a deeper understanding of what Neolithic people knew about how their pots broke (*i.e*. second dimension of the social knowledge of breakage, section 2.3.4.2). This was conducted by simulating daily cooking activities through a series of experimental procedures. As stated in Chapter 2, the 'moment' a pot breaks does not exactly reflect the whole picture when determining the causes and sequences of breakage. In other words, there is a history of breaking that must be taken into consideration (Fréchette 1990, 5). In order to establish how pots were broken, we require knowledge on the composition of the materials under study, and the stresses these specimens are likely to have been submitted to throughout their history as vessels (Rausand and Øien 1996, 73).

The limited ethnoarchaeological lists the following common causes of breakage of pots: breakage by impact like dropping or knocking pots (DeBoer and Lathrap 1979, 129–133; Longacre 1981, 64), or by thermal fatigue or thermal shock (Hildebrand and Hagstrum 1999, 44; Tani 1994, 59). In household pottery assemblages, cooking pots and serving vessels are extensively used in daily activities, and as such they tend to be among the most commonly broken wares within households (Shott 1996, 471; Stanislawski 1978, 223; Varien and Mills 1997, 148). Concordantly, it is also highlighted that these wares, while often break through impact, are progressively affected by thermal stresses during their performance in cooking activities (Tani 1994, 59; Hildebrand and Hagstrum 1999, 27–28; Nelson 1985, 327). Thus, apart from impact, thermal stresses are important in the cracking of pots, regardless if breakage (*i.e*. catastrophic failure) occurs.

As already reviewed in Chapter 4 and 5, SKC and LBK pottery are predominantly organic-tempered with dung or wheat chaff (Cladders 2001, 40; Kreiter *et al.* 2014; Neumannová *et al.* 2017, 182), and their bases manufactured with flat pinched discs or spiral coils. More importantly, to better understand thermal shock during cooking it is necessary to consider how pottery bases were built, as these areas are commonly in direct contact to heat sources. As reviewed in sections 4.1.1.2 and 4.1.2.2, recent evidence suggests cooking was likely to have been performed with these vessels. In addition, some of my preliminary observations on pottery bases from C2/2005 at Tăşnad Sere and sampled features at Eitzum shown in section 9.1, indicate use-related exposure of pots to fire.

Therefore, the focus of failure analysis conducted here was on determining the likelihood of pots breaking during cooking. Accordingly, research questions (from general to specific) for this analysis can be phrased as follows:

1. How did the organic-tempered pottery from the Early Neolithic sites in the Upper Tisa basin and in the Northern Harz region normally break?
2. Is the exposure to thermal stresses from cooking activities a cause of breakage for these ceramic vessels? To what extent did these activities promote crack growth in these containers?
3. How resilient are these vessels to thermal shock? What are the effects of organic temper (*i.e.* dung and chaff)? What are the effects of coiling and pinching techniques?

Before continuing with the experiment design, a few principles regarding thermal shock behaviour are presented.

6.3.1 Thermal shock resilience of ceramics

In many archaeological and ethnographic cooking scenarios, pots are exposed to different heating and cooling conditions, which generate thermal stresses. Thermal stresses occur from temperature gradients (Kingery 1955, 3). In multiphased ceramics, when heating or cooling takes place, these stresses are twofold: (i) those arising from the differential expansion and contraction of the different microconstituents of the ceramics (Rice 1987, 363), and (ii) those arising from the differential expansion and contraction of the ceramic in different locations (Bronitsky 1986a, 38). These stresses are highly dependent on the heating conditions. If heating conditions are uniform, stresses uniquely originate from (i), but if they are non-uniform, both (i) and (ii) occur (such as in a pot where the outside is hotter than the inside).

A common cause for ceramic failure triggered by thermal stresses is thermal shock. This can be defined as a "sudden [and one might add drastic] transient change of temperature" (Kingery 1955, 3). Thermal shock resistance, which will be termed here as 'resilience' due to our use of the word resistance for a larger theoretical construct (as stated in Chapter 2), can be defined as the ability of a material to endure quick temperature changes without failing (Kingery *et al.* 1976, 822). Due to their brittle nature, failure in ceramics occurs through fracture, and thus ceramic materials can be resilient to thermal shock in two ways: by preventing crack initiation or by reducing crack propagation (Hasselman 1969).

In brittle solids like ceramics, fracture is a function of the defect population, *i.e*. the severity, amount and location of flaws in the material. When thermal stresses are applied, either by (i) or (ii), these flaws act as stress concentrators and cracking occurs when the "strain energy released is equal to the surface energy created" (Kingery 1963, 292). In conditions of thermal shock, there is not enough time for heat conduction to take place (usually due to poor thermal conductivity), and the stress (σ) can be given by the following formula (Tite *et al.* 2001, 313):

$$\sigma = \frac{SE\alpha\Delta T}{1-\mu}$$

Where,

ΔT = temperature difference,
E = Young's modulus,
α = thermal expansion coefficient,
μ = Poisson ratio, and
S = geometric constant dictated by the shape of the pot (*Ibid.*).

By rearranging this formula (*Ibid.*), we can state that when the stress, resulting from a high enough temperature difference, matches the fracture strength (σ_f) of the ceramic, cracks are formed:

$$\Delta T_c = \frac{\sigma_f(1-\mu)}{SE\alpha}$$

Thus, for a ceramic to be resilient to thermal shock, one strategy is to reduce the chances of failure by decreasing the number of flaws per unit of volume, *i.e.* increase the fracture strength of the ceramic. Fracture strength is often defined as the amount of stress a material can withstand before a crack initiates (Müller 2016b, 610). This can be attained by manufacturing vitrified ceramics, which have good thermal conductivity and high fracture strength. However, much like glass, once cracks are formed, the result is catastrophic for these materials, as there are no phases to stop cracks from propagating.

The second way ceramics can be resilient to thermal shock is by restricting crack propagation. If no external loads are applied, during thermal shock the main driving force for propagating cracks is the ceramic's stored elastic energy (Tite *et al.* 2001, 314). In brittle solids a crack will propagate uncontrollably if the release of stored elastic energy associated with this crack is greater than the energy required to create a new crack surface (a fundamental component of Griffith's (1920) criterion). The intrinsic or stored energy during crack initiation plus the energy dissipated during the generation of a new surface is termed fracture energy (Müller *et al.* 2014, 264). By modifying Griffith's formulations, fracture by thermal stress would not lead to catastrophic failure if "the total elastic energy is less than the fracture energy required to propagate a crack over an area equivalent to the cross sectional area of the specimen" (Hasselman 1969, 600). Therefore, a ceramic with high fracture energy, often equated with toughness (Müller *et al.* 2014, 264), can also be resilient to thermal shock. In other words, to increase the thermal shock resilience of a pot it is not necessary to focus on preventing cracks by reducing the amount of flaws, but on stabilising crack propagation (Kingery *et al.* 1976, 830). Thus, thermal shock resilience can be increased through the addition of heterogeneities, such as temper, which act as energy dissipators.

6.3.1.1 Factors influencing thermal shock resilience of tempered ceramics

The thermal shock resilience of a pot is dependent on many factors: the material properties of the ceramic (such as thermal expansion and conductivity, and strength/toughness; Davidge 1979, 122; Müller *et al.* 2014, 263), the size and geometric characteristics of the vessels, and the conditions of heating and cooling.

Two material properties are important to consider: the coefficient of thermal expansion and the thermal conductivity of the ceramic and its constituents. The first of these properties is easy to conceptualise. Since thermal stresses are caused by the expansion of the ceramic matrix or its other constituents (*e.g*. temper), how much a material expands has an effect on the severity of the thermal stress. Some engineering materials are designed to address the issue of crack initiation by reducing the coefficient of thermal expansion, which prevents crack initiation is prevented and reduces the energy required for crack propagation (West 1992, 13). However, this requires the manufacture of high-temperature ceramics, which are not of interest to us here.

The ability of a material to transfer heat, a.k.a. its thermal conductivity, is another important factor (Müller 2016, 620). When heat is not transferred uniformly across a material, a temperature gradient is formed. Temperature gradients can generate thermal stresses when the body being heated cannot freely expand (Kingery *et al.* 1976, 817). Thus, under conditions of thermal shock, the thermal conductivity of the material can influence the intensity of the thermal stress. Most archaeological ceramics are tempered, which is detrimental for heat conductivity and thermal shock resilience of the pot, as it creates a larger temperature gradient (Hein *et al.* 2008, 42). Similarly, porosity decreases the thermal conductivity of the specimen, as pores behave as heat obstructers, generating a larger temperature gradient (Coble and Kingery 1955; Hein *et al.* 2008, 36). However, in certain situations low thermal conductivity can be beneficial (Kingery 1955, 11). For example, despite their low conductivity, limestone temper in ceramic crucibles, are beneficial in reducing heat loss, which happens due to cracks formed by lime hydration (Allegretta *et al.* 2014, 108).

Other material properties that should be considered are strength and toughness. Both have already been defined and their implications for thermal shock resilience considered above. Materials science testing on replicates of archaeological pottery mostly illustrate that the addition of temper increases the toughness of the ceramic, which in turn increases the thermal shock resilience of specimens through energy dissipating mechanisms (Bronitsky and Hamer 1986a; Müller *et al.* 2014; Müller *et al.* 2015; Skibo *et al.* 1989; West 1992).

Vessel geometry and thickness also play a role. It is stated that the more spherical the vessel is, the better the heat transfer properties (Amberg and Hartsook 1946, 448; Bronitsky 1986a, 38). However, the effects of pot geometry has also been recently addressed by using a finite element method (FEM), which showed that under low temperature heating (up to 100°C) flat-based pots possess a higher heat conductivity than globular pots (Hein *et al.* 2015, 49). Furthermore, thick vessel walls is stated to be detrimental for thermal conductivity, which in turn creates a larger temperature gradient (Bronitsky 1986a, 38; Kingery 1955, 9; Rice 1987, 369). Yet, research about the influence of these two variables is limited.

Porosity can increase thermal shock resilience by improving vessel toughness, as pores arrest cracks and decrease thermal stress (Vokaer 2010, 118). However, porosity can also significantly reduce heat conductivity (Hein *et al.* 2008, 36), in turn creating thermal gradients that may be conducive to an increase in thermal stress (Kingery 1955, 8; Rice 1987, 363). Thus, porosity can also reduce the resistance of a ceramic specimen to thermal stress (Coble and Kingery 1955, 37). This ambiguity certainly warrants a more detailed analysis.

The heating and cooling conditions are fundamental for understanding the thermal shock behaviour of ceramics. In cooking scenarios, where pots are placed over or near a fire, heating is not uniform, as it is generally only a part (*i.e*. the base or a section of the vessel wall) of the exterior surface of the pot that is heated (Skibo 1992, 152–157). In addition to the stresses mentioned above (i and ii), in these cooking procedures ceramics will create tension between heated and non-heated areas (see also Hein *et al.* 2015).

6.3.1.2 The effects of organic fibre temper on the thermal shock resilience of low-fired ceramics

Considering the Neolithic pottery analysed here was tempered with organic fibres, it is important to review the effects these have on the thermal shock resilience of ceramics. The effects of thermal shock on organic- and fibrous-tempered pottery has been tested for mohair (goat hair), and sisal (leaf) by West (1992), and for horse manure by Skibo *et al.* (1989). Both papers provide information on the resilience of the material to crack propagation rather than initiation. Load-displacement curves presented by West (1992) highlighted an inverse correlation between the firing temperatures of fibrous specimens with their crack propagation toughness (*Idem*, 79–84). While this effect has been mostly attributed to the increase of porosity in low-firing temperatures (West 1992, 25), often in organic-tempered pottery some charred remains and mineral components of the fibres are preserved even after the pots are fired (Mariotti Lippi and Pallecchi 2017, 566), and thus it is possible these fibres have some effects in energy dissipation mechanisms.

No descriptions of cracking mechanisms and patterns, as well as fracture surfaces (*e.g*. Buessem and Bush 1955, 32; Danzer *et al.* 2008, 277–278), in organic-tempered pottery (*e.g.* Gogotsi *et al.* 1977; Xu *et al.* 2014) exist. Moreover, neither cow dung- nor wheat chaff-tempered ceramics have been tested. Therefore, in order to answer the questions posed above it is essential to firstly determine how cracks are developed in ceramics tempered with chaff and cow dung when submitted to thermal stresses. This entails understanding the specific fracture patterns, energy dissipation mechanisms, and mode of fracture of the fibre-tempered ceramic specimens.

6.3.1.3 The effects of coiling on the thermal shock resilience of low-fired ceramics

Once more, considering that SKC and LBK pottery bases were sometimes manufactured with coils (sections 4.1.1.2 and 4.1.2.2), the effects of coiling on thermal shock resilience are reviewed next. To my knowledge there is no literature considering the effect of coiling techniques on the thermal shock resilience of ceramics. For this reason, the following formulations are purely theoretical, and simply provide a background for making an educated guess in the following section. In theory, the main effects of coiling on ceramic microstructure are twofold: (i) orients particles along the coils and (ii) creates space for thermal expansion of clays in areas between coils.

In the study of pottery manufacturing techniques, it has been shown that coils tend to align non-spherical particles along the walls of vessels (Berg 2008, 1185; Rye 1977; 1981, 68; Shepard 1956, 183–184). If pottery bases were coiled in a spiral, such as the Neolithic pots studied here (Appendix 2), this forming technique would create a concentric particle alignment. Particle alignment, particularly of platy and fibrous additives, has been hypothesised to increase thermal shock resilience based on evidence of the increase in fracture energy of tempered ceramics (Müller *et al.* 2015, 841). However, this is relative to the direction of the applied stress, as multiphased ceramics with oriented fibres are "usually strong in one direction and weak in others" (West 1992, 20).

Coils in pottery also introduce weak areas in the joins, where cracks can propagate (Rye 1981, 67). However, these weaker areas could assist in diverting cracks, and thus dissipating energy from the applied stress. Alternatively, these areas of weakness could improve thermal shock resilience by allowing room for thermal expansion of clays, which would prevent the initiation of cracks. Japanese potters from Hida Folk Village, an open-air museum in Takayama (04/05/2019), have explicitly mentioned to me how grooves made in bases can assist clay expansion when placing vessels directly over the fire.

6.3.1.4 Methods for estimating thermal shock resilience

A first approach to estimating thermal shock resilience in tempered ceramics is by obtaining information on other material properties of the ceramic. One commonly measured property is toughness (K). A standardised flaw is introduced in the ceramic, normally by notching or indenting it. The specimen is then mounted on a three- or four-point-bend Instron Mechanical Tester (Kilikoglou *et al.* 1998; West 1992). The data are visualised in load-displacement curves, which show the stability of crack propagation (Figure 6.14). The more stable the crack, the more resilient the ceramic is to thermal shock. Other researchers have established thermal shock resilience of pots indirectly by measuring other material properties, such as the thermal diffusivity, apparent porosity, elasticity, and tensile strength (Steponaitis 1983; 1984).

A second and more direct approach involves exposing the ceramic to thermal shock by heating and quenching samples usually in a medium like water. In most studies, specimens are then submitted to a standardised test, such as three-/four-point bend machine or an impact tester, and thermal shock resilience is estimated according to the residual strength of the specimen (Bronitsky and Hamer 1986a; Müller *et al.* 2014; Skibo *et al.* 1989; Warfe 2015). In another study, the survival rate of specimens according to a fixed set of thermal shock cycles are used as an estimation of thermal shock resilience (Reid 1989).

Limitations of both these approaches are often not mentioned, but undoubtedly include the fact that thermal shock resilience is always indirectly estimated by the residual strength of the specimen. Through these approaches, energy dissipating mechanisms cannot be understood in detail. Secondly, since thermal stresses occur without the application of a load, submitting samples to bend or impact tests substantially changes the nature of the stress. Furthermore, considering that temper particles are often aligned in different ways, it is possible that final thermal shock resilience estimations are partly influenced by the direction of the load, whether it is through impact or bending. Lastly, by using water as a medium for either heating or quenching, these methods add other factors, such as the permeability of the specimen. For example, theoretically a permeable ceramic specimen could cool down quicker than a less permeable one when cooled directly in water at room temperature.

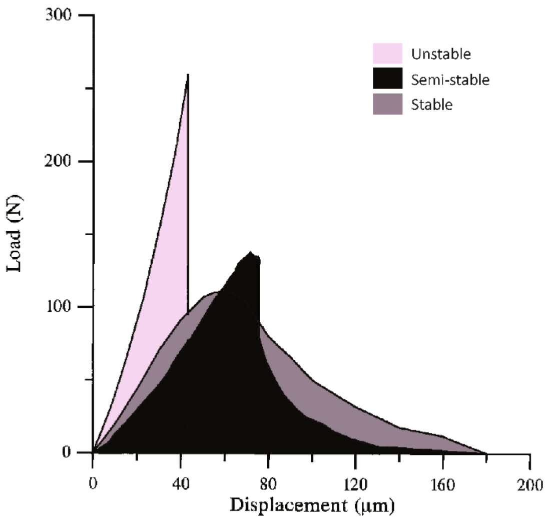


Figure 6.14: Example of 'typical' load-displacement curves obtained through three-point-bend tests, and the different modes of fracture (after Tite et al. 2001, with permission by copyright holder).

Thermal shock resilience can be determining by directly measuring the thermally induced cracks in the ceramic. With a thermal cycler (see section 6.3.2.2), ceramics can be subjected to thousands cycles of thermal shock at a fixed temperature, and crack initiation and propagation can be closely monitored. Here, the thermal shock resilience of specimens can be estimated in three ways. Firstly, if specimens fail, one can obtain the survival rate of the specimens according to the exact number of cycles the specimen survived. If specimens do not fail, then two other parameters can be used: crack growth and crack path tortuosity. In terms of thermal stresses, stronger materials will require higher amount of energy in the form of temperature change for crack initiation (Bronitsky 1986a, 40), and thus untempered specimens are unlikely to develop cracks. However, in tempered ceramics thermal shock resilience has been mostly linked to the ability of the material to reduce crack propagation. For this reason, crack growth and crack path tortuosity can be another way of estimating thermal shock resilience (*e.g*. Qi *et al.* 2019). The former simply refers to the increase in crack length under cyclic loads or stresses. In principle, the longer the crack is, the less effective the material is at arresting cracks; hence, the lower its thermal shock resilience. However, crack arrests are not the only way in which energy can be dissipated by a ceramic material, which is why tortuosity was incorporated as another parameter. Tortuosity can be defined as the degree of twistedness of a crack (Akhavan *et al.* 2012), where more tortuous cracks have more turns. Crack path tortuosity is influenced by the toughening mechanisms at play in the ceramic, such as crack tip deflection. This was the approach taken in this dissertation, as it allows direct observation of crack propagation and energy dissipation mechanisms without submitting samples to different types of stresses.

6.3.2 Thermal shock experiment design

Ceramic discs designed to represent vessel bases were created using three different compositions and two different manufacturing methods. Bases were selected because these areas are thought to be the main part of the vessel in contact with heat source and thermal stresses. With the use of a thermal cycler (see section 6.3.2.2), the discs were submitted to thousands of thermal shock cycles reaching a maximum temperature of 600°C and cooled to room temperature without use of any liquid. The maximum temperature was selected to represent the harshest conditions possible during cooking practices, based on published ethnographic and experimental data on cooking scenarios (Duričić 2014, 269; Gur-Arieh *et al.* 2013, 4338; Portillo *et al.* 2017, 132).

The aim of the experiments was to firstly understand the effects of organic fibre-tempered ceramics and coiling on the thermal shock resilience of low-fired ceramics (*e.g*. Bronitsky and Hamer 1986b; Müller *et al.* 2014; Neupert 1994; Tite *et al.* 2001), and secondly understanding the nature of crack initiation and propagation in these ceramics under specific conditions of thermal shock. Thus, the ultimate goal is not to determine the potter's 'rational' choices for improving vessel performance in cooking activities, but simply to understand how these materials behave under specific conditions and their implications for the development of a social knowledge of breakage.

The objectives are then as follows:

1. Establish the mode of fracture of the specimens (*e.g*. Stable or Brittle).
2. Identify the main energy dissipating mechanisms, cracking and fracture patterns of the organic fibre-tempered microstructures exposed to thermal shock.
3. Determine the resilience of organic fibre-tempered low-fired ceramics (either with cow dung or chaff), and of coiled and pinched ceramics.

Based on these objectives and materials science principles stated above, two main hypotheses were set:

1. Organic temper (chaff or dung) increases the toughness of specimens through energy dissipating mechanisms generated by pores and non-fully combusted fibres, which makes them more resilient to thermal shock.
2. Coils in untempered specimens increase the thermal shock resilience of the ceramics by preventing crack initiation, as the spaces between coils allow clays to expand and relieve tensions created by thermal stresses. In organic-tempered specimens, coils reduce the strength of the ceramic by introducing more flaws but increase toughness by aligning voids and fibres perpendicular to the applied stresses, which would also increase the thermal shock resilience of these specimens.

6.3.2.1 Sample preparation

A total of 60 ceramic discs were manufactured. Ten discs were made per variable (this number follows suggestions by Shepard 1956, 134; cf. American Society of Testing Materials Standards), which included three types of fabrics made with two different manufacturing techniques. However, only one disc per parameter could be tested for thermal shock (Table A7.4 in Appendix 7), due to time constraints generated by several problems with the equipment. The three types of compositions tested comprised: chaff-, dung-, and untampered. Chaff and dung were selected because these are the two sources of organic temper identified so far in Early Neolithic SKC and LBK pots. The tempered discs were made with 5g of dry dung or chaff per 100g of dry non-micritic micaceous clay obtained from the town of Tășnad Sere (northwest Romania).

These proportions approximated the 25-30% volume estimates of organic matter from petrographic and experimental studies (Neumannová *et al.* 2017; Seidler and Amicone 2017). Additional information on clay selection and processing is given in Appendix 7. Untempered discs were used as a control, and in this way two extremes are established in terms of porosity: slightly porous untempered and highly porous organic-tempered specimens.

Two manufacturing processes were used in the attempts to reproduce the Neolithic manufacturing techniques of pottery bases, *i.e*. pinched/pressed and coiled. Following suggestions from Hein *et al.* (2008, 37) on specimen preparation, discs were manufactured using a plastic mould one centimetre thick and six centimetre diameter. Pinched specimens were simply pressed into the plastic moulds and then smoothed over with a rolling pin. For creating the coiled specimens, a clay extruder with a 12mm opening was utilised. This device not only ensured a standard size of coils, but also that particles were consistently oriented. After coils were confectioned, they were gently pressed inside the plastic mould in a spiral from the centre to the periphery. These specimens were then also smoothed using a rolling pin.

All tempered and untempered specimens were left to dry in their moulds for a week in open air conditions, and then dried without their moulds at 110°C for 24 hours to avoid cracking. Specimens were fired at 800°C for one hour and left to slowly cool down for 36 hours. This firing temperature was selected based on results from compositional studies on SKC and LBK pottery cited in Chapters 4 and 5, and on the basis that at this temperature the porosity of specimens would be at its highest (Rice 1987, 351).

Before thermal shock procedures, a few variables were monitored to ensure the size, geometry and texture were consistent in all specimens. The length, sphericity and circularity of specimens were calculated using image analysis techniques specified in section 6.1.2, while specimen thickness was measured manually with a Vernier caliper. Sphericity was calculated according to the formula given in section 6.1.2.5, and circularity was estimated as follows:

$$\text{Circularity} = 4\pi \times \frac{\text{Area}}{(\text{Perimeter})^2}$$

Lastly, specimens were also radiographed before experiments to make certain that no significant macro-cracks were formed during manufacture, and to observe the differences in void and fibre orientation according to manufacturing technique. X-ray radiographs were obtained from a X-tech µCT cabinet with a Dextela 2923 CMOS detector (resolution of 75µm). Radiographic settings varied slightly according to specimen but ranged between 50kV with 110A and 55kV with 90A. All these results are presented in Appendix 7.

6.3.2.2 Equipment: The thermal cycler

The thermal cycler apparatus consisted of two opposing 1000kW light bulbs surrounded by elliptical reflectors (Figure 6.15), but for our experiments only one of these bulbs was used. Samples were placed on a specimen mount, and a thermocouple was attached to the side of the specimen being directly heated. Both the thermocouple and the device are connected via a serial port to a computer that records temperature fluctuations and controls the heating. When the device is turned on, the reflectors focus the beam of light generated on the flat surface of the ceramic specimen. In this way, temperatures created by this device can exceed 1000°C in a matter of seconds, but for our purposes these did not exceed 700°C. Once the set temperature is reached, the light is turned off until the temperature reached 350°C, upon which the process starts again. Before testing, the distance between the heat source and the specimen mount was calibrated to ensure only the centre of the discs was being heated. The device allowed submitting samples to a thousands of cycles in approximately six hours and 40 minutes.

Figure 6.15: The thermal cycler apparatus created by Adam Wocjik with a ceramic disc specimen mounted.

6.3.2.3 Procedures

Specimens were wet polished on one of the exterior surfaces until flat and then dried before thermal shock tests. Afterwards, specimens were placed on a specimen mount and heated non-uniformly at the centre of the polished side. The heat was applied until the thermocouple attached to the specimen marked 700°C, at which point the heat was turned off and the specimen left to cool down naturally down to 300°C. This was repeated a thousand times, with each cycle lasting 24 seconds.

After a thousand cycles, specimens were impregnated with a fluorescent particle inspection dye to highlight cracks, wet polished, dried at 220°C for an hour, and photographed. It is important to mention that dye penetration techniques on ceramics mostly highlight surface breaking macro-cracks under UV light (Wobker 2015, 125), which is why X-ray radiographs were also used to observe internal cracking. These radiographs were taken with two settings: at 55kV and 90A, and at 50kV and 110A. These procedures were repeated once more to two thousand cycles.

6.3.2.4 Data processing and analysis

Crack length and crack tortuosity (T) were measured with the use of photographs of specimens under UV light. Cracks were segmented through Enhance Contrast filter and then selected by Colour Threshold command in ImageJ. Images were then binarized and cracks with gaps were filled through directional filtering (MorphoLibJ plugins; Legland *et al.* 2016). Lastly, cracks were thinned down with the Skeletonize command in order to facilitate measurements. Lastly, the Geodesic distance of crack paths were determined through Geodesic Diameter function (MorphoLibJ plugins) and a simple Feret measurement from the inbuilt ImageJ particle analyser functions. The Geodesic distance was used as the crack length of the longest visible crack.

Tortuosity was calculated by considering the range of angles displayed by different segments of the longest crack. After the crack was segmented, as indicated above, it was partitioned into segments of 100µm, and the angle of each segment obtained by inbuilt features of ImageJ/Fiji particle analyser. Tortuosity was then calculated by the following ratio:

$$T = \frac{Q_3}{Q_1}$$

where Q_1 and Q_3 correspond to the first and third quartile of the distribution of angles from the different crack segments.

Qualitative information on the type of energy dissipation mechanisms were also described through microscopic examination of dyed discs. These may include energy dissipation by crack branching, arrest, deflection, bridging, or lamination (West 1992, 19–21; Müller *et al.* 2010, 2458). These results are presented in section 9.2 and 9.3.

6.2.3 Three-point-bend tests

The flexural strength of specimens was measured independently as part of a *post hoc* test to support results from thermal shock experiments. For this purpose, a three-point-bend test was conducted on unshocked ceramic discs using a Hounsfield HK55 testing machine (Figure 6.16). Three ceramic discs per parameter were tested, and they were manufactured in the same way as specified for the thermal shock tests (Table A7.4 in Appendix 7). Specimens were placed with a support span of 25mm and set at a continuous crosshead speed of 100µm/min.

A few clarifications must be made first regarding the changes made to this standardised test. It is important to note that these tests are usually conducted using rods or beams, and flexural strength is then calculated using the following equation:

$$\sigma = \frac{3FL}{2bd^2}$$

where,

F = breaking force in Newtons,
L = support span,
d = depth or thickness of the specimen, and
b = width of specimen

Another important requirement for this test is that the ratio between the depth or thickness of the specimen and the distance between the supports should at least be 1:15.

Manufacturing rod- or beam-shaped specimens would have either altered the fabrication process substantially (particularly the coiling), making the comparison with thermal shock specimens difficult, or introduced additional defects if discs were manufactured as discs and then cut. By maintaining the disc shape and dimensions, results from thermal shock and strength tests can be better compared. Given the cylindrical geometry of the samples made for this test, however, the standard formula for flexural strength could not be used. Thus, to make results comparable to the published literature, flexural strength was calculated through finite element analysis (FEA) using the information obtained from the three-point-bend test (see below).

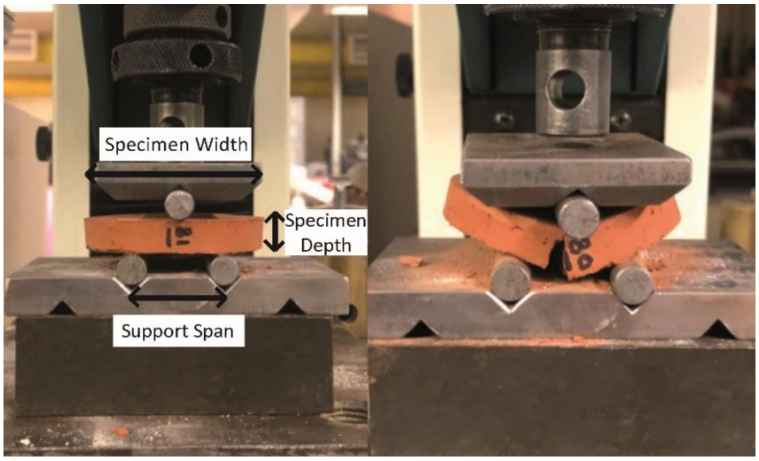


Figure 6.16: Set up for the three-point-bend test on ceramic discs.

Lastly, this standardised test can also provide quantitative information on the feasibility of stable crack growth (Kilikoglou *et al.* 1998; Müller *et al.* 2014). To perform these tests, authors usually notch the specimens before mounting them in the bend tester, which generates a consistent defect in all specimens. However, for our tests, the decision was made not to notch the discs as this would reduce the effect of randomly distributed defects in the organic-tempered samples, which was shown to be an important contributor to thermal shock resilience (see section 9.2).

6.2.3.1 Finite element analysis

Finite element analysis (FEA) is a numerical method commonly used by engineers to assess the stresses of materials under external loads, among many other applications (Reddy 2005, 2, 13). Inputs required for the calculations usually include the Young's modulus, Poisson ratio, shape and size of specimens, as well as the method of loading (Kilikoglou and Vekinis 2002, 1319). The latter includes information such as the constraints, boundary conditions, the supports used and the contact points.

Given the unconventional geometry of specimens, the calculation of flexural strength using FEA modelling was deemed necessary. Firstly, a model for a beam under external load from a three-point-bend test was created in FEA, using experimental data from a known material: alumina (Figure 6.17). This process required the modelling of the supports and anvils used by the machine and the test constraints. To check that these constraints had been correctly judged, the specimen geometry applicable to a standard bend test (using a conventional rectangular x-section specimen) was modelled and the stresses (for a given load) compared to those calculable by the standard equation provided above. The validated alumina beam model was then adapted to account for a cylindrical or disc shape of the test specimens, and the failure loads measured from the model were used to determine the failure stress.

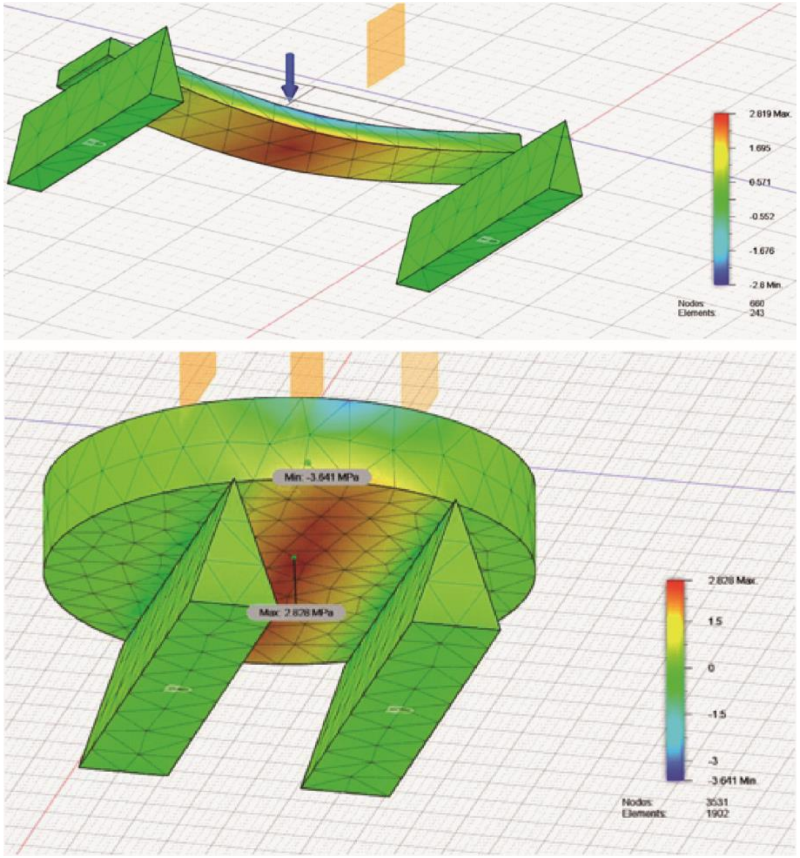


Figure 6.17: Result from an FEA analysis of an alumina beam (top) and disc (bottom) in a three-point-bend setting. The stress calculated from the standard equation for an alumina beam was also 2.8 MPa.

The results obtained from the FEA modelling only varied 5% from values given by the standard flexural strength equation for three-point-bend tests, if the diameter of the disc was used as the specimen width (*b*), *i.e.* assuming a situation where the specimen is rectangular, not circular. Nonetheless, the calculations using FEA were necessary given that the effect of the change in specimen geometry was unknown, the span-depth ratio of specimens was unfavourable, and the adjustment in flexural strength values provided a reliable comparison to published material where beam specimens have been used (Müller *et al.* 2015; Warfe 2015).

6.2.3.2 Weibull modulus

In brittle materials, cracks originate from internal defects, which are varied in terms of their number, size, shape, orientation, among others. Partly due to this variation, fracture strength for a set of specimens manufactured in exactly the same way can diverge significantly (Green 1998, 286). The Weibull modulus provides a measure of this variation within a set of ceramic specimens (Davidge 1979, 134–135). Based on the assumption that the weakest link in a specimen fails first, and that defects are randomly distributed throughout the specimen, the probability of failure can be calculated as follows (Green 1998, 287):

$$P = 1 - exp\left[- \int \left(\frac{\sigma - \sigma_{min}}{\sigma_0}\right)^m dV\right]$$

where,

m = Weibull modulus,
dV = infinitesimal volume,
σ_0 = characteristic strength, and
σ_{min} = minimum fracture strength

For handling strength data, the formula is usually written in the following way (*Idem.*, 288):

$$\ln\left[\ln\left(\frac{1}{1 - P}\right)\right] = m \ln \sigma_f$$

P can be calculated by firstly ranking the fracture strength (σ_f) data from weakest to strongest, and then applying the following formula (*Ibid.*):

$$P_i = \frac{i - 0.5}{n}$$

where P_i is the probability of failure of the i^{th} specimen and n corresponds to the total number of tested specimens. Afterwards, $\ln\left[\ln\left(\frac{1}{1 - P}\right)\right]$ is plotted against the natural logarithm of the fracture strength with a regression line added, and the Weibull modulus corresponds to the gradient of this line. The higher the m value, the lower the variation in fracture strength for a set of specimens (Davidge 1979, 136). In other words, the higher the Weibull modulus, the more consistent the distribution of uniform defects. For ceramics, the modulus is normally around ten.

The Weibull modulus was calculated for specimens from the six conditions tested, *i.e.* untempered pinched, untempered coiled, chaff-tempered pinched, chaff-tempered coiled, dung-tempered pinched and dung-tempered coiled. While the number of specimens required for these calculations are usually around 20 or 30, which is well above the number tested, the modulus still provides a useful calculation to assess the distribution of flaws between specimens of a same condition. The results of the Weibull analysis are presented in section 9.3, and their implications discussed in section 9.3.1.

Chapter 7. Sherd-size distribution and morphometric results

The following chapter presents and discusses the main results from sherd-size distribution and morphometric analysis of sherds from the sampled SKC and LBK sites. It is oriented towards answering a series of questions related to the third dimension of the social knowledge of breakage (*i.e.* what people do with broken pots). These questions include: were fragments quickly buried or left exposed? how were potsherd assemblages formed? How were pits filled? For this reason, the chapter was structured to answer these questions first and leave the broader discussion on the social knowledge of breakage for Chapter 10, where results and discussions from all chapters are integrated. I start by describing some fundamental results obtained from various tests on sherd-size distributions and morphometric analysis, which provided the groundwork for interpreting archaeological assemblages (together with the information in sections 6.1.1.1-6.1.1.3), and then move on to presenting data on Early Neolithic sites (section 7.2).

7.1 Sherd-size distribution and morphometric tests

7.1.1 Sherd-size distributions

Fragment sizes change substantially between primary (Ep1, Ep2, Tsi) and secondary rupture (Cpl and Hpl). Table 7.1 and Figure 7.1 synthesise these findings. On one side of the spectrum, ploughed assemblages, *i.e.* Cpl and Hpl, have little variation in size and are almost entirely beneath the 2000mm^2 mark. Relative cumulative frequency and kernel density curves also show that these samples are well-sorted (Figure 7.1). Nonetheless, their sherd-size logarithmic distributions (phi-scale) range between negatively skewed to normal (corroborated by Shapiro-Wilk test for normality, p=0.2053).

On the other side of the spectrum, we find samples Tsi — archaeological pots found *in situ* —and Ep1 and Ep2 — freshly broken experimental pots. A commonality of these samples is their poor sorted logarithmic distributions. Nonetheless, there are important differences in their distributions. There is a log-normal distribution of fragment sizes in Tsi (p=0.0709) and Ep2 (p=0.6457) samples, while in the Ep1 sample the distribution is negatively skewed (Figure 7.2). These results can be explained by both the differences in primary rupture procedures and in ceramic composition. As mentioned before (section 6.1.1.1) and demonstrated in Chapter 9, low-fired tempered pottery is not strong, but can possesses numerous energy dissipating mechanisms. Thus, these ceramics are more resilient to crack propagation than crack initiation. In contrast, high-fired ceramics are stronger, *i.e.* they have less flaws and therefore less opportunity to initiate cracks, but once cracks are formed, they easily lead to specimen failure. With high energy stresses, in this case impact, the shockwave created tends to produce more small fragments than in non-impacted vessels, as more stress is applied to a higher number of flaws, and as a result more cracks are initiated; in addition, shattering can also occur. Therefore, the high energy process does not leave room for energy dissipation, which produces a negatively skewed distribution of fragment sizes, as observed in sample Ep1. In turn, the log-normal distribution observed on fragments from vessels found *in situ* can be explained by the lack of shockwave during the vessel breakage, as the vessels are contained by the soil matrix. This reduces the chances of already formed cracks in the ceramic to reach a critical state and leaves more room for energy dissipation mechanisms to occur, leading to higher numbers of large-sized fragments. Lastly, the differences observed between Ep1 and Ep2 samples relate simply to the differences in the strength of the vessels. In other words, the stronger the vessel, the less negatively skewed the samples after submitted to impact processes. This points to the fact that not only post-depositional, but also breakage processes (*i.e.* how the pot was broken) can be highly influential in the distribution of fragment sizes. It is important to note, however, that Ep1 is an extreme scenario, as the ceramics were highly porous and fragile (Vindrola-Padrós 2015), and the impact procedure was quite severe, *i.e.* pots being dropped from up to 2m high to a concrete floor. Mann-Whitney U-tests support the main differences outlined (Table 7.2).

ID	Context	Sherd-size distribution information		So	Implications
		Mm Scale	Phi (ϕ) Scale		
Cpl, Hpl	Ploughed surface finds	Predominantly small-sized fragments*	Negative skewness (Cpl) to log-normal distribution** (Hpl), and well- to moderately sorted	0.48 to 0.59ϕ	Predominantly affected by secondary rupture
Tsi	Pottery found i*n situ*	Variation in sherd sizes*	Log-Normal distribution** and poorly sorted	0.72ϕ	Low energy primary rupture
Ep1, Ep2	Freshly broken pottery (experimental pots)	Variation in sherd sizes	Negative skewness (Ep1) to log-normal distribution** (Ep2), and poorly sorted	0.7 to 0.81ϕ	High energy primary rupture

*Table 7.1: Summary of results from sherd-size distribution tests. *Statistically significant from the other samples according to Mann-Whitney U tests; **Statistically significant according to Shapiro-Wilk test for normality.*

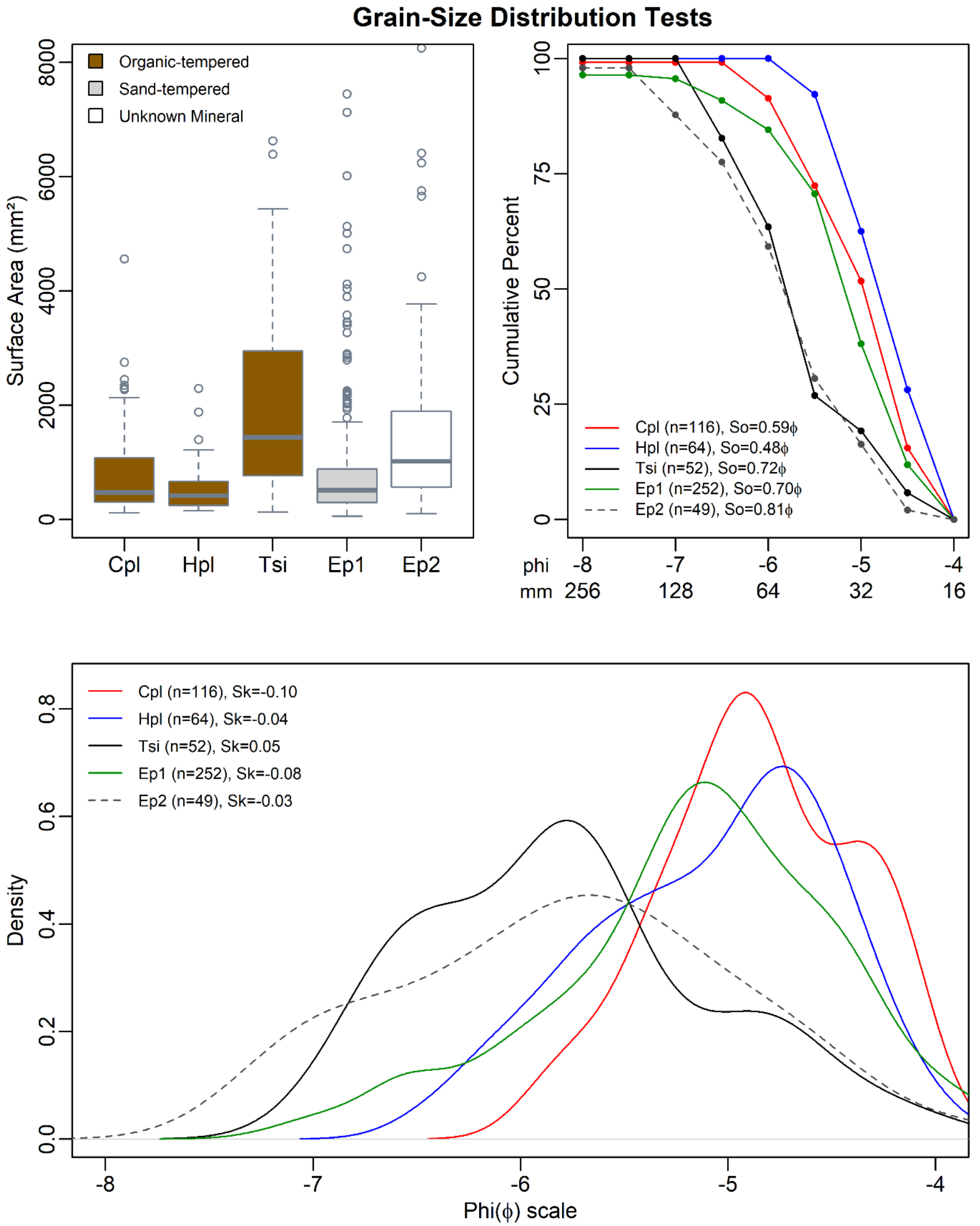


Figure 7.1: Sherd-size distribution of archaeological potsherds from ploughed assemblages (Cpl, Hpl), pottery found in situ at the site of Tășnad Sere (Tsi), and low-fired (Ep1) and high-fired (Ep2) pots broken in drop experiments.

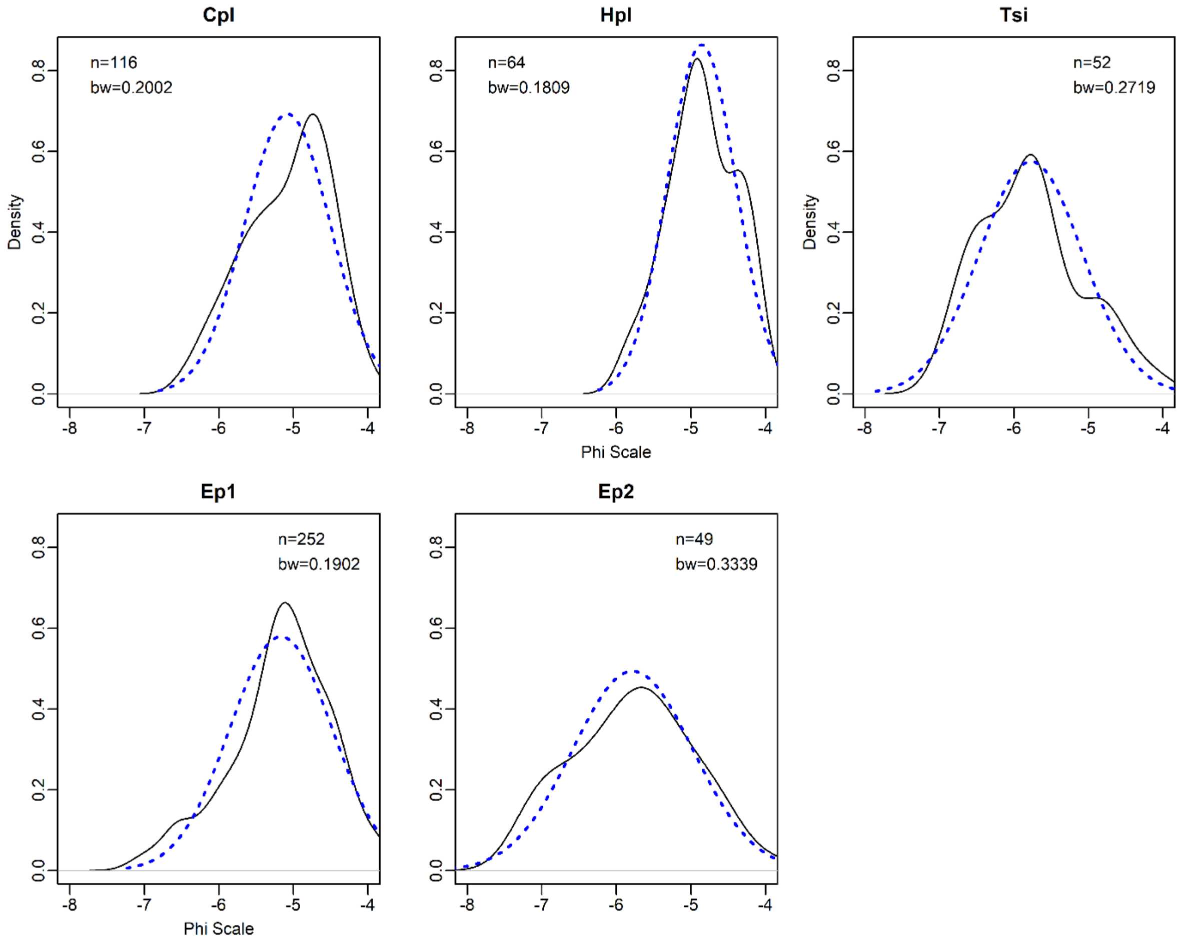


Figure 7.2: Kernel density plots showing sherd-size logarithmic distributions of each individual sample. The dotted blue line indicates a log-normal distribution according to the sample mean.

Surface Area

	Cpl	Ep1	Ep2	Hpl
Cpl				
Ep1	0.56			
Ep2	**4.7×10^{-4}**	**3.2×10^{-5}**		
Hpl	**0.02**	0.07	**1.3×10^{-6}**	
Tsi	**3.5×10^{-8}**	**3.7×10^{-9}**	0.15	**4.6×10^{-10}**

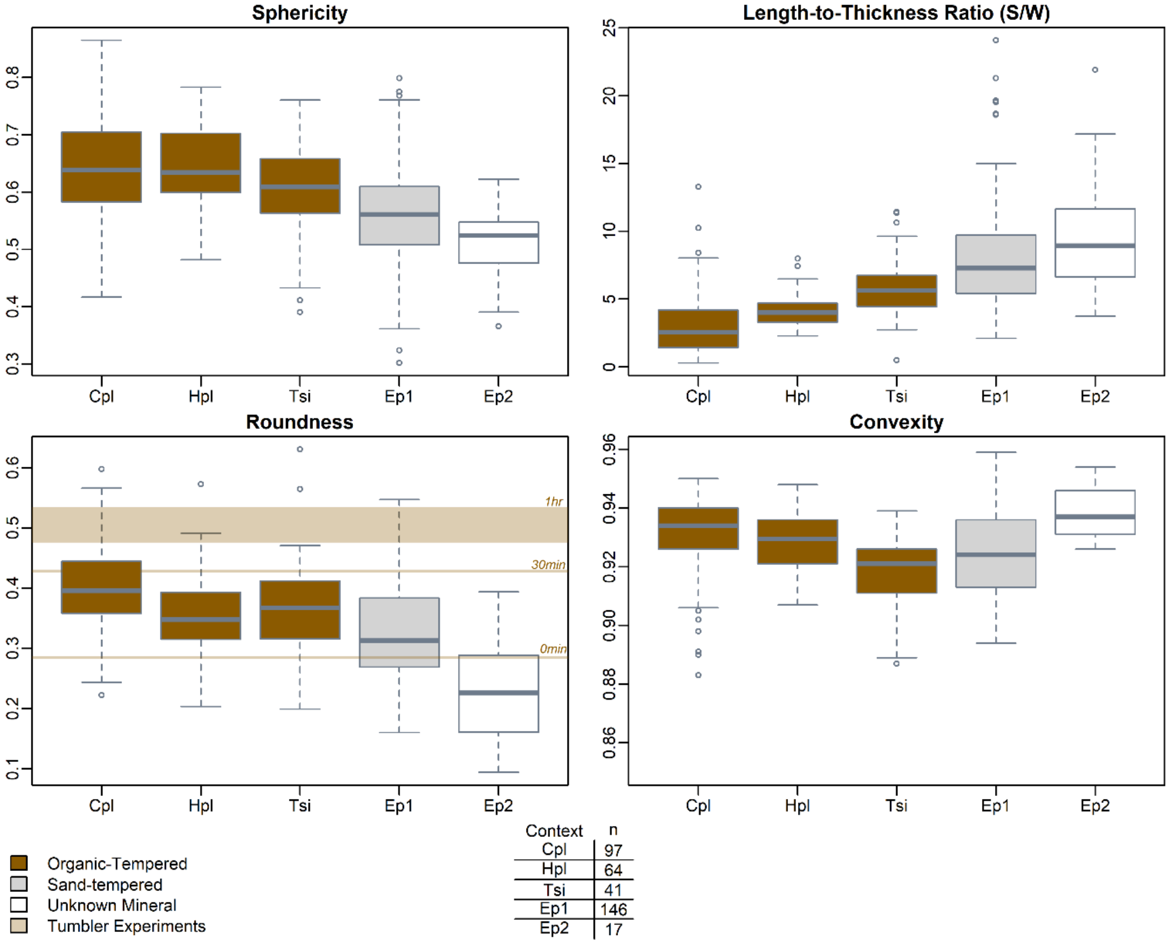
Phi-scale

	Cpl	Ep1	Ep2	Hpl
Cpl				
Ep1	0.27			
Ep2	**2.4×10^{-7}**	**8.4×10^{-7}**		
Hpl	**0.03**	**7.9×10^{-4}**	**1×10^{-9}**	
Tsi	**6.6×10^{-9}**	**4.7×10^{-8}**	0.88	**9.1×10^{-11}**

Table 7.2: P-values of Mann-Whitney U tests of sherd size distributions according to surface area and phi-scale. Bold numbers indicate statistically significant differences between samples.

7.1.2 Morphometrics

Figure 7.3 and Table 7.3 summarise the results of morphometric tests of the four chosen shape descriptors: sphericity, length-to-thickness ratio (S/W), roundness, and convexity. As neither compositional nor granulometric intra-sample variation was significant (Vindrola-Padrós *et al.* 2019, 25), results are presented according to sample contextual information. In general, values obtained fitted the expectation that there would be a contrast between finds from the ploughzone (Cpl and Hpl) and those from primary rupture contexts (Ep1, Ep2 and Tsi).



Context	n
Cpl	97
Hpl	64
Tsi	41
Ep1	146
Ep2	17

Figure 7.3: Morphometric results of archaeological potsherds from ploughed assemblages (Cpl, Hpl), pottery found in situ at Tășnad Sere (Tsi), low-fired (Ep1) and high-fired (Ep2) pots broken in drop experiments, and data from tumbler experiments (Beck et al. 2002).

Fragments analysed from the ploughzone are highly spherical and compact, which corroborates the assumption that these artefacts have been submitted to a high degree of secondary rupture (Dunnell and Simek 1995, 309). As sample composition does not seem to be a significant factor, the differences among the ploughed samples are most likely due to different intensities of farming activities. In contrast, Ep1, Ep2 and Tsi samples are significantly more elongated according to both sphericity and S/W values. The high range of values obtained for sample Ep1 is most likely explained by the different way in which vessels hit the ground and broke during drop experiments.

As with sphericity and S/W, roundness values also indicate a contrast between rounded sherds from the ploughzone and angular experimental samples. Ploughed sherds are more prone to abrasion due to their exposure to erosive agents, while freshly broken fragments not at all. When compared to results from Beck et al.'s (2002) tumbling experiments, the values for ploughed samples are equivalent to sherds abraded for about an hour. Despite this result, there is a difference between Hpl and Cpl assemblages, as well as among Ep1 and Ep2 samples. These differences can be attributed to either compositional or hardness differences between samples (Vindrola-Padrós *et al.* 2019, 26).

The low convexity values of fragments from *in situ* pots were an important result in the recent publication (*Ibid.*; Figure 7.3). As these values indicate a statistically significant higher level of roughness than other samples (Table 7.4), it could be stated that weathering would have been the predominant post-depositional process. Contrasted with Ep1, the degree of roughness for Tsi fragments is higher, which can point to the compositional and/or granulometric differences between samples. Energy is dissipated in both samples through different cracking mechanisms, leading to different degree of edge roughness. In organic-tempered pots, crack tip deflection, arrests, and bridging would be more common, as, apart from small inclusions, elongated pores and some remaining fibres could potentially toughen the ceramic (see section 9.2). In comparison, in mineral-tempered ceramics crack deflection would be the predominant mechanism. Grain size differences can also account for the observed pattern, as larger particles would result in an increase in the tortuosity of crack paths. Leaving these microstructural factors aside, another explanation could be that the difference observed is due to how pots are broken in their burial spot compared to being struck. In the former, cracks paths are more tortuous, as pots are not critically loaded by compressive or bend stresses, giving more opportunity for energy dissipation mechanisms to happen. In contrast, in high energy impact procedures, crack paths are quickly produced and there is little time for energy dissipation mechanisms to occur (Müller *et al.* 2016, 520), which is why transgranular cracking can occur. For now, these explanations remain theoretical, but is a path for further investigations.

Lastly, Figures 7.4-7.7 describe the relation between size, expressed as surface area, and each of the shape parameters used for morphometric tests. The relationship between sphericity and size (Figure 7.4), mainly demonstrates the difference between small and spherical ploughed fragments, and experimentally broken fragments, which are small- to medium-sized and considerably elongated. Immediately recognisable in Figure 7.5 is the expected direct correlation between surface area and the S/W ratio for Ep1, Ep2, and, to an extent, the fragments from pots recovered *in situ*. In contrast, Cpl and Hpl samples illustrate how through fragmentation by ploughing this relationship is considerably weakened, as fragments become smaller. For this reason, the relation between surface area and the S/W ratio provides another way of distinguishing deposits formed by the dumping or placing of complete or freshly broken pots from those that are the product of more lengthy and subtractive processes, such as trampling or ploughing. The relation of roundness to surface area does not show any significant patterns, except the very clear contrast between small and angular fragments from Ep2 from the rest of the samples. Finally, the low convexity values of Tsi shows some relation to sherd size, which can be explained by the fact that the smaller the fragment, the less pronounced energy dissipation mechanisms will be; thus, they present smoother values than larger fragments. Furthermore, sherds from pots found *in situ* possess evenly spread values for all shape descriptors, making them distinctive from other assemblages.

Sample ID	Context	Shape Descriptor Information	Implications
Hpl, Cpl	Ploughed surface finds	Spherical and compact**, slightly angular to slightly rounded, and with a smooth surface texture	Samples more prone to rupture than abrasion
Tsi	*In situ* pottery	Slightly spherical, moderately compact/oblong, slightly angular, and highly rough**	Samples affected by postburial weathering
Ep1, Ep2	Freshly broken pottery (experimental pots)	Slightly elongated to elongated**, angular to highly angular**, variable convexity*	Samples without secondary rupture

*Table 7.3: Summary of results from morphometric tests (after Vindrola-Padrós et al. 2019, Table 2[1]). *Variation due to the compositional differences of specimens, **Samples are statistically significant from the other samples*

Sphericity

	Cpl	Ep1	Ep2	Hpl
Ep1	**2.1x10^{-13}**			
Ep2	**1.13x10^{-8}**	0.19		
Hpl	1	**4.4x10^{-10}**	**6.9x10^{-8}**	
Tsi	**0.04**	**0.04**	**1.4x10^{-3}**	0.11

S/W

	Cpl	Ep1	Ep2	Hpl
Ep1	**3.7x10^{-29}**			
Ep2	**5.8x10^{-16}**	0.09		
Hpl	0.34	**1.6x10^{-15}**	**3.1x10^{-11}**	
Tsi	**5x10^{-6}**	**1.2x10^{-3}**	**3.5x10^{-5}**	**0.02**

Roundness

	Cpl	Ep1	Ep2	Hpl
Ep1	**1.8x10^{-12}**			
Ep2	**5.9x10^{-15}**	**2.5x10^{-5}**		
Hpl	**1x10^{-3}**	0.14	0.62	
Tsi	0.25	**0.01**	**1x10^{-8}**	1

Convexity

	Cpl	Ep1	Ep2	Hpl
Ep1	**9.3x10^{-3}**			
Ep2	1	**0.01**		
Hpl	1	0.31	0.62	
Tsi	**1x10^{-3}**	0.95	**1x10^{-3}**	**0.02**

Table 7.4: P-values from pairwise t-tests with Bonferroni correction of morphometric samples (after Vindrola-Padrós et al. 2019). Bold numbers highlight statistically significant differences between samples.

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[1] Reprinted from Journal of Archaeological Science, 104, Bruno Vindrola-Padrós et al., Working with broken agents: Exploring computational 2D morphometrics for studying the (post)depositional history of potsherds, 19-33, Copyright (2019), with permission from Elsevier

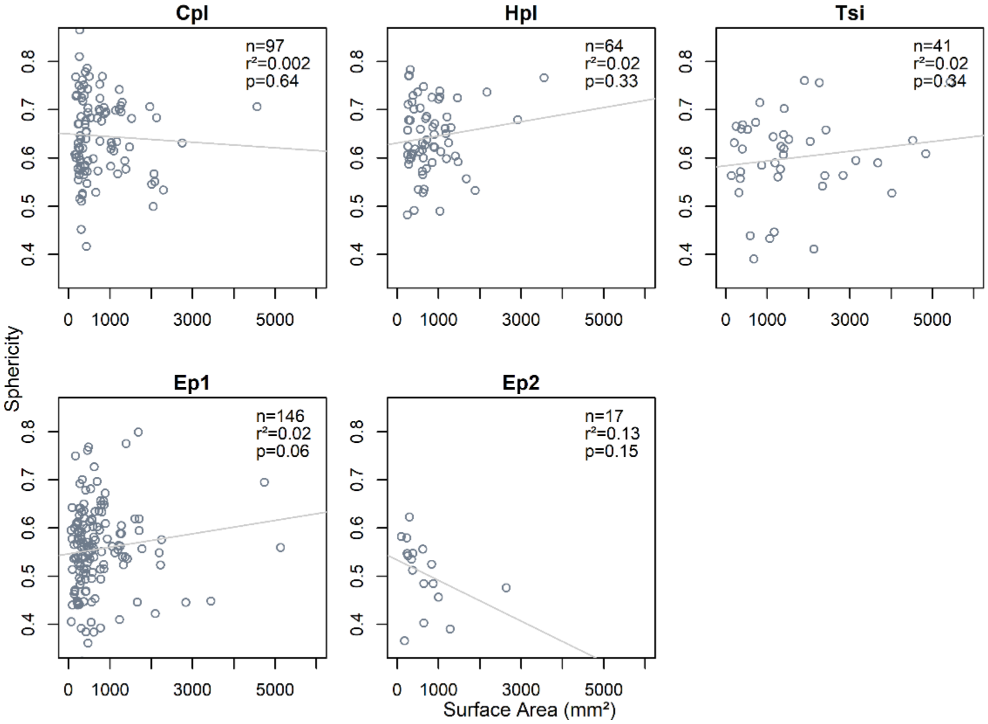

Figure 7.4: Relation between surface area and sphericity of morphometric samples.

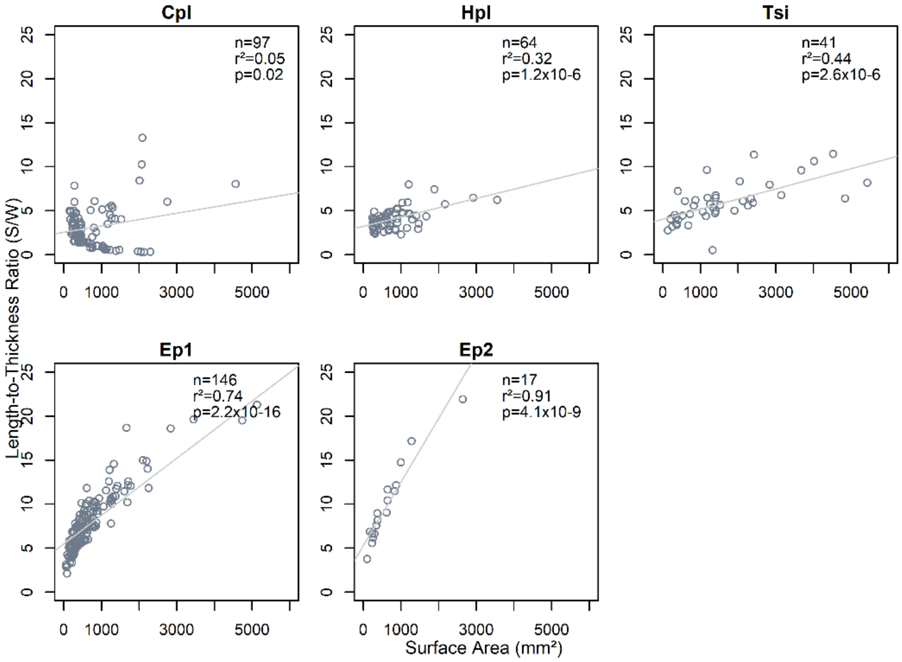

Figure 7.5: Relation between surface area and length-to-thickness ratio of morphometric samples.

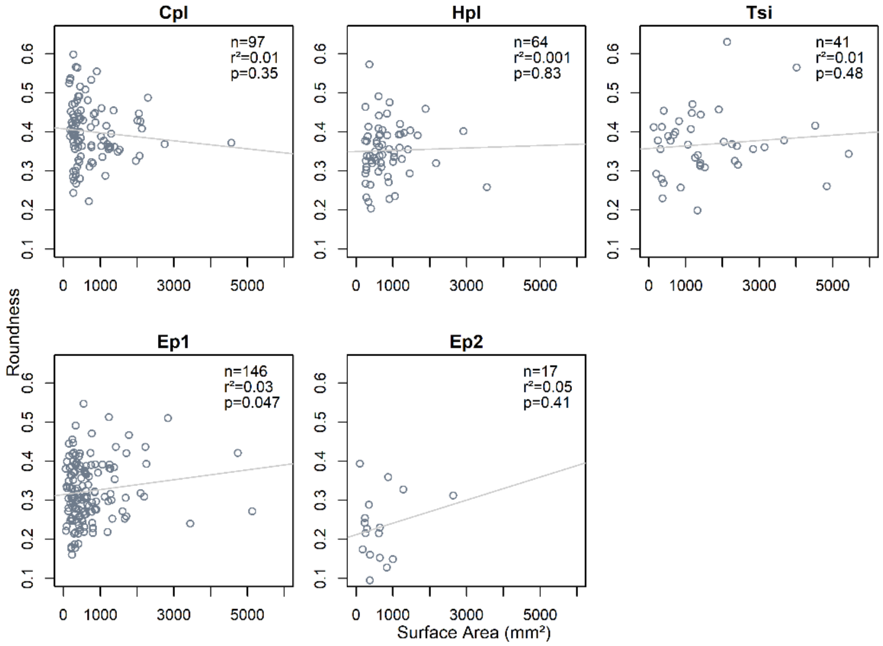

Figure 7.6: Relation between surface area and roundness of morphometric samples.

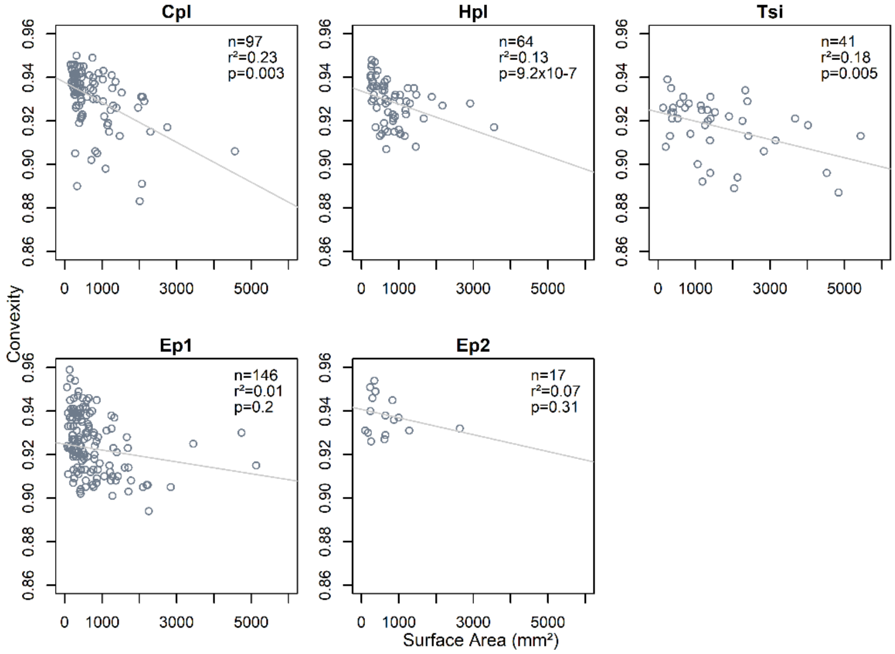

Figure 7.7: Relation between surface area and convexity of morphometric samples.

7.1.3 Summary

Tables 7.1 and 7.2 synthesize the information from both sherd-size and morphometric tests. Assemblages that have gone through secondary rupture or fragmentation, such as sherds from the ploughzone, are easily distinguishable through their sherd-size distributions and some large-scale morphometric parameters, as abrasion appears to be a minor influence. In contrast, a process like fluvial action, as seen in a few samples from Beck *et al.*'s (2002) tumbler experiments

(Figure 7.3), sherd roundness increases much more rapidly than sphericity. Another important observation was the clear distinction of fragments from pots recovered *in situ* from the rest of the samples. These can be distinguished by their high sherd size variation, poor sorting and log-normal distribution, as well as morphometrically by their low convexity values.

The central concern for my research questions, however, is on the distinction between potsherd assemblages that could have been deposited immediately after breakage, and those formed after a considerable time of being exposed. The results from these tests show various avenues to separate these two. On the one hand, provided conditions of primary rupture of vessels are not severe, such as in high energy impact procedures, sherd-size distributions show assemblages of pottery broken just before deposition or during burial are varied in terms of sherd sizes, have log-normal distributions and are poorly sorted. Morphometric results also highlight these sherds are considerably more elongated, angular and generally have a rough surface texture. These results provide a framework through which to assess the veracity of the 'landfill analogy' proposed for many European Early Neolithic pits, and consider other interpretations about the deposition of these assemblages.

Based on the results displayed, certain categories can be constructed to describe and understand potsherd assemblages (Tables 7.5 and 7.6). These categories are merely used for descriptive purposes and should not be taken as absolutes. To give the reader a reference to interpret the results of data from archaeological assemblages, in every remaining graph from this chapter I have added grid lines representing the boundaries of every size and shape category presented in Tables 7.5 and 7.6.

Category	Surface Area (mm^2)	Category	Sorting Coefficient (So)
Very small	<1000	Very well sorted	<0.46
Small	1001-2000	Well sorted	0.46-0.55
Medium	2001-3000	Moderately sorted	0.56-0.65
Large	3001-4000	Poorly sorted	0.66-0.75
Very Large	>4000	Very poorly sorted	>0.75

Table 7.5: Sherd-size distribution categories created from test results.

A few more general statements are made from these results. First large numbers of small fragments cannot be taken on their own as indicative of secondary rupture such as trampled or ploughed assemblages, the entire distribution of sizes and shape descriptors must be observed in order to arrive at this conclusion. Secondly, there tends to be confusion in the archaeological literature that the mean sherd size can be used to represent the most frequent sherd size in an assemblage (*e.g*. Blackham 2000; Last 1998; Nielsen 1991). The mean sherd size would be an accurate representation in an assemblage where the sherd-size distribution was normal. However, as seen in my results, sherd-size distributions can only be log-normal, and this occurs only in certain scenarios. For this reason, the use of mean sherd sizes should be generally discouraged. In this regard, it is also important to note that the use of arithmetic means also disregards the 'tails' of sherd-size distributions. I have attempted to overcome this limitation by considering the 5th and 95th percentile in the calculation of the sorting coefficient (So), also known as inclusive graphic standard deviation.

Category	Sphericity	Category	S/W	Category	Roundness	Category	Convexity
Highly Elongated	<0.51	Very Compact	<2.51	Highly angular	<0.31	Highly Rough	<0.921
Elongated	0.51-0.55	Compact	2.51-5	angular	0.31-0.35	Rough	0.921-0.93
Slightly Elongated	0.551-0.6	Moderately compact/oblong	5-7.5	Slightly angular	0.35-0.4	Smooth	0.931-0.94
Slightly Spherical	0.61-0.65	Oblong	7.5-10	Slightly rounded	0.41-0.45	Highly Smooth	>0.94
Spherical	0.651-0.7	Very oblong	>10	Rounded	0.46-0.5		
Highly Spherical	>0.7			Highly rounded	>0.5		

Table 7.6: Morphometric categories created from test results.

7.2 Results from Early Neolithic sites

To establish the total estimates of ceramic material retrieved and sampled from each site, I have used the most pristine records available from each site. In the case of zone D at Eitzum, I have utilised the records established immediately after excavation of the material in 1987, which have been kindly provided by the Braunschweig Landesmuseum (BLM). These records consisted of potsherd counts and weights. Similarly, I have utilised the inventoried counts of sherds from Méhtelek-Nádas at the Jósa András Museum (Kalicz 2011). Since the estimates of the total amount of pottery from Eitzum Zones A and B, Klein Denkte, Călinești-Oaș-D.S.M. and Tășnad Sere were never carried out or were ongoing at the time of my analysis, for these sites I have calculated the total amount of pottery according to the material available at the museums. In this case, total numbers were calculated according to weight, as fragments excluded from my analysis were weighed rather than counted.[1]

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[1] This was specified in section 6.1.2.1.

7.2.1 Tășnad Sere

7.2.1.1 Basic Recording of Material

The number of sherds sampled from Tășnad Sere, following the selection criteria mentioned in chapter 6, were exceptionally high (Table 7.7). Sherd samples represent around 90% in weight of the sherd population for each context selected. As a reminder, different recovery methods in 2005 and the 2012-2019 UCL excavations can be influential in the number of sherds, as the intensive excavations in the latter would have likely retrieved more finds.

Feature	Sherd-size Distribution Sample (n1)			Morphometrics Sample (n2)			Total Weight (g)
	Weight (g)	No.	Percent*	Weight (g)	No.	Percent*	
C2/2005	115250	2418	95.86	61696	1649	51.32	120229
H1/UCLT1	109857	6166	93.70	81514	5484	69.53	117244
Out/UCLT1	5167	305	87.46	3716	266	62.90	5908
7/UCLT1	18684	745	80.35	13264	619	57.04	23254
4/UCLT1	98	4	100	45	3	45.92	98
8/UCLT1	34	1	100	34	1	100	34
9/UCLT1	61	2	100	0	0	0	61
12/UCLT1	216	7	100	28	4	12.96	216
13/UCLT1	116	8	100	116	8	100	116
15/UCLT1	5	1	100	5	1	100	5

*Table 7.7: Sample size information of features from Tășnad Sere. *Percentages are calculated according to weight of fragments.*

In part to allow an assessment of fragmentation between features from these two very different excavation methods, EVEs and the brokenness ratio were incorporated. These were calculated from base fragments, partly because these diagnostic parts of vessels are generally thicker; thus, they preserve better than rims and are more likely to be recovered in rescue excavations. The estimated vessel equivalents or EVEs highlight the predominance of small and medium-sized vessels at Tășnad Sere (Table 7.8). The EVEs also indicate a large number of vessels and a great variety of vessel sizes are represented in pit with oven C2/2005 and in House 1 (H1/UCLT1), which could be corroborating that these areas correspond to habitation structures or storage areas, where varied types of activities unfolded. The low degree of brokenness of the material from C2/2005 seems consistent with this observation, but more detail of this is given below. However, the material found in H1/UCLT1 also shows a higher degree of brokenness, even higher than values obtained for the material in pit fill 7/UCLT1. This could signal a high amount of trampling in the area, but further results on sherd-size distributions and morphometric analysis of fragments presented below clarifies this interpretation. Lastly, the values obtained for Out/UCLT1 are moderate. Considering the sherd-size distribution data presented below, it is most likely that these brokenness values are a representation of a small group of well-preserved base sherds, which could be related to the selective preservation of thicker bases, found within a highly fragmented assemblage.

Feature	Vessel Size*	Base Sherd(s)	EVE	Total EVEs	Brokenness ratio (s/v)**
C2/2005	Very Small	29	12.55	62.305	38.81
	Small	127	31.275		
	Medium	73	14.925		
	Large	19	3.255		
	Very Large	2	0.3		
H1/UCLT1	Very Small	11	4.05	43.605	141.41
	Small	148	29.36		
	Medium	95	9.35		
	Large	7	0.85		
Out/UCLT1	Very Small	3	1.2	4.5	67.78
	Small	11	2.75		
	Medium	4	0.55		
7/UCLT1	Small	19	4.575	6.6	112.89
	Medium	16	2.025		

*Table 7.8: Calculation of estimated vessel equivalents (EVEs), and the brokenness ratio (s/v) from Tășnad Sere according to feature. The EVEs are used to calculate the size of vessels represented in an assemblage, while the brokenness ratio is a measure of fragmentation of an assemblage, which is calculated by dividing the number of fragments over the EVEs. *Sizes were determined from projected vessel diameters (defined in section 6.1.2.3.1) **Sherd numbers are equivalent to sampled fragments (n1).*

7.2.1.1.2 Fabric characterisation and typological considerations

As shown in Figure 7.8, all three contexts have ceramics predominantly tempered with organic matter, and in smaller frequencies may also have mineral inclusions in addition to the plant temper. According to the petrographic study carried out on material from UCLT1, these minerals are likely to be either quartz, fragments of metamorphic rocks, or amphibole (Seidler and Amicone 2017, 1, 2). Only a very small number of fragments were seen to lack any inclusions or vegetal matter. The grain and voids left from the burning of the plant additives have in general a size of 1-2mm, which corresponds to the ‘semi-fine’ category. These granulometric results also align well with observations made in the aforementioned petrographic study, as the two groups identified with mineral and plant temper (Type Ia and Type IIb) had average grain sizes of 0.97 and 1.12mm respectively (*Idem*, 5). Lastly, almost the entire ceramic assemblage analysed from Tășnad Sere possesses soft surfaces. Considering the compositional information obtained, while there is a predominance of organic matter in these ceramics, the still large percentage of sherds composed both of vegetal matter and mineral inclusions (*ca.* 40%) in C2/2005 would warrant for some caution when analysing the sherd-size distributions and morphometric parameters. However, differences between sherd-size distribution and morphometry of uniquely organic-tempered and organic-tempered sherds with mineral inclusions were negligible (see Appendix 8).

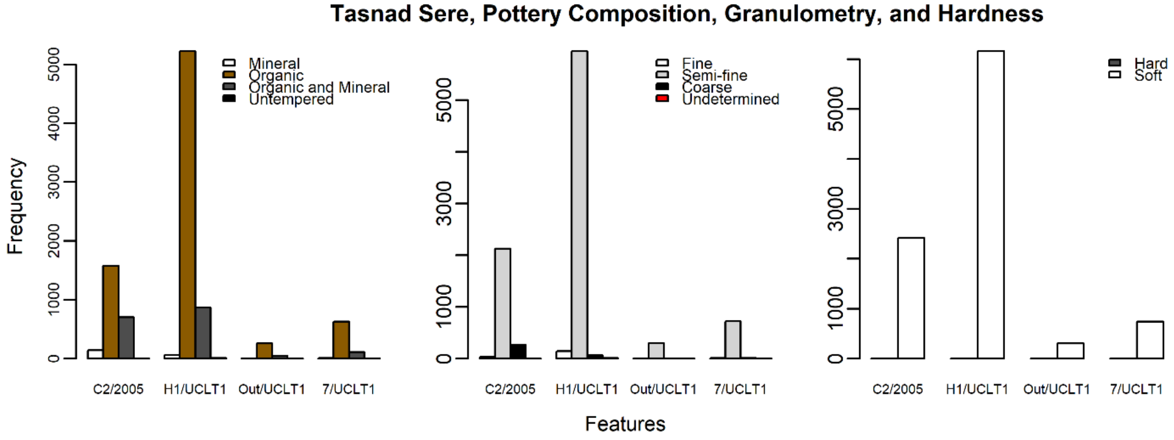


Figure 7.8: Composition, granulometry and hardness of sherds from Tășnad Sere. Contexts include the pit with oven C2/2005 and features from UCL Trench 1 (UCLT1), such as House 1 (H1), its outside area (Out) and the pit fill (7).

7.2.1.1.3 Postdepositional information

As no cleaning brushes were used for washing the material from UCLT1, and a considerable amount of material from C2/2005 had been unprocessed, the effects of washing were considered negligible for the ceramic's preservation. In terms of the preservation of vessel parts, Figure 7.9 highlights a high frequency of body fragments, followed by a considerable number of bases. In slight contrast to the material from C2/2005, the disproportionate amount of body fragments to other vessel parts in contexts from UCLT1 already signals a high amount of fragmentation. However, this interpretation is given further consideration, as excavation retrieval methods are also likely to factor into this pattern.

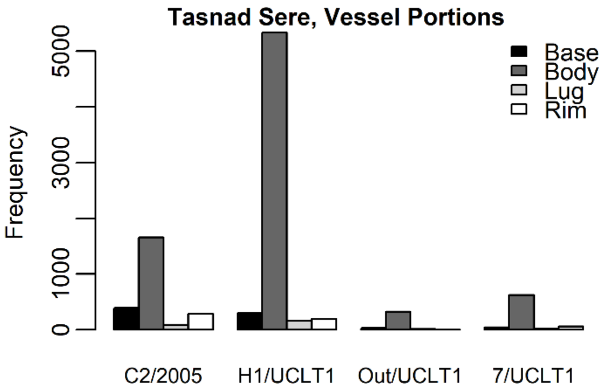


Figure 7.9: Parts of vessels represented in contexts sampled from Tășnad Sere. These include the pit C2/2005, House 1 (H1/UCLT1), its outside area (Out/UCLT1) and the pit fill (7/UCLT1).

7.2.1.2 Sherd-size distribution and morphometric results

Figure 7.10 summarises the sherd-size distributions for all contexts from Tășnad Sere. Immediately distinguishable are the differences between C2/2005 and contexts H1/ and 7/UCLT1. The former has a well-sorted distribution of mostly medium-sized fragments, while the latter contexts show moderately to poorly sorted distribution of predominantly small-sized sherds. In comparison, the possible outside area of the house (Out/UCLT1), has even smaller fragment sizes than H1/UCLT1 and pit 7/UCLT1, as well as a well-sorted distribution. These values are suggestive of secondary rupture processes. With the exception of 9/UCLT1, similar distributions are also seen for postholes, as the ceramic material is unsurprisingly very small to small.

Morphometric results also contrast between C2/2005 and contexts from UCLT1 (Figure 7.11). Although sphericity values do not show a difference, C2/2005 fragments are more oblong, angular, and possess a rougher surface texture than fragments from H1/, Out/ and 7/UCLT1. Fragment morphometry from UCLT1 show there is some similarity between the house, outside areas, and pit fill; however, the former is composed of more elongated, oblong, and rougher fragments than the latter two. This information indicates that material inside the house is generally less affected by erosion and secondary rupture processes, but, as is seen in the next section, these values vary according to the location within the house. For the other two large contexts from UCLT1 (7/ and Out/UCLT1), the only observable morphological difference between them is their degree of roundness, as fragments from outside areas are slightly more angular than those from the pit. In comparison to all these contexts, sherds from postholes are generally compact, round and have smooth textures, which suggests fragments were considerably moved around before being deposited in postholes.

So far, the well-sorted small sherd assemblage in Out/UCLT1 is showing a predominance of secondary rupture processes, most likely to be trampling. These sherd-size distributions and the roundness of fragments highlight some differences with pit 7/UCLT1 and house H1/UCLT1, as results from these contexts show a variety of processes must have been operating (discussed below). Setting the differences in roundness aside, which can simply be explained by the higher intensity of trampling that occurred outside of the house, the overall similarity in morphometric values between the outside areas and the pit fill could suggest the former was partly feeding fragments into the fill of the latter. Evidence from postholes in UCLT1 mostly points to small fragments being moved considerably before their deposition, most likely resulting from transit in these areas of the house. These 'transit areas' in H1/UCLT1 are discussed in more detail below. In contrast to contexts from UCLT1, at C2/2005 there are very clear signs of an almost entirely 'undisturbed' ceramic assemblage deposited in this feature.

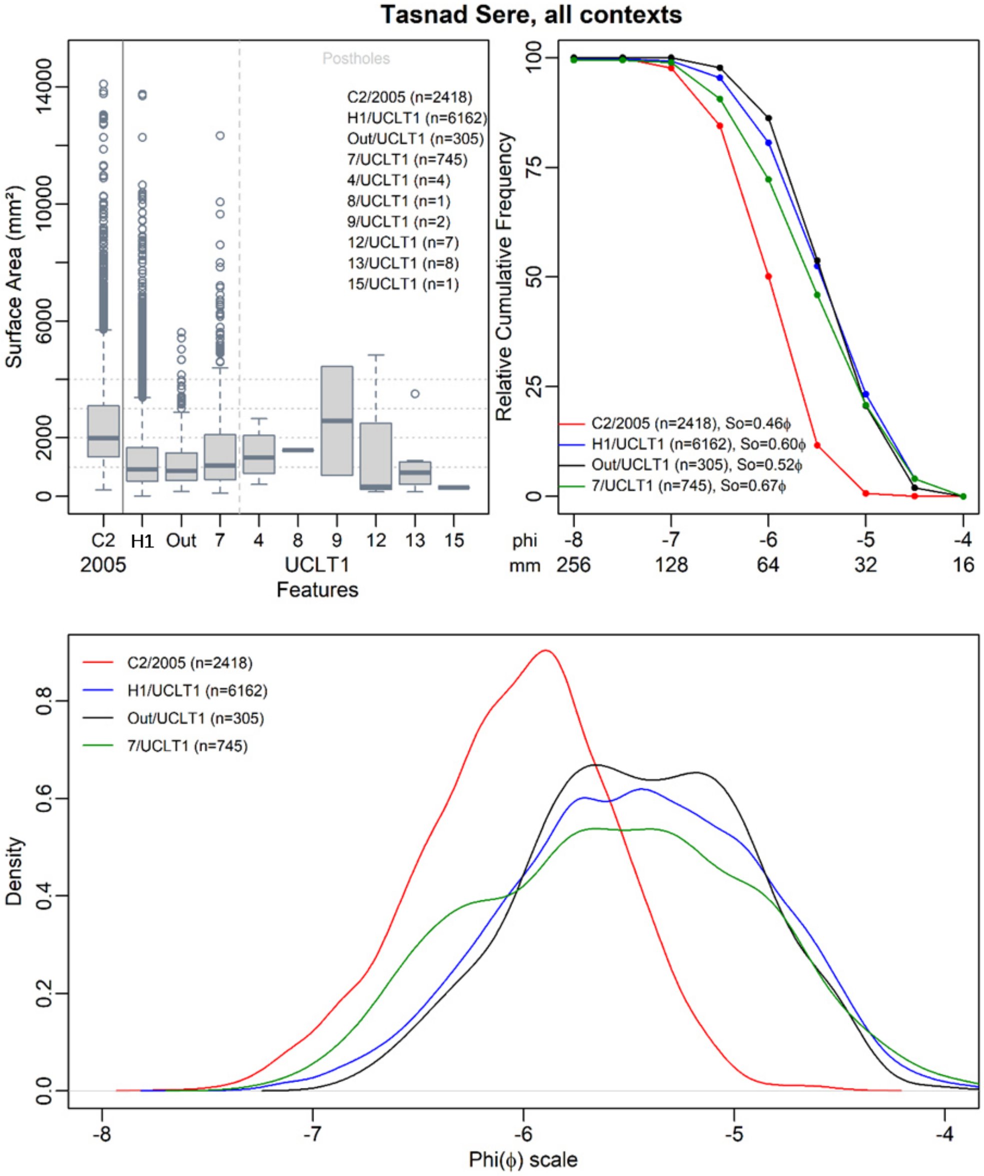


Figure 7.10: Sherd-size distributions from all sampled contexts at Tășnad Sere.

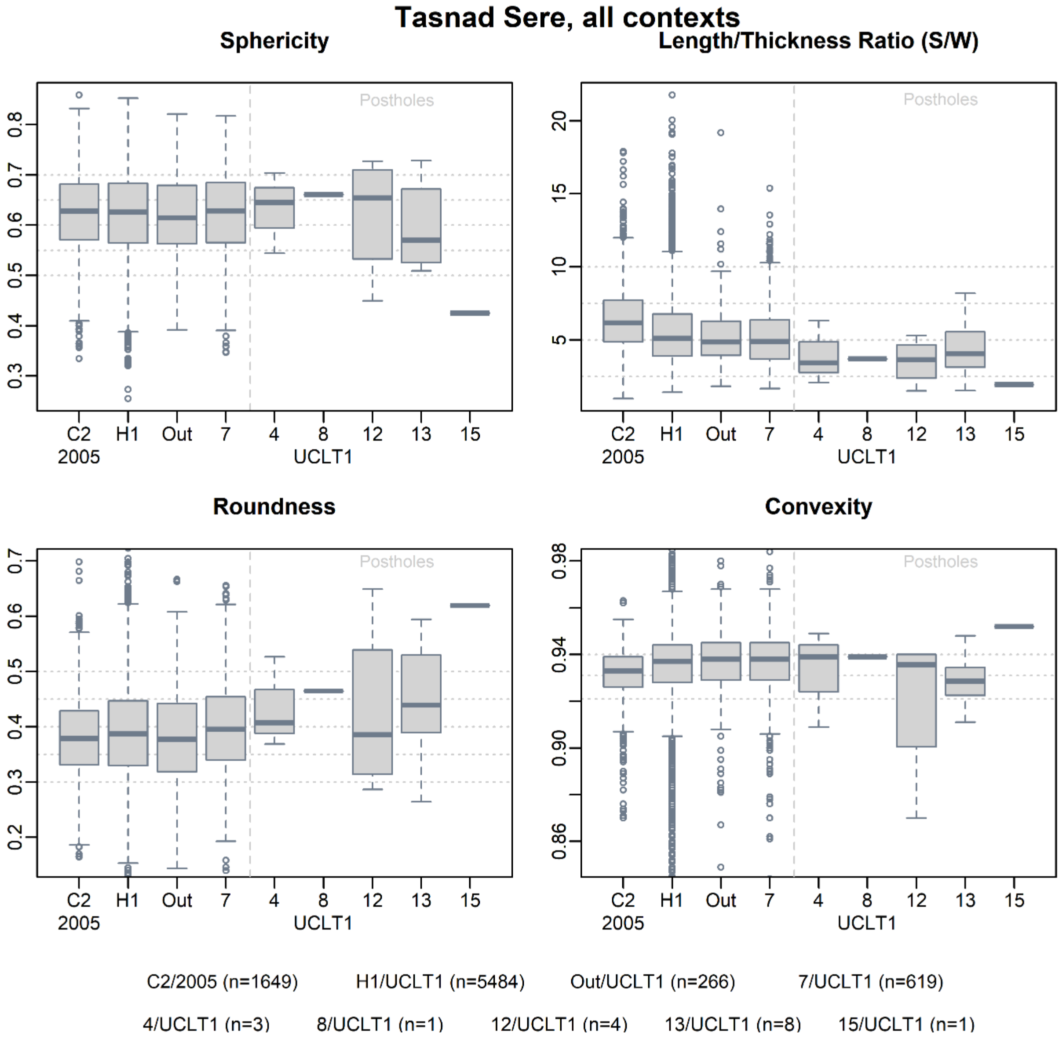


Figure 7.11: Morphometric results from all sampled contexts at Tășnad Sere.

7.2.1.2.1 Occupation layer: H1/UCLT1 and Out/UCLT1

Without any section drawing of the house and its outside areas, the stratigraphic record of H1/UCLT1 and Out/UCLT1 is limited to the distribution of finds. Figures 7.12 and 7.13 give information on where most of the pottery fragments and other finds have been found according to spits. Thus, this information gives an idea of the topography of the house floor and outside area. We see that clearly the northern sector of the house (from row 6 to 8) is at a higher topographical level than its opposite, and there is an inclination from west to east, with the latter being at a deeper level. We also observe that the bulk of the ceramic material, represented by the 1st and 3rd quartile, in each square is restricted to just two or three spits, which corresponds to 10-15cm deposits of fragments. These graphs were done for all rows and columns of the trench, and they show the same patterns, but in order not to overwhelm the reader with graphs, all this information is available in Appendix 8. Furthermore, these rather thin deposits display very little variation in fragment sizes at different depths. Once more, for the same reasons mentioned above, this information is made available for the reader in Appendix 8.

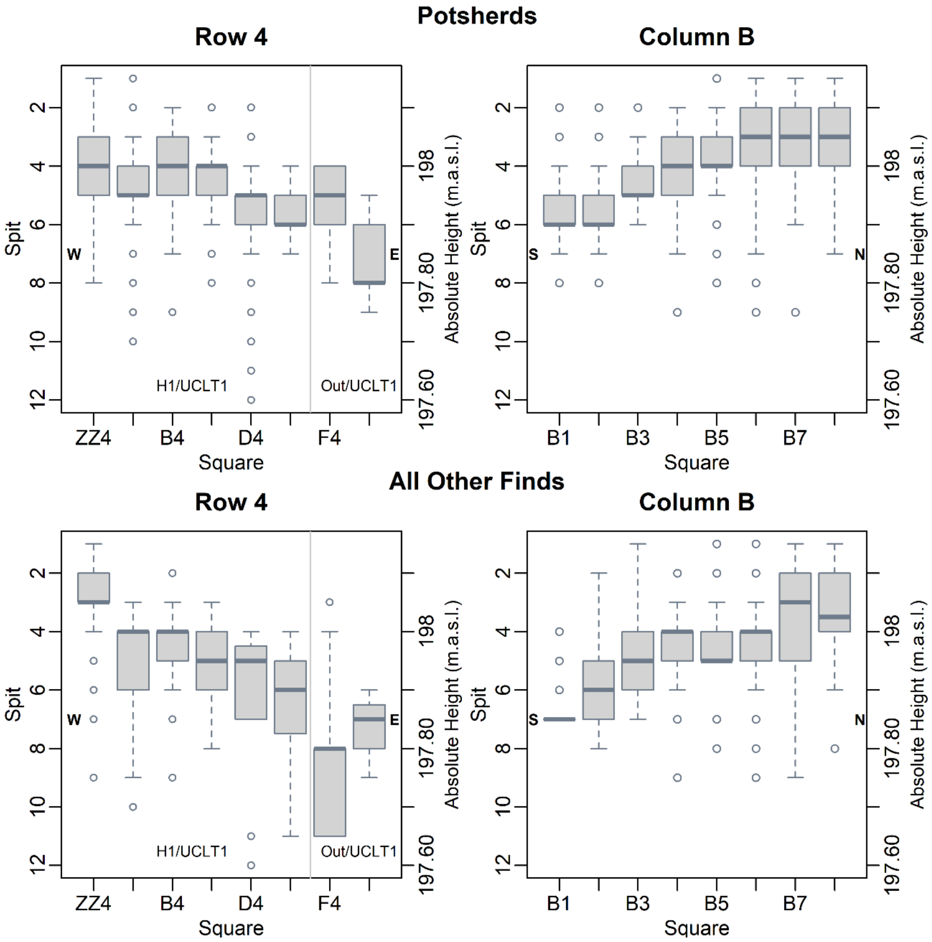


Figure 7.12: Stratigraphic positioning of potsherds (top) and all other finds (bottom) at H1/ and Out/UCLT1.

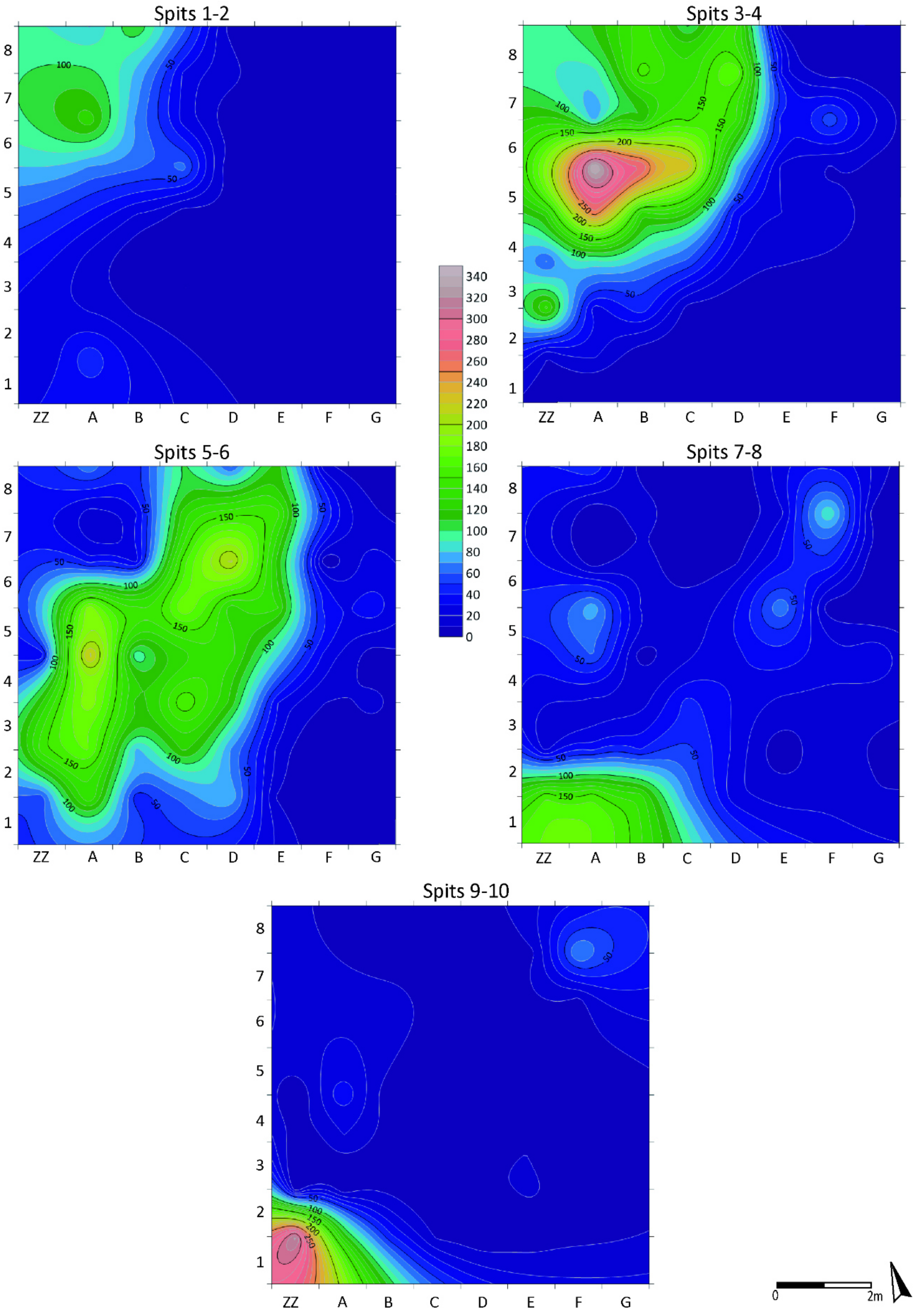
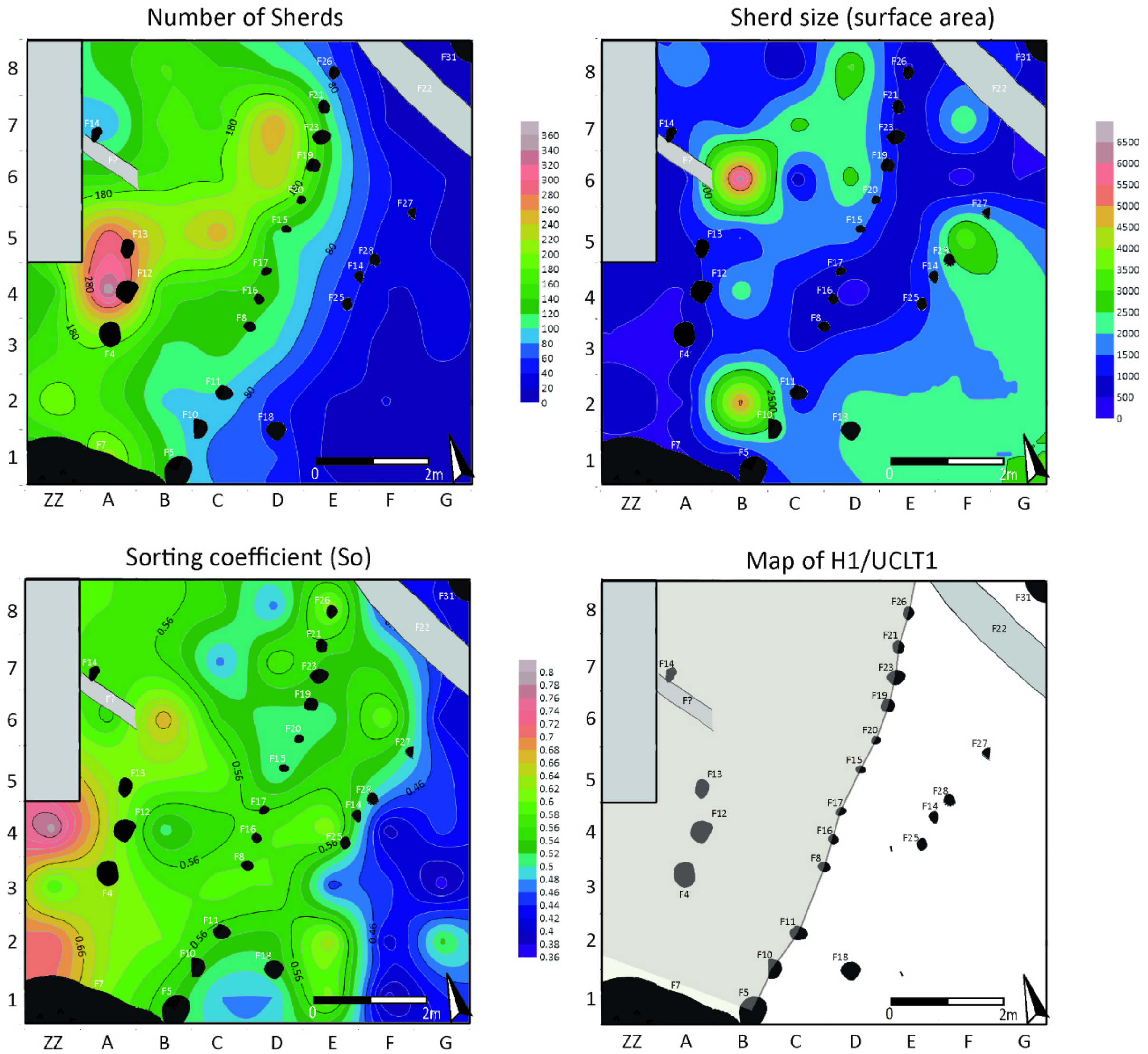


Figure 7.13: Density maps of distribution of all finds from H1/ and Out/UCLT1 according to spit (map created with Surfer using kriging). Values are averaged by square.

The size distributions and frequency of sherds in the house and its eastern 'outside' area are presented in rows from a west-east direction in Figures 7.14 and 7.15. There is a predominance of very small to small fragments in almost every area in and out the house. Results also show that there are progressively lower numbers of sherds towards the east (red curve in Figure 7.15), better sorted distributions (*i.e*. from poorly sorted distributions from the west to well-sorted distributions to the east), and fragment sizes also seem to decrease (Figures 7.15, 7.16 and 7.17). This pattern becomes more prominent in squares at the 'boundary' between H1/ and Out/UCLT1. Furthermore, there is also a high concentration of medium-sized fragments in the central sector of the house, particularly around Squares ZZ4,A4 and A5, which is also a hotspot of bones, refired fragments, and some vessels found *in situ* (see section 8.2.1.6). In Figure 7.14, two concentrations of large fragments are also clearly visible towards the north sector (*ca*. square A6) and in the central-southern portion of the house (*ca*. square B2). It must be also noted that small differences between density maps and boxplots are due to the fact that in the former values are averaged, while the latter provides a more accurate picture of the entire size distributions.

Figures 7.18 to 7.22 exhibit results from the various shape descriptors used. In Figure 7.16, fragment sphericity is shown to be higher in areas around the central sector of the house, *i.e.* around the C and D column, and in outside areas of the house, signalling a higher degree of fragmentation. Other than this pattern, there does not seem to be much variation between squares. As sherds decrease in size from west to east, the values obtained from the S/W ratio show a similar trend (Figure 7.18 and 7.20), with sherds from D column displaying the lowest numbers inside H1/UCLT1. Slightly rounded fragments were also prominent in square units towards the eastern areas of the house (Figure 7.21). This pattern is suggestive of some exposure to abrasive processes, which may have occurred while the house was inhabited. The highest peaks of convexity values presented in Figures 7.18 and7.22 within the house are around columns C and D, and the lowest in the area are found in a cluster around square C1 and in squares A3-A5 (*i.e.* the central sector of the house). In the outside area of the house, fragments range between smooth and very smooth.



Number of Sherds

Sherd size (surface area)

Sorting coefficient (So)

Map of H1/UCLT1

Figure 7.14: Density map with distribution of sherd sizes at H1 and Out/UCLT1 (map created with Surfer using kriging). Values are averaged by square.

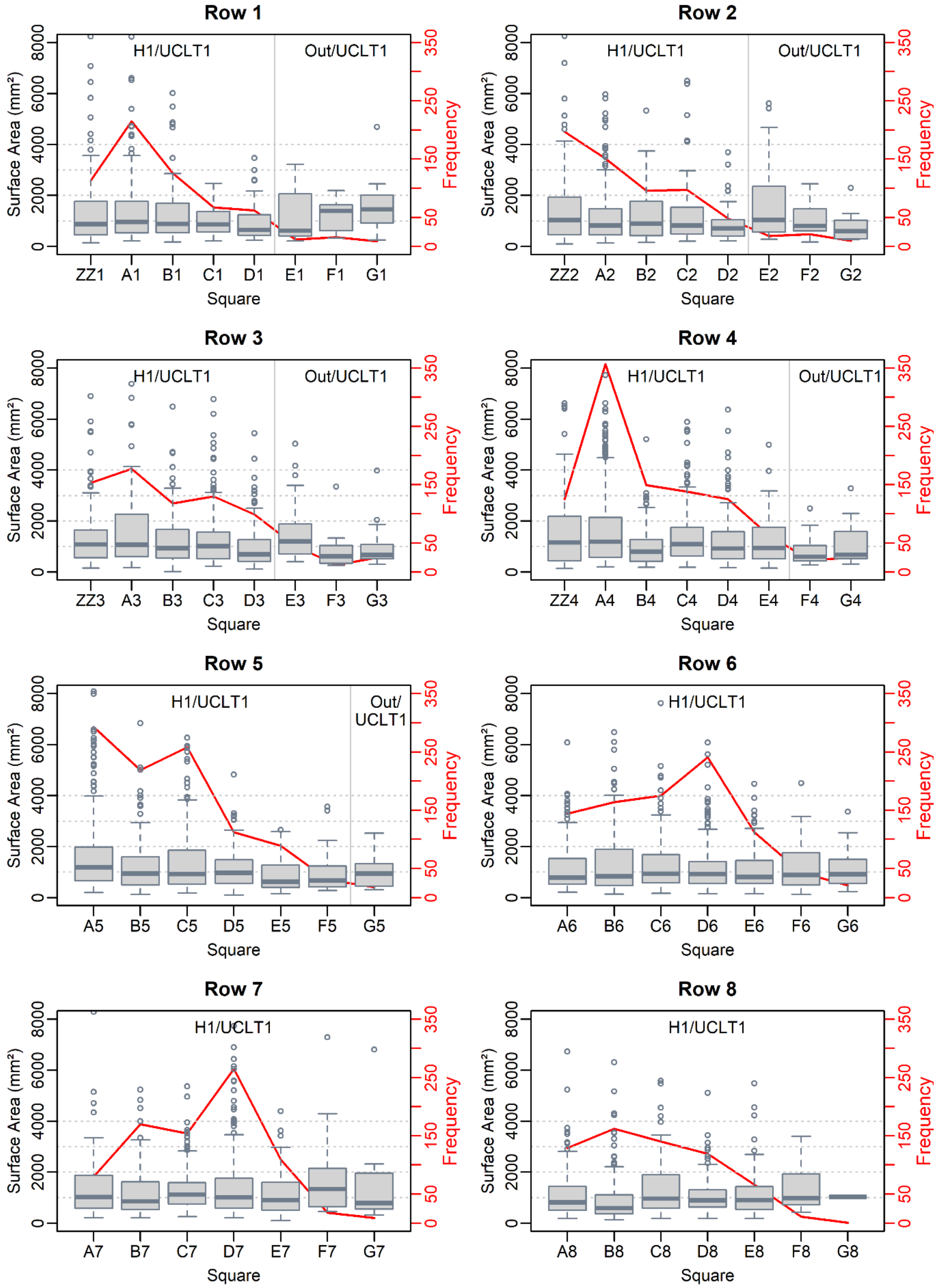


Figure 7.15: Frequency and sherd-size distributions of assemblages per square unit in H1/ and Out/UCLT1.

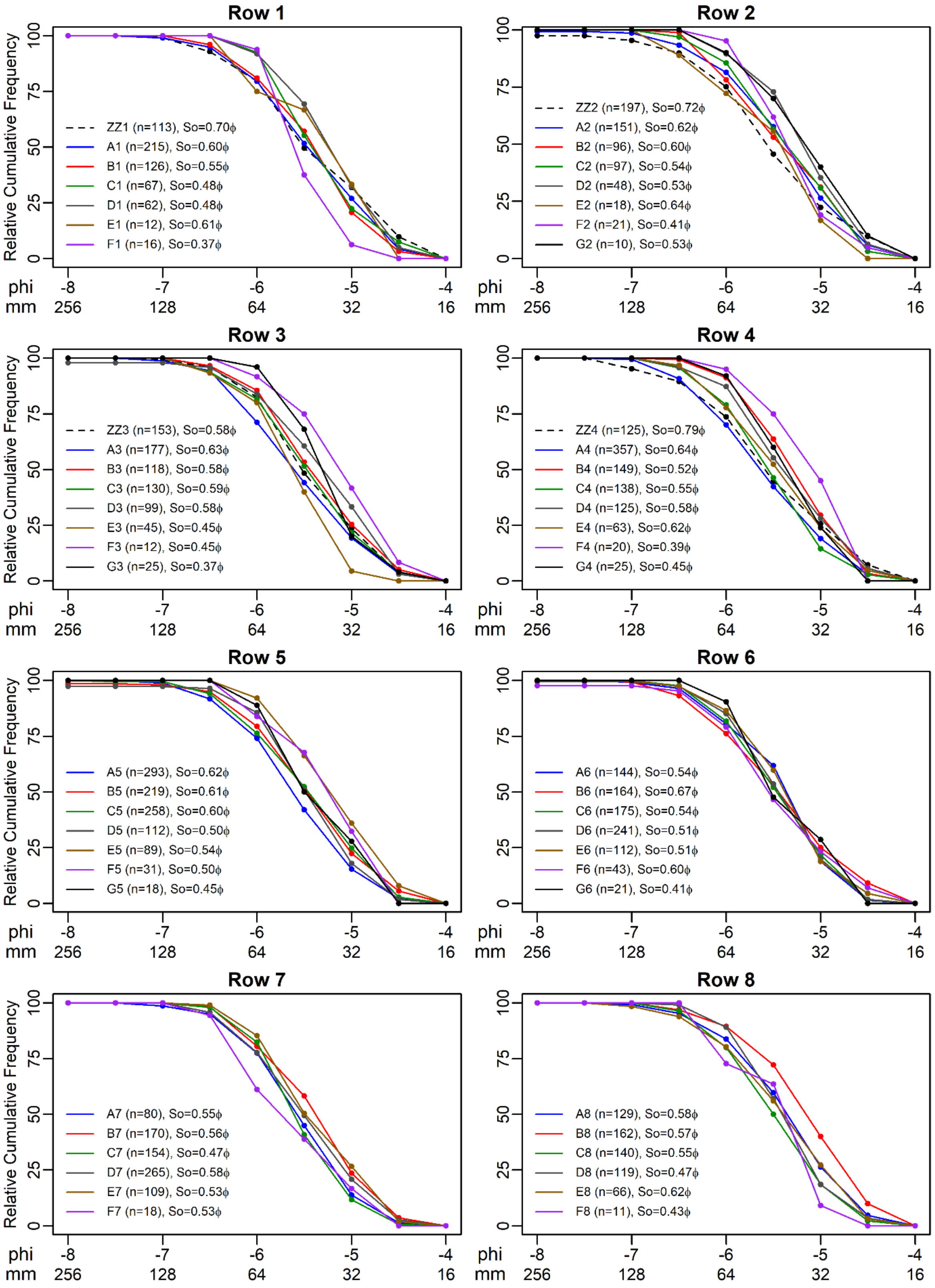


Figure 7.16: Relative cumulative frequency curves and sorting values of potsherds per square unit in H1 and Out/UCLT1.

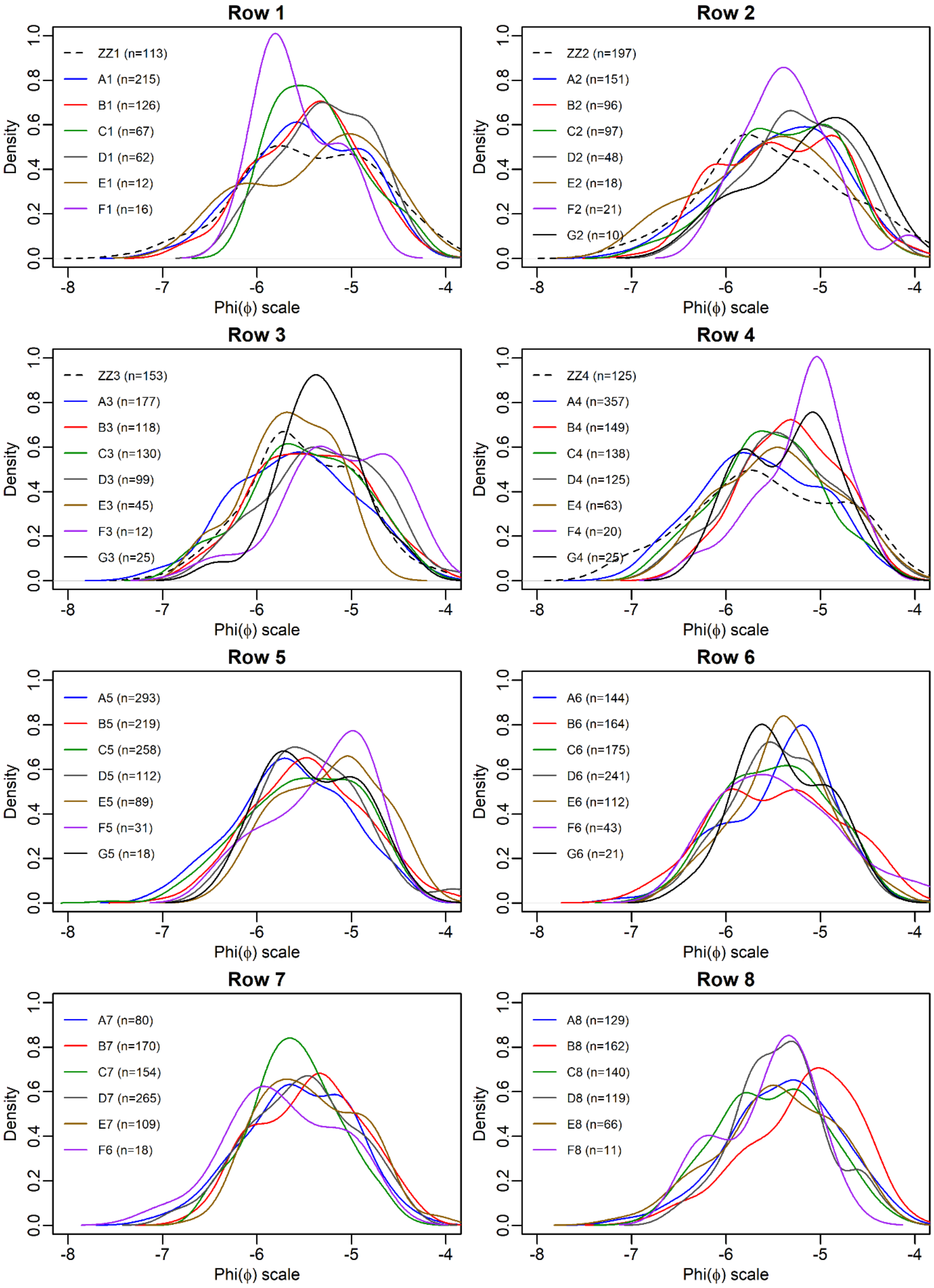


Figure 7.17: Log-normal Kernel density curves of sherd-size distributions of assemblages according to square units in H1 and Out/UCLT1.

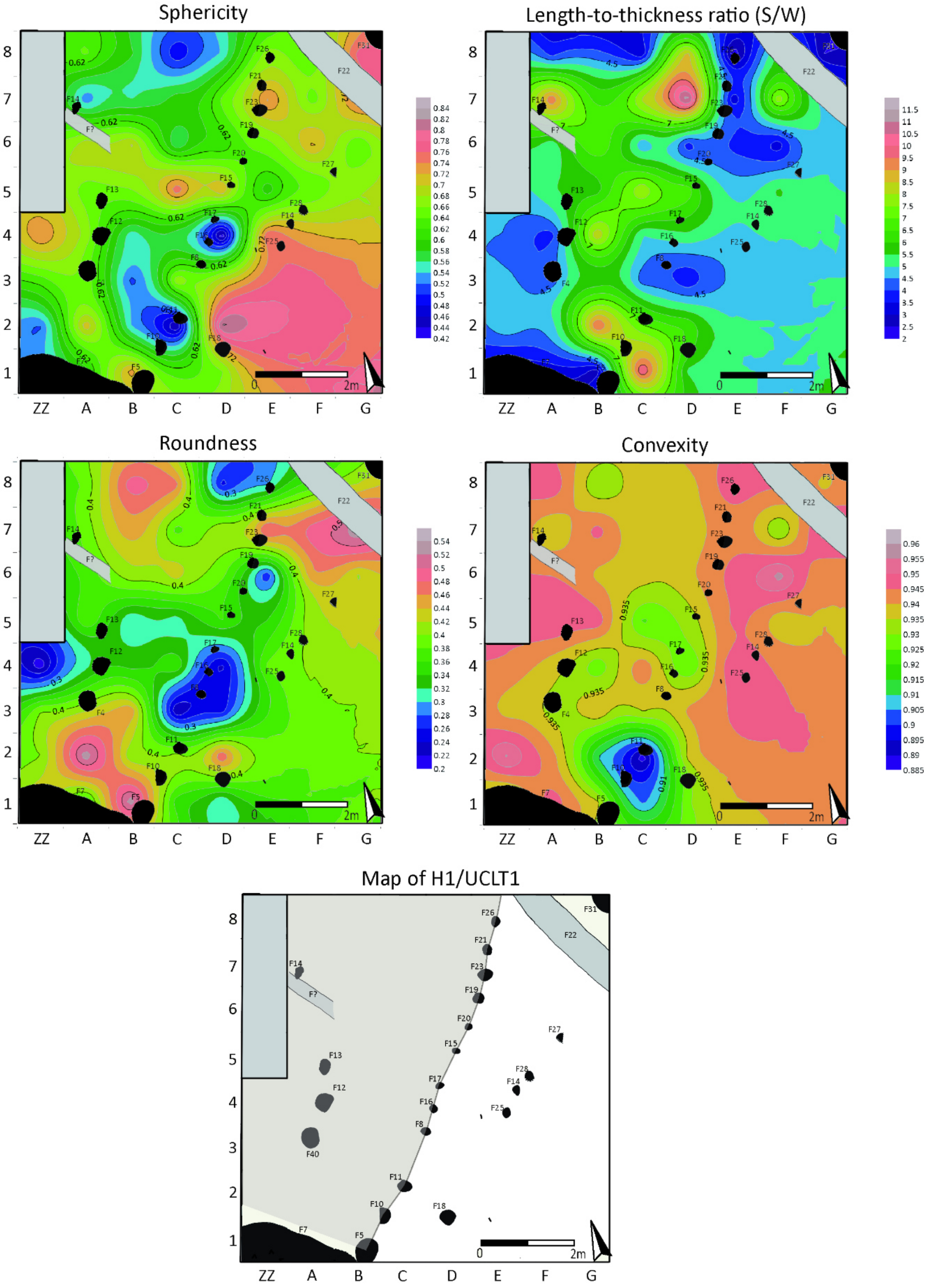


Figure 7.18: Density map with distribution of sherds according to different shape descriptors (map created with Surfer using kriging). Values are averaged per square.

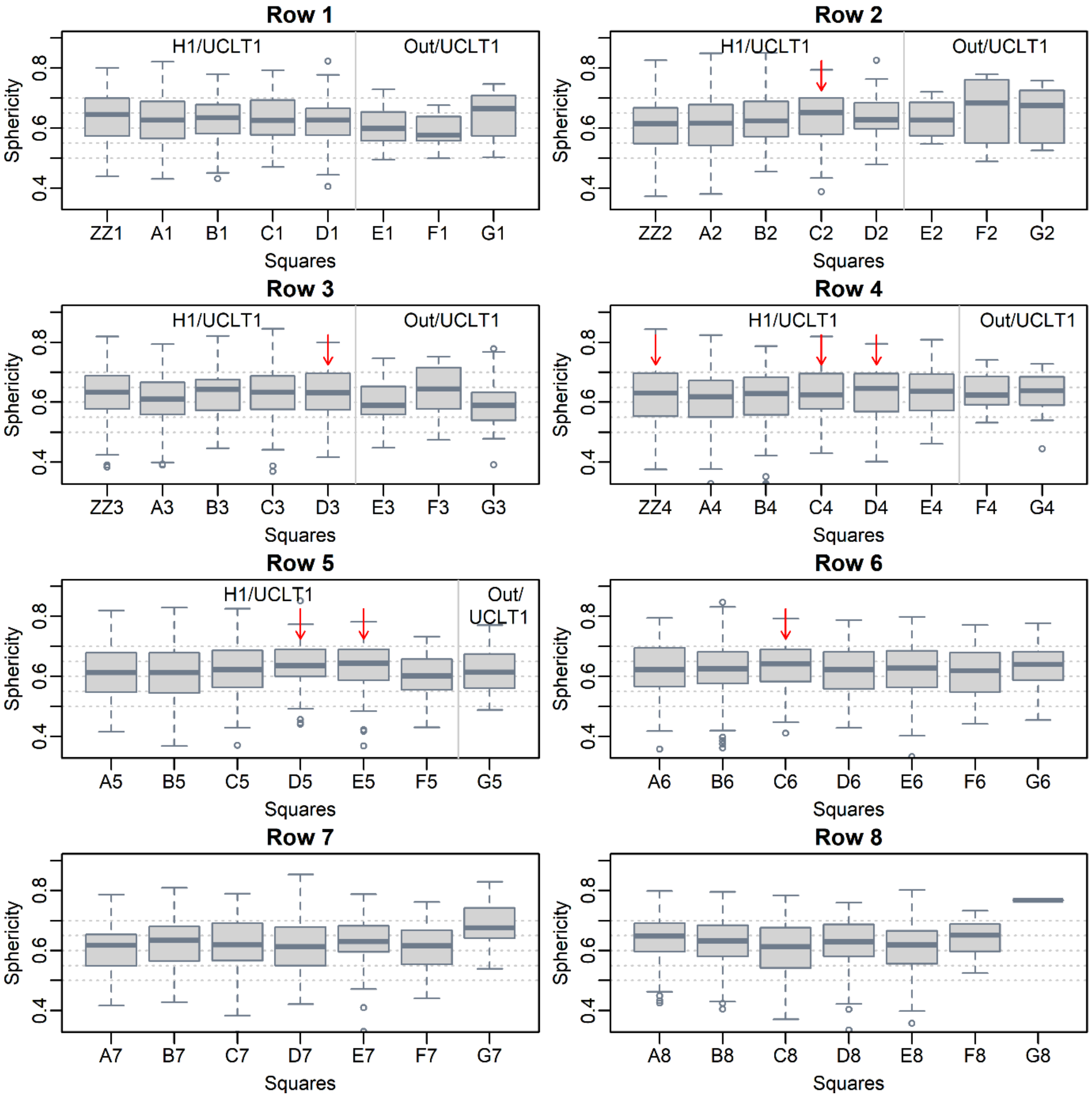


Figure 7.19: Sphericity values according to square units in H1 and Out/UCLT1.

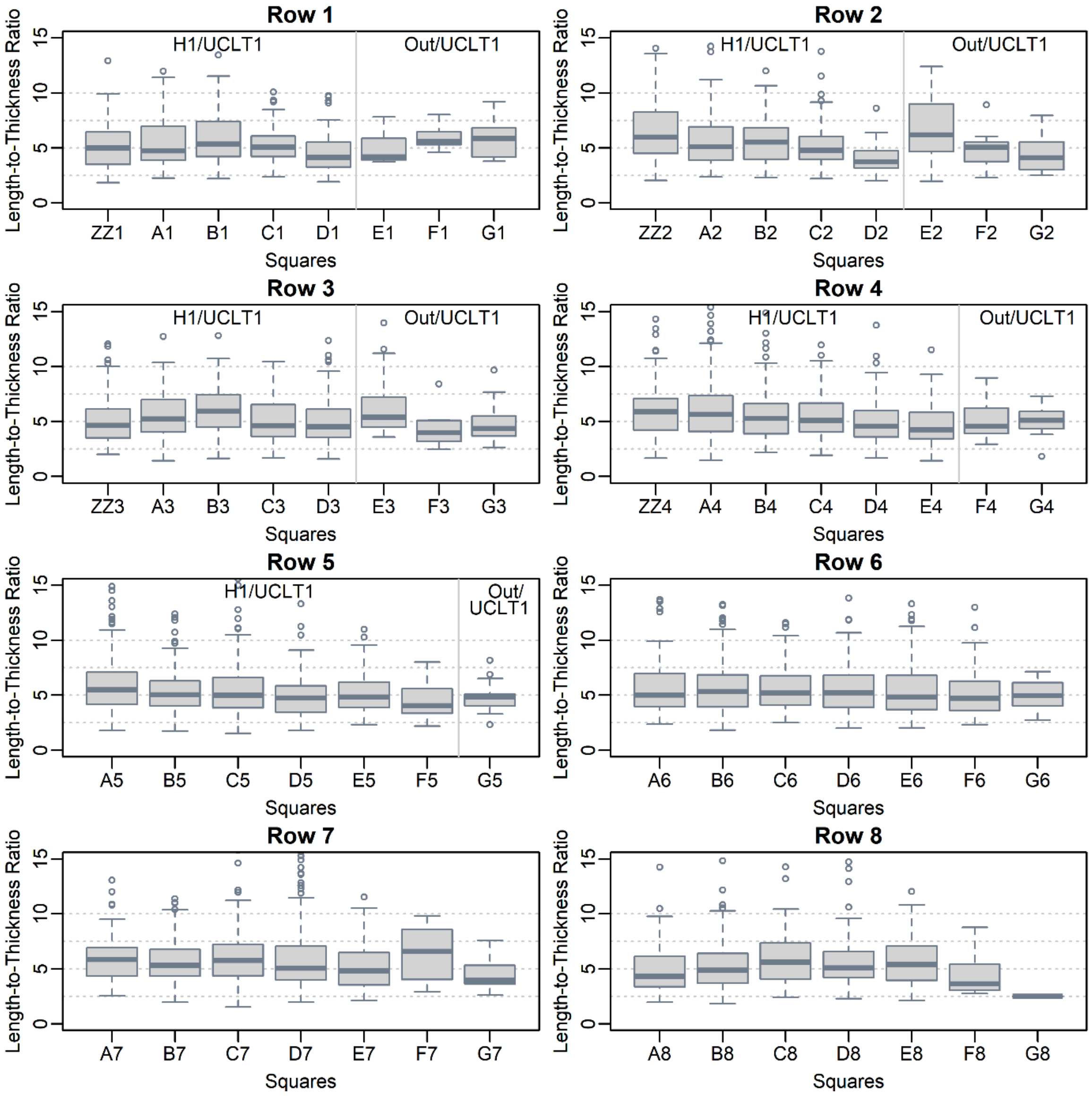


Figure 7.20: Length-to-thickness ratio (S/W) values according to square units in H1/ and Out/UCLT1.

These patterns of slightly decreasing sizes and frequencies of fragments, as well as increasing sphericity, from west to east are not likely due to postdepositional processes, as areas outside the house do not follow these trends. Therefore, these patterns can be better explained by activities within the house. It is likely that the compact and spherical shapes of small-sized fragments commonly found throughout columns C and D are indicating secondary rupture due to trampling. Thus, probably these rows were transit areas inside the house, and in this process several fragments might have been incorporated in the floors of the house, as SKC houses were sometimes made with clay floors (see section 4.1.1.1). In comparison, the cluster of larger, more elongated and rougher fragments observed in the central sector of the house can be related to activities performed near hearths, such as cooking or food processing (also discussed in section

8.2.1.6). Alternatively, these fragments could have been placed or dumped after house occupation (clarified below). Furthermore, the information from the outside areas of the house indicates a severely fragmented assemblage, which can be explained by trampling. This observation is supported by the predominance of small-sized fragments displaying a well-sorted distribution, compact morphology and highly smooth surface texture.

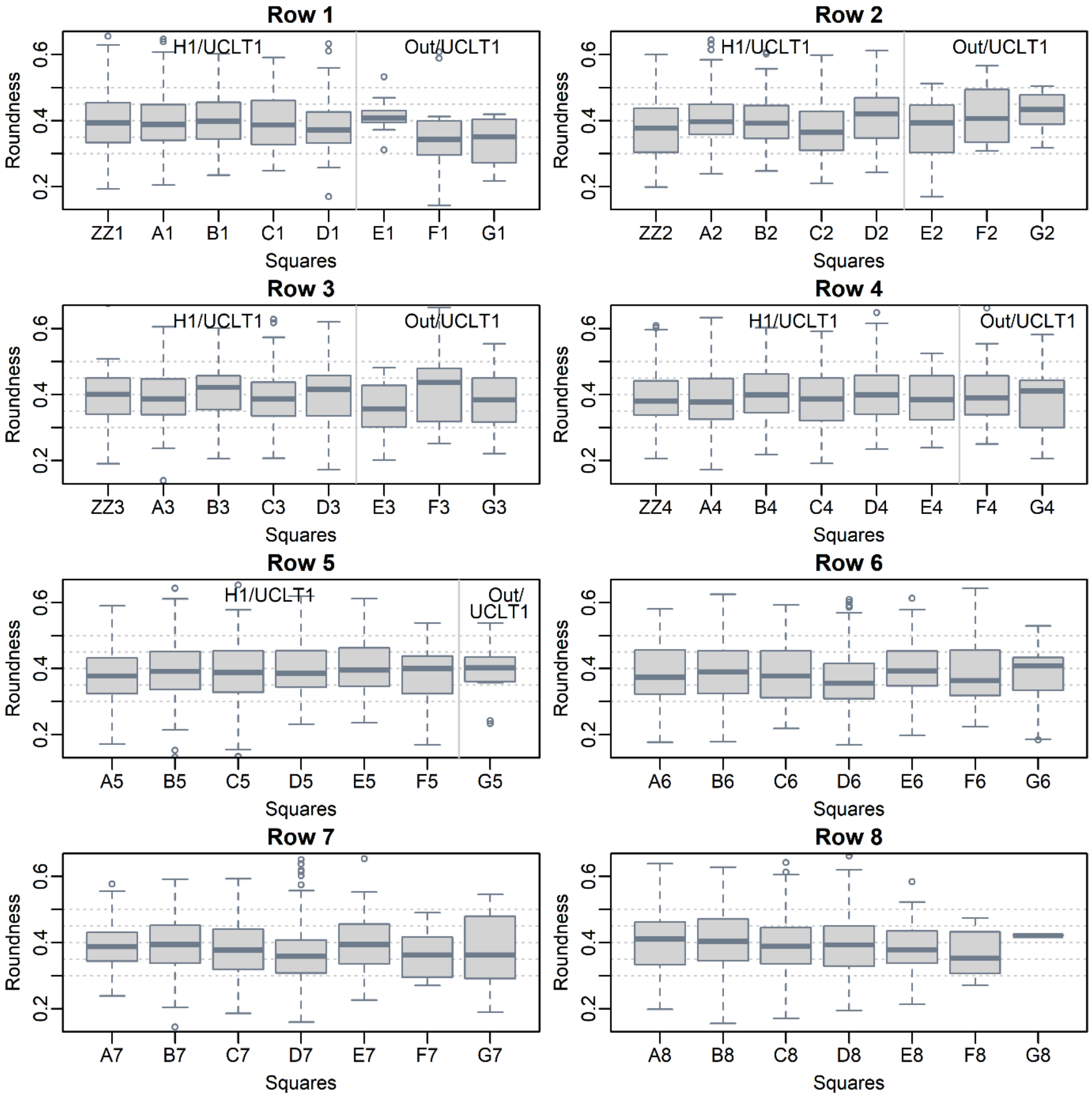


Figure 7.21: Roundness values according to square units in H1/ and Out/UCLT1.

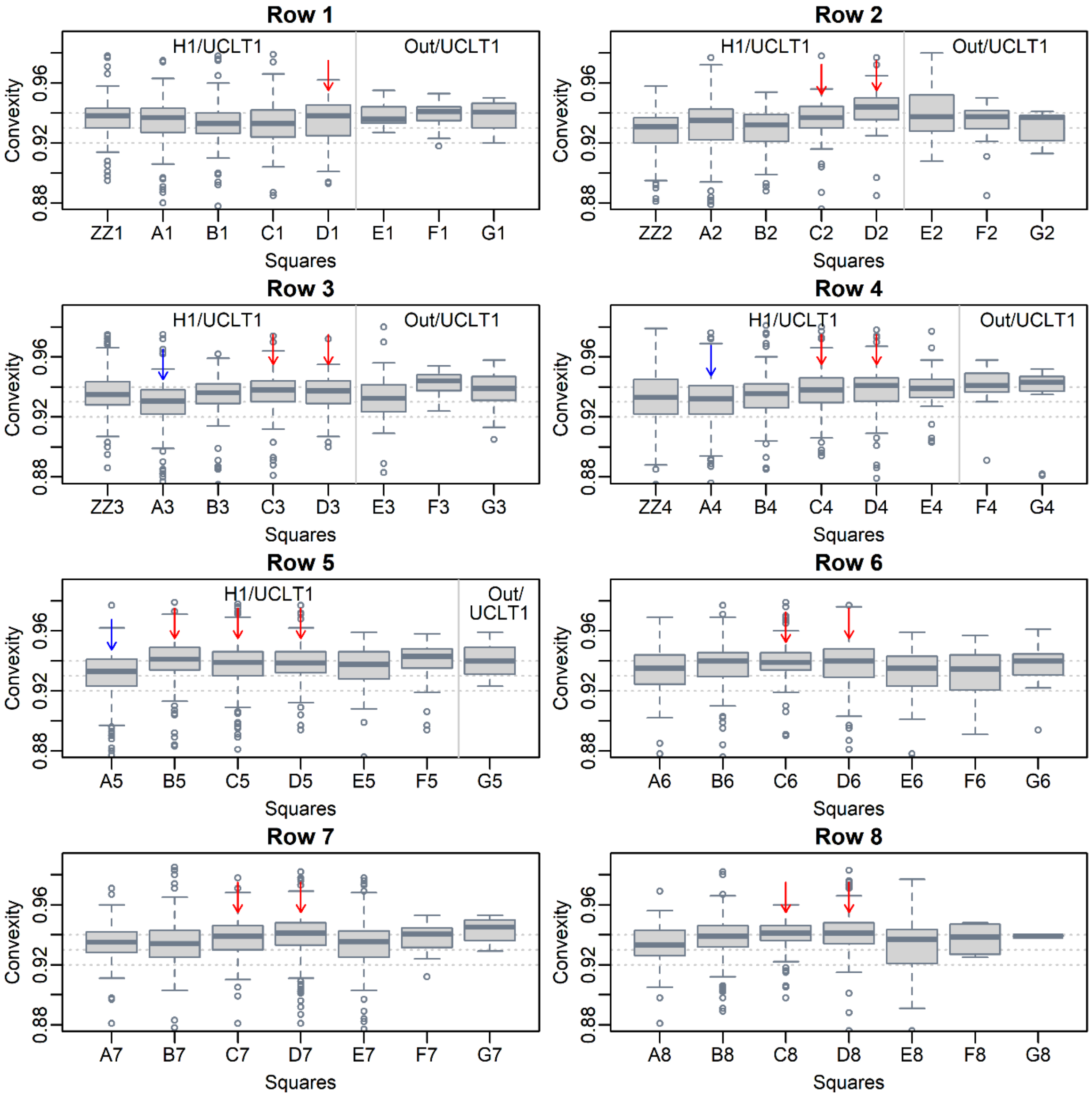


Figure 7.22: Convexity values according to square units in H1/ and Out/UCLT1.

7.2.1.2.2 Pit fill 7/UCLT1

From the plan view of the 3d reconstruction of the pit, we observe immediately that there are few finds around the edges of the pit, and most are found towards the middle portion (Figure 7.23). The profiles of the pit show that a considerable portion of the lower spits of the pit were filled mostly with sediment, and only later did finds become part of the infill (Figure 7.23). However, it is also possible that these lower spits without finds is the result of soil forming processes. For example, the dark colouration detected in the lower spits of the pit may be the result of leaching, where finer sediments and other soluble substances are illuviated into the 'natural' layer below the pit. Nonetheless, the first deposited finds inside the pit indicate two depressions existed (red arrows in Figure 7.23). Also displayed in this figure are two vessels found *in situ* (Plate VIII, 1-2), which are distributed at the margins of the excavated portion of the pit in middle and upper spits.

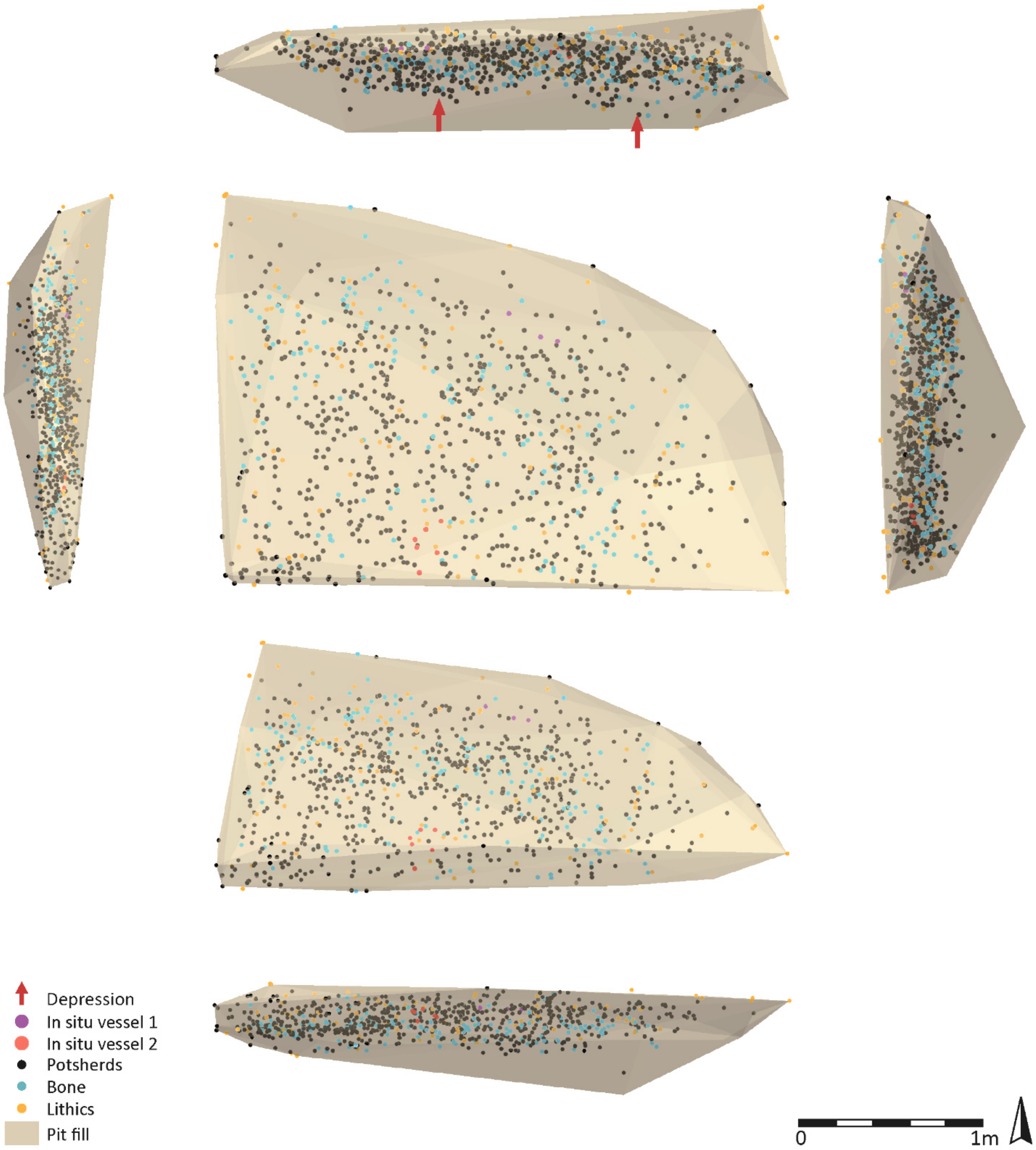


Figure 7.23: Plan and profile views of the three-dimensional reconstruction of pit fill 7/UCLT1.

Sherd-size distributions and concentrations (according to kernel density function) are displayed in Figure 7.24 in 15cm spits. All spits are predominantly constituted by very small to small fragments, with some areas containing medium and large sherds. Data for the lower spit of the pit shows a progressive increase in fragment size from the north-eastern slope towards the southwest. A linear regression model showed significant p-values (0.008) but also extremely low r-squared values (0.03). This means that while there is a significant trend of spatial sorting of fragment sizes in this spit, a large part of the variation observed cannot be explained solely by the linear model. The variation could be explained by topographical differences in the pit at the time of deposition or, more simply, two intercutting pits that eroded during use. In Figure 7.24, areas where medium and large fragments were found in the pit are generally areas of higher density or clustering of material (represented by more shaded areas in the map) and are related to the depressions described above. These depressions seem to be catchment areas for material deposits, adding variation to the way in which fragments are spatially distributed. In the middle and upper spits of the pit, the distribution of medium and large fragments shifts gradually towards the east. In the middle spit, the catchment area seems to be around the middle sector of the excavated portion of the pit, where medium- to large-sized fragments are accumulated and very small to small fragments are relegated to a periphery. Therefore, it does seem downslope processes are still important in sorting some of the material, but there is also evidence that other processes such as dumping from the edge of the pit or placing (such as in structured deposition) start taking place, the latter is demonstrated by some pots recovered *in situ* (Figure 7.23). Stratification of the pit deposits would clarify between these processes (section 6.1.1.3), but because of soil forming processes layers in the pit were difficult to identify. Lastly, in the upper spit of the pit there are fewer areas of fragment density and large fragments are predominant in the north and northeast end of the pit, suggestive of dumping or placing events near the edge of the pit. In addition, there is no clear indication of spatial sorting of fragment sizes in this spit.

Morphometric values show ambiguous evidence regarding deposits. On the one hand, values from the length-to-thickness ratio correspond well with the trend observed in sherd-size distributions (despite the result from the linear model; Figure 7.25), with more oblong fragments concentrated in the southwest end of the pit, and then northeast in the middle and upper spits. On the other hand, sphericity and roundness values are distributed in all spits with more angular and elongated fragments in ‘concentrated’ areas (shaded areas in maps from Figure 7.25 and 7.26). This could be indicative of material falling into pit depressions by deliberate placing or dumping. In the upper spit the eastern end displays angular and elongated fragments. In this sense, this concentration matches the distribution of large fragments mentioned above. Lastly, if one looks at convexity values, rough fragments are more evenly distributed in the lower and middle spits but appear more restricted to the northeast in the upper spit of the pit.

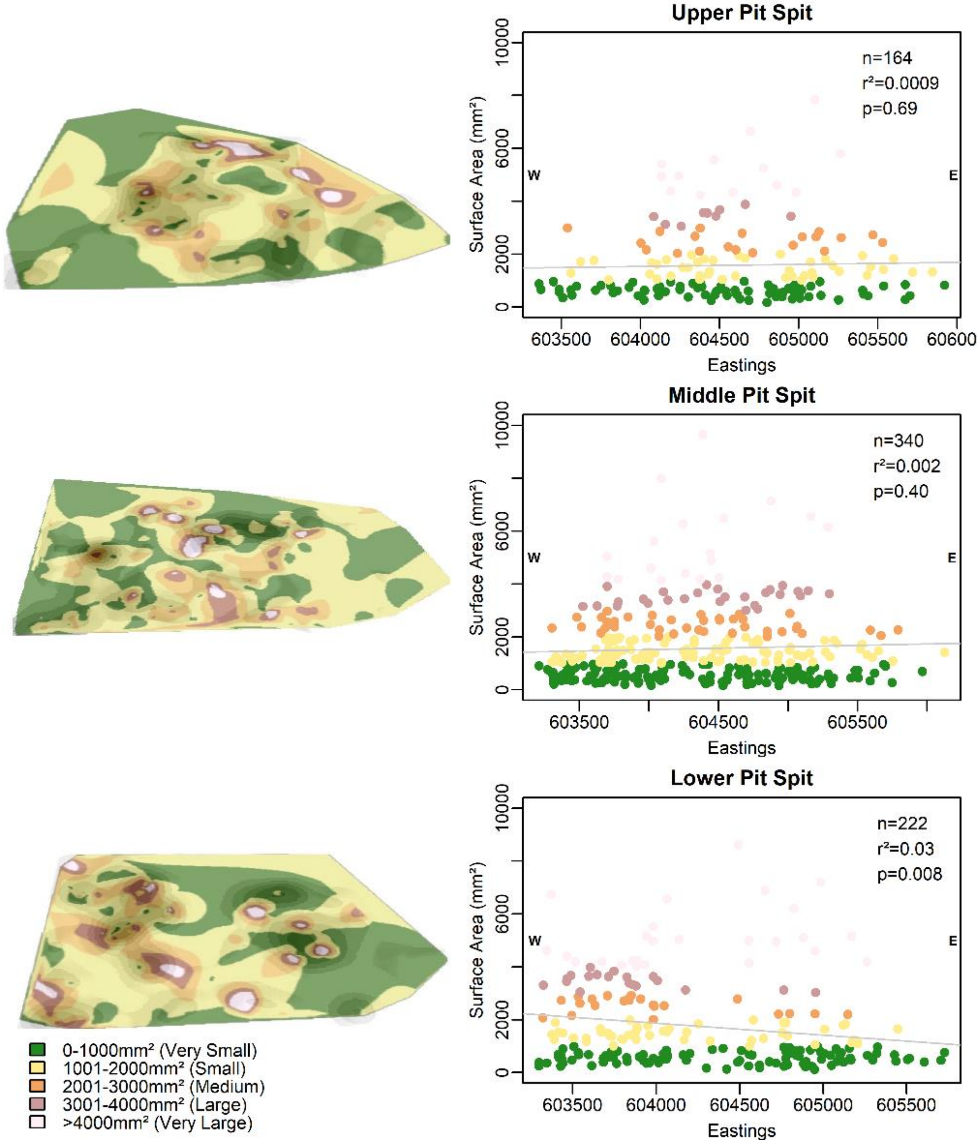


Figure 7.24: Spatial distribution of sherd sizes in three spits of pit fill 7/UCLT1. On the left, interpolation of fragment surface areas according to artificial spits (using natural interpolation function in ArcScene 10.5) with shaded areas representing find concentrations according to kernel density function.

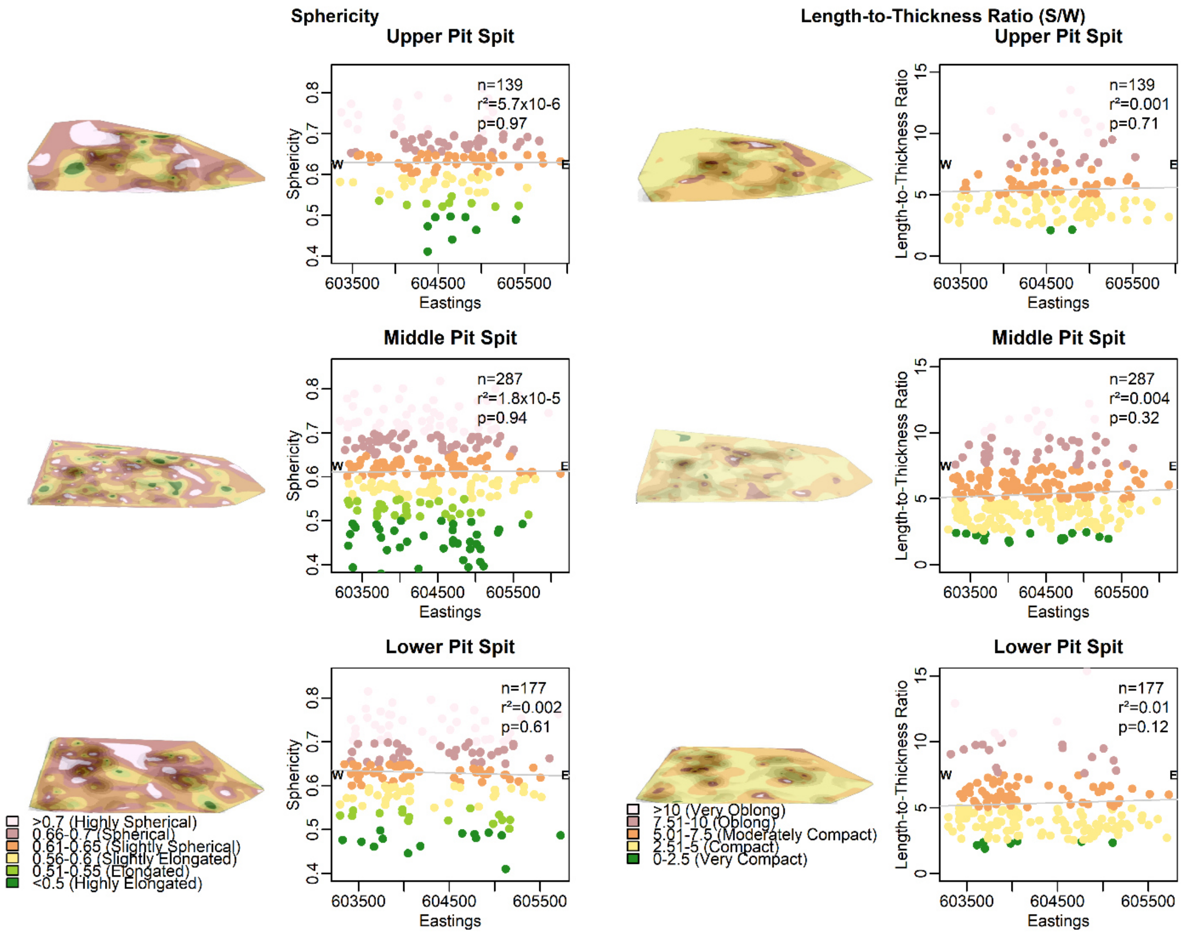


Figure 7. 25: Distribution of sherds according to their sphericity and compactness (S/W) in three spits of pit fill 7/UCLT1.

In sum, the pit infill (7/UCLT1) seems to have occurred in several stages and this seems to rule out the hypothesis that pits are backfilled. In a first stage, there were few to no sherds being deposited, as shown by the almost complete lack of cultural material observed in the lowest spits of the feature. Alternatively, the lowest spits of the feature can also simply be the result of post-depositional processes, such as leaching (as discussed above). At a second stage, the pit was probably infilled gradually in a northeast to southwest direction, and potsherds deposited in depressions or catchment areas. This was indicated by the distribution of finds, the spatial sorting of sherd sizes, and the concentration of material shown in the density maps. Furthermore, considering the predominance of smaller-sized fragments in the pit infill and the spatial sorting of fragment sizes from northeast to southwest, it is likely most of the potsherds infilling pit 7/UCLT1 had come from the outside areas of the house, where material had been previously trampled and transported. This interpretation is also supported by the fact the sherd-size distribution and morphometric values for fragments found outside the house and in the infill of the conjoining pit feature are very similar. Once areas of depression were filled, the areas of deposition of large fragments seems to shift more towards the central areas of the pit. At this point some amount of intentional dumping or placing of material must have occurred, as shown by the pots retrieved *in situ* from the middle and upper spit of the pit. These stages of pit infilling involved both gradual downslope deposition of fragments and some amount of intentional deposition of material at the margins of the pit, as is also indicated by the distribution of large sherd sizes towards the east of the pit's upper spit. By the time the pit was almost filled, there is a small accumulation of large, angular, and elongated fragments with rough surface texture in the north-eastern end, which are all indicators that this material was not eroded or fragmented. Therefore, the potsherds deposited in these areas are likely to have been intentionally deposited right after vessel breakage.

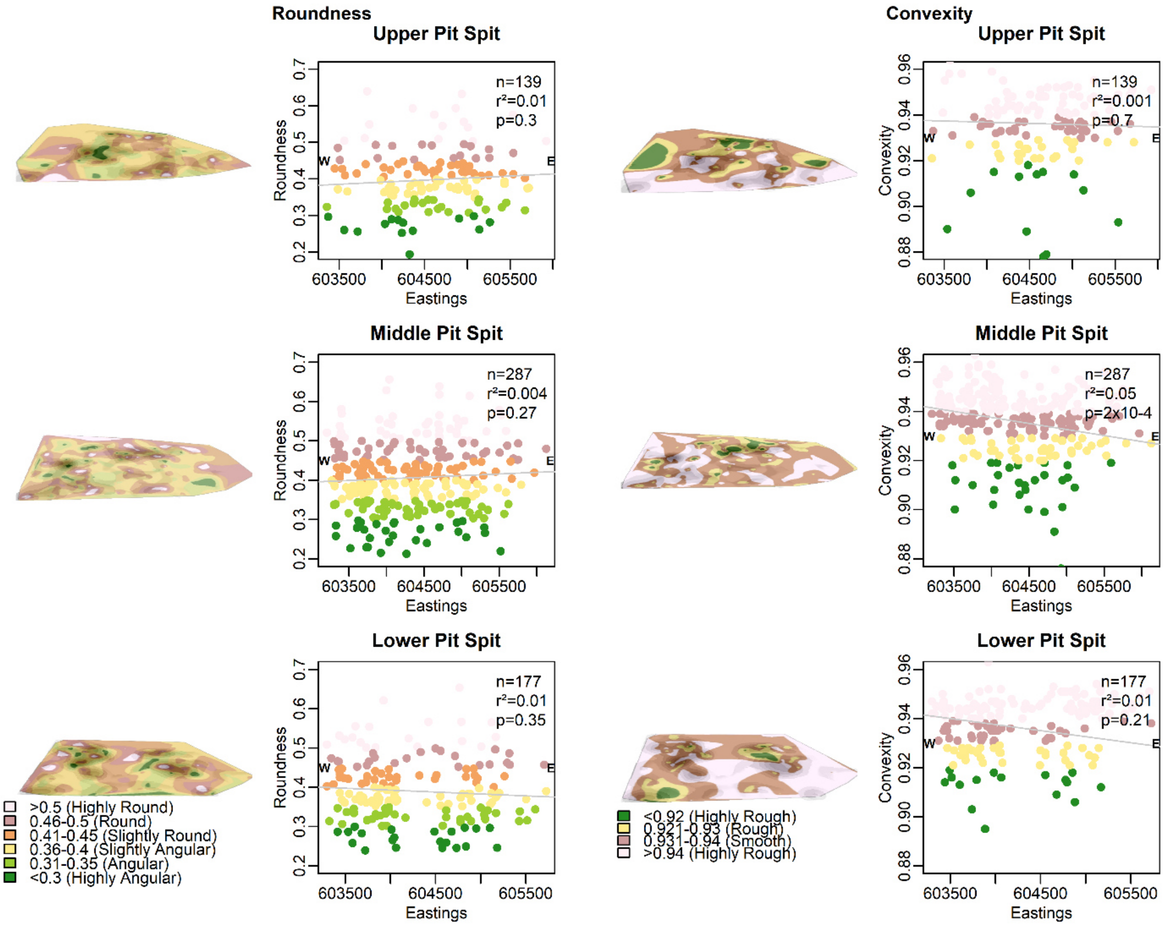


Figure 7.26: Distribution of sherds according to their roundness and convexity in three spits of pit fill 7/UCLT1.

7.2.1.3 Evidence from the analysis of soil samples from UCLT1

Evidence obtained from bulk soil samples analysis, soil micromorphology and microbiological analyses (Paraskova 2018; Sommer *et al.* 2019) provide further information on the use of space within House 1 (UCLT1). Firstly, the presence of ash, charcoal, and burnt bones observed in the field and in soil micromorphology samples 3A and 3B from feature 4/UCLT1 (Sommer, fieldnotes; Paraskova 2018, 48), suggests there might have been a hearth in the central sector of the house. While in an intra-site comparison magnetic susceptibility (χ) levels are higher in this sector (25 $x10^{-8}$ m^3kg^{-1}; Appendix 4), these values are very low compared to other sites (*e.g.* Ecsegfalva; Crowther 2007). One possible explanation for these low χ values is because in this sector of the house samples were only analysed from well below the occupation layer (*ca*. 15cm). At feature 12/UCLT1 (also located in this central sector of H1/UCLT1), X-ray fluorescent (XRF) elemental characterization of soil samples from spit 8 (well within the occupation layer) included high percentages of sulphur, calcium, inorganic phosphorous and potassium. Much like the information from feature 4/UCLT1, these results could also corroborate the presence of ash (S, Ca, K, and P), and decomposed bone (Ca; Sommer *et al.* 2019, 4). Furthermore, in this sector of the house high enzymatic concentrations of acid phosphatase (1256±78 nm pNP/g soil/hr)[2], chitinase (1176±23 nm pNP/g soil/hr) and xylosidase (1310±110 nm pNP/g soil/hr), carbon (Loss on Ignition 4.47%), and lipolytic microorganisms (reaching maximum of 1250±208 CFUs $x10^3$ per gram of soil) have been detected, indicating organic decomposition of vegetable or animal fats occurred in this area. This last information is suggestive that food was probably also processed in this sector (Paraskova 2018, 69 and data in Appendix 4; Sommer *et al.* 2019). In sum, the multiple analyses of soil samples obtained from H1/UCLT1 show it is likely that a hearth or firing structure was located in the central sector of the house, but a more systematic analysis of samples from the occupation layer will be needed to confirm this assertion.

Some samples from 7/UCLT1 also provide information on the potential origin of pit deposits. For example, similar percentages of sulphur, inorganic phosphorus, calcium and potassium from H1/UCLT1 are also found at the top of pit fill 7/UCLT1 (*i.e.* spit 8; Sommer *et al.* 2019, 4). In addition, like the abovementioned sector of H1/UCLT1, evidence obtained from soil micromorphology samples 5, 6 and 7, and bulk soil sample analysis shows presence of micro-ash and charcoal in the pit as well (Paraskova 2018, 68 and Table 5). Furthermore, similar concentrations of acid phosphatase and lipolytic microorganisms described above for the central

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[2] Units correspond to nanomoles p-nitrophenol/grams of soil per hour

sector of H1/UCLT1 were also detected in pit fill 7/UCLT1, indicating decomposition of vegetable or animal fats and leading to the suggestion that the pit was partly used for organic refuse (Sommer *et al.* 2019, 5). Nonetheless, all this information could be also suggesting that some deposits from the pit may originate from the house, which is further discussed below.

7.2.1.4 Summary and discussion of results

At a first glance it could appear that the sherd size differences between C2/2005 and contexts from UCLT1 could be related to archaeological recovery methods. Indeed, one could argue if rescue excavations would have been more detailed, the results would certainly tilt sherd-size distribution curve of C2/2005 more towards the finer fraction. However, if one takes a closer look at the EVEs and brokenness ratio, one notes that C2/2005 has a considerably less broken assemblage and the number, types and range of vessels sizes represented is rich (see Table 7.8). Thus, all the information obtained on sherd-size distributions and morphometric analysis points to the conclusion that this is a very well-preserved ceramic assemblage, with no significant traces of erosion or secondary rupture. Such can be the case of storage and/or workshop areas and would imply that the ceramic material was left abandoned and unreclaimed. The large number of clay weights (n=33), spindle whorls (n=2) and miniature vessels (n=9) retrieved from this context also supports this hypothesis. Further comparison with other similar features could substantiate this interpretation.

The depositional processes responsible for the finds in H1/ and Out/UCLT1 are probably anthropogenic in origin and related to the cumulative effect of common daily activities. This includes the unintended trampling of fragments in 'areas of transit', and the deposition of mostly compact, rounded and smooth sherds inside postholes. The accumulation of larger fragments in the central sector of the house (Figure 7.27) probably responds to intended actions during household practices. These household practices can be further characterised by integrating evidence from microbiological, bulk soil sample and soil micromorphology analyses. Given the possibility of a hearth being located in the central sector of the house (as suggested by the presence of ash and bone fragments) and animal and plant decomposition occurred in this area (as indicated by the concentrations of acid phosphatase and lipolytic microorganisms) it is likely that this sector was linked to cooking and food processing. SKC hearths are normally preserved in pit complexes, but hearths are rare inside rectangular wattle and daub houses (Bánffy 2004, 42). Because of their rarity, their specific roles are hard to pinpoint. Some Early Neolithic sites from neighbouring areas could give us some clues on the specific role of hearths in houses. At Sesklo

(Thessaly, Greece), squared hearths are consistently at the centre of the house, and probably linked to cooking activities (Souvatzi 2013, 55). In sites in Macedonia, hearths could be linked to food preparation and processing (Naumov 2013, 72), and are often made of stones, potsherds and clay, such as at Mrševci and Angelci (*Idem*, 74). At the Karanovo (Bulgaria) type-site, during the first phase of occupation hearths were commonly built along walls of one-roomed rectangular buildings, and sometimes accompanied by ground stones and storage vessels (Bailey 2000, 49–50). Therefore, an indoor hearth remains a possibility in H1/UCLT1 at Tășnad Sere and could be linked to food preparation. A systematic bulk soil sample analysis of the entire occupation layer would help confirm the presence of this hearth, as well as indicate if food processing was performed. Furthermore, the ongoing three-dimensional reconstruction of the UCL-Satu Mare museum excavation through photogrammetric techniques could also serve to corroborate the sherd deposition patterns described above.

An alternative explanation is that the accumulation of sherds inside the house is the result of post-abandonment discard, but in this case we would expect a higher variation in shapes and sizes of fragments, and some stratification of sherd-size distributions showing differences between deposition during house use and after abandonment. The deposition of hanging pots from the collapse of roofs during post-abandonment house decomposition, could also explain the accumulation of large sherds in the central sector of the house. However, evidence presented in section 8.2.1.5 on *in situ* vessels found in this sector of the house indicate they were deliberately placed, which supports the cooking/food processing hypothesis. More evidence on potsherd and vessel reuse at UCLT1 is provided in the next chapter.

Data obtained from the pit infill provides some of the missing picture on what happens to broken pots. From the analysis of this feature, a significant portion of the fragmentary material found in the pit may have originated from adjacent areas like Out/UCLT1, where trampling was probably common. In addition, a small portion could be attributed to dumping or placing events at the pit margins, as was seen by a few pots found *in situ* and the distribution of large elongated, oblong, angular and rough fragments in the northeast end. The multiple analyses conducted on soil samples from pit fill 7/UCLT1 also show that the upper spit of the pit fill may have originated from the central sector of the house. This connection was suggested by the similar concentrations of lypolithic microorganisms and acid phosphatase, as well as comparable percentages of sulphur, inorganic phosphorus, calcium and potassium, in both areas. Thus, apart from the use of the pit at

UCLT1 as an organic refuse deposit, this information could also suggest the material from the central sector of this house could have been dumped or placed into the nearby pit (Figure 7.27).

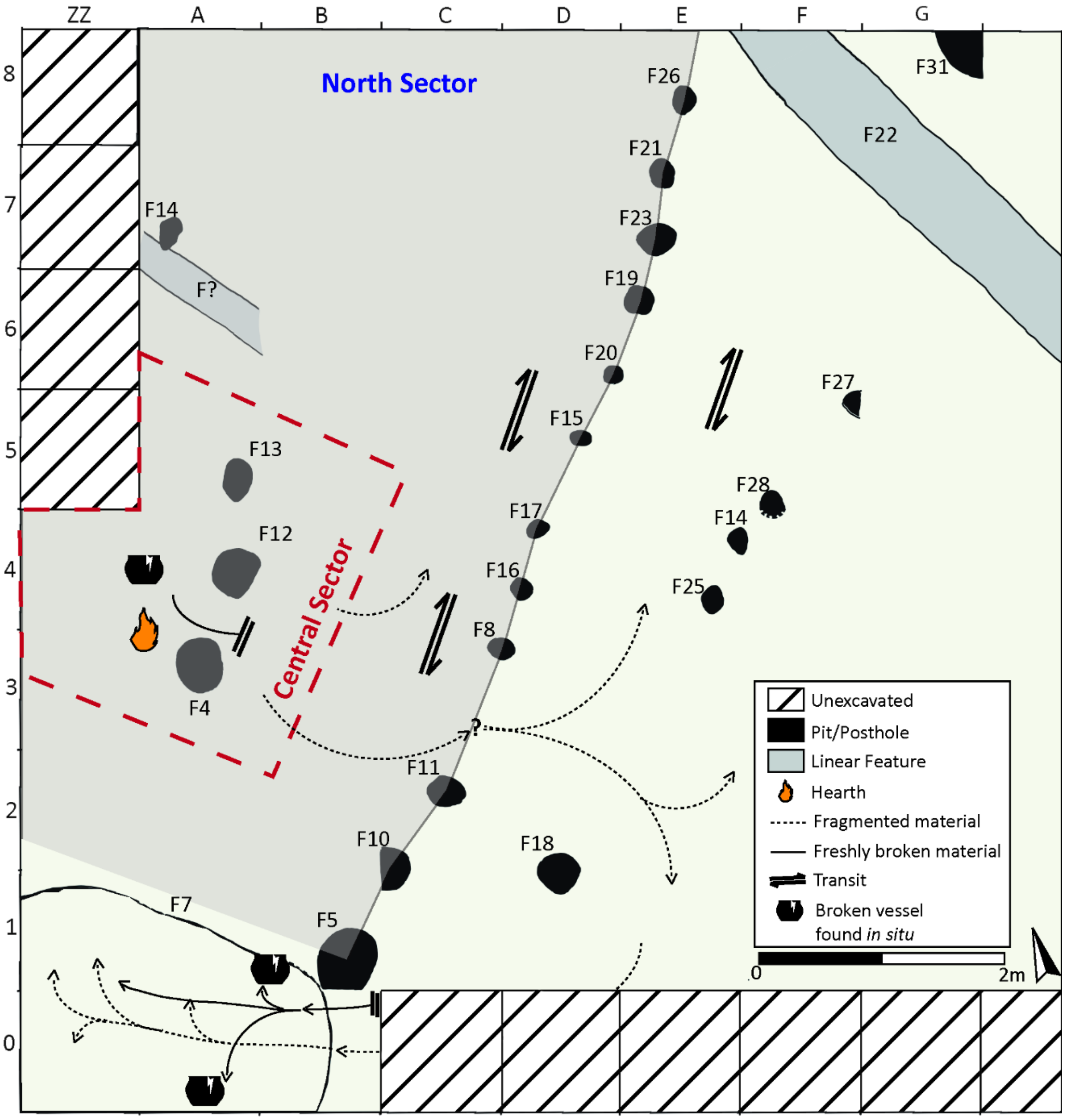


Figure 7.27: Hypothetical reconstruction of fragment movement and deposition in UCLT1.

In this sense, at Tășnad Sere there are a variety of ways in which fragments are dealt with from the moment of their creation. Inside the house analysed, a considerable portion of the house probably consisted of very small trampled fragments, as shown in certain transit areas (Figure 7.27). These could have been integrated into the floors of the house, but unfortunately to this day no clay floors have been retrieved at the site. Furthermore, in the area tentatively designated here as a workshop/storage area, *i.e.* C2/2005, and the house (H1/UCLT1) we find an abundant assemblage of potsherds, which implies fragments were an important addition to social life both inside and outside different structures. While more research will be carried out on some of the other houses excavated in 2009 (see section 5.1.4.1.2.2), we can state at this point that broken objects seem to be lying out and about, exposed and moving. This is also supported by the sequence of filling of the pit from UCLT1, where most of the materials deposited have been exposed to secondary rupture and/or erosion before they were deposited, which points at a connection between outside areas of the house and the pit fill. This exposure brings opportunity for further actions, such as sherd and vessel reuse, but this is discussed in the next chapter. In contrast, there are some parts of ceramic vessels that appear to have little to no exposure before deposition in the pit, and which were further fragmented on the spot of deposition (possibly due to soil compaction), such as the two *in situ* vessels recovered from the upper spit of this feature. We also discussed how fragments were possibly moved from the central sector of the house into pits (Figure 7.27). Thus, it would appear a small number of broken pots were deposited not long after their primary rupture, while the vast majority were kept close and circulated around the house and adjacent areas by the effect of house maintenance or of human transit in these areas.

7.2.2 Călinești-Oaș-Dâmbul Sfintei Mării

7.2.2.1 Basic recording of material

As there is no complete inventory of ceramic material obtained from the 1999-2001 excavations, I have based the total amount of potsherds shown in Table 7.9 on the collection available at the Satu Mare Museum. According to one of the excavators, these values should correspond to the entirety of the assemblage retrieved (Astaloș, personal communication 12th September 2017). As seen in Table 7.9, sample size is reduced considerably when applying the sampling criteria outlined in Chapter 6. Nonetheless, the samples for both sherd-size distribution and morphometric analysis appear to be large enough to allow unravelling some (post)depositional processes that were active at this site.

Feature	Sherd-size Distribution Sample (n1)			Morphometrics Sample (n2)			Total Weight
	Weight	Fragment No.	Percent (weight)	Weight	Fragment No.	Percent (weight)	
CC1	4264.5	274	76.32	2643	221	47.30	5587.5
CC2	12227.5	652	86.36	6202	442	43.80	14158.5
CC3	1290.5	138	52.31	982.5	125	39.83	2467

Table 7.9: Sample size information of features from Călinești-Oaș-D.S.M.. Percentages are calculated according to sample weight.

The EVEs show that there is a predominance of small and medium-sized vessels in contexts CC1 and CC2 (Table 7.10). The brokenness ratio is relatively high for context CC1. However, it should also be remembered that only a small section of the pit has been excavated so far. The lack of base fragments in CC3 also points to a highly broken assemblage, but caution should be also taken because of the low sample size analysed from the site. The brokenness ratio of CC2 is moderate to high, which signals again that some degree of fragmentation occurred in this context.

Feature	Vessel size*	Base sherd(s)	EVEs	Total EVEs	Brokenness ratio (s/v)**
CC1	Very Small	1	0.225	1.725	158.84
	Small	7	0.80		
	Medium	6	0.7		
CC2	Very Small	1	0.2	7.8	83.59
	Small	19	5.825		
	Medium	7	1.45		
	Large	3	0.325		

*Table 7.10: Calculation of EVEs and brokenness (s/v) from Calinesti-Oas-D.S.M. according to feature. *Sizes were determined from projected vessel diameters (defined in section 6.1.2.3.1) **Sherd numbers are equivalent to sampled fragments (n1).*

7.2.2.1.1 Fabric characterisation

The composition of the assemblage from Călinești-Oaș-D.S.M. displays some variation, with a dominance of organic-temper with mineral inclusions (Figure 7.28). Petrographic analysis of potsherds from CC3 showed that rounded volcanic rocks were frequently incorporated and were possibly contained in the clay already (Kadrow and Rauba-Bukowska 2017, 423), so is most likely the type of mineral identified in my macroscopic assessment. Inclusion size was highly consistent across all features at the site, with a predominance of the semi-fine fraction (*i.e*. 1-2mm size), and fragments were almost entirely soft. This information warrants that the sherd-size distribution and morphometric analyses should take into consideration the compositional differences of potsherds from Călinești-Oaș-D.S.M., as I have done below.

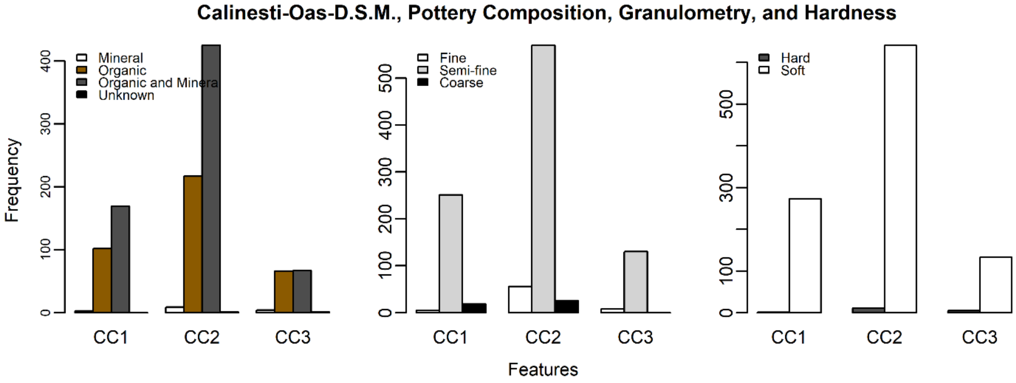


Figure 7.28: Composition, granulometry and hardness of ceramics from Călinești-Oaș-D.S.M..

7.2.2.1.2 Postdepositional information

According to Figure 7.29, body fragments form the vast majority in each context. This could suggest a high amount of fragmentation. Of all the features, CC2 has the highest number of rims and bases, which could indicate that some large parts of vessels were deposited in the pit. There is a high number of fragments that have been severely brushed during washing. This erosive process can have an effect on the surface roughness of fragments, and thus calculation of convexity values should be taken with caution. Nonetheless, since fragments from all contexts appear to be equally affected by the methods of finds processing, a comparison between assemblages can be performed.

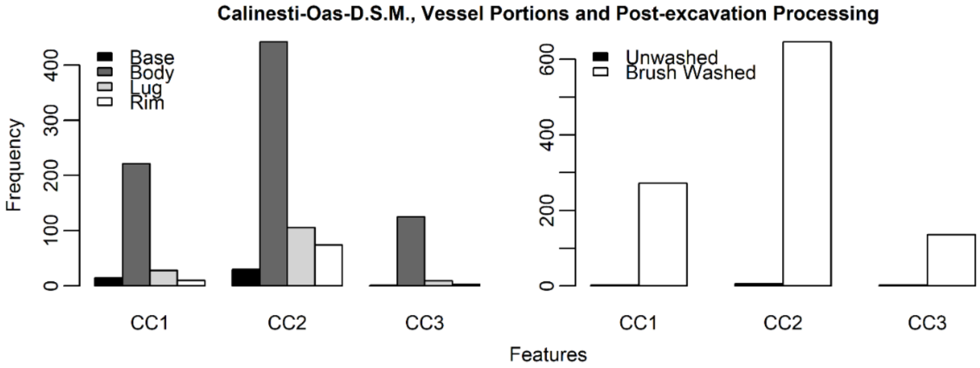


Figure 7.29: Vessel portions represented and traces of post-excavation processing of ceramic assemblages from Călinești-Oaș-D.S.M.

7.2.2.2 Sherd-size distribution and morphometric results

Figure 7.30 summarises the sherd-size distribution information for all three features. This figure shows that, regardless of context, organic-tempered sherds are in general smaller, and display slightly more negative distribution than fragments containing organic and mineral inclusions. The same type of compositional variation is observable in the different shape parameters used. In general, organic-tempered sherds are smoother, rounder and more compact than sherds containing organic and mineral inclusions (Figure 7.31). These differences could indicate that sherds with organic and mineral inclusions are tougher, and that the combination of different types of inclusions can increase the opportunity for crack dissipating mechanisms.

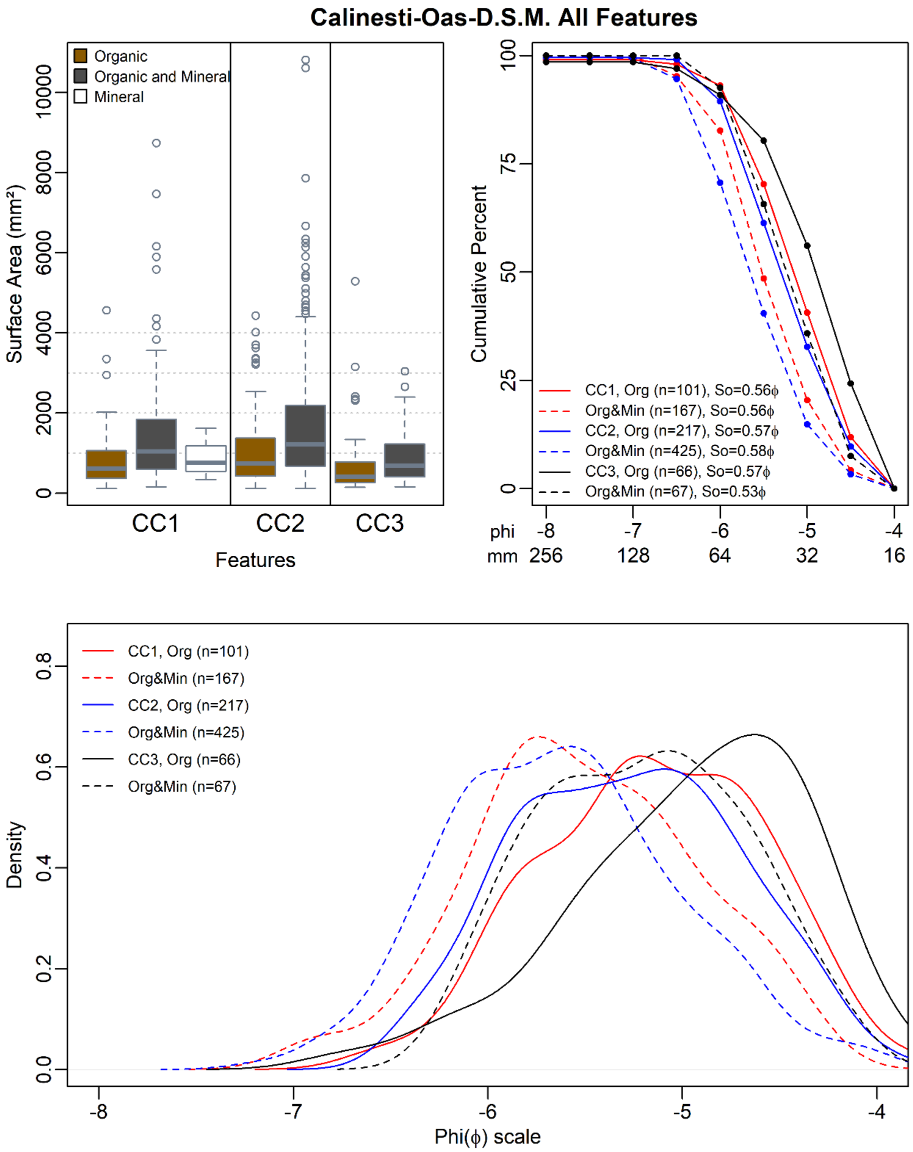


Figure 7.30: Sherd-size distributions of all features sampled in Călinești-Oaș-D.S.M..

Apart from influence of fragment composition, another strong trend observed for all features is the prevalence of very small and small sherds. This trend indicates a high level of fragmentation, particularly severe in feature CC3. This feature also shows a coarsely skewed and moderately sorted distribution of fragment sizes. While composed of mostly small fragments, feature CC2 shows the highest number of fragments and fragment-size variation, which can also be illustrated by the sorting values. There is very little difference in terms of fragment morphometry between the CC1 and CC3 assemblages. Fragments are slightly spherical to spherical, compact to moderately compact, slightly rounded to rounded, and with smooth texture. In slight contrast, fragments from CC2 appear less fragmented, and there are signs that some parts of the assemblage were slightly abraded before deposition. It is also possible that fragment roughness was higher but were affected by post-excavation washing procedures. In sum, the results presented so far show contexts CC1 and CC3 mostly contain very fragmented and abraded potsherd assemblages, suggesting that deposition occurred after a long exposure of sherds to secondary rupture and abrasion.

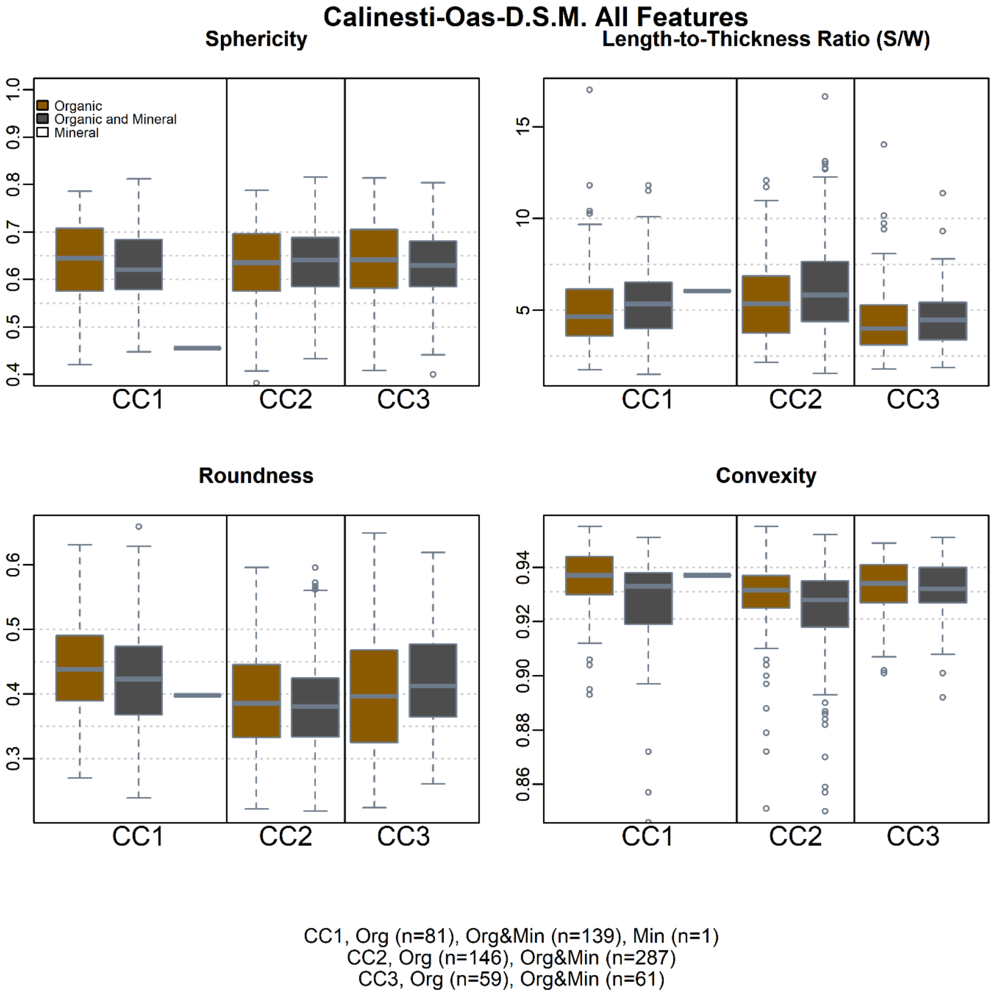


Figure 7.31: Results from shape descriptors of potsherds at Călinești-Oaș-D.S.M.

7.2.2.2.1 Feature CC1

Figure 7.32 shows the sherd-size distribution of the different spits of pit CC1. The similar sherd-size distributions of modern ploughed layers and the pit context suggests the material from the pit infill has a high degree of fragmentation. All spits show a high number of small sherd sizes, negative skewness and moderate to well-sorted logarithmic distributions. The moderate sorting of fragments is restricted to the upper pit spit and suggests different depositional processes might be responsible for its formation. This slightly contrasts with the values from the lower pit spit which shows a well-sorted potsherd deposit. Morphometric values also show that highly spherical and compact fragments are prevalent through all spits (Figure 7.33), but also that roundness of sherds corners is much higher in fragments from the pit fill.

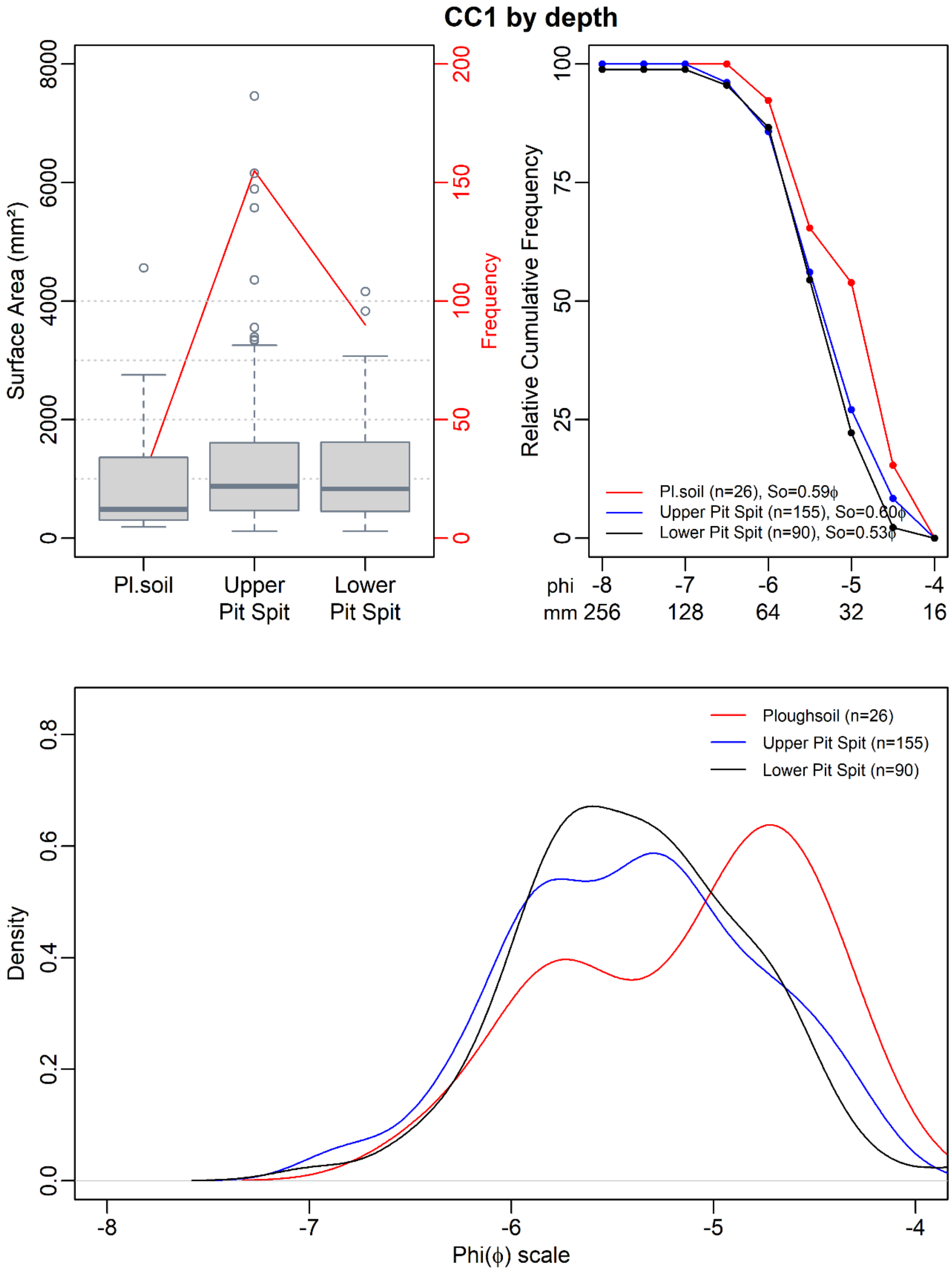


Figure 7.32: Sherd-size distributions of assemblage from CC1 according to different pit spits. Pl.soil = Ploughsoil

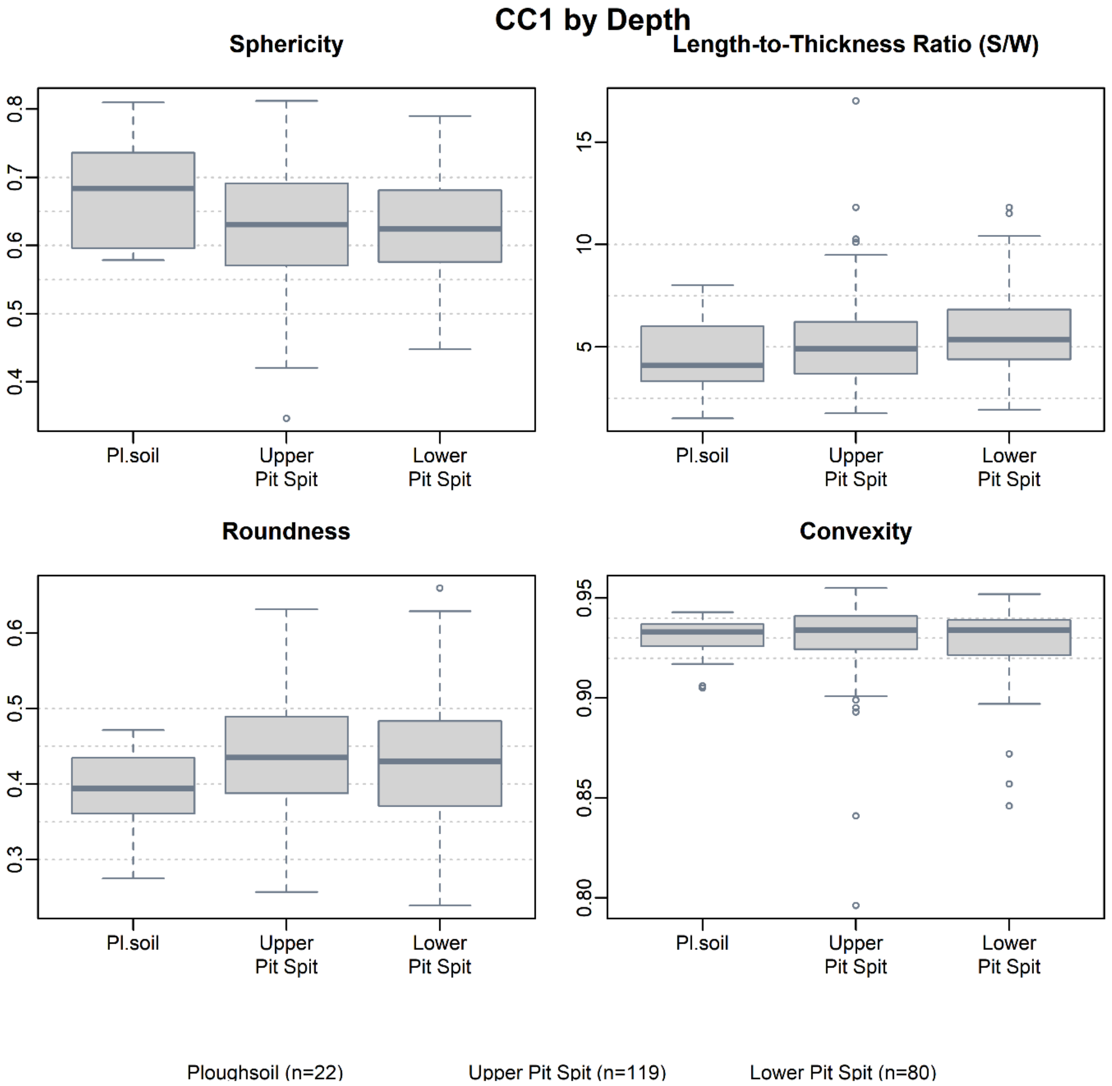


Figure 7.33: Morphometric values of sherds from CC1 according to different pit spits. Pl.soil = Ploughsoil

In Călinești-Oaș-D.S.M., pit CC1 provides the clearest depositional information when sherd-size distribution and morphometric values are examined according to spatial unit and spit. The distribution of fragment sizes in the lower pit spit (Figure 7.34), indicates that very small fragments were present on either end of the pit slopes and slightly larger sherds were deposited in the central area. This observation of spatial sorting of fragment sizes is further corroborated by differences in sorting (So) values per square unit, with the highest numbers observed in the middle and lower parts towards the extremes of the lower pit spit. The distribution curves also indicate a greater size variation for fragments from unit 3-4. Shape descriptors of this spit indicate that fragments overall are spherical/compact, rounded and with a smooth texture (Figure 7.35). Fragments from the middle portion of the lower pit spit, nonetheless, signal a slight decline in sphericity, roundness and convexity, as well as an increase in S/W values. These results show that there is mostly spatial sorting of fragment sizes inwards from the western and eastern slopes of the pit, and that the more elongated, angular and rougher fragments in unit 3-4 are likely to have been deposited by a different process.

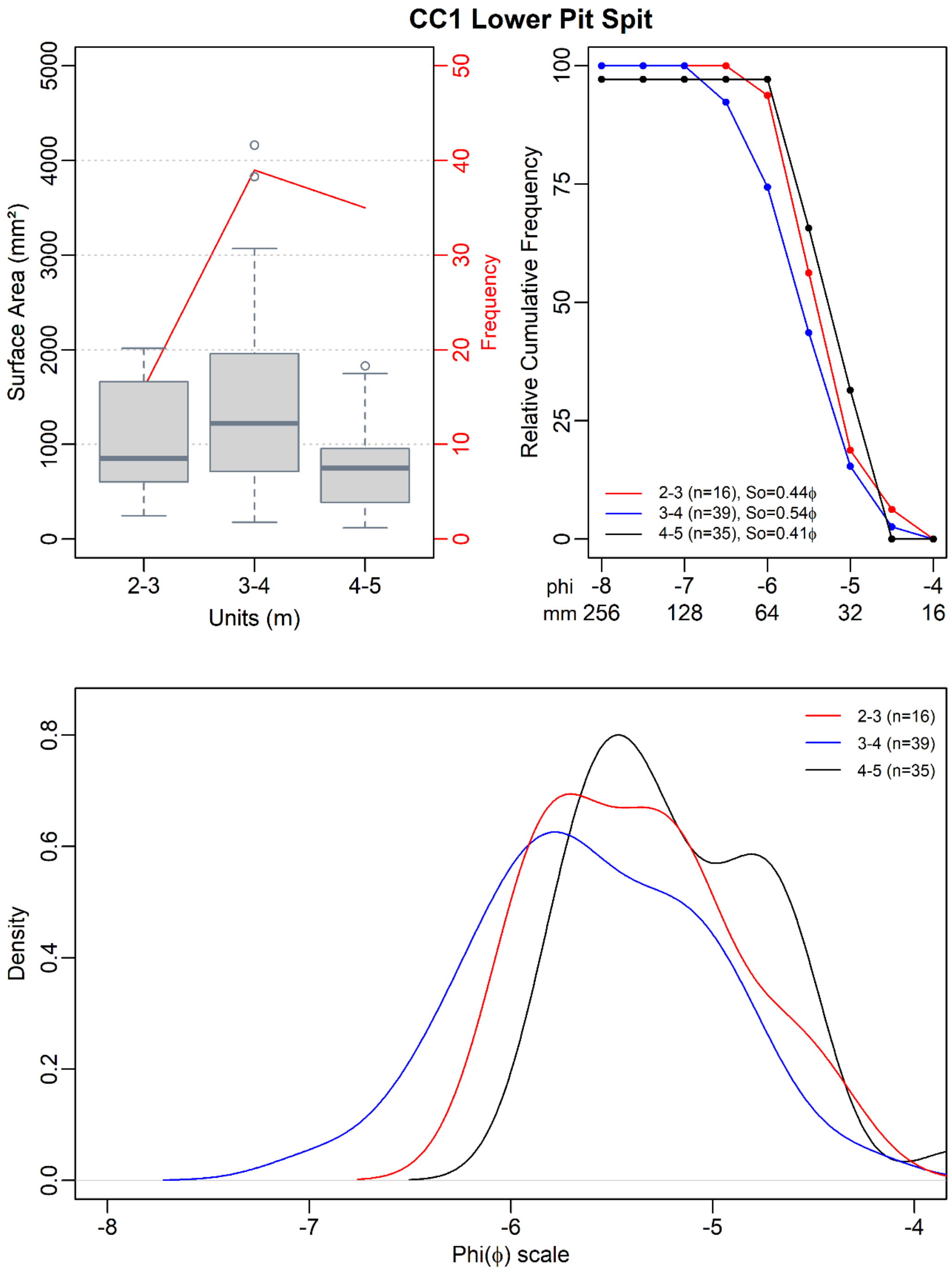


Figure 7.34: Frequency and sherd-size distributions in the lower spit of pit CC1.

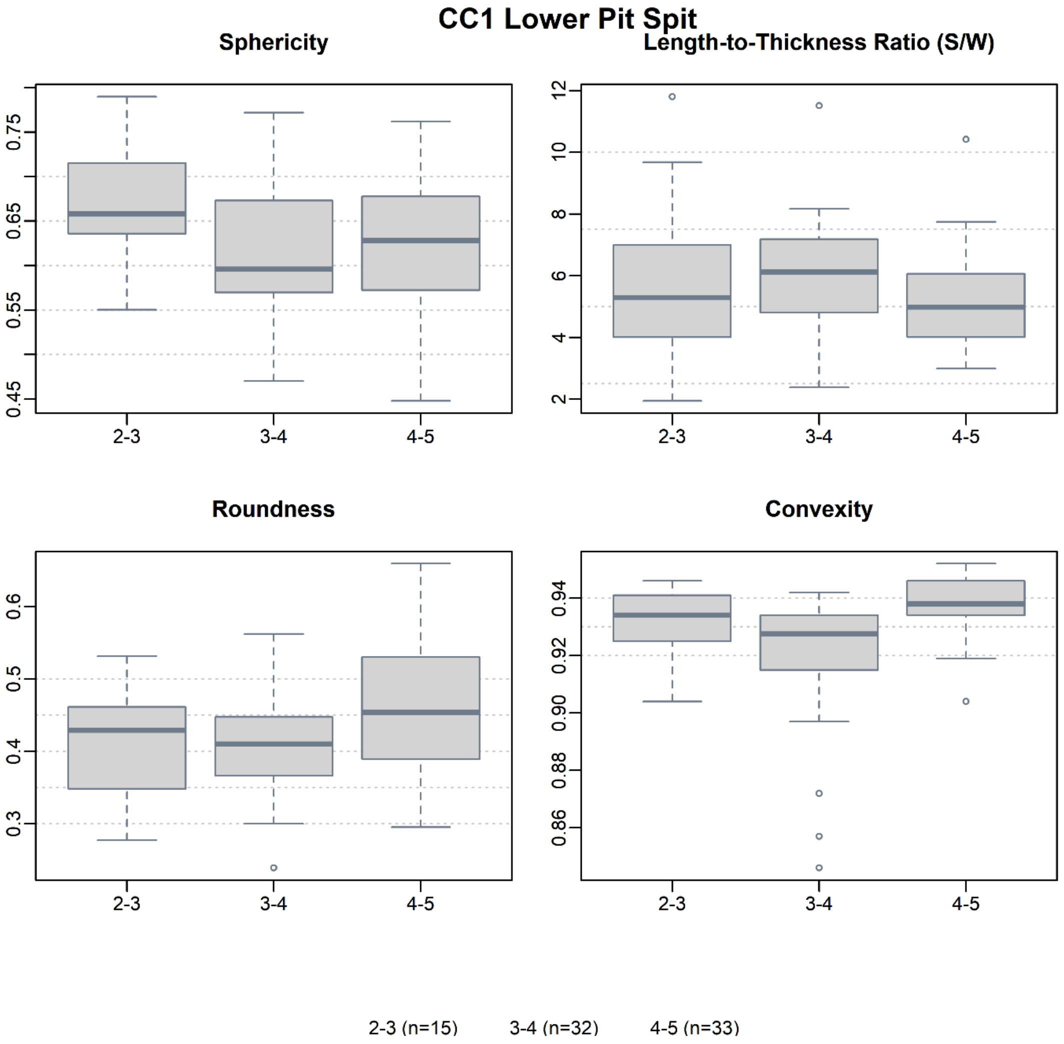


Figure 7.35: Shape descriptors of sherds from the lower spit of pit CC1.

Sherd-size distributions from the upper pit spit also indicate spatial sorting of sherd-sizes from the western to the eastern end of the pit slopes (Figure 7.36). The progressive increase in fragment size is accompanied by a change from negative to positive skewness in the sherd-size distribution of each spatial unit. The overall distribution in the kernel density plot (Figure 7.36) points to some major differences between fragments from the western and eastern ends of the pit. Sorting values from each unit seem to indicate slight topographical differences in the pit structure at the time of deposition. Slight depressions possibly acted as catchment areas for small and medium-sized fragments, resulting in moderately sorted distributions (as in unit 4-5 and unit 6-7), while in slightly more elevated areas the size sorting was poor (like in unit 5-6). This is corroborated by the abundance of sherds in the middle section rather than on either end of the pit. Nonetheless, not all the poorly sorted deposits from the middle and eastern portion can be explained by topographic differences, which suggests that another process might have been responsible.

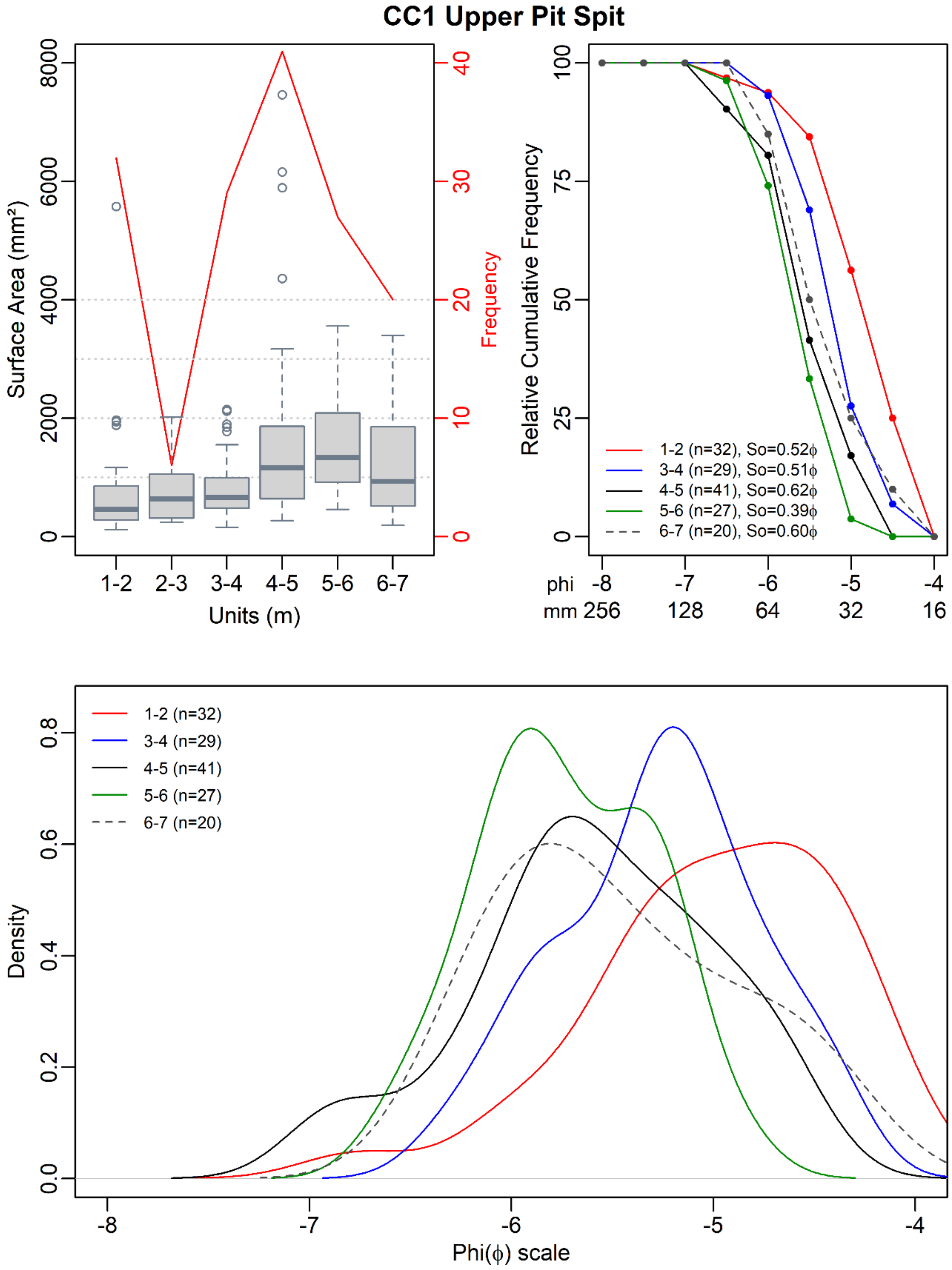


Figure 7.36: Frequency and sherd-size distributions in the upper spit of pit CC1.

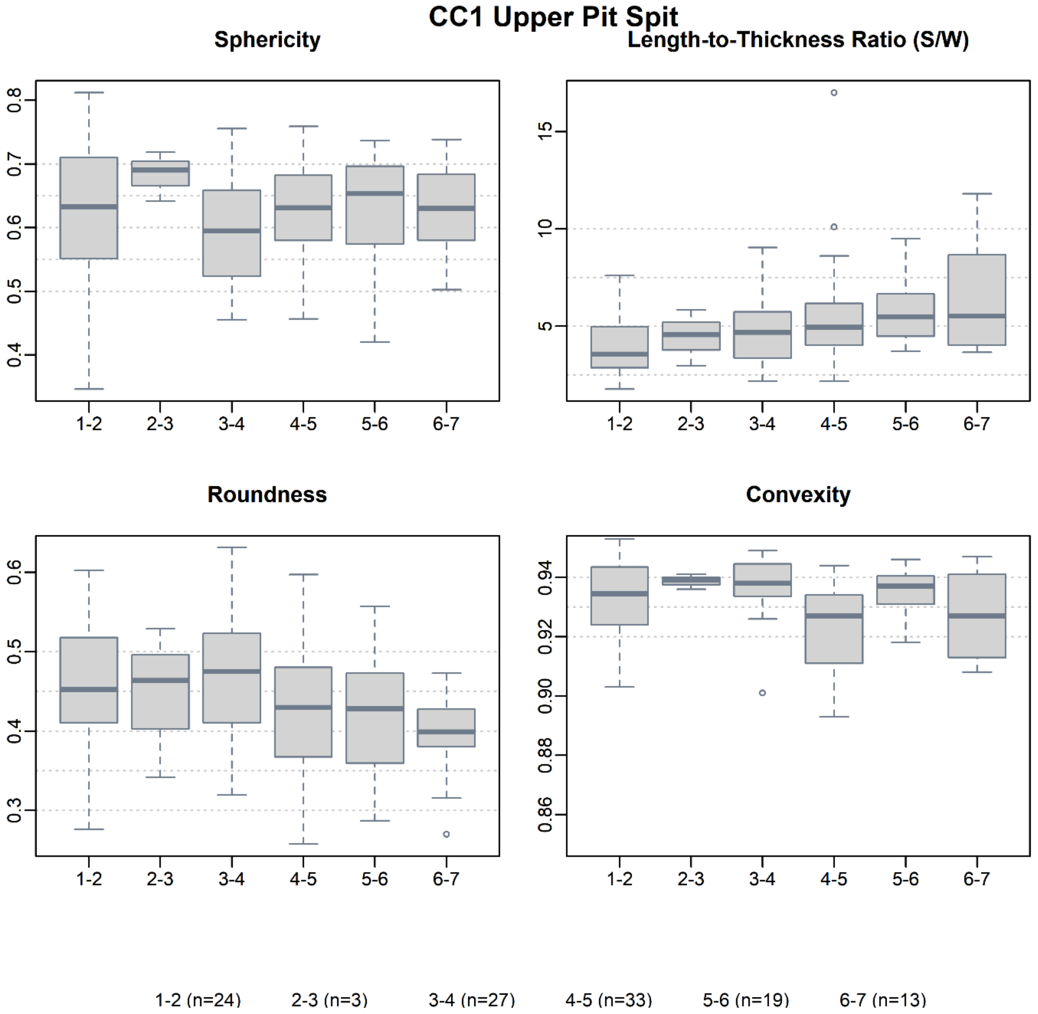


Figure 7.37: Morphometric values of potsherds from the upper spit of pit CC1.

Morphometric data provides more clues on this depositional process, as there is a decline in roundness and convexity as well as a progressive increase in S/W values towards the eastern slope of the pit. Contrary to what has been pointed out for the lower spits of this feature, the morphometric results from the upper pit spit suggest that deposition occurred preferentially from west to east (Figure 7.37). Shape descriptors also show a clear contrast between angular and rough fragments from units 4-5, 5-6 and 6-7 and those from units 1-2, 2-3 and 3-4. This may indicate that a different population of only slightly fragmented and eroded sherds was deposited in this area, which could be the result of deliberate disposal.

Elsewhere (Vindrola-Padrós *et al.* 2019, 28–30) it was suggested that the main process of deposition was the sliding and rolling downslope fall of individual sherds, and that a secondary one was the placing, throwing or dumping of fragments into the feature. Further analysis of this pit seems to corroborate our initial findings. Certainly, the differences in sorting between spits are also a signal of the two mentioned processes occurring in the upper pit spit, while in the lower pit spit the well-sorted assemblage seems to be mostly the product of gradual downslope movement. This suggests that the dumping or placing process observed in the upper pit spit occurred at a later stage than the downslope movement of sherds (*Ibid.*), as this would have required a depression in the middle of the pit to have been formed. In addition, our other main conclusion, namely that fragments must have had a high degree of exposure to erosive processes before they were deposited, is also further substantiated by the more recent findings discussed here.

7.2.2.2.2 Feature CC2

There is a notable similarity of fragment sizes between squares C and D of feature CC2 (Figure 7.38). In square C, small sherds clearly predominate in both spits, but only the upper spit shows a well-sorted distribution. In square D, sherds are even smaller, *i.e.* below the 1000mm^2, and both spits display well-sorted distributions. In both squares, fragment size also increases progressively in deeper areas of the pit complex, which, as we know, tend to be very effective depositional traps. Morphometric values show a similar pattern: the upper spits of both squares display higher values of sphericity, roundness and convexity than material from lower spits (Figure 7.39), suggesting these spits were exposed for a longer time to secondary rupture and abrasion processes. However, there are some differences observed in the lower spits of these squares. Potsherds from the lower spit of square C are significantly more angular, elongated, oblong and rougher than material from square D, which could suggest these areas of the pit were filled in different ways.

With the exception of material from the lower spit of square C, the data suggests that a considerable amount of time had elapsed between the breakage of the pot and the final burial of some of its fragments in the fill. The noticeable high roundness also suggest that fragment movement was also significant before deposition. However, the specific processes by which these assemblages were formed are quite difficult to unravel, because of the lack of spatial information. Despite this loss of information, there is considerable difference between the material deposited in squares C and D that suggests different depositional processes. In D, material was probably deposited during nearby activities. In the lower spit of square C, sherds considerably less exposed to fragmentation and erosion were deposited or maybe even placed. Furthermore, while only a limited number of vessels were refitted from CC2 (Virag 2008), EVEs and MNV estimations also support the claim that some small amount of dumping or placing of relatively well-preserved vessels occurred in this feature. Because the spatial information of refitted sherds was limited to its feature of origin and not their specific excavation unit, unfortunately refitted sherds cannot be mapped. However, refitting rates can be estimated, which amount to 4.2 sherds per vessel. These values support the claim that at least some pots were dumped in this area.

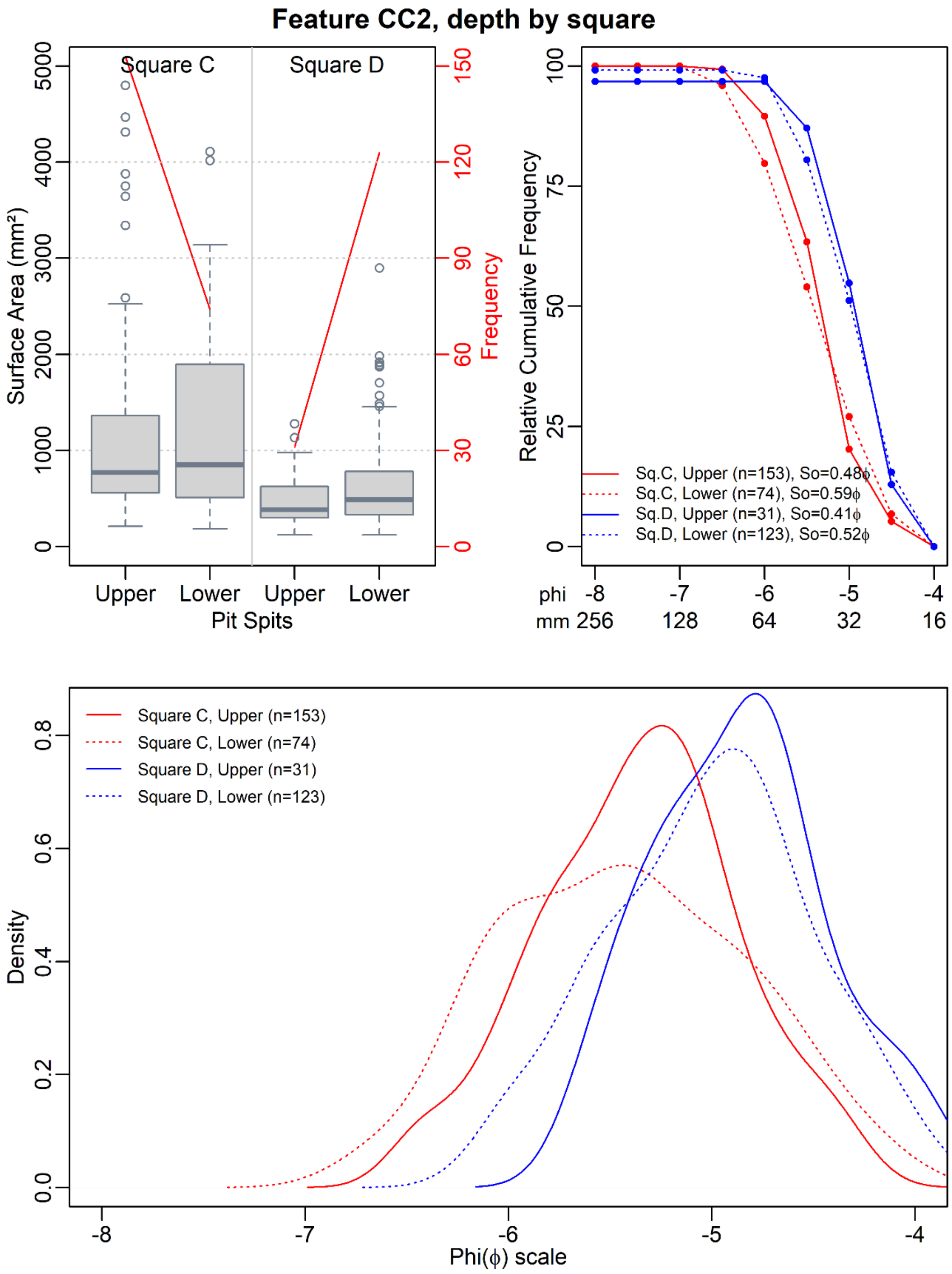


Figure 7.38: Sherd-size distribution of sherds in squares C and D according to upper and lower spits of the pit.

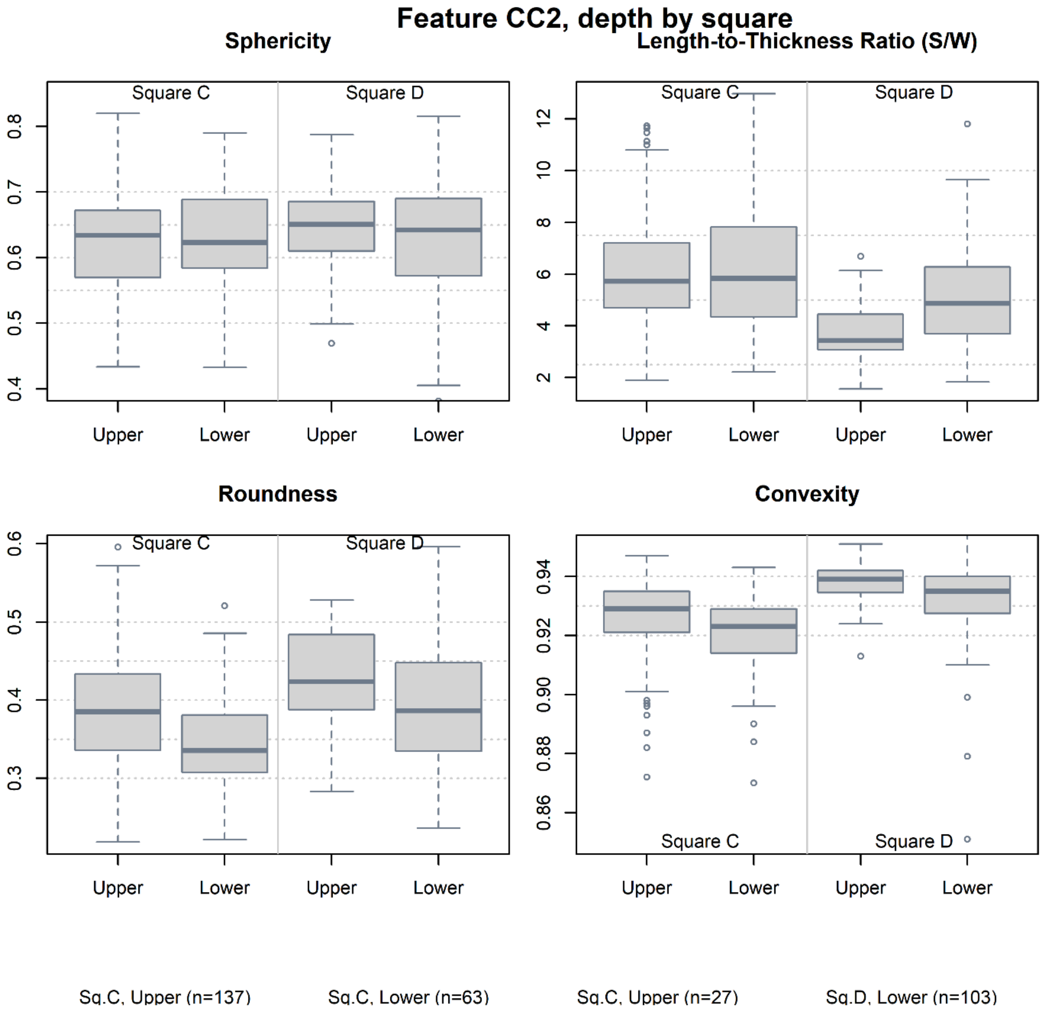


Figure 7.39: Results of morphometric measurements of sherds in squares C and D according to upper and lower spits.

7.2.2.2.3 Summary and discussion of results

There are several clues for unravelling the depositional processes of pits at Călinești-Oaș-D.S.M. We can distinguish between the northern pit complex CC2, the potential household structure in CC1 and the rather shallow feature CC3 in the south of the site. The information from different sectors of the sherd-rich CC2 feature suggested that the deposition of worn fragments inside the pit happened by the unintended result of nearby activities and by placing or dumping of large sherds took place in square C. Feature CC3 presents a different picture. This shallow pit was mostly filled with extremely fragmented material, which could be the result of a reworking of the pit. Some reasons for reworking this pit is to extract organic refuse for manuring, or the maintenance of clay floors, as wattle and daub houses periodically require floors to be redone. However, this remains speculative until further evidence, perhaps from soil micromorphology and bulk sample analyses, is obtained, or evidence of clay floors is revealed in future excavations.

Feature CC1 highlights a very clear process of deposition dominated by downslope movement of sherds through low-energy events. For example, in the clayey soils of the site, in dry conditions granular disintegration of the soil matrix and slope destabilization (as frequently occurs during excavations in the area) could promote downslope movement of fragments lodged in the soil matrix. Other possibilities include trampling by humans and animals near the area. At feature CC1 there is also evidence of discard, but at a much later stage of the life of the pit. This conclusion is supported by some preliminary results from measurements of low-frequency mass-specific magnetic susceptibility (χ) of the limited number of samples retrieved during excavations. χ results indicate differences between unit 4-5 in the upper spit (43 χLF x10^{-8}m^{3}kg^{-1}), and unit 2-3 in the lower spit (22 χLF x10^{-8}m^{3}kg^{-1}), with the latter approaching values close to the sterile area in unit 1-2 (15 χLF x10^{-8}m^{3}kg^{-1}). If the interpretation of the feature as a house or roofed workshop is further corroborated by future excavations, for example by the presence of aligned postholes and the distribution of daub fragments along them, then it is possible finds from the upper spit were part of post-abandonment deposition.

The high level of rounding of fragments could also be the product of chemical weathering. As indicated by Wadell (1933, 331), solvents can also increase roundness of rocks. Since the UTB is a wetland environment and pH measurements from the site indicate soils were acidic (pH 5; Astaloș, personal communication 15th July 2016) chemical weathering might not have been rare. However, one would expect in this case that the effects of chemical weathering would be similar throughout the site, and as mentioned above, there was a modest amount of material that possessed angular values as well. Furthermore, the fact that other sites from the region with similar soils, such as Méhtelek-Nádas, generally showed low roundness values, do not substantiate this argument.

The high degree of fragmentation and roundness of fragments from all features signals that human interaction with broken objects was temporarily extensive. It is clear from the analysis that fragments have a long life before they become deposited in pits. It is therefore not unreasonable to suggest a substantial amount of sherd movement across the site occurred before their deposition into pits. Sherds are deposited in different areas, there was no preferred location. Even after deposition sherd deposits also seem in an active relationship with surrounding activities, as pits appear gradually filled and there is some suggestion of reworking of at least one of the pits.

7.2.3 Mehtelek-Nadas

The results from sherd-size distributions and morphometric analysis tentatively indicate that the material from pit 1-3α was probably sorted by archaeologists at the site. This was revealed during my analysis and not prior. Thus, results obtained from this feature are discussed in Appendix 8.

7.2.3.1 Basic recording of material

Table 7.11 synthesizes the sample size information for the pit features analysed from Méhtelek-Nádas. While fragments measured for sherd-size distribution analysis are numerous, the sample size for morphometric analysis is small and warrants caution in the interpretation of the results. Thus, only coarse-grained information can be obtained from the morphometric study of potsherds from these pits.

Feature	Sherd-size Distribution Sample (n1)			Morphometrics Sample (n2)			Total Number**
	Weight	Fragment No.	Percent*	Weight	Fragment No.	Percent*	
Pit III	16971	489	84.3	3011	110	18.96	580

*Table 7.11: Sample size information from Méhtelek-Nádas. *Percentages are calculated according to number of fragments. **Numbers obtained from Kalicz (2011).*

EVEs highlight that an extraordinary number of small-sized pots were deposited in both contexts (Table A8.2). Around 55 foot-base fragments from pit III and 10 from pit 1-3α could not be measured, as rim chart could not be adapted to the particular shape of these bases. Furthermore, these numbers also do not take into account the vessels that have been reconstructed from the site in previous studies, which add up to 17 in pit 1-3α and 12 in pit III (Kalicz 2011, 15, 16). Considering these limitations, values obtained from brokenness ratio most likely suggest that very little fragmentation occurred.

Feature	Vessel Size*	Base sherd(s)	EVEs	Total EVEs	Brokenness Ratio (s/v)**
Pit III	Very Small	5	3.075	15.325	31.86
	Small	35	9.7		
	Medium	15	2.075		
	Large	3	0.475		

*Table 7.12: Calculation of Vessel EVEs from Méhtelek-Nádas according to feature. *Sizes were determined from projected vessel diameters (defined in section 6.1.2.3.1) **Sherd numbers are equivalent to sampled fragments (n1).*

7.2.3.1.1 Fabric characterisation

Results highlight compositional variation in the assemblages from Méhtelek-Nádas (Figure 7.40), as has already been outlined by petrographic studies (Kreiter 2010; Kreiter and Szakmány 2011). The most common type of inclusion is organic matter, followed by organic with mineral inclusions. Petrographic analysis highlighted that the coarse minerals in the fabric groups identified were either monocrystalline or polycrystalline quartz (Kreiter 2010, 269), which suggests that this is likely to be the mineral I observed in my macroscopic grouping of the material from Méhtelek-Nádas. The granulometry and hardness is quite consistent for the assemblages from both pits, with a clear abundance of semi-fine material and mostly soft surfaces. The slight compositional variability required further assessment of the effects of compositional differences on sherd size and shape distributions. This assessment is outlined below.

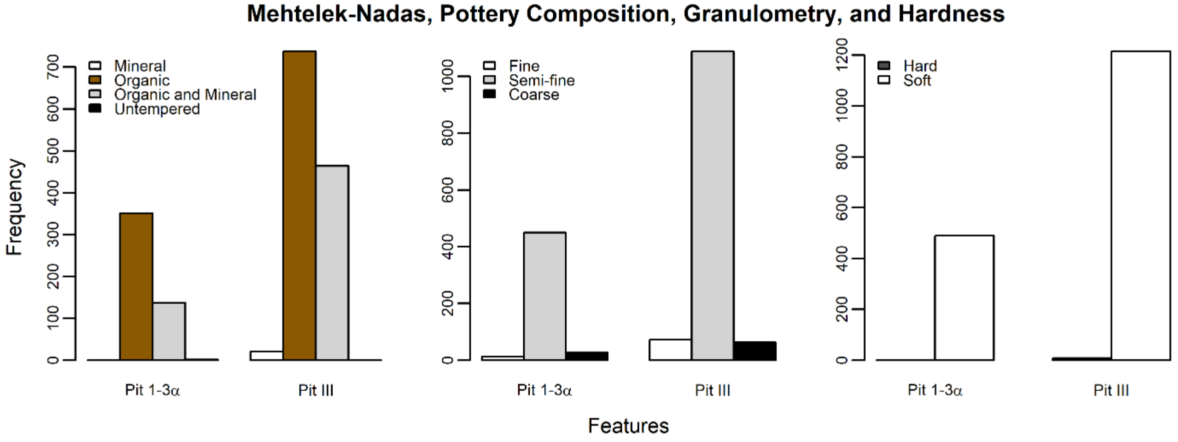


Figure 7.40: Composition, granulometry and hardness of sampled sherd assemblages from Méhtelek-Nádas.

7.2.3.1.2 Postdepositional information

Figure 7.41 highlights there are also high number of fragments that have been washed with cleaning brushes, which could affect some of the values from sensitive shape parameters like convexity.

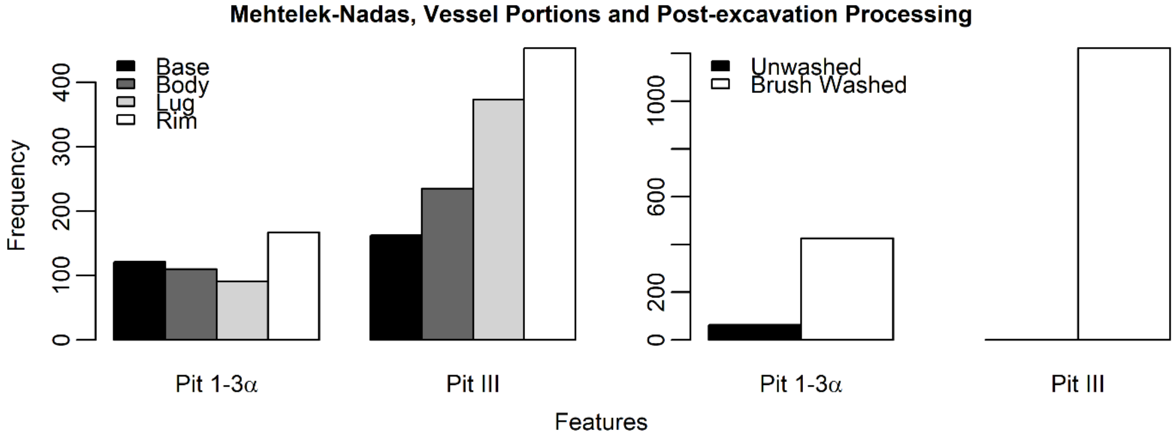


Figure 7.41: Preserved vessel portions and post-excavation traces of sampled sherd assemblages from Méhtelek-Nádas.

7.2.3.2 Pit III

The sherd-size distribution from pit III is negatively skewed and well-sorted with a predominance of small to medium-sized fragments (Figure 7.42). Morphometric data presented in Figure 7.43, illustrate that fragments from both pit contexts are moderately compact/oblong, slightly elongated, slightly angular, and with a highly rough surface. These shape values approximate most of those obtained for pots found *in situ* in the morphometric tests outlined in section 7.1.1, which suggests fragments had little exposure to abrasion or fragmentation before being deposited. This also corroborates the fact that despite finds processing methods, *i.e*. sherds being washed with brushes, the surface texture of the fragments was not substantially affected, as washed potsherds still possess their rough texture.

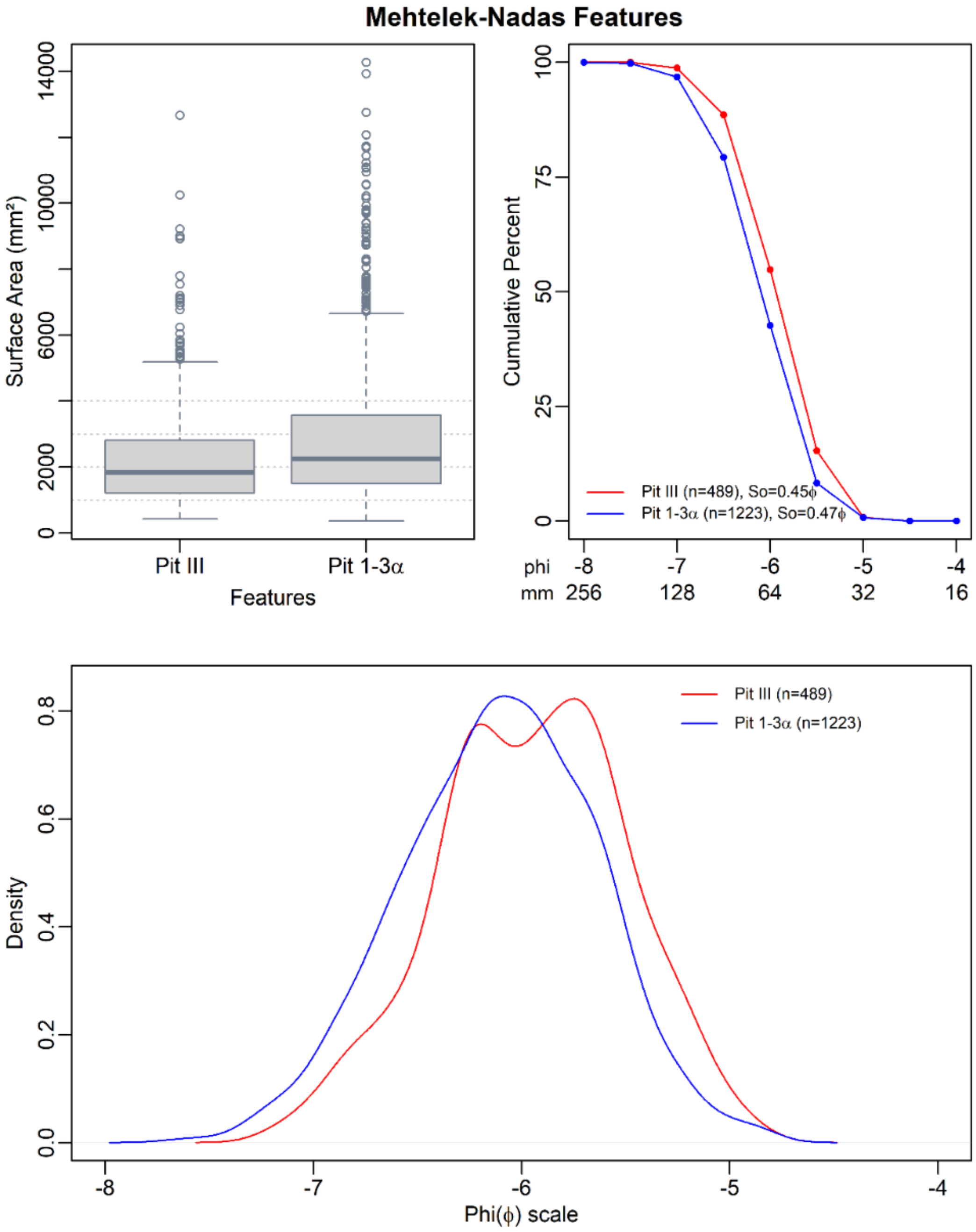


Figure 7.42: Sherd-size distribution of fragment from pits III and 1-3α at Méhtelek-Nádas.

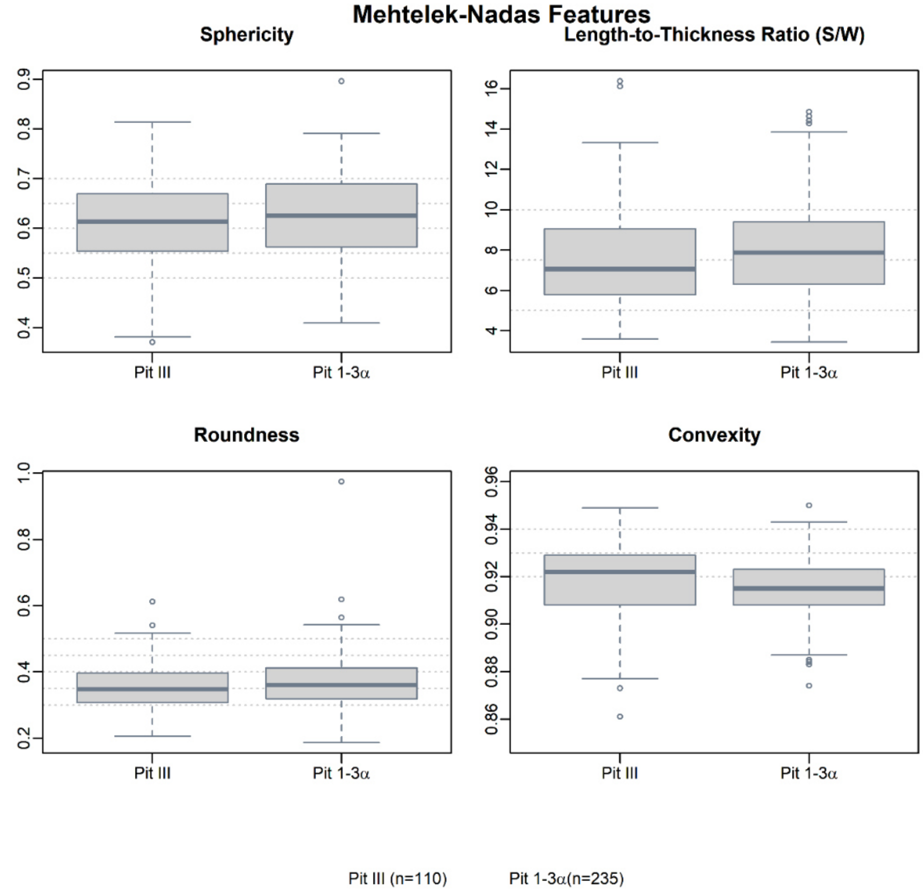


Figure 7.43: Morphometric results of fragments from pits III and 1-3α at Méhtelek-Nádas.

7.3.3.3 Summary and discussion of results

At a first glance, it could be stated that the well-sorted medium-sized fragments and only slight signs of abrasion and/or fragmentation indicate that fragments were altered very little before being deposited in pits. Furthermore, the lack of spatial information does not allow further study of how the pit was filled. Information obtained from pit III tentatively shows that the distribution of well-sorted small/medium-sized fragments may be simply the result of disposal or placing of pottery, which is also corroborated by the almost equal proportion of body sherds to other vessel portions. Considering the contextual information from excavations (section 5.1.4.3.2.2), where a large variety of materials were found, it is possible the feature was used for storage rather than discard. This leaves us with the idea that at least for this area of the site, the interaction with broken materials was fairly limited. However, from the description of the stratigraphy of the pit, *i.e*. black organic fill with burnt daub followed by a yellow loamy deposit (*Ibid.*), it would seem several infilling processes occurred, and the pit might have been repurposed several times.

7.2.4 Eitzum

7.2.4.1 Basic recording of material

Table 7.13 synthesises the sample size analysed from Eitzum. As mentioned before, the total values obtained for Zones A, B, and some features from zone D were calculated using the material that was available at the Braunschweig Landesmuseum (BLM). Overall, the sample size for both sherd-size distribution and morphometric analysis was considered representative of the total amount of material retrieved. Nonetheless, there are some exceptions that require further caution, such as feature 9 in zone A and feature 119 in zone D.

Zone	Feature	Sherd-size Distribution Sample (n1)			Morphometrics Sample (n2)			Total weight
		Weight	Fragment No.	Percent	Weight	Fragment No.	Percent	
A	WLH1	43013	988	91.73	22673	629	48.35	46893
	Above 5	3662	83	45.20	3048	72	37.62	8102
	5	1260	21	100.00	718	17	56.98	1260
	6	176	9	88.89	80	8	40.40	198
	Above ELH1	1670	52	80.83	1236	42	59.83	2066
	ELH1	1114	30	72.72	592	23	38.64	1532
	9	238	8	100.00	70	5	29.41	238
B	Above 13	3510	105	65.83	2406	87	45.12	5332
	13	3176	98	78.75	2018	77	50.04	4033
	Above 14	3554	125	85.06	2772	101	66.35	4178
	14	6475	196	88.57	3354	129	45.88	7311
	P.2	154	5	100.00	118	4	76.62	154
	P.5	86	7	100.00	58	6	67.44	86
	15	8191	246	98.23	4834	186	57.97	8339
	Above 16	2458	81	78.23	1616	64	51.43	3142
	16	655	38	84.95	578	33	74.97	771
	Above 17/18	212	11	100.00	118	8	55.66	212
	17	216	8	100.00	168	7	77.78	216
D	3	28	1	100.00	28	1	100.00	28
	5	61	3	100.00	54	2	88.52	61*
	7	3989	73	87.02	2645	57	57.70	4584*
	10	2094	52	96.90	1412	43	65.34	2161*
	11	5220	162	87.12	3434	127	57.31	5992*
	15	16	1	100.00	16	1	100.00	16*
	21	666	27	66.87	466	11	46.79	996
	22	3261	99	76.53	1477	64	34.66	4261*

23	3522	86	74.56	2266	59	47.97	4724*
24	272	13	53.86	242	11	47.92	505*
25	952	29	76.04	506	20	40.42	1252*
26	12160	300	79.73	7225	227	47.37	15251*
29	16	1	100.00	16	1	100.00	16
36	1024	37	100.00	836	30	81.64	236
81	11254	248	79.12	7352	199	51.69	14224*
108	90	1	100.00	90	1	100.00	90*
114	138	1	100.00	0	0	0.00	138
119	18	2	10.34	8	1	4.60	174*

*Table 7.13: Sample from Eitzum Zones A, B and D. *Values obtained from post-excavation records available at the Braunschweigisches Landesmuseum.**Percentages calculated according to fragment weight.*

As a clarification, when I refer to the pit infilling process I refer exclusively to material from the 'lower layer', which is the unequivocal constituent of pit features. This layer has been mentioned in the literature as the black discolouration or black soil that make up most of the pit fill. There are, however, three exceptions that I had to make, as the stratigraphic information from these features had been lost, which include pits WLH1, 9 and 15. For these features, information from both upper and lower layer was integrated.

Data from EVEs (Table 7.14) mostly corroborates observations that small and medium-sized vessels were predominant at the site (Cladders 2001; Schwarz-Mackensen 1985). Most of the features contain very small numbers of diagnostic fragments, suggesting fragments were exposed for some time before they were deposited. This is corroborated by vessel grouping by Cladders (2001, 51), which showed that the average number of sherds per vessel were 1.5 in zones A and B and 1.8 in zone D. There are however some clear exceptions (Table 7.14), which includes most of the features from zone A as well as features 13 and 14 from zone B. With regard to s/v values, pottery from contexts in zone A and pits 13, 14 and 16 (zone B) have little fragmentation after primary rupture. In the case of features ELH1, 5, and 16 this is probably because of the small sample obtained from these contexts. In zone D, most features show high s/v values, which highlights that secondary rupture was common in this area of the site before deposition. The only feature with moderate s/v values and a reasonable number of EVEs is longpit 26, which highlights that depositon after primary rupture of vessels could have happened somewhere along this feature.

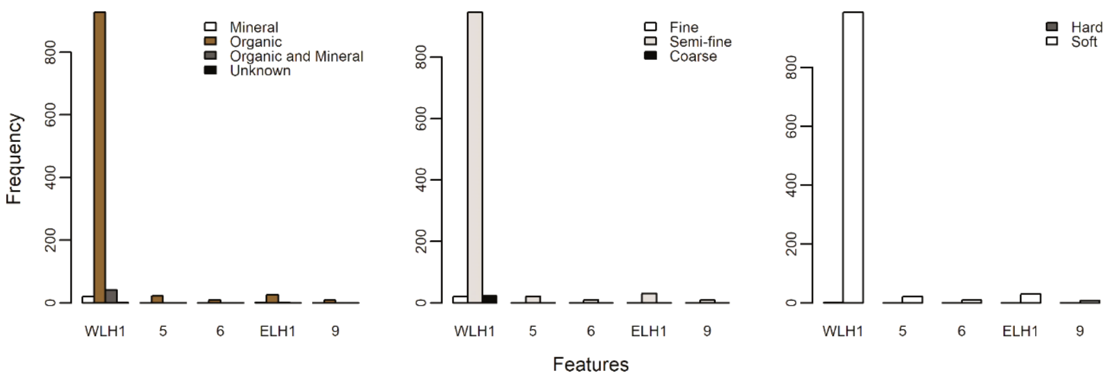
Zone	Feature	Vessel Size*	Base sherd(s)	EVE	Total EVEs	Brokenness ratio (s/v)**
A	WLH1	Very Small	2	0.5	11.725	84.26
		Small	30	7.3		

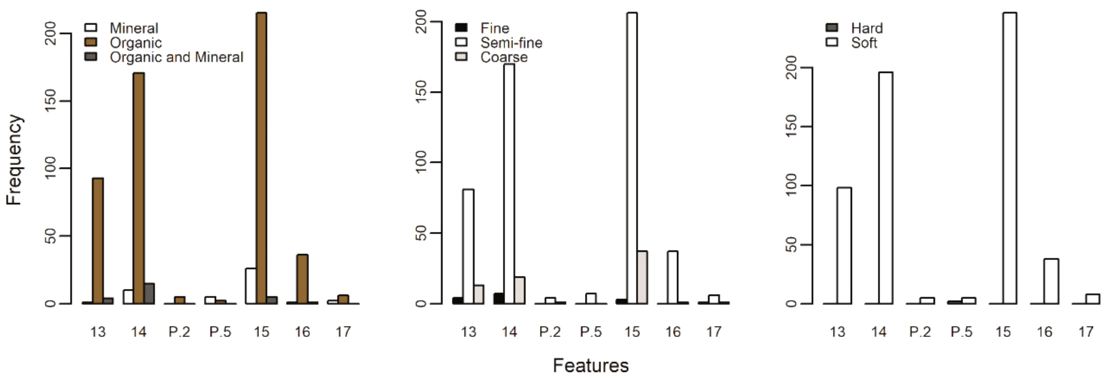
		Medium	17	3.925		
	5	Very Small	2	0.25	2.05	10.24
		Small	5	0.925		
		Medium	6	0.875		
	ELH1	Small	2	0.35	0.4	75
		Large	1	0.05		
B	13	Very Small	3	1.5	4.35	22.53
		Small	11	2.225		
		Medium	1	0.125		
		Large	3	0.35		
	14	Very Small	3	1	3.65	53.7
		Small	8	2.025		
		Medium	3	0.55		
		Very Large	1	0.075		
	P.5	Medium	1	0.1	0.1	70
	15	Small	8	2.35	2.7	91.11
		Medium	2	0.3		
		Large	1	0.05		
	16	Small	5	1	1.125	33.78
		Medium	1	0.125		
	17/18	Medium	1	0.25	0.25	44
D	7	Small	2	0.425	0.55	132.73
		Large	1	0.125		
	10	Small	2	0.675	0.9	57.78
		Medium	1	0.225		
	11	Small	3	0.5	1.55	104.52
		Medium	7	1.05		
	21	Medium	2	0.225	0.225	120
	22	Small	2	0.65	0.65	152.31
	23	Medium	2	0.425	0.5	172
		Large	1	0.075		
	25	Small	1	0.45	0.575	50.43
		Large	1	0.125		
	26	Small	6	0.95	3.65	82.19
		Medium	10	1.625		
		Large	6	0.9		
		Very Large	1	0.175		
	36	Small	1	0.325	0.325	113.85
	81	Very Small	1	0.45	1.35	183.7
		Small	3	0.725		
		Large	1	0.175		

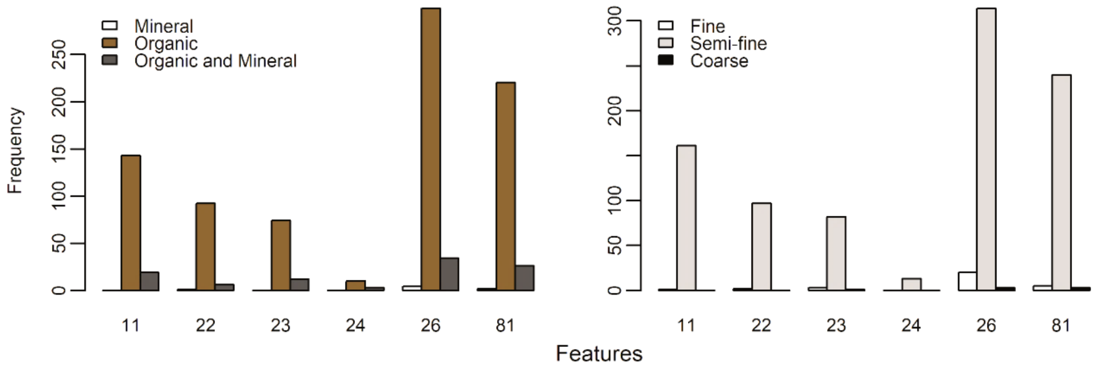
*Table 7.14: Vessel EVEs from Eitzum according to feature. *Sizes were determined from projected vessel diameters (defined in section 6.1.2.3.1) **Sherd numbers are equivalent to sampled fragments (n1).*

7.2.4.1.1 Fabric characterisation

The composition, granulometry and hardness of potsherds from zones A, B and D, show negligible differences (Figure 7.44). Potsherds mostly contained semi-fine organic temper, and they are mostly soft. These results are consistent with the petrograhpic analysis conducted at the site. Furthermore, the mineral inclusions observed in potsherds are likely to be sand, due to the predominance of quartz grains identified in thin-sections (Riederer 1985, 36). Since the assemblage is homogenous in terms of the three variables examined, microstructural differences are unlikely to have influenced the distribution of size and shape of potsherds.


Zone A, Pottery Composition, Granulometry, and Hardness


Zone B, Pottery Composition, Granulometry, and Hardness


Zone D, H4/1987, Pottery Composition and Granulometry

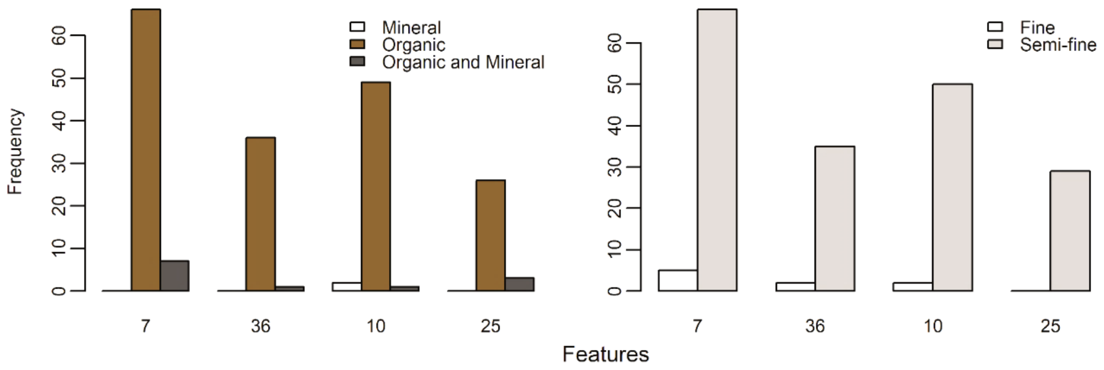

Zone D, H5/1987, Pottery Composition and Granulometry

Figure 7.44: Composition, granulometry and hardness of potsherds from Eitzum zones A, B and D.

7.2.4.1.2 Postdepositional information

Vessel portions from zones A, B and D highlight a high proportion of body fragments (Figure 7.45). Considering that *Kümpfe* or small globular pots are the predominant vessel form and these are mostly medium-sized (*ca*. two litres; Cladders 2001, 9), one would expect a higher proportion of rims and bases. This could indicate that fragmentation in most features of the site was considerable. However, one must also take into consideration that some rims and bases could not be sampled as they were glued together to reconstruct vessels. All sampled material was washed, but very few fragments showed signs of brushing, and thus it is unlikely that shape determination was affected by this process.

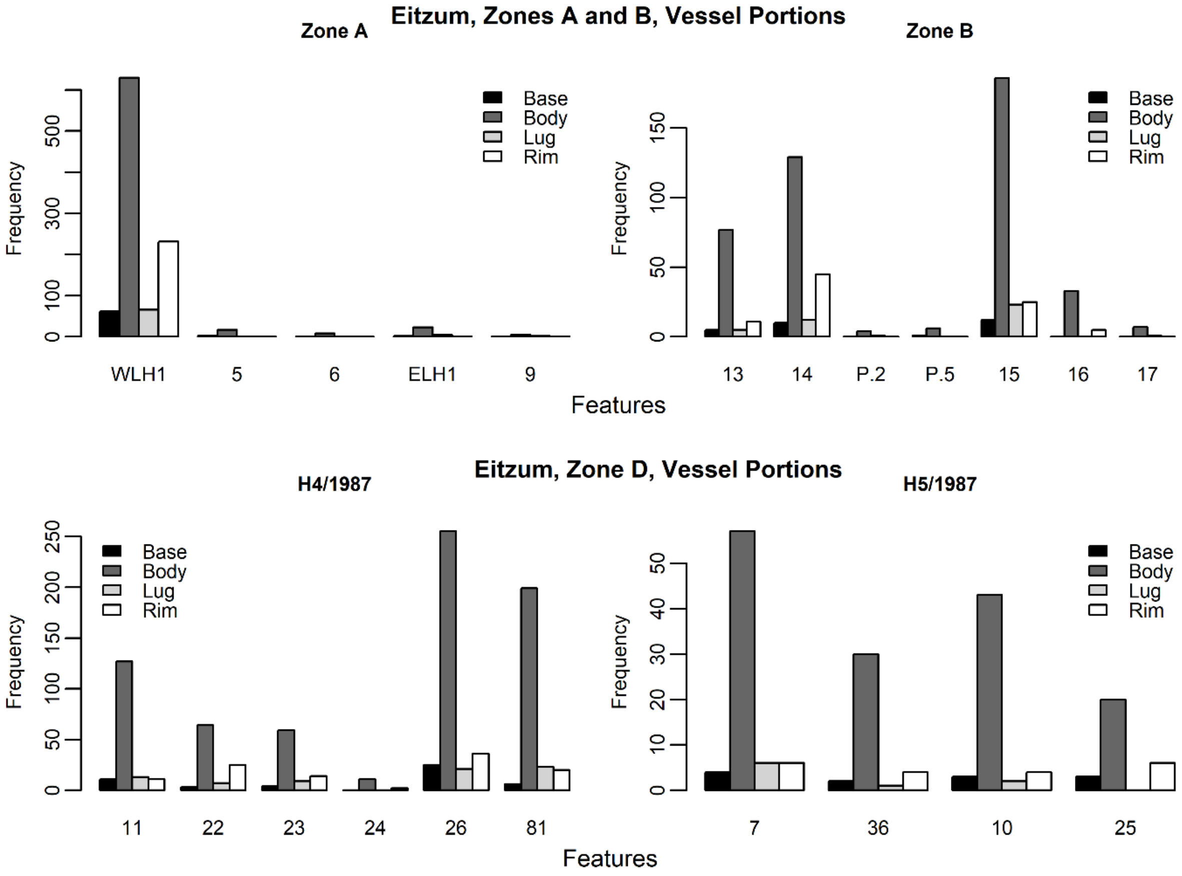


Figure 7.45: Vessel portions represented in Eitzum zones A, B and D.

7.2.4.2 Zone A

From the little stratigraphic information available for this zone, there is not much difference between fragments located above and within features 5 and ELH1 (Appendix 8). This means that no significant postdepositional process has affected the assemblages in the upper layer, as fragments from the pit fill display similar sherd-size distribution and morphometric values.

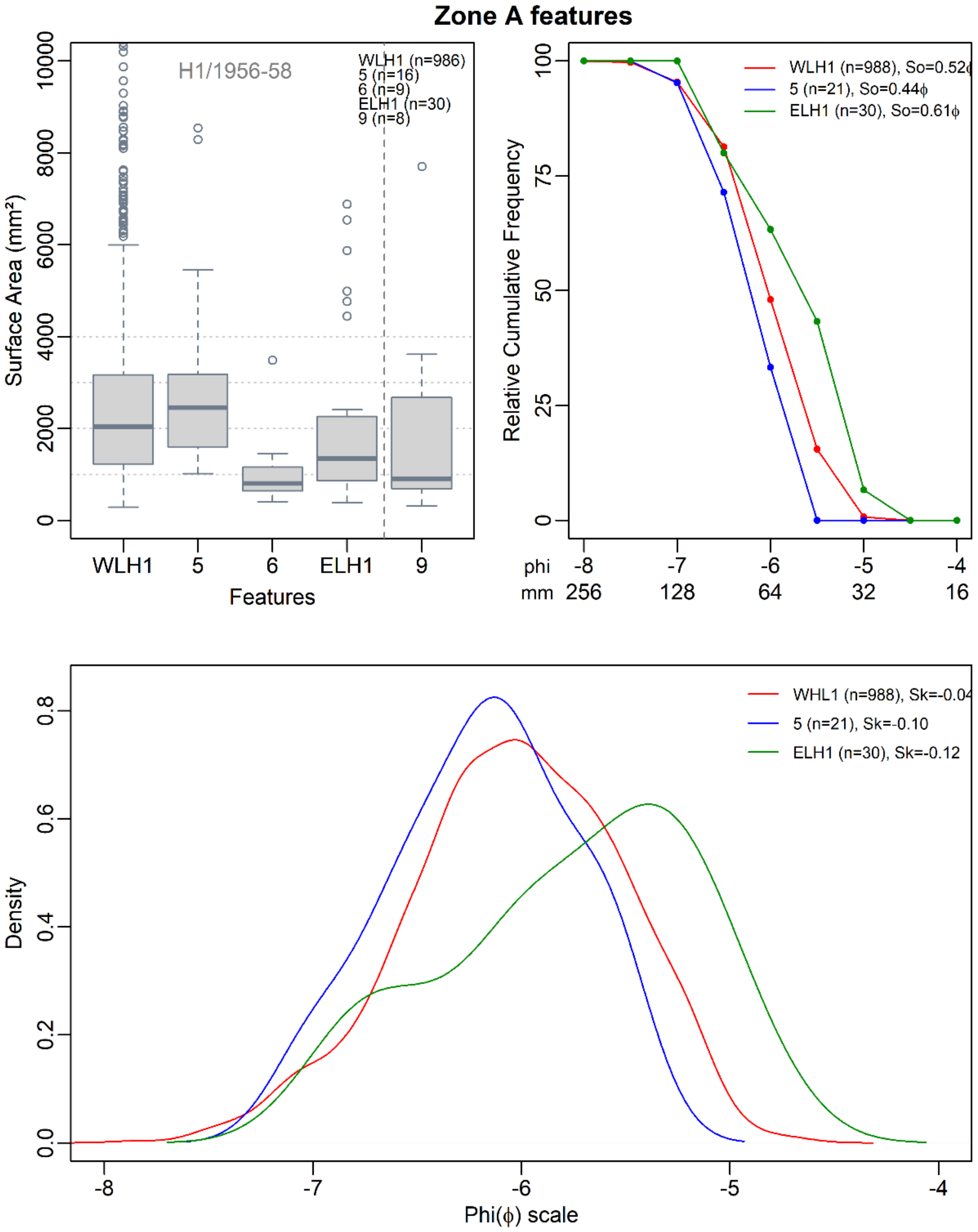


Figure 7.46: Sherd-size distributions from Eitzum zone A.

In the lower layers in zone A, the western longpit from H1/1956-58 (WLH1) presents some contrasts with its eastern counterpart. WLH1 and feature 5, contain a well-sorted distribution of larger sized fragments (Figure 7.46). Similarly, feature 9 has a wide range of fragment sizes. In contrast, ELH1 is mostly composed of small sherds, is moderately sorted and substantially negatively skewed. Little can be said of feature 6, apart from the fact it has contrastingly smaller sherd sizes than other features in this zone. Shape descriptors indicate that the potsherd assemblages from WLH1 and feature 5 are composed of mostly elongated, moderately oblong/compact, slightly angular, and rough fragments (Figure 7.47). This could indicate that fragments from these contexts have experienced little abrasion and breakage before their deposition, which would indicate deposition not long after the rupture of the vessels. In comparison, fragments from all other pits are more spherical, compact and smooth, but, much like WLH1 and 5, display only minimal rounding of their corners. In combination with the sherd-size distributions described above may indicate that fragmentation and not abrasion were the primary agents altering potsherds in these contexts.

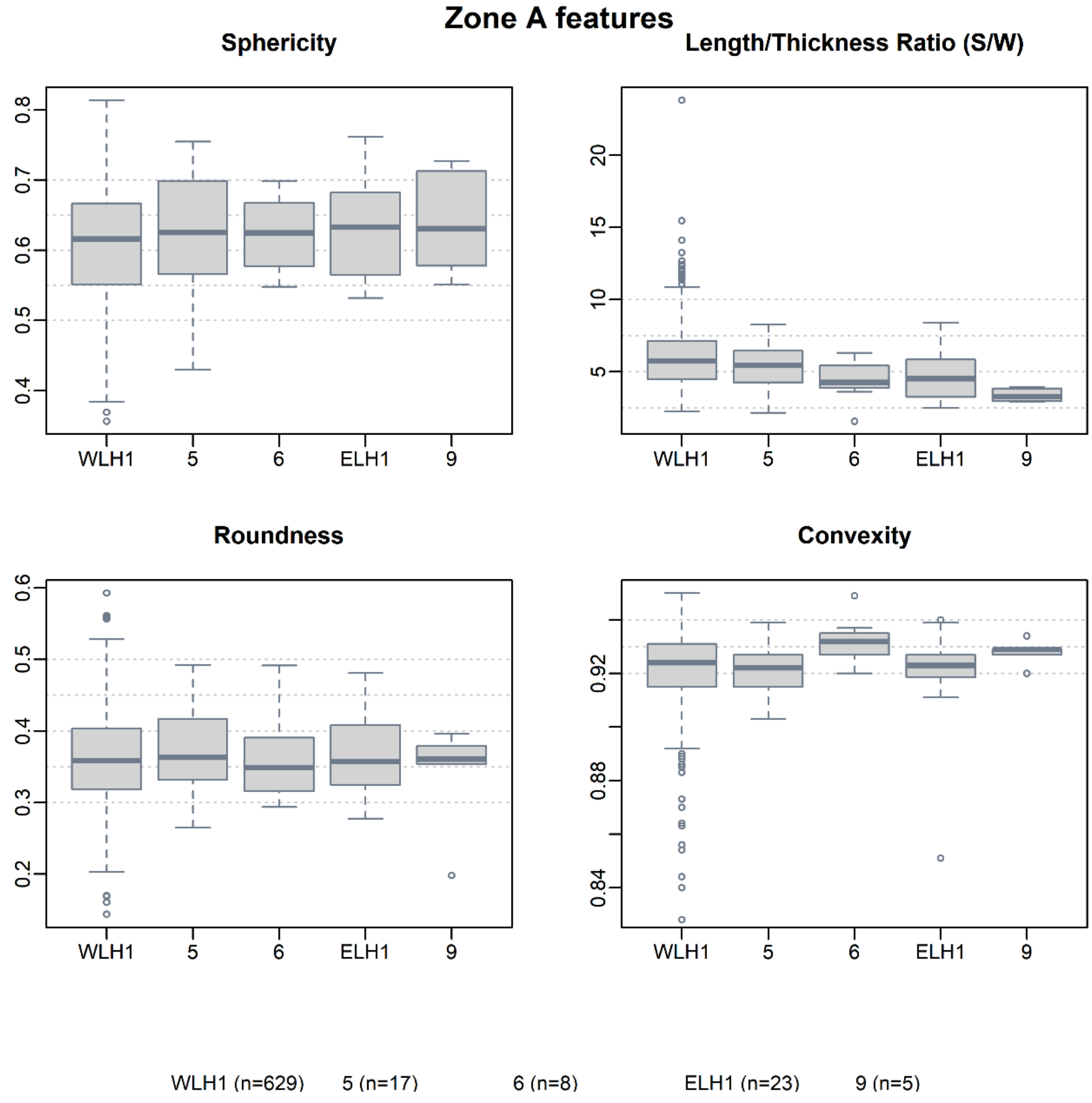


Figure 7.47: Morphometric values of potsherds from Eitzum zone A.

The longpits and pits from zone A indicate some variation in how fragments were deposited. In WLH1 and 5, fragments signal that an intended anthropogenic process (such as dumping, placing or backfilling) shortly after vessel rupture was the main contributor to sherd deposition. Due to their fragmentation, it is likely that the sherds from the remaining pit fills from zone A (6, 9 and ELH1), are likely to have been exposed to trampling before deposition.

7.2.4.3 Zone B[3]

Longpits show a more homogenous picture. Features 13, 14 and 15 have very similar sherd-size distributions, with a dominance of small- to medium-sized sherds, and well-sorted and negatively skewed distributions (Figure 7.48). These results suggest that potsherds with little fragmentation were deposited in these features. In comparison, results from pit 16 indicate moderate sorting, and sherd sizes range from very small to small. The remaining features provide only limited evidence due to small sample size. Fragments from postholes (*i.e*. Pf.2 and Pf.5) are unsurprisingly within the small size range, which probably speaks of some exposure before deposition. The morphometry of fragments from most features are slightly spherical, compact, rough and slightly angular (Figure 7.49). Despite the evidence for fragmentation, fragments in general display very little to no rounding of their corners, with only features 15 and 16 showing some indication of this. Morphometric values show differences between the western features (13 and 14), and the southern/eastern features (15 and 16). The former display more elongated, oblong, angular, and rougher fragments than the latter. Feature 14 possesses higher S/W values, but this is mostly restricted to a particular segment of the feature (see below).

Results highlight that secondary rupture was the predominant process of fragment alteration in zone B before being deposited in the various features. Apart from secondary rupture, in features 15 and 16 potsherds also show some signs of abrasion. In contrast, in features 13 and 14 sherds lack traces of abrasion and show only slight fragmentation, probably suggesting an intended anthropogenic process was partly responsible for the deposition of material in these features.

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[3] Due the limited stratigraphic information at zone B, this information is displayed in Appendix 8.

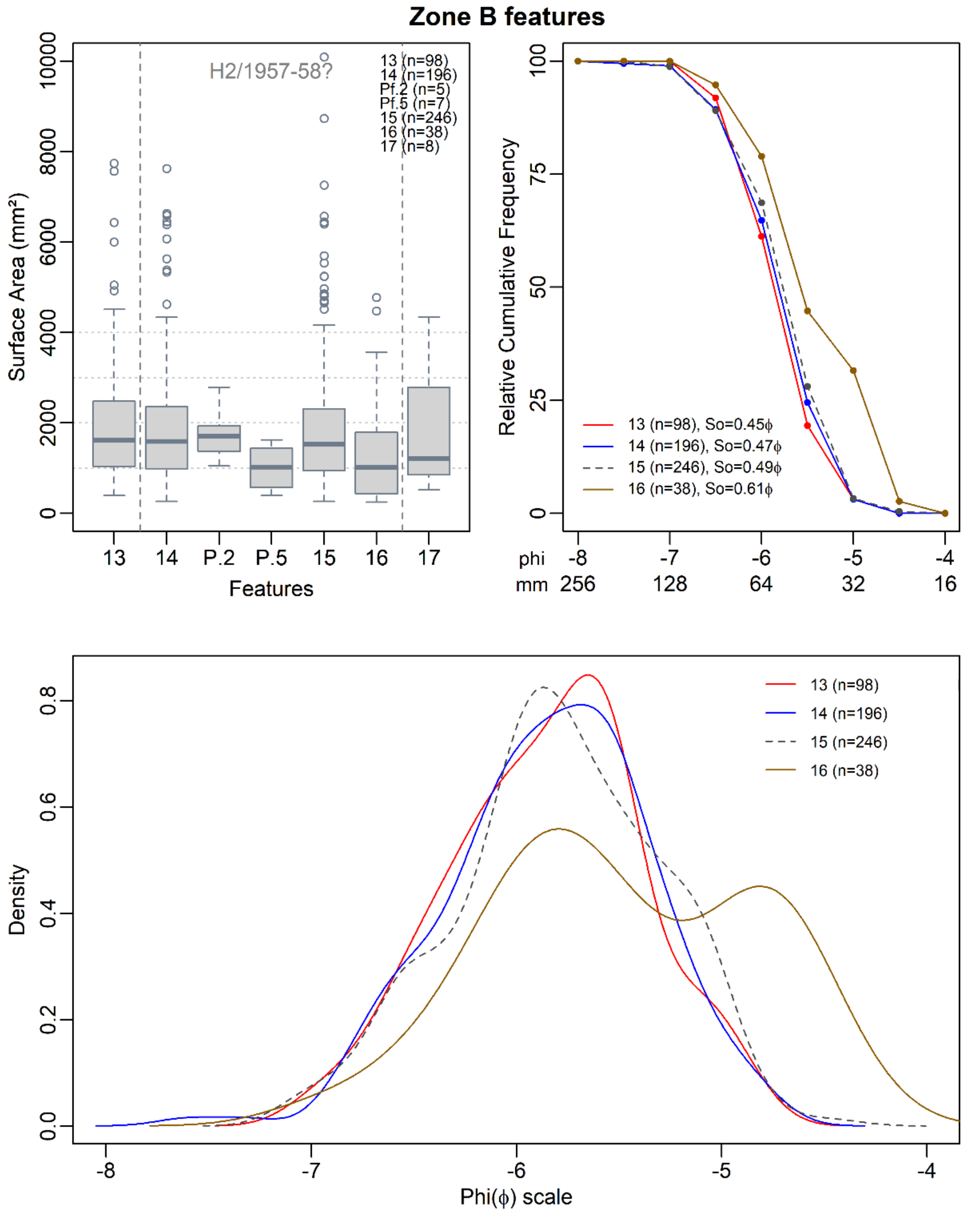


Figure 7.48: Sherd-size distributions of assemblages from Eitzum zone B.

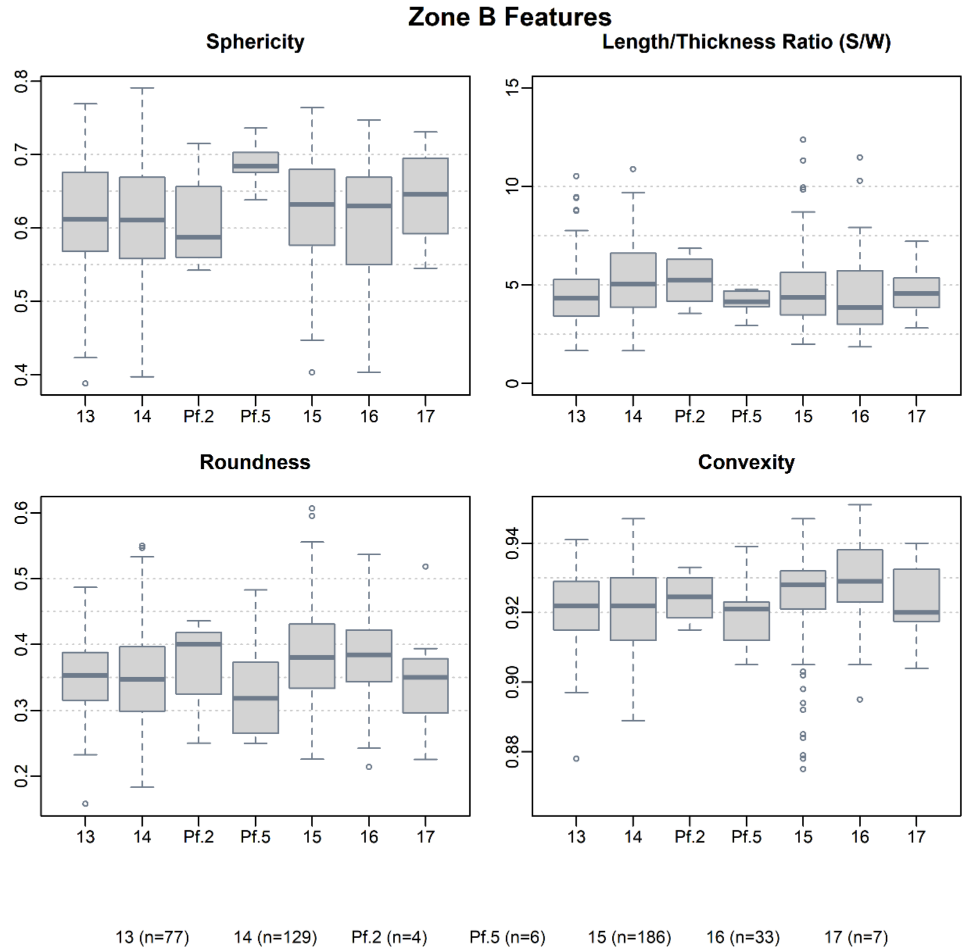


Figure 7.49: Morphometric values of assemblages from Eituzm zone B.

7.2.4.3.1 Feature 14

A deeper examination of the sherd-size distribution in the different spatial segments of feature 14 shows a clear depositional pattern. The middle portion of the longpit (segment 3), contains most if not all of the medium- to large-sized fragments, while in the rest of the segments fragment size decreases progressively from this point (Figure 7.50). The same can be said about the degree of size sorting (So), which changes from well-sorted to progressively very well-sorted values as distance increases from the middle portion of the feature (*i.e*. segment 3) towards the ends (segments 1 and 5). Apart from the spatial sorting of fragment sizes, feature 14 also show indications of shape sorting. Potsherds become progressively more spherical/compact and rounded towards the middle of the feature (Figure 7.51). The surface texture of fragments, however, becomes rougher. The latter can be explained by the slight influence of fragment sizes on convexity values explained in section 7.1.2.

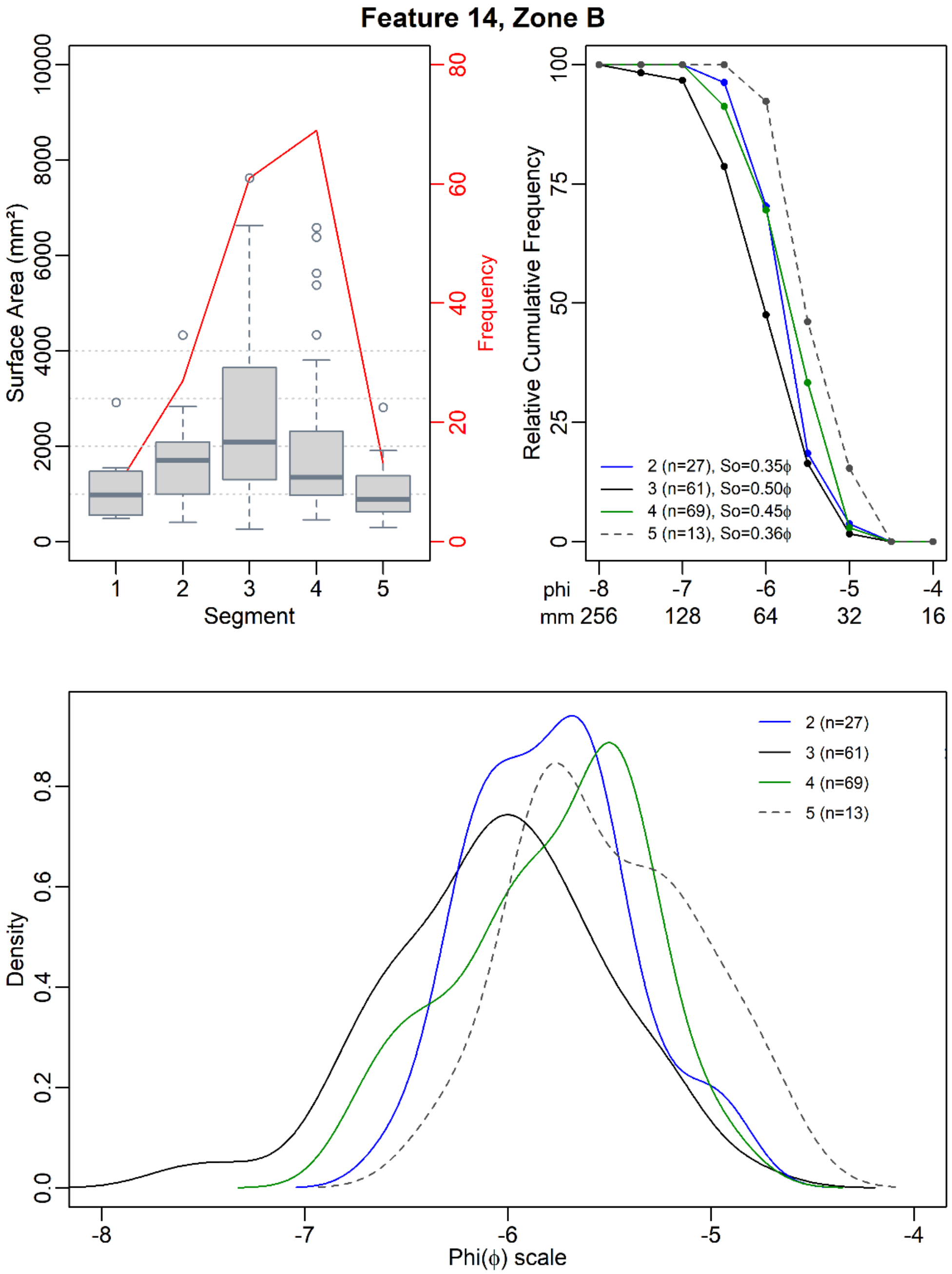


Figure 7.50: Sherd-size distribution according to segments of longpit 14 at Eitzum zone B.

Overall, the sherd-size distribution has a good correlation to the topography of the longpit. The deeper portions of this pit are around segment 3, and were excellent traps for deposits, which is where most of the larger, rounded and spherical fragments are found. This topography suggests deposition from marginal areas towards the middle of the pit. Nonetheless, the sorting values (So) could also give clues of how this feature was infilled. Low energy processes would create spatial sorting of a small range of fragment sizes, corresponding to well-sorted logarithmic distributions. Thus, in feature 14 there is some indication that small amounts of fragments were gradually deposited. The combination of spatial shape and size sorting also illustrates that both sliding and rolling mechanisms created this pattern. Following the scree slope rockfall model presented in section 6.1.1.3, the data supports the interpretation that slow and gradual downslope movement must have been the prevalent process behind the infilling of this pit. Nonetheless, the material from segment 3 is likely to be also the product of either dumping or placing (structured deposition) of fragments, as suggested by the almost lack of fragmentation and erosion of sherds.

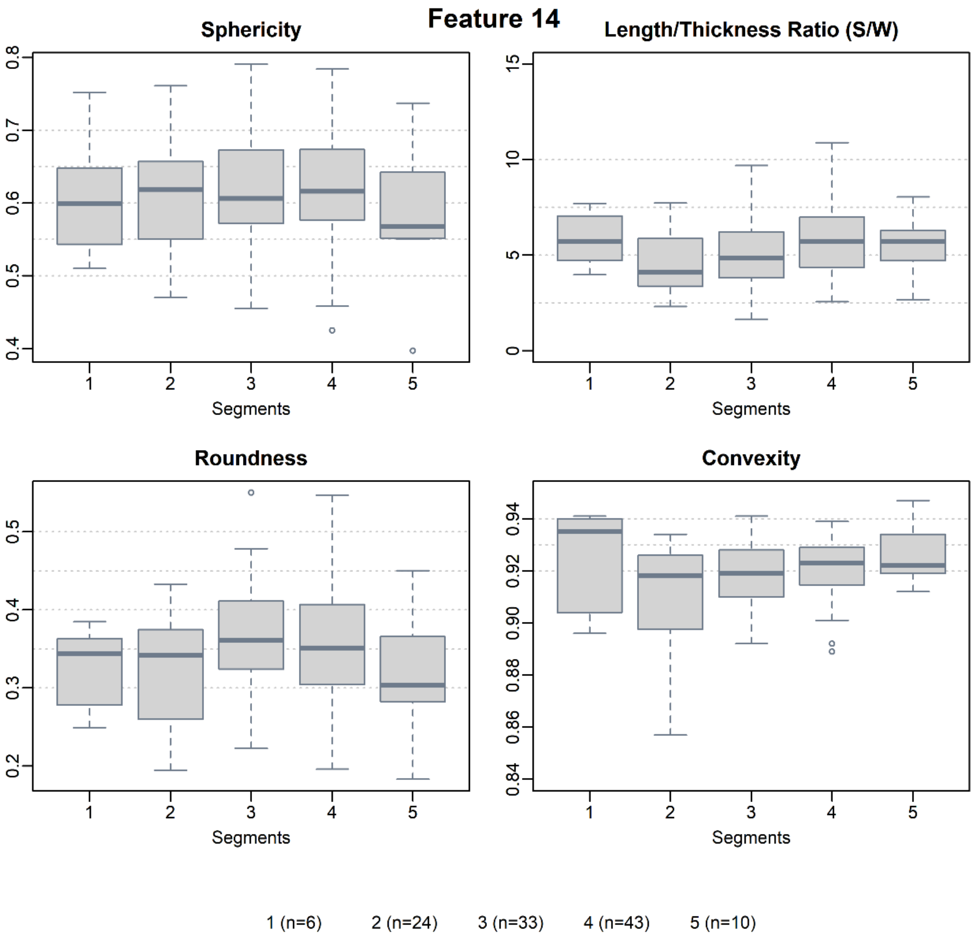


Figure 7.51: Morphometric values according to segments of longpit 14 at Eitzum zone B.

7.2.4.4 Zone D

7.2.4.4.1 The features from H4/1987

Longpits 11, 26, and 81 from H4/1987 are similar in terms of their moderately sorted values, large range of sherd sizes and positively skewed logarithmic distribution (Figure 7.52). Their adjacent features, *i.e.* 22 and 23, are closer to poorly sorted assemblages, but have similar sherd-size ranges. In stark contrast, the assemblage in trench 24 is exceedingly well-sorted and negatively skewed, indicating a much more fragmented assemblage. Further clarification of the deposition is elucidated below. From the remaining features, despite anomalous values for posthole 114, postholes 15 and 119 possess the expected small fragment distribution. As features 81 and 108 are shallow according to site descriptions, fragments are surprisingly large. In terms of morphometry, there appears to be little difference in the shapes of fragments in each pit (Figure 7.53). Generally, fragments are slightly spherical and compact, slightly angular and with a smooth texture. The only feature that is different is trench 24, which shows a significant amount of sphericity and compaction, and more angular values. Information from posthole is ambiguous, the low sphericity and high roundness values of potsherds from posthole 15 contrast with the high sphericity and low roundness of feature 119, showing more variation in these deposits than is normally suspected.

At a first glance, pit contexts analysed from H4/1987 show little variation in both sherd-size distributions and morphometry. Values mostly indicate that various depositional processes were probably responsible for the infilling of features 11, 22, 23, 26 and 81. As in the other zones from Eitzum, there is also a predominance of secondary rupture rather than abrasion. The exception to this pattern is feature 24. The fragmentation conditions in the vicinity of this feature must have been more severe. A more detailed spatial distribution analysis of finds is carried out in the next subsections that will provide a better picture of depositional processes.

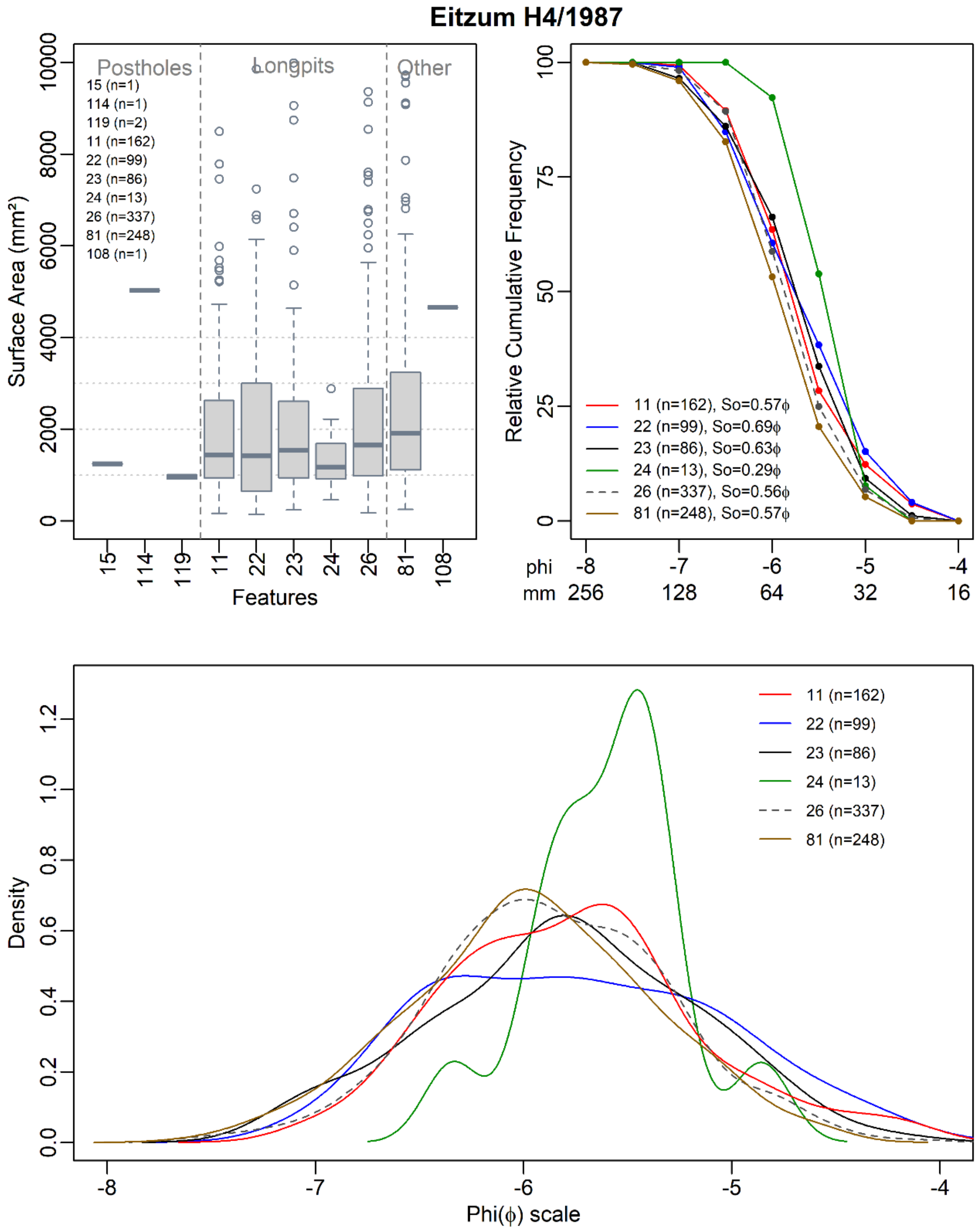


Figure 7.52: Sherd-size distributions of assemblages from H4/1987 at Eitzum.

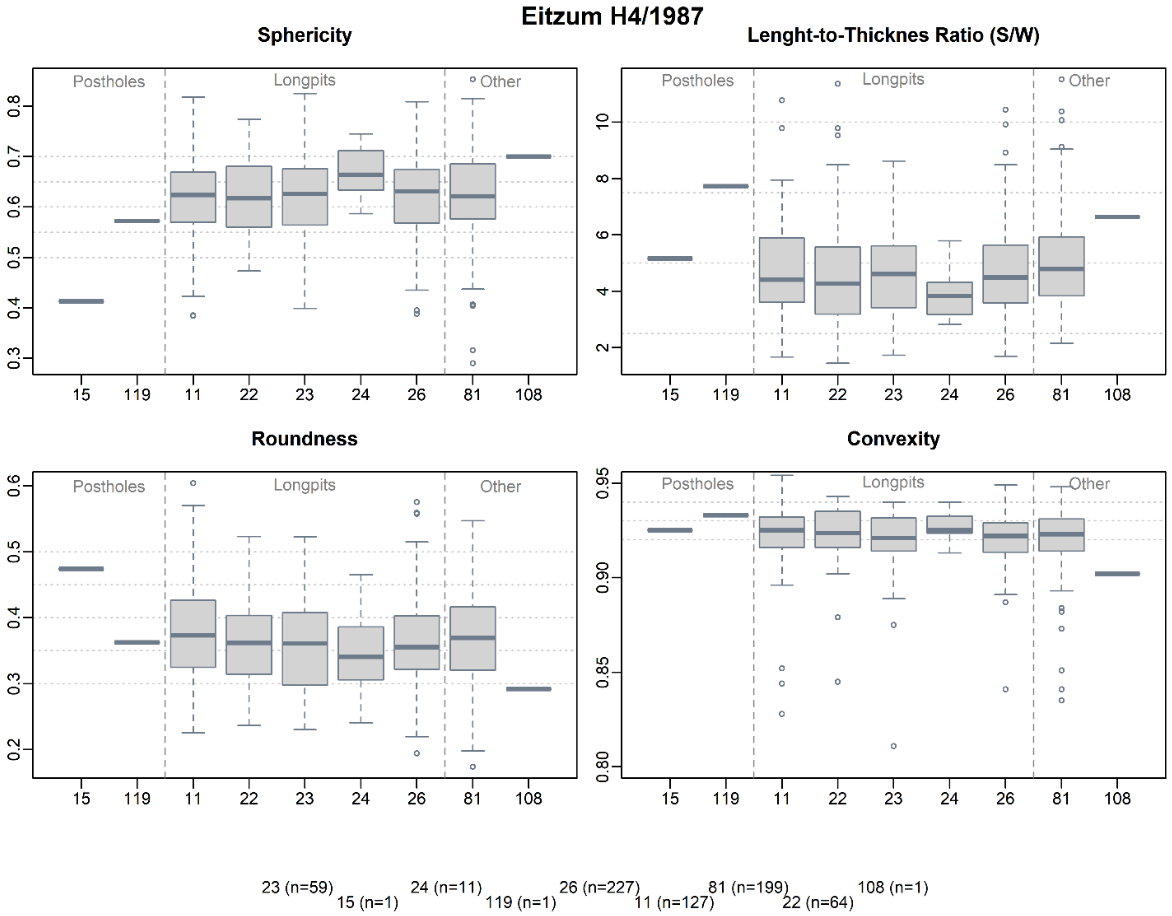


Figure 7.53: Morphometric values obtained for assemblages from H4/1987 at Eitzum.

7.2.4.4.2.1 Features 11 and 22

The spatial distribution of sherd sizes from the northern end of feature 11 (segment 1) to the southern end of feature 22 (segment 7) presents compelling evidence of at least one type of depositional process (Figure 7.54). From one of the hypothetical entrances of the house approximately around the shallow depression constituting segment 4 (Stäuble and Lüning 1999, 181), there seems to be a progressive increase in fragment sizes from segment 3 to 1, and from segment 5 to 7. However, sorting values for each segment are varied. This spatial sorting suggests the downslope movement of fragments, which originated somewhere in the vicinity of segment 4. The results of the shape parameters, however, are hard to disentangle (Figure 7.55). Fragments from segment 4 are more elongated and angular, which suggests little exposure to fragmentation and/or abrasion before deposition. In fact, their low convexity values could be an indication of some pots being deposited in this area and broken during burial. There does not seem to be a spatial sorting of fragments according to shape.

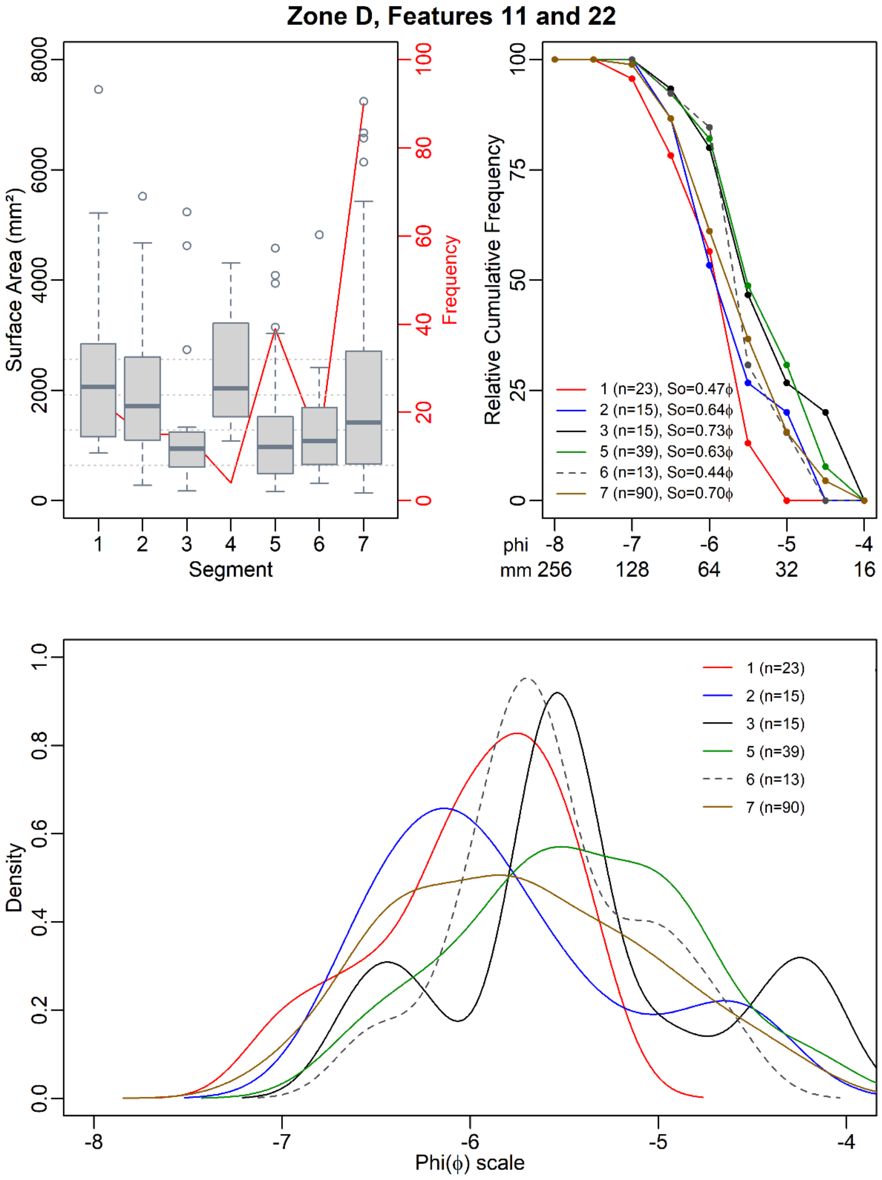


Figure 7.54: Sherd-size distributions of assemblages from longpit 11/22 in zone D by spatial segments.

In segments 6 and 7 (Figure 7.57), fragments only appear in substantial numbers at around the top spits (strata 1 and 2), which indicates that deposition of the majority of fragments did not occur until well after a portion of the pit was already filled. The first pit spit with potsherds, *i.e.* stratum 3, has predominantly small fragments. There is a substantial contrast in strata 1 and 2, with larger amounts of predominantly small sherds deposited, displaying a moderately sorted distribution. Since all spits show a positively skewed distribution, this is an indication of very little alteration of fragments from their formation until their deposition. Morphometric values show differences in the range of values between strata, however. Fragments are more spherical/compact, angular and rough in lower spits (strata 2 and 3), and more elongated and less angular in stratum 1. This once again shows fragmentation rather than abrasive processes was the main process responsible for size and shape alteration. In contrast, in segments 1 and 2 the distribution seems much more homogenous (Figure 7.56), predominantly a low frequency of small, spherical/compact, and mostly angular sherds in all strata.

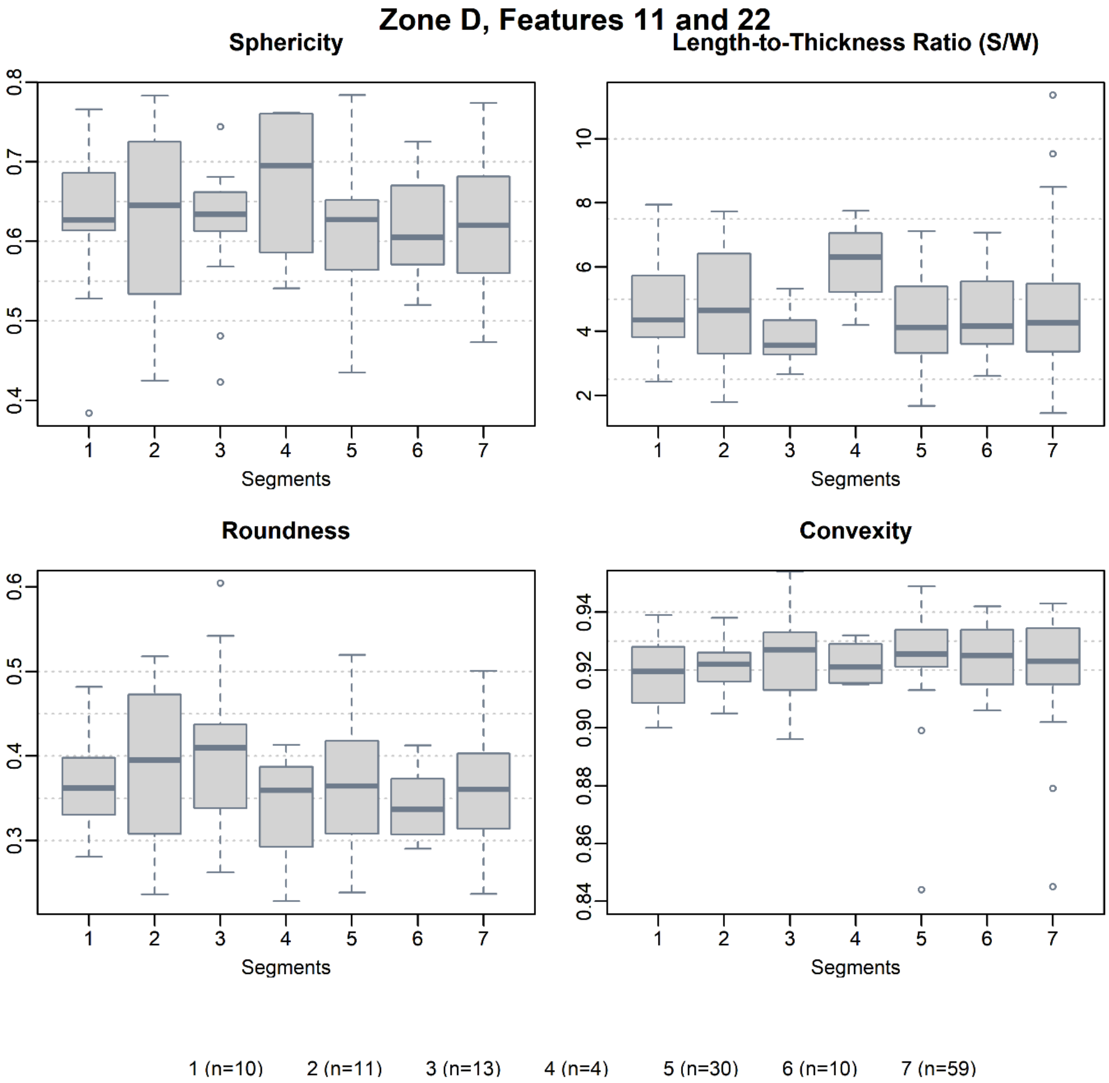


Figure 7.55: Morphometric values obtained from longpit 11/22 in zone D by spatial segments.

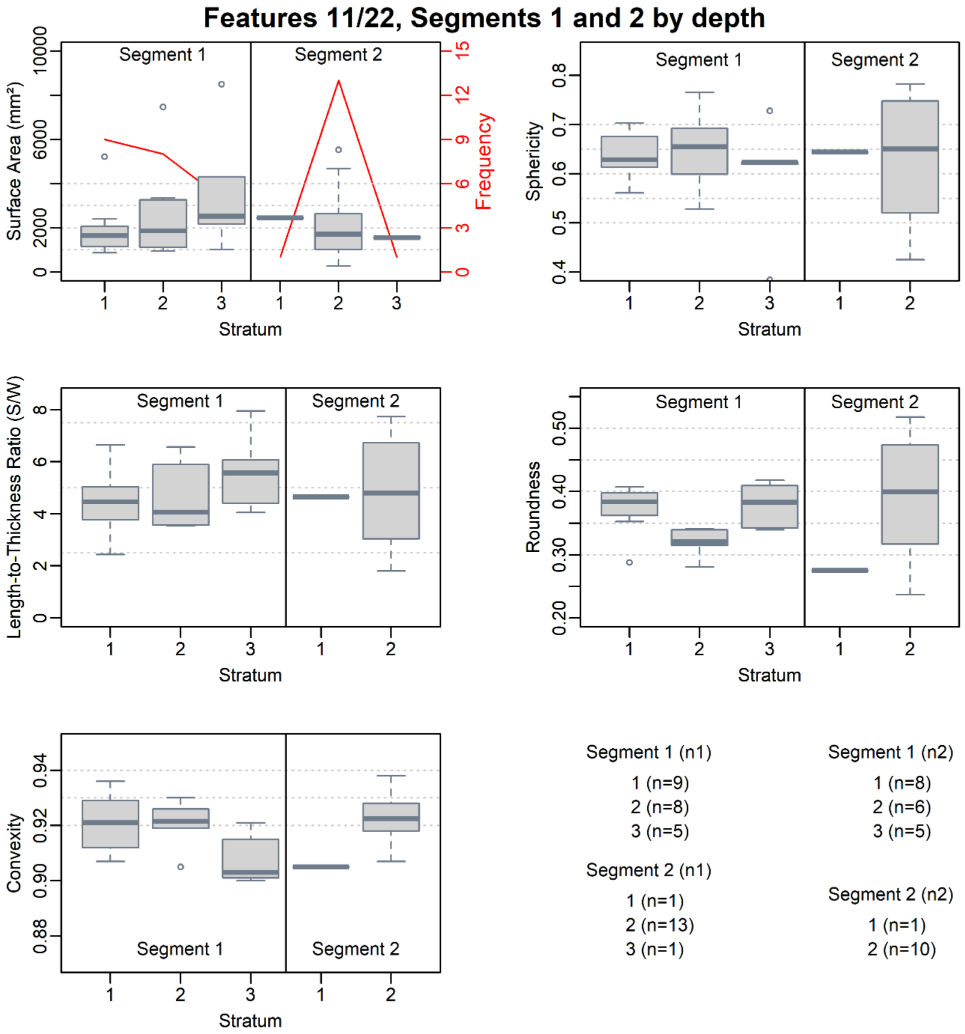


Figure 7.56: Sherd-size distributions and morphometric values of stratigraphic units in segments 1 and 2 of longpit 11/22 in zone D.

Different depositional processes occur in the north, central and southern portions of longpit 11/22. In the north (segments 1-3), there is indication of a downslope movement of small spherical/compact fragments throughout the entire sequence. In the central area (segment 4), there is indication of the 'placing', as suggested by the low number of large potsherds. In contrast, the deposition in the southern portion of longpit 11/22 (segments 5-7) was clearly a multi-staged process. In the first stage of deposition the pit and pit/trench intersection were filled without any sherds, followed by some downslope deposition of potsherds. As described above, the combination of the spatial sorting of fragments from a hypothetical 'point of origin' around segment 4, and the stratigraphic evidence displaying little variation of fragment sizes and shapes in the lower strata support this interpretation. There is suggestion of a quick deposition during the last phases of pit infilling, which could be linked to a backfilling or a large dumping episode (this is further clarified below).

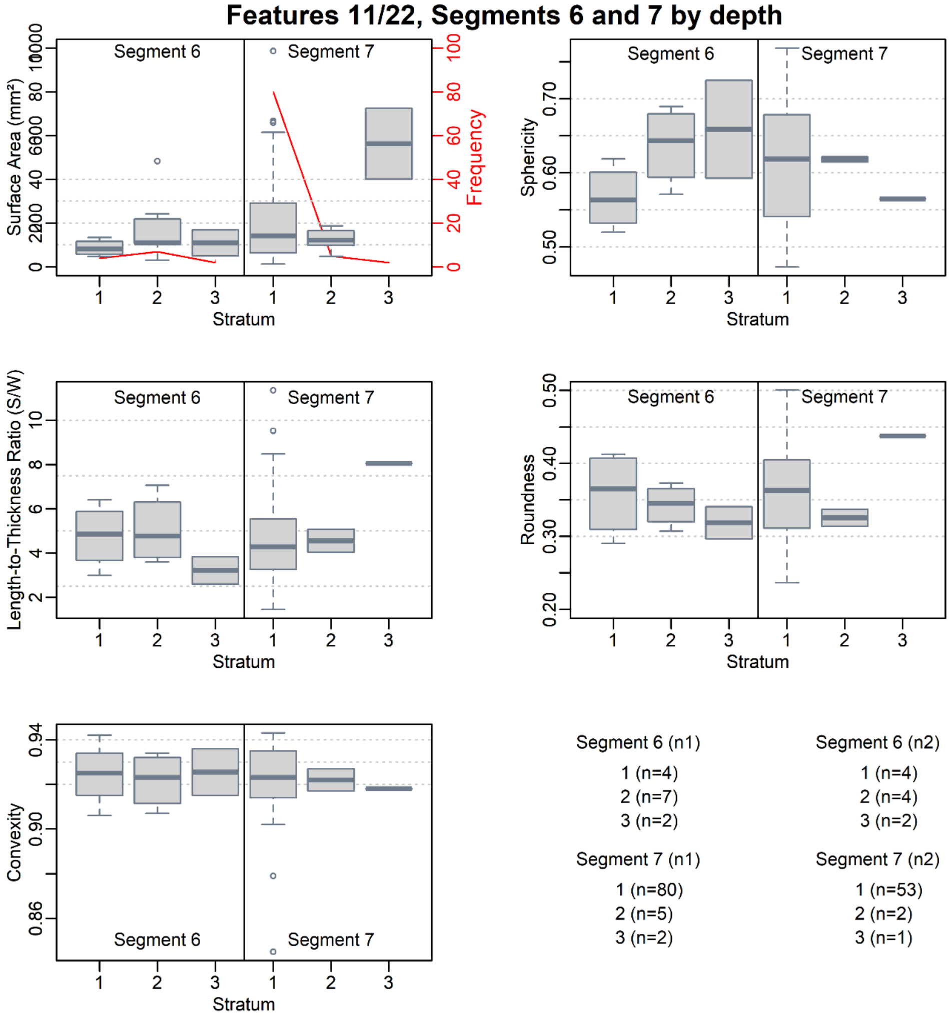


Figure 7.57: Sherd-size distributions and morphometric values of stratigraphic units in segments 6 and 7 of longpit 11/22 in zone D.

7.2.4.4.2.2 Features 23 and 26

In contrast to features 11/22, here the spatial distribution of fragment size from north to south does not show any clear pattern (Figure 7.58). With closer scrutiny some patterns come to light. First of all, there is a clear contrast between the abundance and size distribution of fragments between segments from the north (segments 8 to 10) and the south (segments 12 and 13) of longpit 23/26, with the latter possessing a larger number of fragments and a greater range of sherd sizes. There is also a well-sorted sherd-size distribution in the north and poorly sorted log-normal distribution in the south. Thus, several processes were involved in the deposition of sherds in the southern portion of longpit 23/26. There is an increase in fragment sizes, and in size sorting (So) from segment 11 to 13, which once more suggests downslope movement. Morphometric values from segments 8 and 9 are more spherical and rounded than other areas of features 23 and 26 (Figure 7.59). Fragments from segments 10, 12 and 13 display some indications of portions of pots broken *in situ*, possibly after burial. This is suggested by low convexity and angularity of fragments in this area. Some of these pots were refitted in Cladder's (2001) study. These values suggest that in the northern portions of this longpit a different process seems to have taken place than in the south, not attributable to discard. The southern portion of the longpit, however, seems to display a combination of depositional processes, as shown in by the poorly sorted log-normal distributions and the high number of fragments, but this is further clarified below.

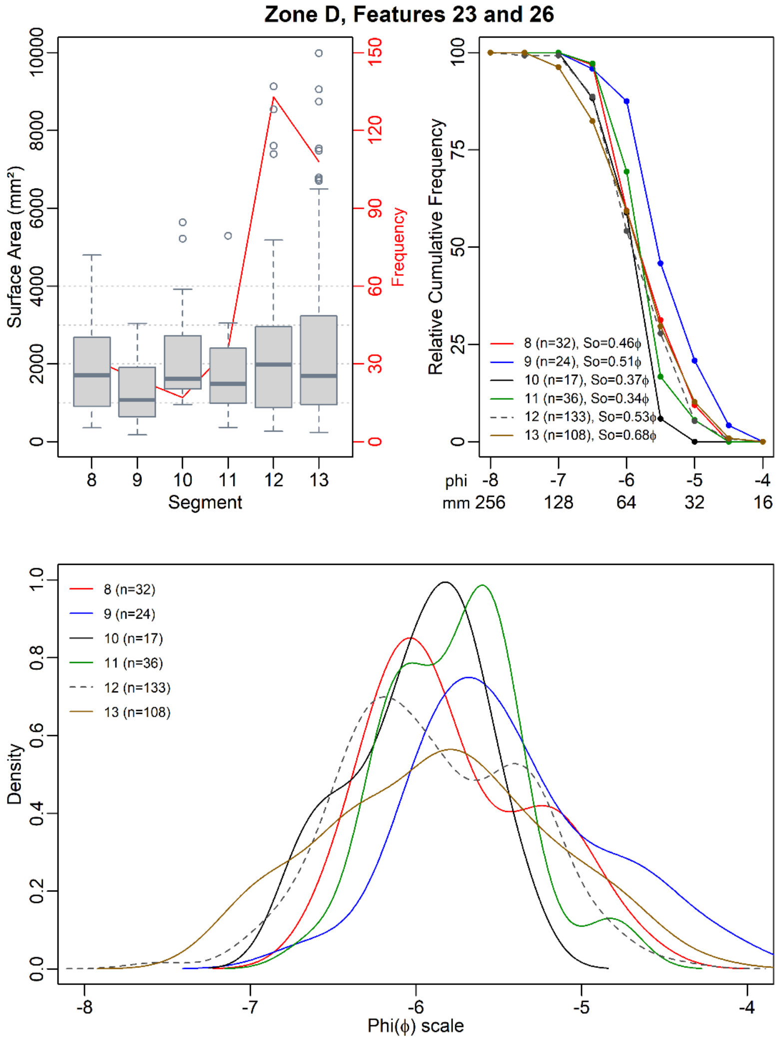


Figure 7.58: Sherd-size distribution of sherd assemblages in segments from features 23/26 in zone D.

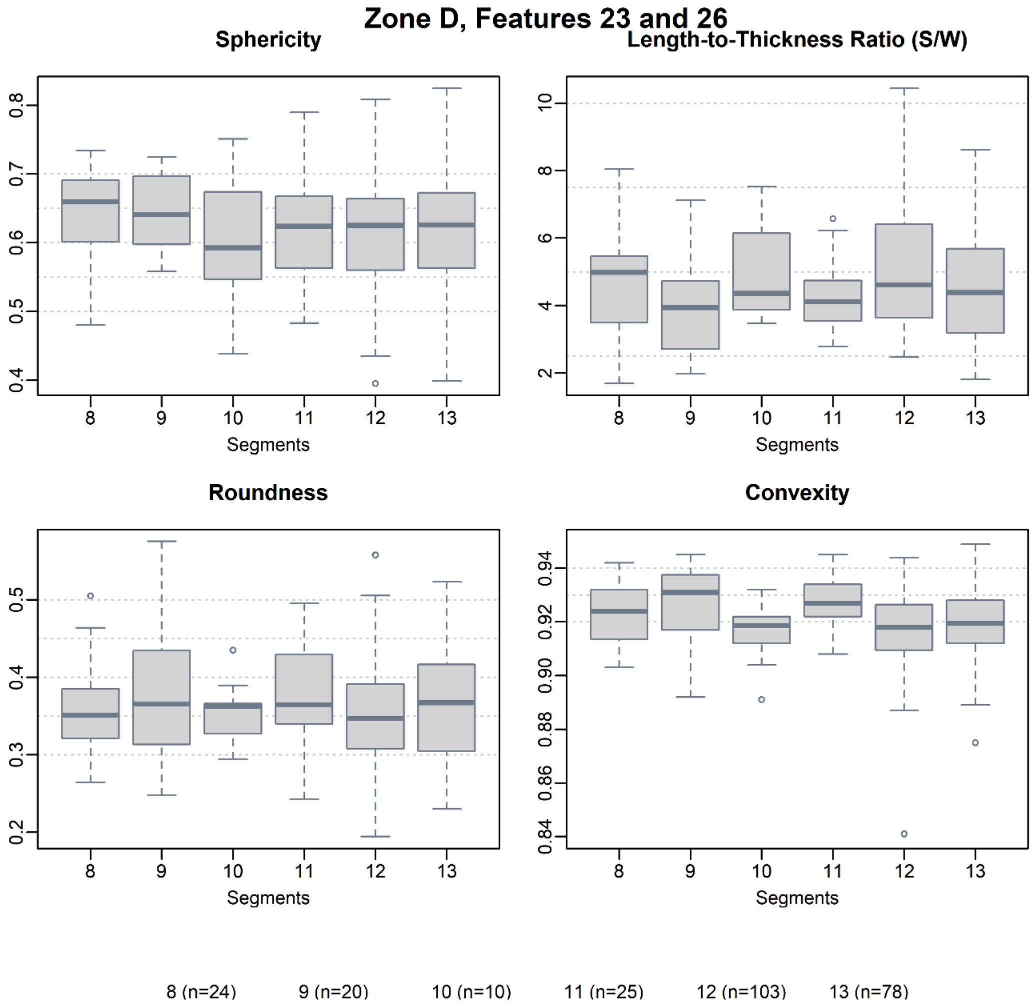


Figure 7.59: Morphometric values of sherd assemblages in segments from features 23/26 in zone D.

The spatial distribution of fragments from west to east shows a significant pattern mostly around segments 12 and 13 (Figures 7.60 and 7.61). There is a clear spatial sorting of both size and shape of fragments with a gradual increase in fragment sizes, and roundness from east to west. In contrast, sphericity tends to decrease. This gradual increase, however, is interrupted by a high range of fragment sizes in square 82. The degree of size sorting (So) per square units corroborates this observation. In unit 82, the potsherd assemblage becomes poorly sorted, which contrasts with the well-sorted values of adjacent units. This suggests that once more, downslope sorting mechanisms are significant, but not uniquely responsible for the infilling of the whole area. Quite possibly a combination of gradual and unintended downslope deposition of small fragments and the purposeful dumping or placing of freshly broken sherds or portions of pottery were responsible for the pit fill. Further spatial distribution analysis in direction W-E was not possible for the rest of longpit 23/26, because some square units did not have sherds. For example, fragments from squares 62 to 78 were little to none.

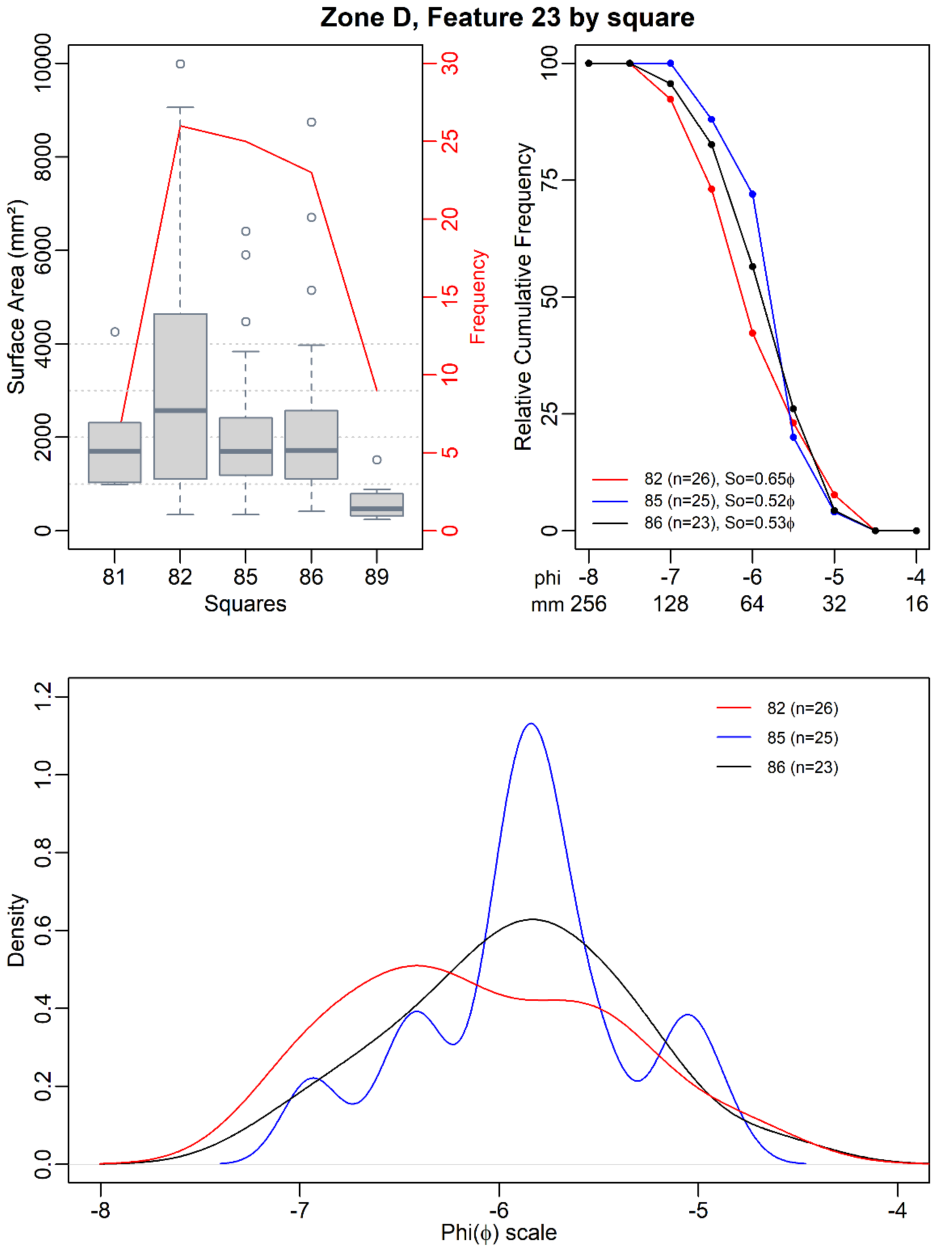


Figure 7.60: Sherd-size distributions of assemblages in the west to east section of segment 12 and 13 of feature 23/26 in zone D.

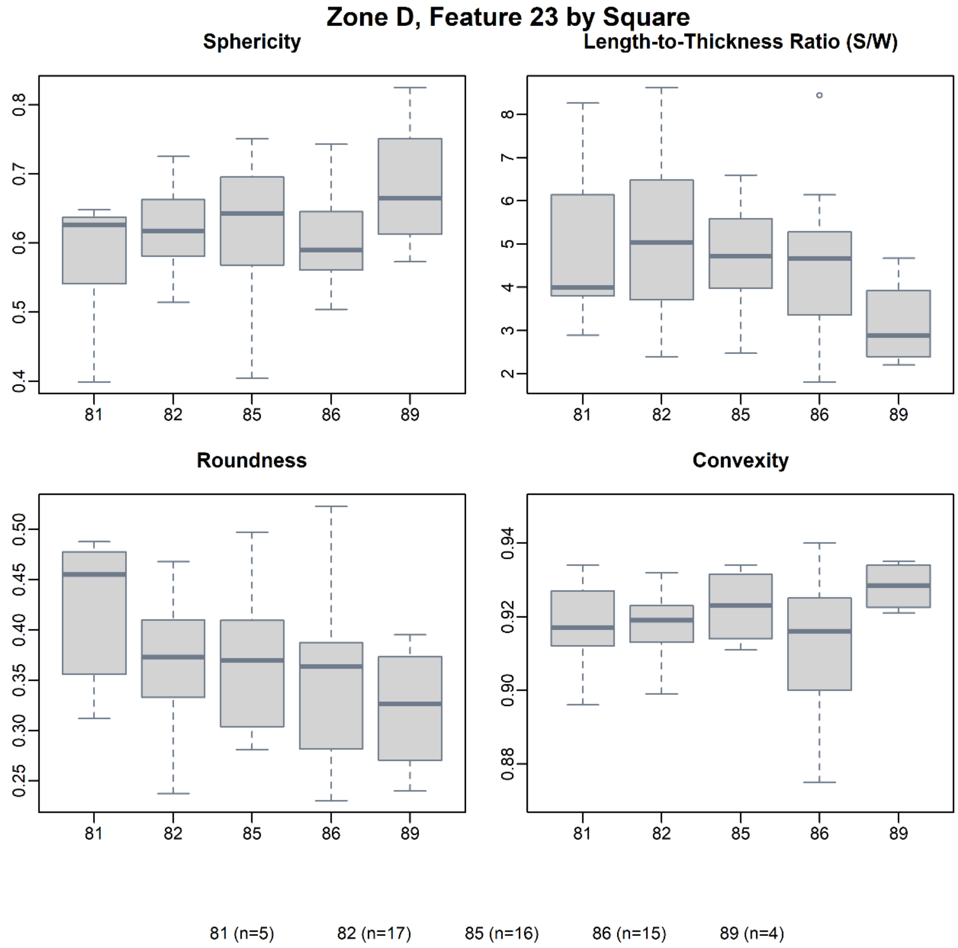
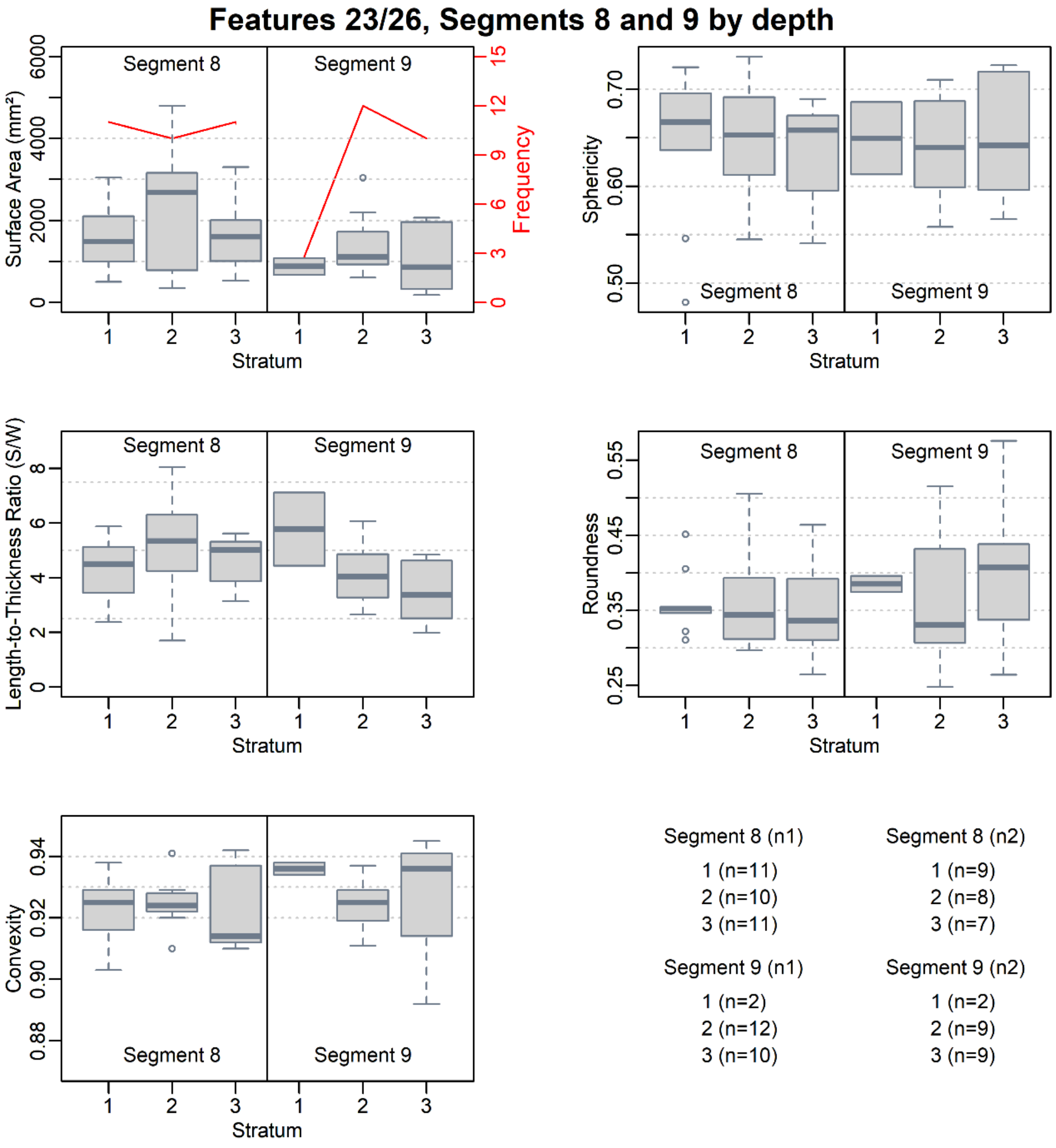


Figure 7.61: Morphometric values of assemblages in the west to east section of segment 12 and 13 of feature 23/26 in zone D.

The stratigraphic information provides some key elements to unravel the depositional sequence of segments 8 and 9, and segments 12 and 13. In Figure 7.62, segments 8 and 9 have a very clear homogenous or stratified deposit of small fragments throughout the stratigraphic sequence, which is consistent with a gradual process of slow deposition mentioned above. Morphometric values also show little variation in fragment shapes, as spherical, compact and angular fragments seem to be prevalent in all strata. In segments 12 and 13 (Figure 7.63), the lower spits (*i.e.* strata 5-7) have only sporadically deposited fragments, and that potsherd deposition only occurs from stratum 3. From this point upwards, the deposits appear to be poorly sorted in terms of sherd sizes. Shape descriptors also illustrate a stratified mixture of material, indicated by the up- and down-shift in values according to spit (Figure 7.63). This signals high energy process, probably related to human dumping rather than placing.



Segment 8 (n1)
1 (n=11)
2 (n=10)
3 (n=11)

Segment 8 (n2)
1 (n=9)
2 (n=8)
3 (n=7)

Segment 9 (n1)
1 (n=2)
2 (n=12)
3 (n=10)

Segment 9 (n2)
1 (n=2)
2 (n=9)
3 (n=9)

Figure 7.62: Sherd-size distribution and morphometric values of assemblages from different strata in segments 8 and 9, feature 23/26 in zone D.

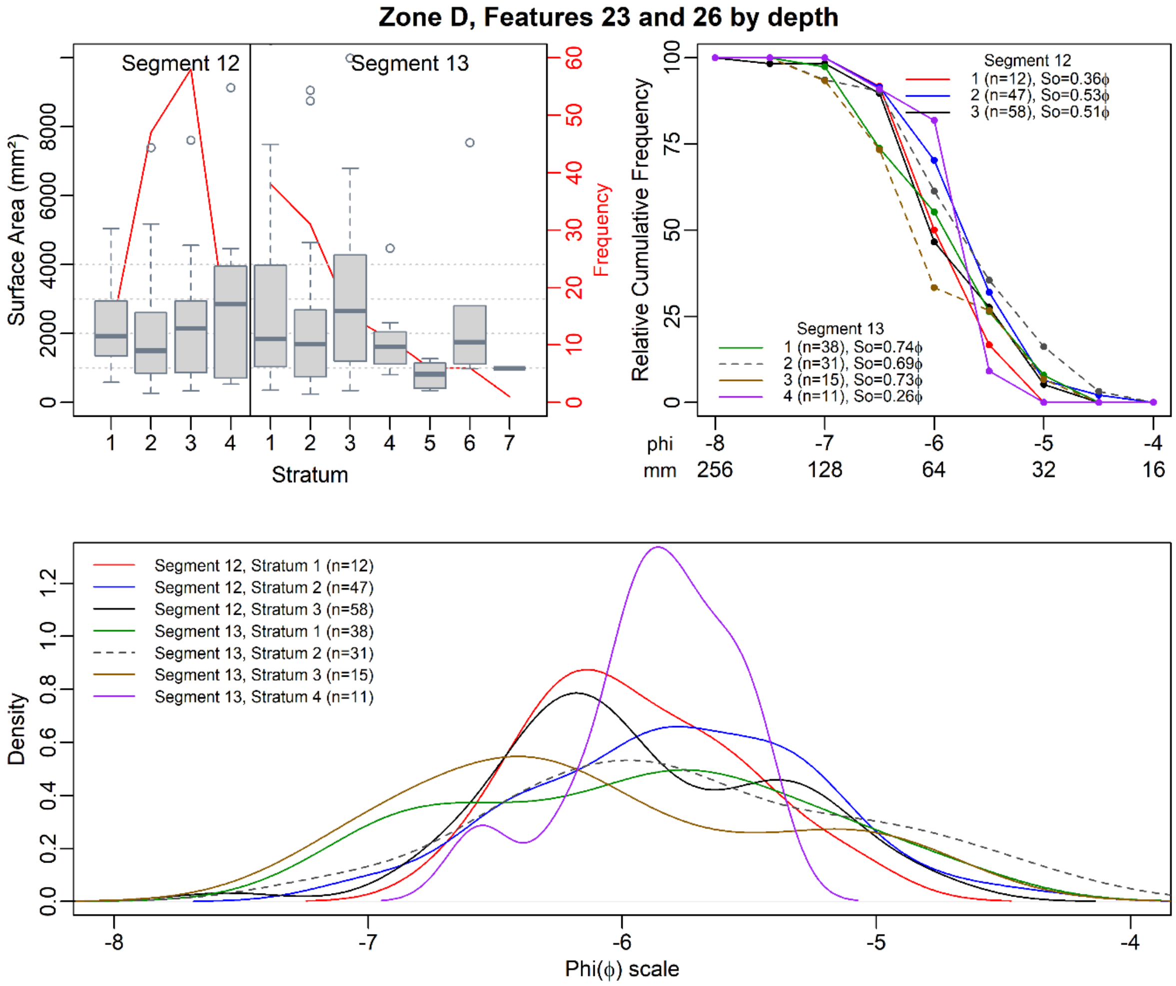

Zone D, Features 23 and 26 by depth

Figure 7.63: Sherd-size distribution of assemblages from different strata in segments 12 and 13, longpit 23/26 zone D.

Similar to longpit 11/22, the deposition in longpit 23/26 should be considered in terms of a tripartite division between north, centre and southern areas. The northern portion of the pit consisted of few significantly fragmented but not abraded potsherds, but the lack of spatial patterning makes the interpretation somewhat difficult. The low frequency of small potsherds rules out the dumping of freshly broken pots. The shallow area around the centre of the pit seems also to suggest some form of ‘placing’ of rather large portions of pottery occurred in this area. The southern area of the pit, which possesses most of the sherds from this feature, signals that a combination of depositional processes were at work. After the deposition of the first sterile layers, there is indication of slow and gradual downslope fragment deposition. According to the spatial sorting patterns, this process must have occurred from both a north-south and east-west direction. Afterwards, the stratified deposits from the last three strata is a recurrent high-energy process of deposition that can be attributable to dumping near the edge of the pit (see section

6.1.1.3). Thus, contrary to the unstratified deposits from the southern portion of longpit 11/22, this is not likely to be caused by backfilling. As a rule, fragmentation rather than abrasion of sherds is predominant throughout the longpit, which suggests these areas were commonly transited.

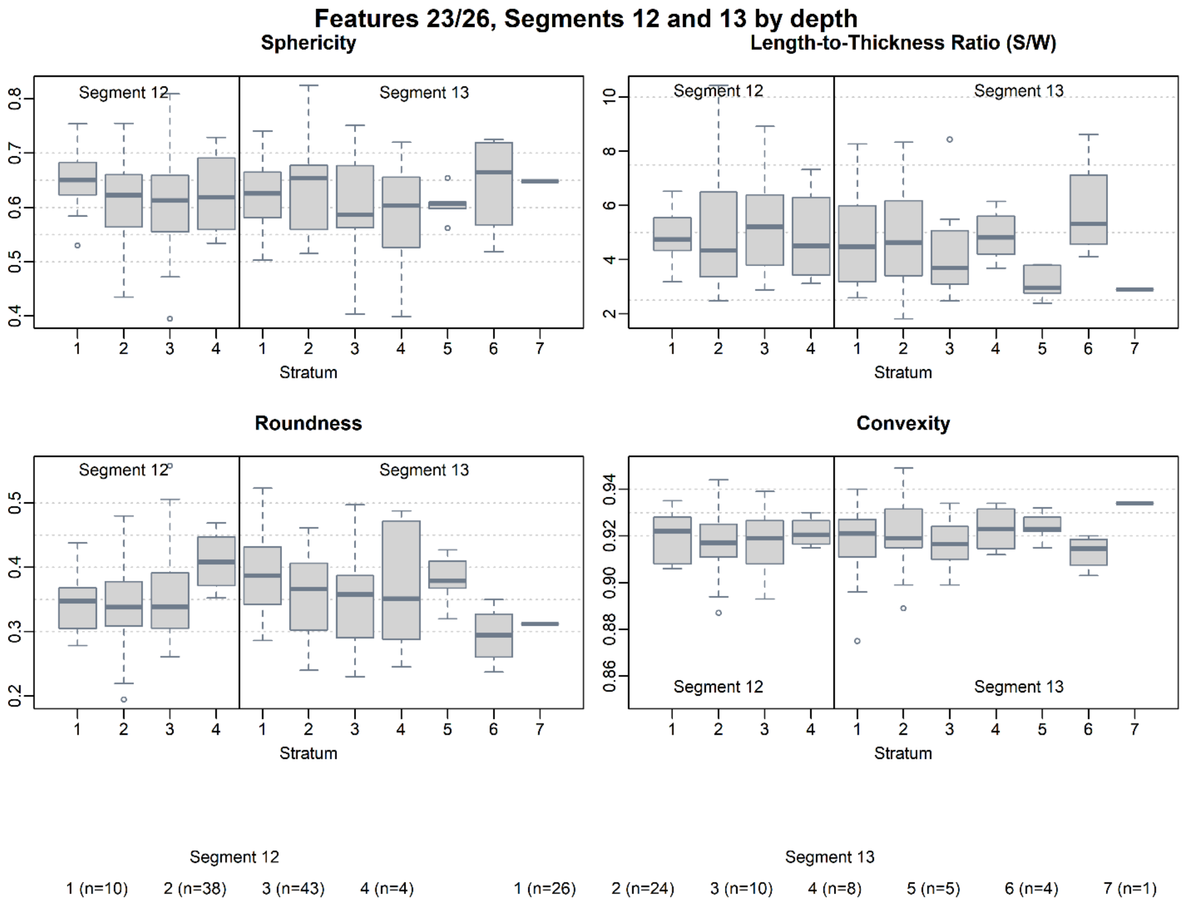


Figure 7.64: Morphometric values of assemblages from different strata in segments 12 and 13, feature 23/26 in zone D.

7.2.4.4.2 The features from H5/1987

In contrast to H4/1987, the western and eastern longpits of H5/1987 seem once more to have different sherd-size distributions (Figure 7.65). Feature 7 contains a higher variety of fragment sizes ranging from small to large, is moderately sorted and positively skewed, while feature 36 is predominantly filled with small sherds and displays a well-sorted distribution. These contrasting values point to different depositional environments. A surprising result is that the so-called occupational surfaces in Eitzum display a relatively varied range of fragment sizes. While feature 25 has a well-sorted and slightly negatively skewed distribution of fragment sizes, feature 10 is moderately sorted and positively skewed. There is also once more a tendency that small fragments accumulate in postholes.

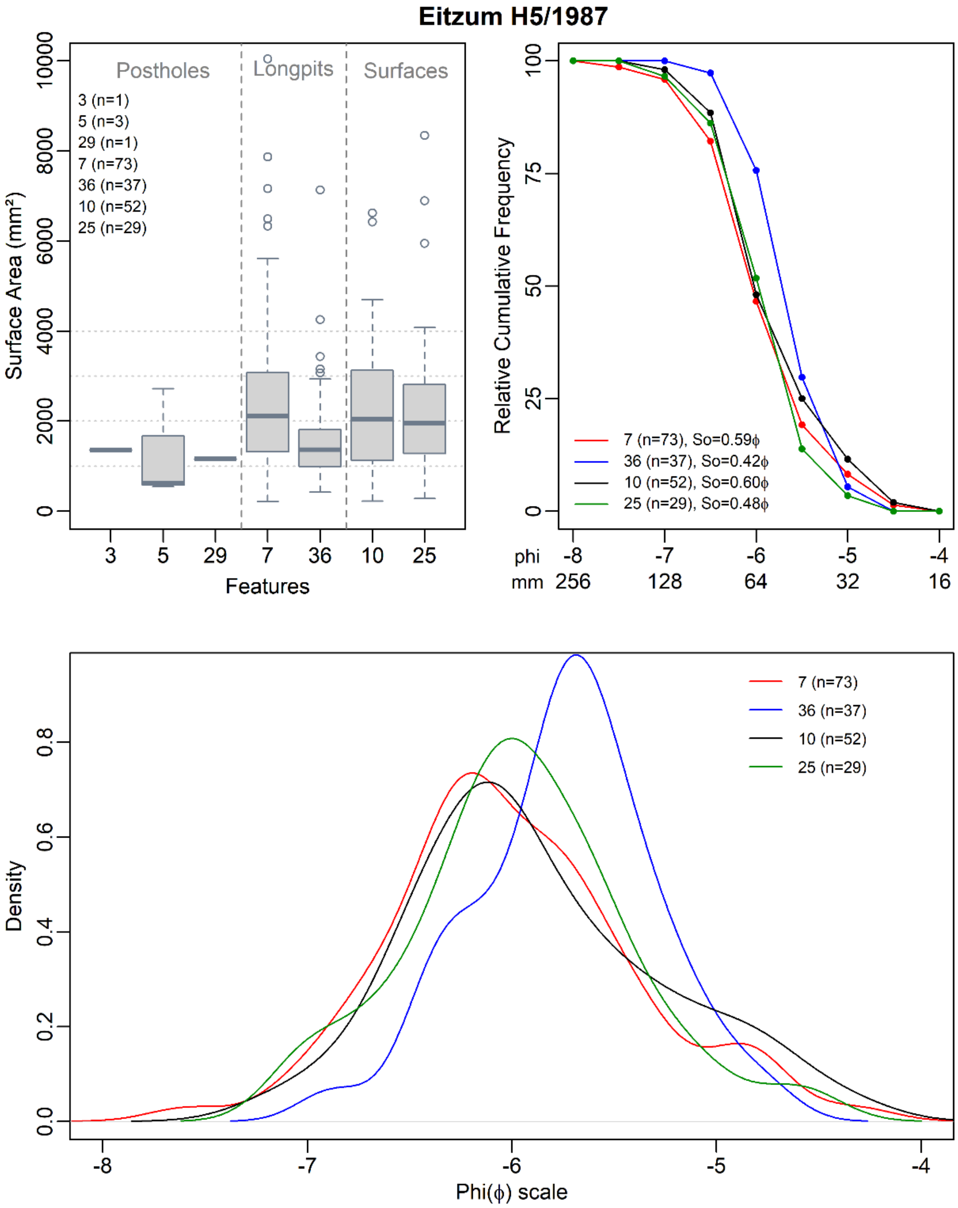


Figure 7.65: Sherd-size distribution of features from H5/1987 in zone D.

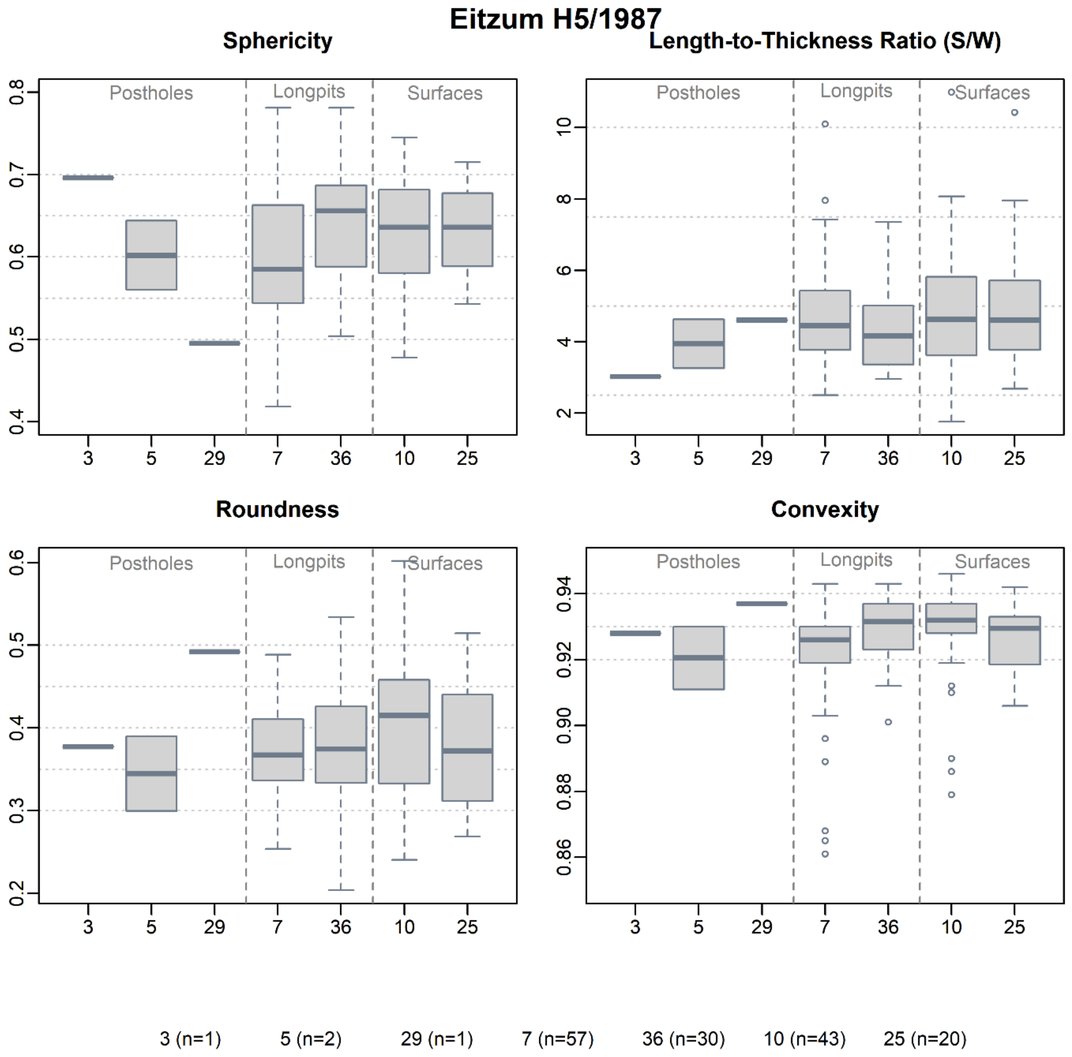


Figure 7.66: Morphometric values of features from H5/1987 in zone D.

With the exception of feature 7, sherds from H5/1987 are predominantly spherical and compact, and only slightly rounded (Figure 7.66). The most noteworthy contrast is between longpits 7 and 36. The former is composed of less spherical/compact, more angular and rougher fragments than the latter, which probably suggests different activities and/or functions were associated to each feature. Even though sphericity values are constant, there are differences between occupation surfaces (features 10 and 25), since roundness and convexity values vary. Material from feature 10 shows substantially more rounded fragments and smoother surface textures than sherds from feature 25. These more rounded fragments might have been transported longer distances before deposition, which supports the excavators claim that these deposits are the result of colluviation.

Results from H5/1987 suggest different depositional patterns in longpits. While in longpit 36 deposition happened well after fragmentation, the size and shape parameters from feature 7 show evidence of very little exposure to abrasive or fragmentation processes. This could imply a fair amount of dumping or placing must have taken place in this feature not long after pots were broken. Nonetheless, as convexity values illustrate, fragments from this feature do not appear to have been broken *in situ*, which rules out the 'structured deposition' of partially broken vessels.

7.2.4.5 Summary and discussion of results

Depositional patterns inside longpits are, to a certain extent, varied. When possible, these features should not be analysed, and perhaps excavated, as a single spatial unit. The western and eastern longpits of house H4/1987 make this very clear, as there is a division between north, central and southern areas. The western longpit from H1/1956-58 displays a similar pattern, at least in terms of a division between north and south, but pit 14 in zone B deviates from this norm. Thus, at least three different depositional processes were detected at Eitzum. The most prevalent and ubiquitous process was the gradual downslope movement of significantly fragmented potsherds.

Following the downslope rockfall model discussed before, the process was repeatedly observed in almost all of the features from zone A, B and D, but more clearly in the spatial distribution of fragment sizes and shapes in features 14 from zone B and features 11/22 and 23/26 in zone D. The fill of feature 14 is dominated by this process, which adds up to a considerable amount of material. The longpits of house H4/1987 also illustrate this process in the northern end of these features, but towards the south it was most likely just the beginning, for here a different set of depositional events occurred. Evidence from most pits studied suggest fragments are normally trampled before deposition. This connection is not at all radical, as human or non-human trampling near heavily transited areas also tends to destabilise slopes (Carson and Kirkby 1972, 193) and prevent vegetation growth.

The discard (*i.e.* dumping and backfilling) of potsherds was more restricted and highly localized. The data collected from WLH1 in zone A and features 11/22 and 23/26 in zone D provide clear evidence of this activity. Phosphate analysis at H4/1987 showed that, despite the overall lower levels of phosphate concentrations compared to other äLBK sites, the southern sectors of longpits from H4/1987 have significantly higher concentrations than other areas (Stäuble and Lüning 1999, 181). There is some variation in the way discard was undertaken. In zone D, there is a contrast between the quick pit-infilling of the south end of feature 11/22, and the rather gradual discard of freshly broken sherds observed in the southern portion of longpit 23/26. The former remains the only area of the site where fragments were quickly buried. Given the proximity of discard areas to the household, even after deposition there is still some potential for interaction between people and their broken pots.

Some evidence of structured deposits around central areas of houses was also suggested, such as in both longpits of H4/1987, and perhaps in segment 3 of feature 14 (zone B).

7.2.5 Klein Denkte

7.2.5.1 Basic recording of material

Table 7.15 summarises the ceramic material sampled from the pits at Klein Denkte. While the total population refers to the material available at the museum at the time of my analysis, as can be seen almost all the ceramic material from each context was sampled.

Feature	Sherd-size Distribution Sample (n1)			Morphometrics Sample (n2)			Total Weight (g)	Total Number
	Weight (g)	No.	Percent*	Weight (g)	No.	Percent*		
59	692	57	94.79	476	49	65.21	730	58
67	322	42	100	276	41	85.71	322	42
71	5347	134	92.98	2765	99	48.08	5751	136
72	448	10	94.51	228	7	48.10	474	11
74	1191	60	98.67	731	54	60.56	1207	61
101	1820	61	96.30	1024	45	54.18	1890	64

*Table 7.15: Sample size information of features from Klein Denkte. *Percentages are calculated according to weight of fragments.*

While the EVEs are quite limited due to the small number of diagnostic sherds (*i.e.* base fragments), mostly small and medium vessels are represented (Table 7.16). According to s/v values, vessels with secondary rupture originate from contexts 59 and 101. In general, fragments seem to have been rarely discarded immediately after vessel primary rupture. Cladders (2001, 50) has obtained very similar results, and states that there is an average of 2.2 fragments per vessel unit.

Feature	Vessel Size*	Base sherd(s)	EVE	Total EVEs	Brokenness Ratio (s/v)**
59	Medium	1	0.25	0.25	228
71	Very Small	1	0.525	2.375	56.42
	Small	4	1.85		
101	Small	2	0.45	0.625	97.6
	Medium	1	0.175		

*Table 7.16: Calculation of vessel EVEs from Klein Denkte by feature. *Sizes were determined from projected vessel diameters (defined in section 6.1.2.3.1) **Sherd numbers are equivalent to sampled fragments (n1).*

7.2.5.1.1 Fabric Characterisation

Most fragments sampled from Klein Dentke are tempered predominantly with semi-fine organic matter and have a soft surface (Figure 7.67). There is a small number of fragments that also possess some mineral inclusions in addition to organic matter. As mentioned before, minerals identified in oldest LBK pottery in the region make sand the most likely source (Riederer 1985, 36). Due to the little variation in composition, granulometry and surface hardness of ceramics at Klein Denkte, these parameters were not further assessed during analysis of size distribution and morphometry of fragments.

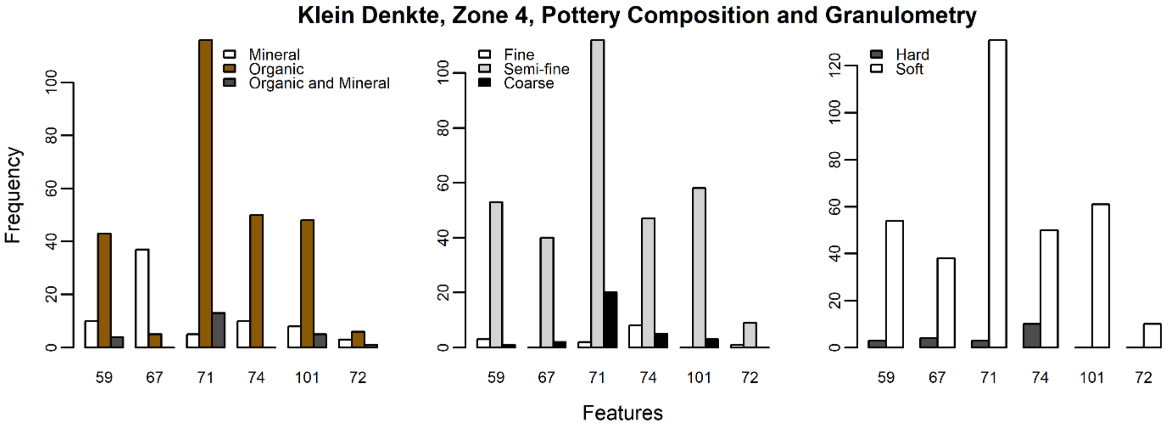


Figure 7.67: Composition, granulometry and hardness of ceramics from Klein Denkte zone 4.

7.2.5.1.2 Postdepositional information

Vessel portions represented in each feature at Klein Denkte are shown in Figure 7.68. Overall, there is a high proportion of body fragments, only feature 71 has a reasonable amount of rim and base fragments. As bowls and globular vessels are the most common vessel types (Cladders 2001, 50), which have a two-litre capacity (*Idem*, 6, 9), the proportion of rim to body sherds should not be that substantial, unless intense fragmentation occurred. As with sherds from zone D in Eitzum, the sampled potsherds from Klein Denkte were all washed, but show very little traces of brushing.

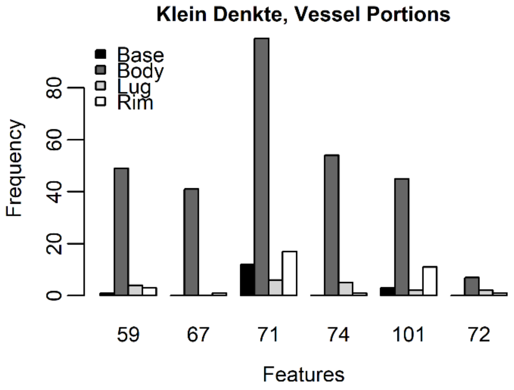


Figure 7.68: Vessel portions in Klein Denkte zone 4.

8.2.5.2 Zone 4 features

In zone 4, features show a definite difference in terms of depositional patterns. In the sherd-size distribution of features 59, 67 and 74 very small sizes are prevalent and possess negatively skewed logarithmic distribution curves (Figure 7.69). The only difference between these features is their degree of sorting, with features 59 and 67 close to well-sorted distributions, while feature 74 is poorly sorted. On the opposite end, features 71, 101, and 72 have a large range of fragment sizes, and moderate to poorly sorted and positively skewed logarithmic distributions. Contrary to data obtained from features 59, 67 and 74, these sherd-size distributions indicate that features 71 and 101 are likely to be the result of a variety of depositional patterns. Morphometric information describes assemblages as spherical, compact to moderately compact/oblong, slightly rounded and with a rough surface texture (Figure 7.70). An in-depth discussion of most of these features is given in the following sections.

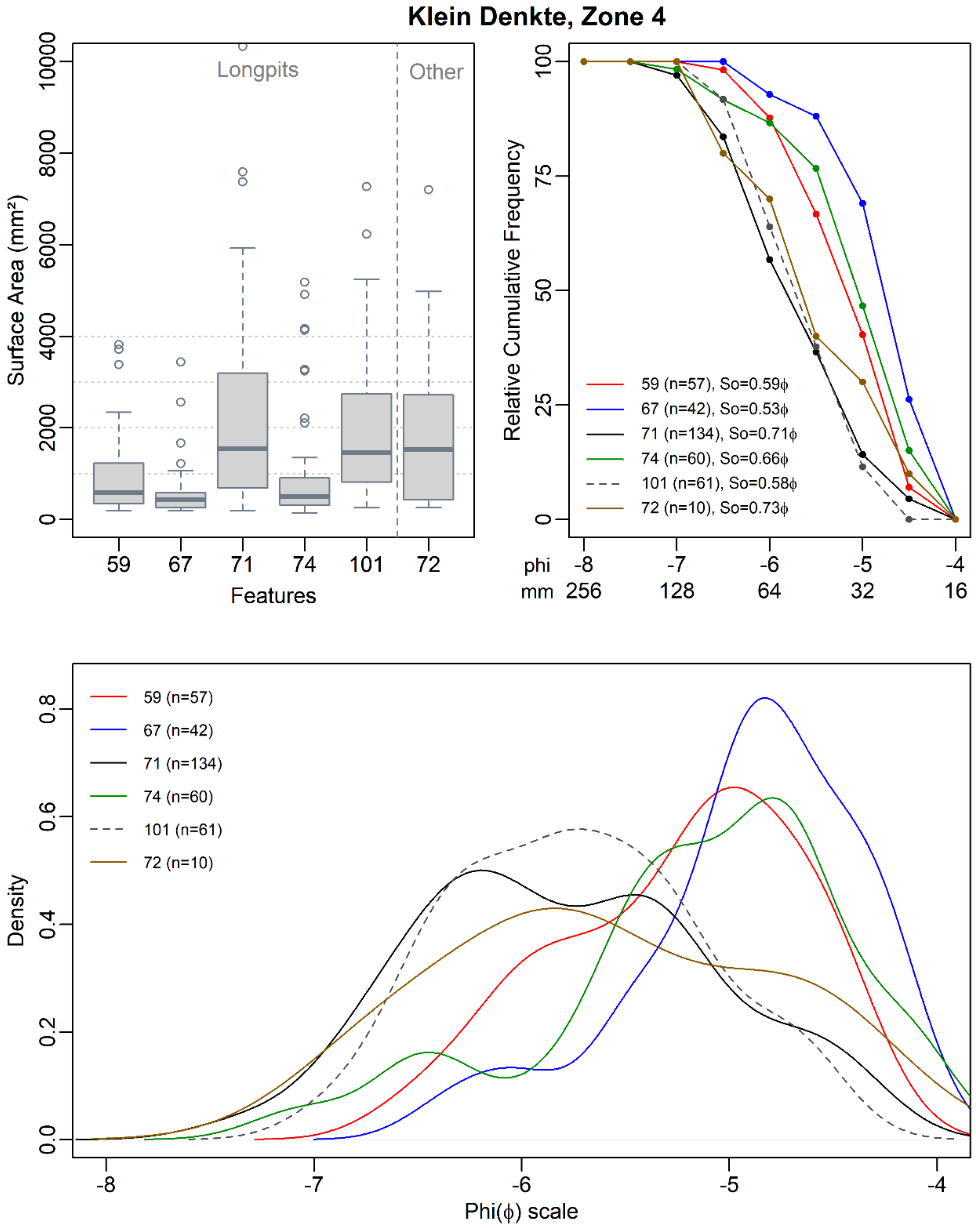


Figure 7.69: Sherd-size distributions of assemblages from Klein Denkte zone 4.

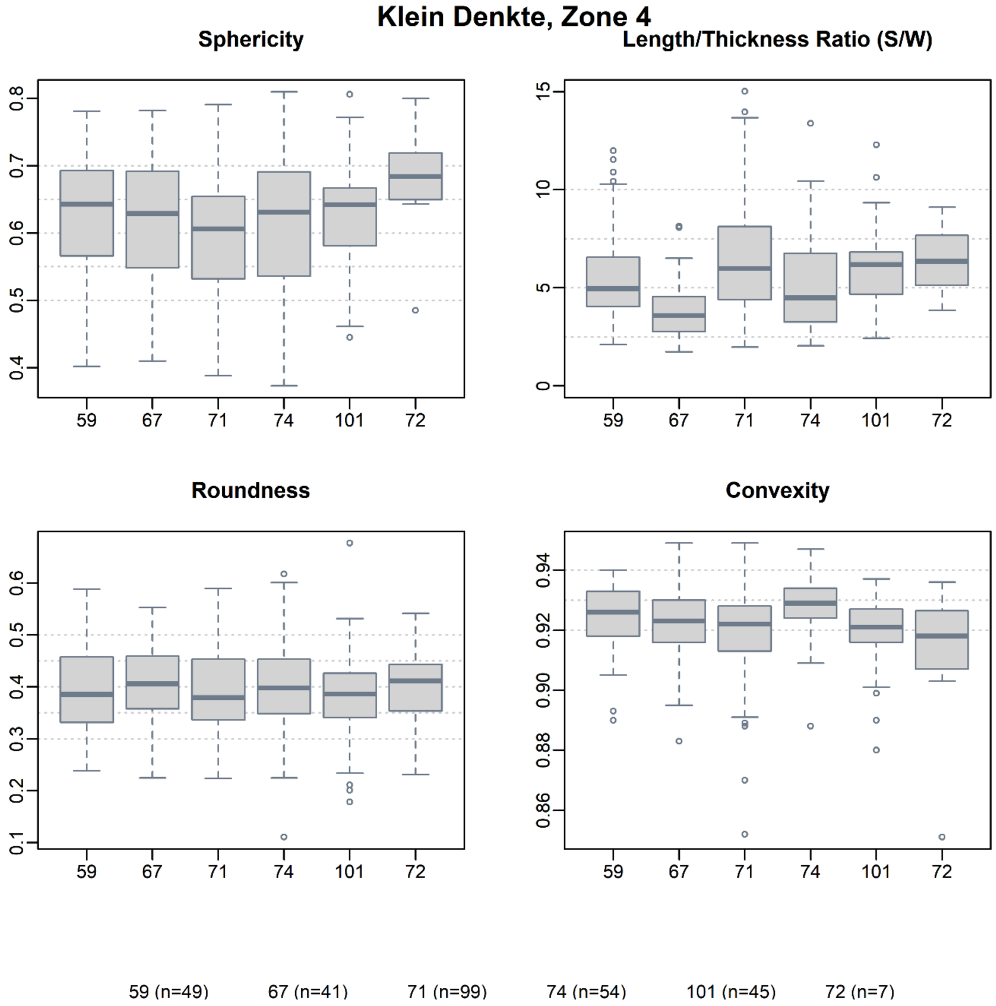


Figure 7.70: Morphometric values of assemblages from Klein Denkte zone 4.

7.2.5.2.1 Feature 59

Fragments progressively increase in size from the pit ends to the middle portion (Figure 7.71), as well as an increase in potsherd numbers. Morphometric parameters also highlight shape sorting of fragments in feature 59, with an increase in sphericity, compactness, roundness, and roughness of fragments from the edges of the pit towards the central areas in segments 3 and 4 (Figure 7.72). Unfortunately, the restriction of the sample size did not let further calculation of sorting and skewness of sherd-size distributions in the majority of the segments. Even if the sample size of each segment is not ideal, the spatial analysis of fragment sizes gives an indication of spatial sorting of fragments in terms of size and shape. Deposition also appears to be restricted to the upper spit of the fill.

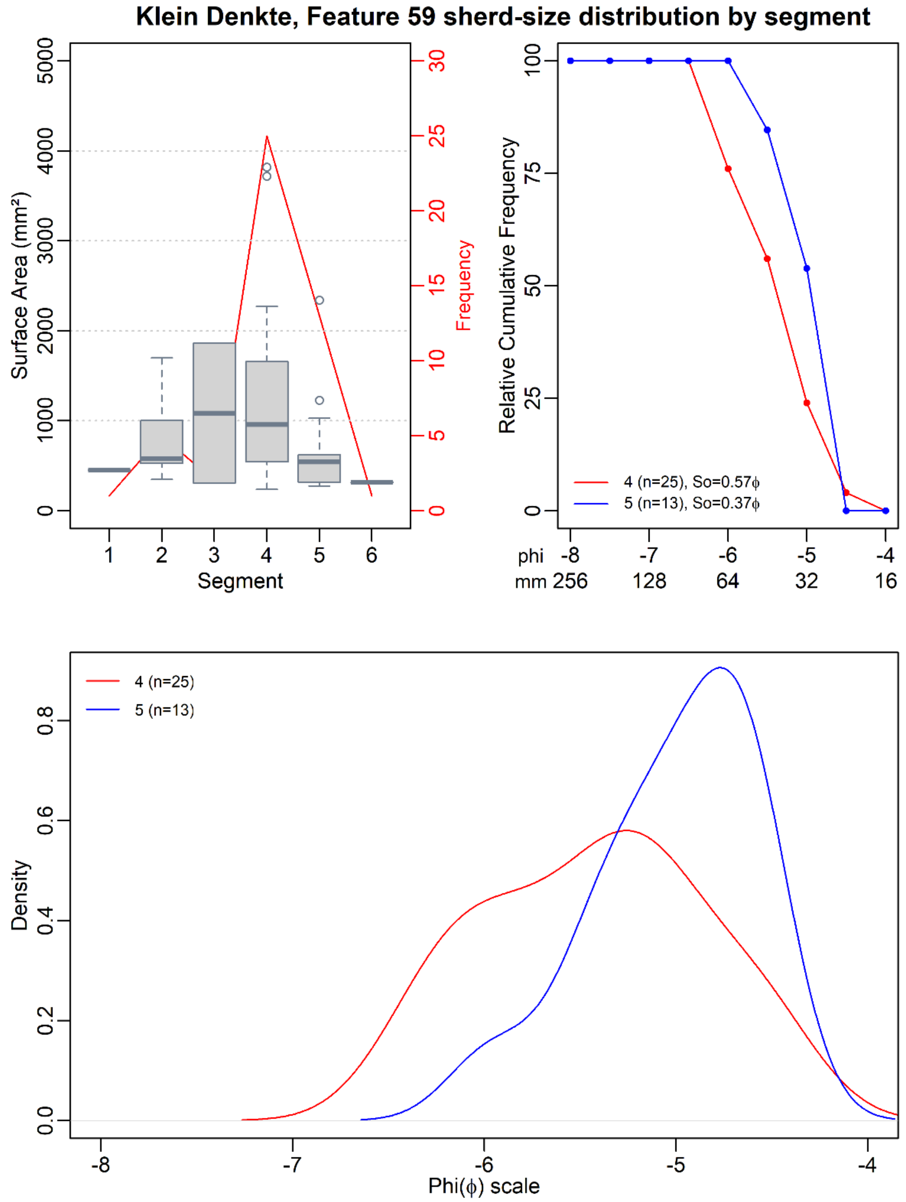


Figure 7.71: Sherd-size distribution in longpit 59 at Klein Denkte zone 4.

The overall depositional pattern in longpit 59 appears clear, it has a ‘typical’ pattern signaling the gradual downslope movement of fragments. Deposition probably occurred from both ends of the pit towards the deeper central portion. However, this was unlikely a process of dumping, but rather of unintended deposition. Furthermore, potsherds are significantly fragmented and slightly rounded, which is an indication of a long history of exposure to erosive processes. Unfortunately, comparison with the eastern longpit, *i.e*. feature 67, was not possible, as sample size from this feature was too small.

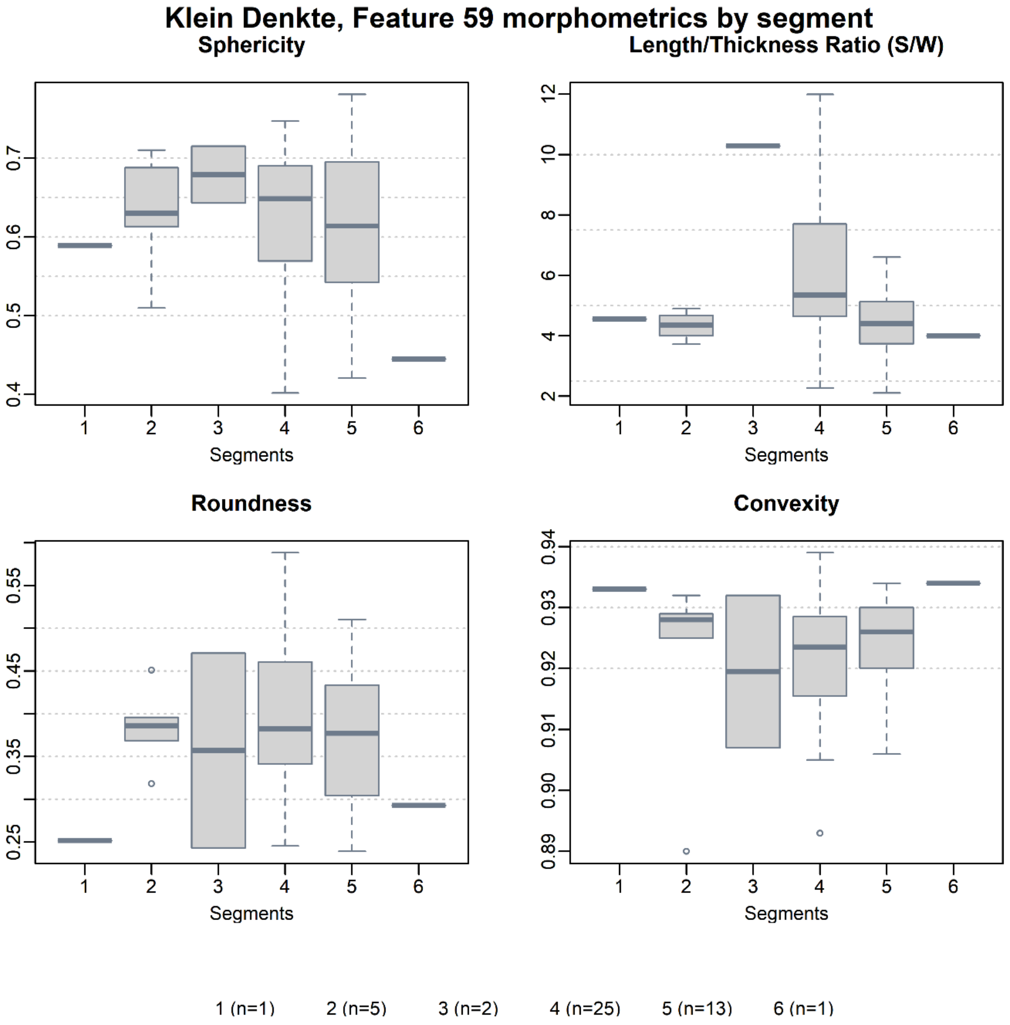


Figure 7.72: Morphometric values of sherds in longpit 59 at Klein Denkte zone 4.

7.2.5.2.2 Feature 71

At feature 71, the distribution of fragments is restricted to the central part of the pit, corresponding to segments 2, 3 and 4, and no apparent pattern is discernible (Figure 7.73). The extremely large fragments identified in segment 5 correspond to base fragments assigned to the same vessel unit (vessel number 124) and is a single pot deposit. There is, however, a large variation of fragment sizes in the middle portion of the pit. The skewness of sherd-size distribution curves and their degree of sorting also indicate a heterogenous assemblage. Morphometric values corroborate this statement as sphericity, roundness and convexity values are generally low (Figure 7.74), which highlights that fragment alteration before deposition was little to none. Stratigraphic information from feature 71 was limited to stratum 1 and 2, with a large abundance of material (107 fragments) in the former over the latter (9 fragments). For this reason, no further analysis could be performed. Nonetheless, the information does point to a quick deposition during the last stages of the pit's infilling.

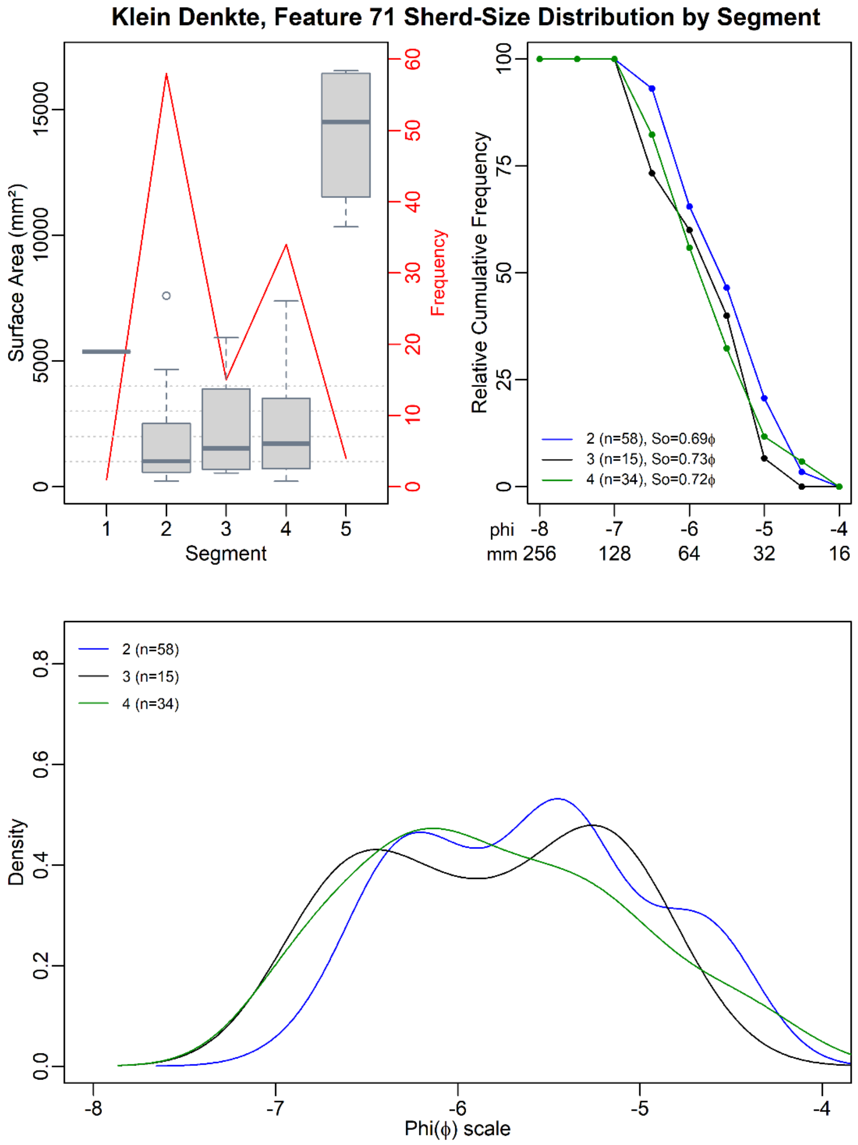


Figure 7.73: Sherd-size distribution in longpit 71 at Klein Denkte zone 4.

Potsherd deposition in longpit 71 highlights an entirely different process than feature 59. The variation in fragment size distributions is mostly of a late stage of discard of only slightly altered fragments and the placing of a pot at the southern end (segment 5; see Stäuble 2005, Figure 7). This depositional process probably occurred rapidly and was restricted to the central areas of the pit. If Stäuble’s (2005) interpretation of the house is correct, it is possible that feature 71 only corresponds to the southern half of house H2/1987, and thus the majority of the discarded deposit lies to the south end of the house.

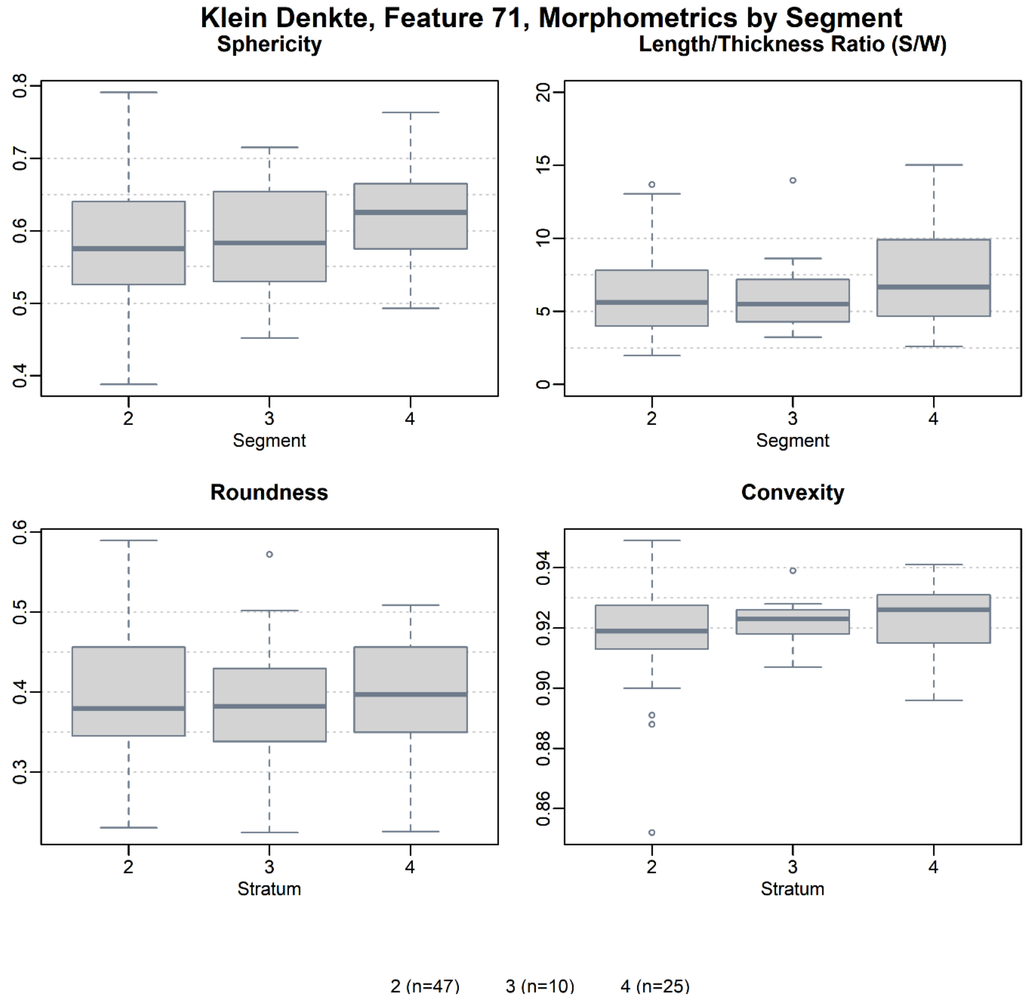


Figure 7.74: Morphometric values of sherds in longpit 71 at Klein Denkte zone 4.

7.2.5.2.3 Feature 74

While the sample size for feature 74 is small, the spatial sorting of very small body fragments cannot be neglected (Figure 7.75). Size parameters indicate a progressive decrease of fragment sizes towards the central segment of the pit, *i.e.* segments 3 and 4. Distribution curves also show that fragments are very negatively skewed and well- to moderately sorted, which describes an extremely fragmented assemblage. Morphometric parameters also show an increase in sphericity and compactness, but a decrease in roundness, towards segment 3 (Figure 7.76). Only the two upper spits of the pit contained ceramics, and 78.33% (n=47) were from stratum 1. Of the remaining percentage, 16.67% (n=10) was found at the ‘planum’ level or starting level of the excavation, and only 5% (n=3) originate from stratum 2. While the pit reaches 0.75m, in general it is extremely shallow, which limits the catchment potential of this depression.

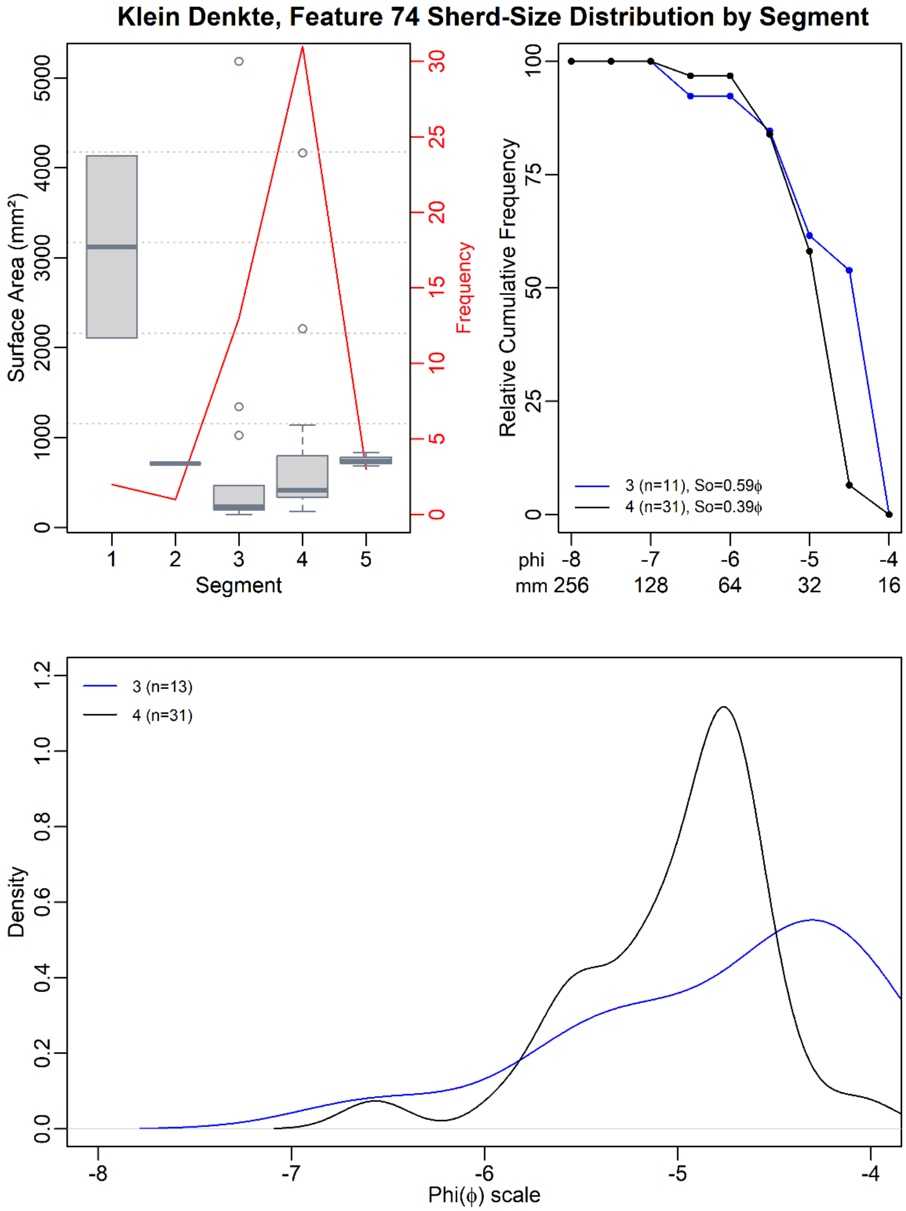


Figure 7.75: Sherd-size distribution in longpit 74 at Klein Denkte zone 4.

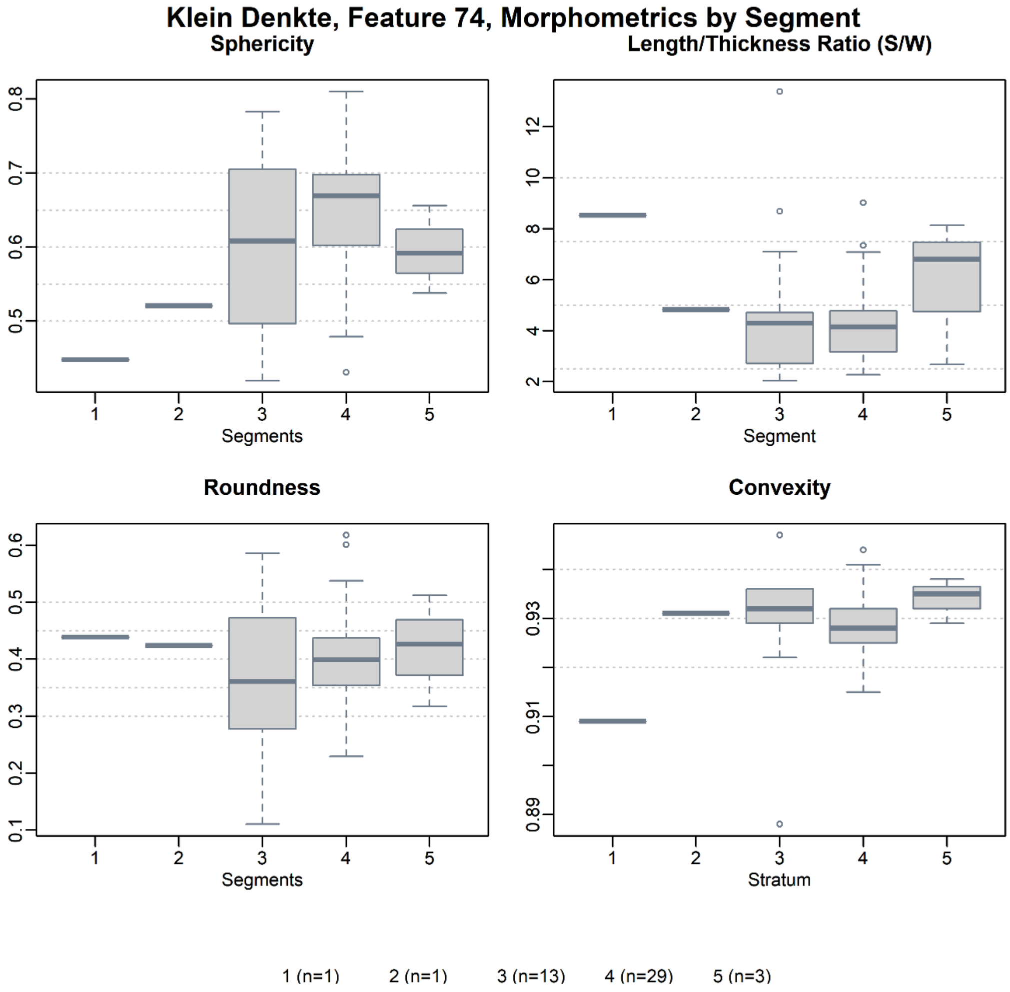


Figure 7.76: Morphometric values of sherds in longpit 74 at Klein Denkte zone 4.

The extremely fragmented state and slight roundness of sherds is highlighting a prolonged exposure to erosive processes. The size and shape sorting of sherds highlights a specific depositional process, selecting smaller-sized fragments with spherical, compact and more angular shapes. Considering that the majority of fragments are from the small sherd-size fraction, which are equivalent to smallest gravel sizes (Table 6.), one possibility to explain this spatial patterning is selective transportation by episodic water currents (section 6.1.1.3). Models created from gravel-sized particles in river currents describe downstream selective transportation as a common occurrence on relatively short distances, where smaller-sized gravel particles are generally transported longer distances and gives rise to negatively skewed logarithmic distributions (Ferguson *et al.* 1996, 181; Parker 1991). This downstream fining happens because larger particles require higher stresses to mobilise (see also Boaz and Behrensmeyer 1976, 55 on bones in fluvial environments). This also means that the turbulence intensity of the flow has an effect on deposition patterns. As flow becomes weaker, larger particles are deposited and finer ones continue in motion (Powell 1998, 5–6). In terms of shape sorting, a few studies of gravel river beds have shown that more spherical-shaped particles tend to move longer distances than blade or disc-shaped particles (Hattingh and Illenberger 1995, 189). However, in the discussion of the effects of roundness in the sorting of particles there are opposing views (as synthesised by Resentini *et al.* 2018, 285), and should not be taken as a reliable parameter. The deposition of potsherds in pit feature 74 could thus be the result of surface wash of sherds from the edges of the pit towards the deeper central areas. These processes could occur during sporadic rains when rooftops drained water into the longpit.

7.2.5.2.4 Feature 101

At feature 101, there is no apparent patterning in the spatial distribution of fragments, but accumulation was slightly higher in segment 2 (Figure 7.77). In this segment, there is also some variation in fragment sizes from small to medium, and logarithmic distribution curves show a positively skewed and well to moderate sorted assemblage. Morphometric values indicate the deposition of only slightly altered fragments, generally slightly elongated or slightly spherical, with low roundness values and moderate to high oblongness (Figure 7.78). Convexity values indicate that 48% of the assemblage is very rough, which is an indication of *in situ* breakage or the deposition of fragments just after breakage. Once again, the depth of the longpit was limited to the two upper spits or strata, with 81.97% (n=50) belonging to stratum 1. From the remaining sample, 8.20% (n=5) were found in stratum 2 of the pit and 9.83% were found at the planum.

The ceramic assemblage in pit 101 may indicate quick depositional events in the area corresponding to segment 2 and 3, towards the end of the pit's infilling. This is marked by the low levels of abrasion and/or fragmentation projected in morphometric parameters, the lack of any spatial sorting of sherds, and the shape of size distribution curves. This does not rule out minor depositional process like downslope deposition, but it does show that backfilling was likely to be the predominant mechanism responsible for the pit infilling.

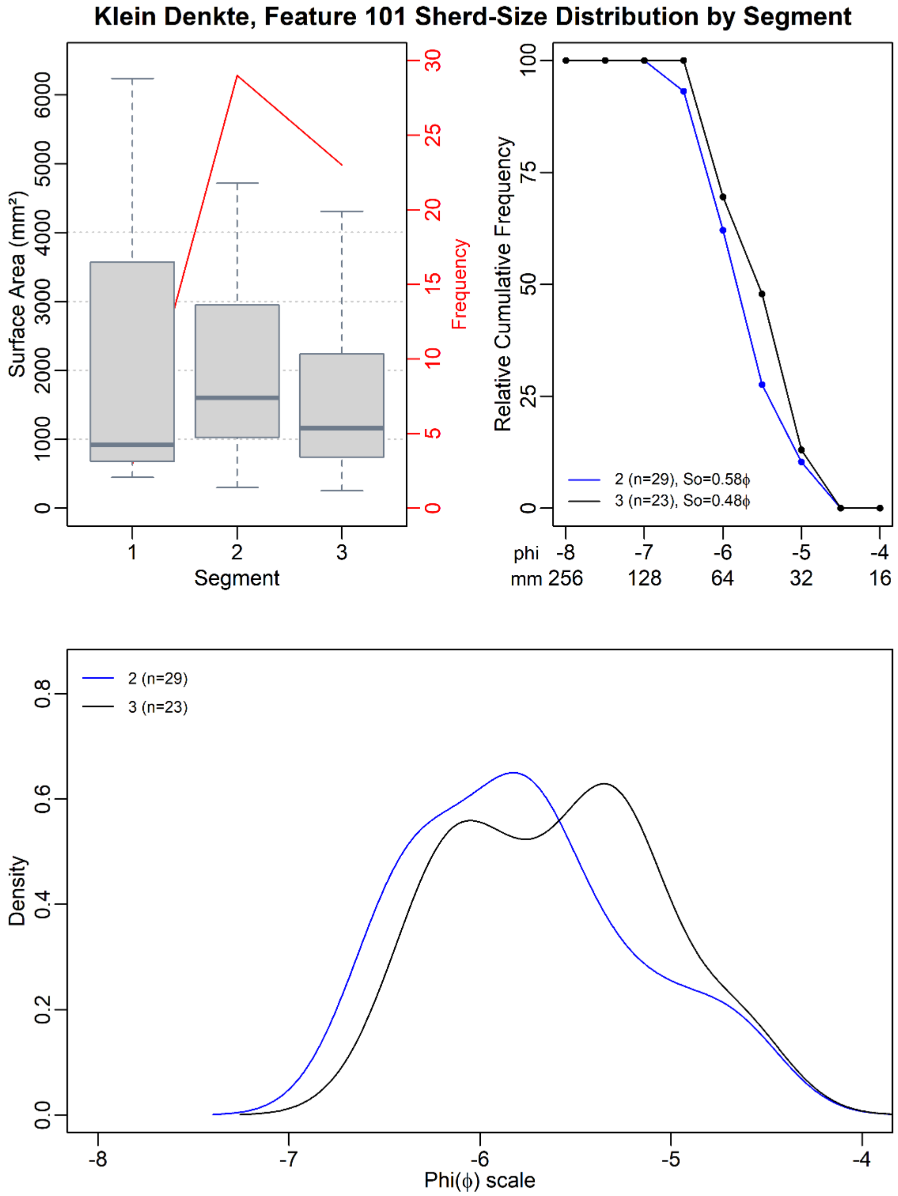


Figure 7.77: Sherd-size distribution in longpit 101 at Klein Denkte zone 4.

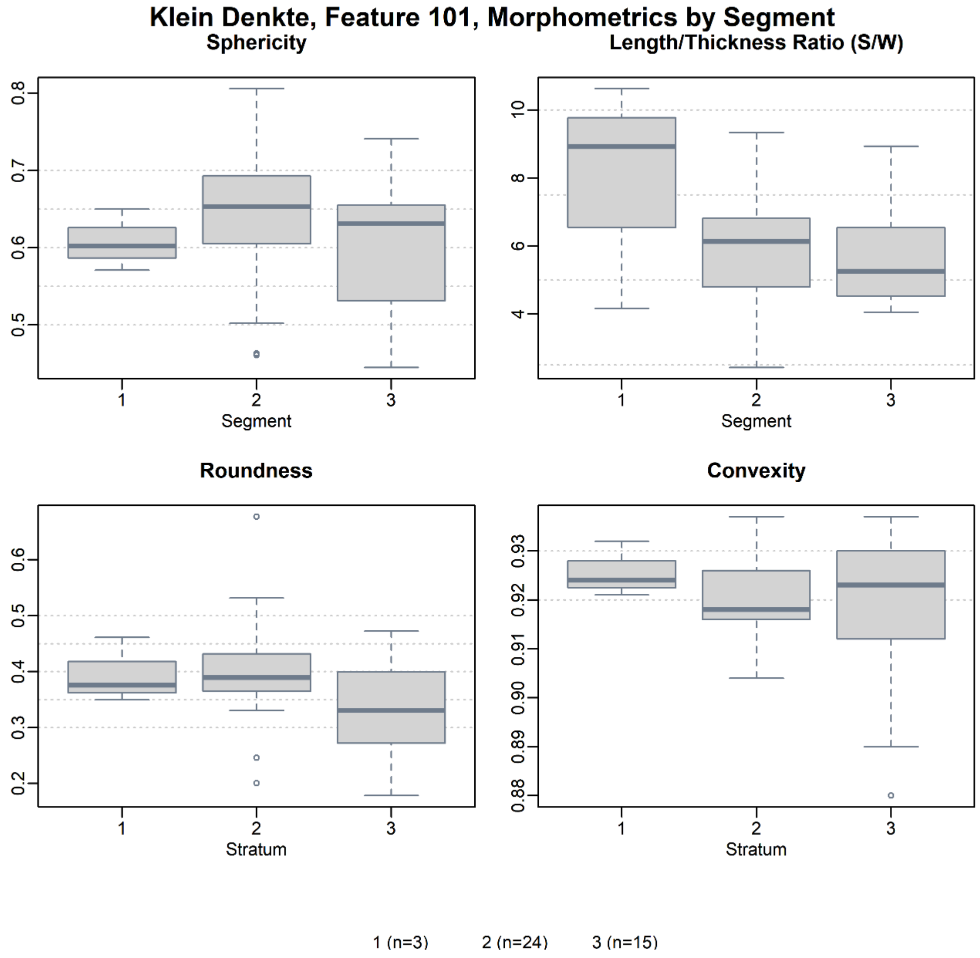


Figure 7.78: Morphometric values of sherds in longpit 101 at Klein Denkte zone 4.

7.2.5.3 Summary and discussion of results

At Klein Denkte, there is a difference between longpit depositional patterns. We observe gradual deposition of highly fragmented sherds in longpits 59, 67 and 74. Feature 59 has very clear patterns of downslope deposition, as indicated by spatial sorting of size and shape of potsherds. In longpit 74, selective transport of smaller-sized fragments was evident, which was likely caused by downstream fining of sherds by episodic water flow from the draining of water from the house. In both features, deposition happened from NW to SE and SE to NW towards central areas of the pits. There are also small and large discard locations, which correspond to features 101 and 71 respectively. Deposition in these locations was quick in the last stages of pit infilling, and with little to no alteration of sherds after the breakage of vessels. Given the lack of stratification in these areas, backfilling seems the most likely scenario. Some structured deposits were observed in segment 5 of longpit 71 and in segment 1 of longpit 74. Feature 74 was only tentatively ascribed to H3/1987 by Stäuble (2005, 23–25), and the author also suggested that it could form part of the northern sector of H2/1987, in which case the structured deposit would be located at the middle portion of the house. This would also mean a similar tripartite division of longpits. However, this would need to be tested at other sites.

According to EVEs and MNV, as well as the data obtained from Cladders (2001), the greatest numbers of identifiable vessel units are located in pits 71 and 101, which also supports the claim that this pit was a location for backfilling and structured deposition. If Stäuble's (2005, 23) interpretation of H2/1987 is correct, then discard areas outside this house would be located in the southern portion of its western and eastern longpits respectively. In general, the highly fragmented potsherd assemblages found in longpits at Klein Denkte, and the prevalence of long and gradual depositional processes outline the extended interaction of humans with their broken pottery. Once again, it seems likely that accumulation only became a significant process in certain areas of the site towards the end of pit use-life (features 71 and 101).

7.3 Discussion of main results: How were Early Neolithic deposits formed?

I would like to start by pointing out some limitations and offer clarifications. The degree of resolution in (post)depositional studies using size distribution and morphometry of potsherds is highly dependent on the sample size. For this reason, recovery during excavations has an important effect on the (post)depositional analysis of potsherds. This was evident in the information from sites excavated with high spatial resolution, like Tășnad Sere, and those with very limited spatial information, such as Méhtelek-Nádas. There is also a difference of preservation between different regions. Apart from pit infills, it is certainly difficult to compare information from the UTB, where occupation surfaces are often preserved, with sites from the NHF, where it is generally assumed that postdepositional erosion has removed the occupation surface. However, I consider that the areas where materials are preserved in LBK sites, *i.e.* pit fills, provide us with enough information to attempt an inter-regional comparison. While sherd-size distribution and morphometric analyses are heavily constrained by the variation in microstructure and material properties of ceramic fragments studied, I have been fortunate in that the assemblages of both regions analysed were fairly homogenous in terms of composition, granulometry and hardness, which ruled out any microstructural factors influencing data from size and shape parameters. This homogeneity enables me to expand my results from thermal shock and strength tests outlined in Chapter 9, which were originally designed to explain behaviour of ceramics from the UTB region, to include LBK sites as well.

Despite these limitations, there are clear depositional processes in both regions that allow to answer the questions, of how pits and house deposits are formed. Two main factors have been observed to influence the size and shape sorting of fragments in both regions: the depositional processes and the topography of pits. The most common depositional process is the downslope movement of sherds. There is spatial sorting of fragment sizes from smaller to larger. With the exception of catchment areas, this spatial sorting aligns well with low Sorting coefficient (So) values per segment in a pit. On occasions, spatial shape sorting can accompany these patterns, which can indicate a rolling mechanism. The sorting of fragment shape corresponds in principle to an increase in sphericity and roundness of sherds as the distance from the start of the slope increases. Such was the case in pits CC1 from Călinești-Oaș-D.S.M., feature 14 (zone B) at Eitzum and feature 59 (zone 4) at Klein Denkte. The small depressions inside pits that work as catchment areas were important as well. Just like in sedimentary basins, the deepest areas of pits generally have the thickest sequence of potsherd deposits. Thus, unless there is a high-energy depositional process occurring or the size and shapes of sherds in the vicinity are homogenous, poorly sorted size distributions and higher heterogeneity in the shape of potsherds are found in these catchment areas, which often can obscure depositional patterns. Clear evidence of this process was seen in pit 7/UCLT1.

7.3.1 A comparison between the (post)depositional processes in SKC sites from the UTB and LBK sites from the NHF

In the SKC sites, there is a high amount of material accumulation in all portions of the sites, from post-holes to living structures and pits. In the latter, we see unequivocal evidence of long processes of fragmentation and erosion prevailing before fragments are deposited, which is comparable to other SKC regions (*e.g*. Teleorman County; Thissen 2015). In these pits, one of the main mechanisms of pit infilling was simple gradual downslope movement of sherds from the vicinity, as was more clearly seen in pit 7/UCLT1 (Tășnad Sere) and CC1 from Călinești-Oaș-D.S.M. On occasions, this mechanism generated a substrate where some later dumping events took place. Individual dumping events of fairly freshly broken pottery were also observed in some areas of 7/UCLT1 (Tășnad Sere), CC1 and CC2 (Călinești-Oaș-D.S.M.). In pit 7/UCLT1, we could even establish a connection between these events with activities inside the H1/UCLT1 house. However, contrary to LBK sites, pits do not seem to have been 'designated' discard areas, as they are heavily mixed, gradually filled, and perhaps even reworked, *e.g.* pit CC3 (Călinești-Oaș-D.S.M.), which was also observed in other SKC regions (*e.g.* Macphail *et al.* 2008, 65). Other areas, like in C2/2005 at Tășnad Sere and pit III from Méhtelek-Nádas, seem to be designated for storage or part of workshops, and consequently we find complete or partially broken pots are better preserved in these areas. Evidence from the wattle and daub house at Tășnad Sere provides us with a genuine picture of the absolute ubiquity of broken pottery in the daily life of Early Neolithic populations, where large amounts of sherds are found on living surfaces and outside houses. In some transit areas in the house, sherds were moved, become rounded, stepped on and even could have been inserted into floors. In central areas of the house, where possibly food processing and cooking occurred, large sherds were left there for further uses (see section 8.2.1.5).

On LBK sites from the NHF, there is much less accumulation in these features than in SKC sites (see below). While probably exposed for some time, as indicated by their fragmentation levels, LBK potsherds had very low levels of abrasion, as attested in most features, even inside postholes, from zones A, B and C at Eitzum and features 71 and 101 at Klein Denkte. This result is surprising considering organic-tempered ceramics are particularly more sensitive to abrasion (Beck *et al.* 2002; Skibo *et al.* 1989; Vaz Pinto *et al.* 1987, 128). Thus, compared to SKC sites, there is considerably less movement of sherds through domestic spaces. Alternatively, this lack of abrasion could indicate the effect of differences in soils, as the shrinking/swelling of the sticky and slightly acidic clays found in most of the UTB is more corrosive than the loessic substrate in the NHF. However, the high angularity of sherds from the two pit contexts at Méhtelek-Nádas suggests the opposite.

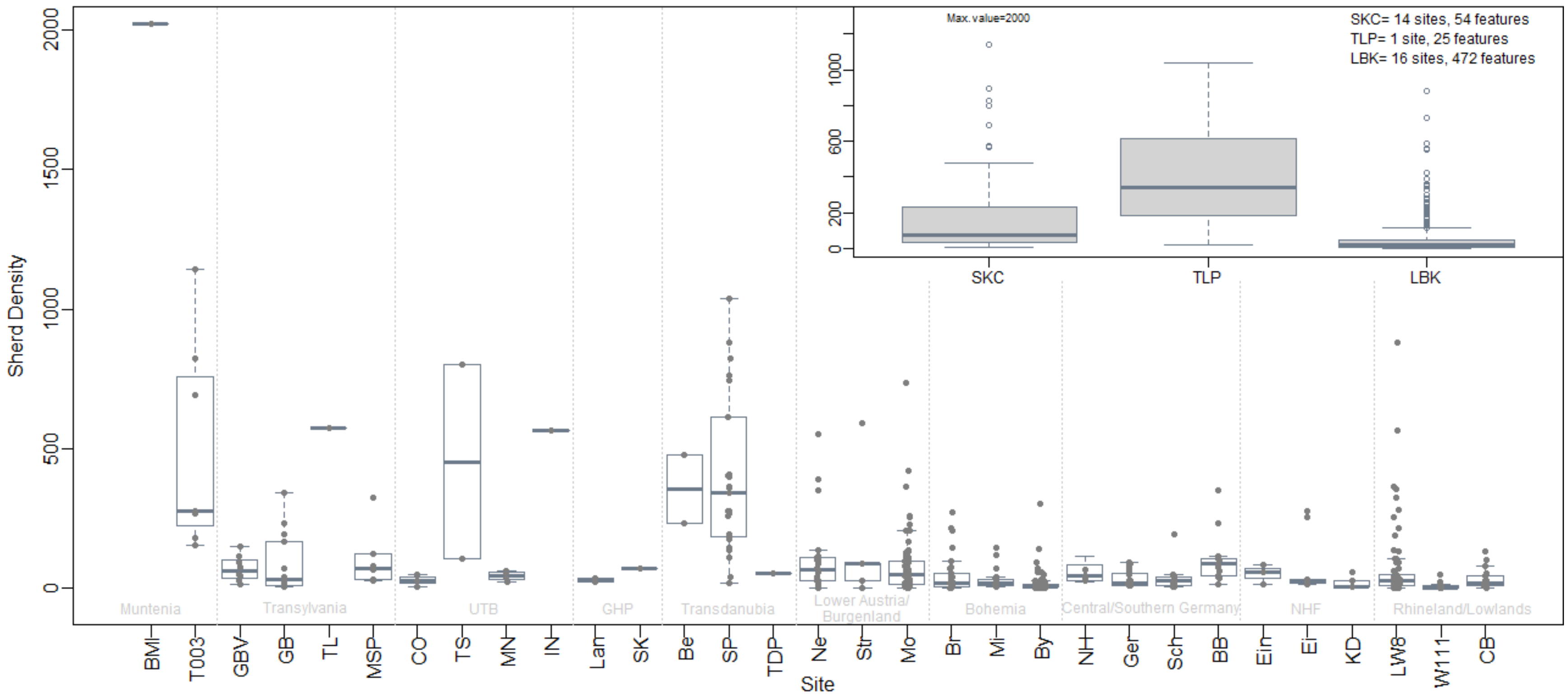
The enigmatic longpits from Eitzum and Klein Denkte, which are supposed to have been part of äLBK houses, showed some distinctive patterning of sherd deposition. Two different modes of deposition were identified. The first mode, observed in houses H1/1956-58 (zone A) and H4/1987 (zone D) at Eitzum, and tentatively in H2/1987 (zone 4) at Klein Denkte and H5/1987 (zone D) at Eitzum, consisted of a tripartite division of longpits in northern, central, and southern sectors with different types of depositional processes *predominating* in each. In the north, we observe lower numbers of fragmented sherds sorted by the gradual downslope movement of sherds or the selective transportation of sherds by water (feature 74 at Klein Denkte). In the central sector, we observed pots that seem to have been placed deliberately near the house entrance, which can be classified as structured deposits. Meanwhile, in the southern areas of longpits, and after the downslope deposition of sherds had covered the lower strata of the pit, clear examples of dumping/backfilling of a considerable number of largely freshly broken pots was detected in the upper strata. Thus, here there is a clear process of discard in some restricted areas of longpits in the last stages of pit infilling. Similar patterns of discard areas in southern sectors of longpits have been found at House 1 at Neckenmarkt (Lenneis and Lüning 2001), House 23 at Miskovice (Last 1998, 25–26), Bruchenbrücken (Last 1995, 161; Stäuble 1997) and House 1 at

Enkingen (Reuter in Stäuble and Lüning 1999), which has led the authors to suggest backfilling. Phosphate analysis at other äLBK sites also show higher concentrations in the lower end of these longpits, for example for House 1 at Enkingen and House 15 at Schwanfeld (Stäuble and Lüning 1999). If this tripartite division actually links to some architectural models of LBK houses (Waterbolk and Modderman 1959; see also Pavlů 2000, 198–216; Soudský 1966) is a different question, and is certainly not the focus of the present study. However, such suggestions have been made before (Bradley 2001, 52).

The second mode of pit infilling at LBK sites is represented by feature 14 (zone B) at Eitzum and H1/1987 (zone 4) at Klein Denkte. In these longpits, deposition appears to be predominant in central areas, and shows clear indications of downslope movement of fragments from the pit's edges. Some examples of this type of deposition pattern are also recorded in feature 1935 in sector A24 at Bylany (Končelová *et al.* 2019), and House 32 at Miskovice (Last 1998, 26).

The huge contrast in accumulation of material between SKC populations in the UTB and LBK groups from the NHF warrants a larger-scale investigation. Figure 7.79 synthesises published sherd densities in pits from SKC and LBK sites (Appendix 9). The pattern that is immediately recognizable is that the sherd density of pits from SKC sites is higher than those from LBK sites. The so-called Transdanubian Linear Pottery culture (Bánffy 2004, 22) represented at Szentgyörgyvölgy–Pityerdomb, which is considered to be one of the sites where the LBK began in Central Europe (Bánffy and Oross 2009, 179; Stadler and Kotova 2010, 343), has the highest density of pottery finds for both regions. There seems to be an abrupt decrease in sherd density west of Transdanubia, and then a progressive decrease from that point onwards until the westernmost end of the distribution of oldest LBK sites, *i.e.* the Rhineland and the Rhine/Meuse delta (Lowlands). While this pattern could be partly explained by erosive processes that dominate most of the LBK sites on German Loess, this cannot account for the pan-regional pattern observed for the entire archaeological record of Central Europe. Therefore, we should consider that the region-specific trends observed in my analysis of SKC sites in the UTB and LBK sites in the NHF are related to a much larger cultural process.

The suggestion could be made that the social knowledge of breakage had transformed at this point in regions west of Transdanubia, to one that involved less accumulation of pottery. Yet, what is clear, for the moment, is that in Early Neolithic sites investigated there is hardly any evidence to support what I have termed 'the landfill analogy'. In SKC sites, broken pots appear to be exposed a long time before deposition, and discard areas are revisited. While potsherds are sometimes discarded in predetermined areas in LBK sites, these are very restricted and still remain available, as they are closely amounted near households. As Bickle (2020, 189) suggests, “moving around an LBK settlement meant being surrounded by the residues of everyday life scattered around […]”. Phenomenologically, in LBK settlements the accumulation of broken pottery in specific locations of longpits signals the awareness that inhabitants had of their cultural debris, as there appears to be a ‘need’ to place it in specific locations. Furthermore, although the lack of preservation of house floors is a major issue, the rather widespread pattern described above allows suggesting that the lack of house assemblages could also be related to its maintenance. At SKC settlements, the situation is different. Awareness of material accumulation can be observed in the maintenance of transit areas cleared of medium to large sherds, and in the rather sporadic disposal of pots from houses into pits. Yet, most sherds seem to be in the background of daily SKC household activities. This will be discussed more thoroughly in the last chapter of this dissertation. We now move to the next chapter in order to answer the second part of the question: what happens to pots once they are broken?



BMI	Boldul lui Moș Ivănuș (n=1)	TS	Tășnad Sere (n=2)	TDP	Tiszaszőlős-Domaháza-puszta (n=1)	NH	Niederhummel (n=4)	LW8	Langweiler 8 (n=78)
T003	Teleor003-Măgura Buduiasca (n=6)	MN	Méhtelek-Nádas (n=4)	Ne	Neckenmarkt (n=22)	Ger	Gerlingen (n=23)	W111	Weisweiler 111 (n=20)
GBV	Ghioroc Balastiera Vest (n=8)	IN	Ibrány-Nagyerdő (n=1)	Str	Strögen (n=5)	Sch	Schwanfeld (n=15)	CB	Cannerberg (n=22)
GB	Gura Baciului (n=14)	Lan	Lánycsók (n=2)	Mo	Mold (n=67)	BB	Bruchenbrücken (n=14)		
TL	Turdaș-Luncă (n=1)	SK	Szentpéterszeg-Körtvélyes (n=1)	Br	Březno (n=32)	Ein	Einbeck (n=3)		
MSP	Miercurea Sibiului-Petriș (n=6)	Be	Becsehely (n=2)	Mi	Miskovice (n=19)	Ei	Eitzum (n=10)		
CO	Călinești-Oaș-D.S.M. (n=3)	SP	Szentgyörgyvölgy–Pityerdomb (n=25)	By	Bylany (n=137)	KD	Klein Denkte (n=5)		

Figure 7.79: Sherd density per pit for some Early Neolithic sites in south-eastern and central Europe. Sherd density is calculated following Kazdová (1984, 166; see also Last 1998) as: number of sherds over pit volume (Length x Width x Depth/2). n=pit features.

Chapter 8. Wear analysis results

The analysis of wear on potsherds provides answers to the question of what exactly happened to pots once broken. Traces of wear have also revealed information about the perceived signs of breaking, and the precautions taken in anticipation of the actual vessel breakage. The chapter is divided in two main sections. Firstly, the results from drilling tests are presented. The second section presents results from three sites that showed evidence of wear on sherds.

8.1 Drilling test results

8.1.1 Perforations with different tool shapes and compositions

The specimens drilled using type A perforators in a time-limited format, showed a considerable difference between perforations made with obsidian and antler perforators and those done with harder materials like flint and limnic quartzite. The effort to perforate with obsidian and antler (and presumably bone as well) is higher than with the lithic materials tested (Figure 8.1). On the opposite end, steel blades can easily and quickly drill through ceramics. Flint and limnic quartzite rocks are almost indistinguishable when it comes to the effort required to create a perforation on ceramics, partly because of their similar hardness. It is also clear that for these lithic perforators, the degree of effort to drill these ceramics increases through time as the tools become blunt.

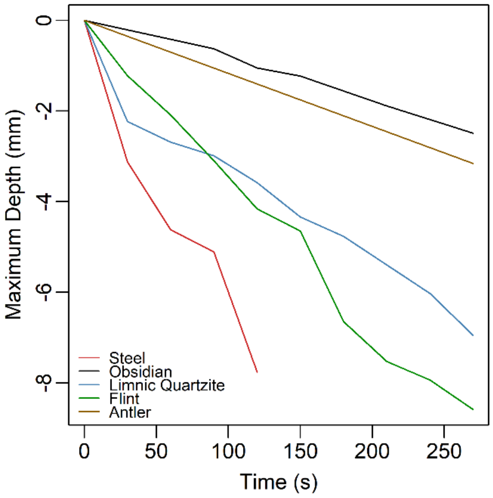


Figure 8.1: Degree of effort, according to perforation depth over time, for the raw materials tested.

Figure 8.2 displays the 3d reconstruction of perforations from all materials tested at different stages of drilling. Due to its brittleness, it becomes clear that obsidian tends to chip quicker and change its morphology more than the other materials (Figure 8.2). This brittle behaviour influences the shape of the perforation wall in the ceramic, as the jaggedness seen on the profile curve changes through time. In the 3D mesh (Figure 8.2), we can observe how the tip of the perforation changes shape and the section becomes angular again towards the end of the drilling process. In contrast, flint and limnic quartzite get rounder edges through use, with very little chipping. Consequently, the profile of the perforations is not as changing as obsidian-drilled holes, but not as stable as steel blades.

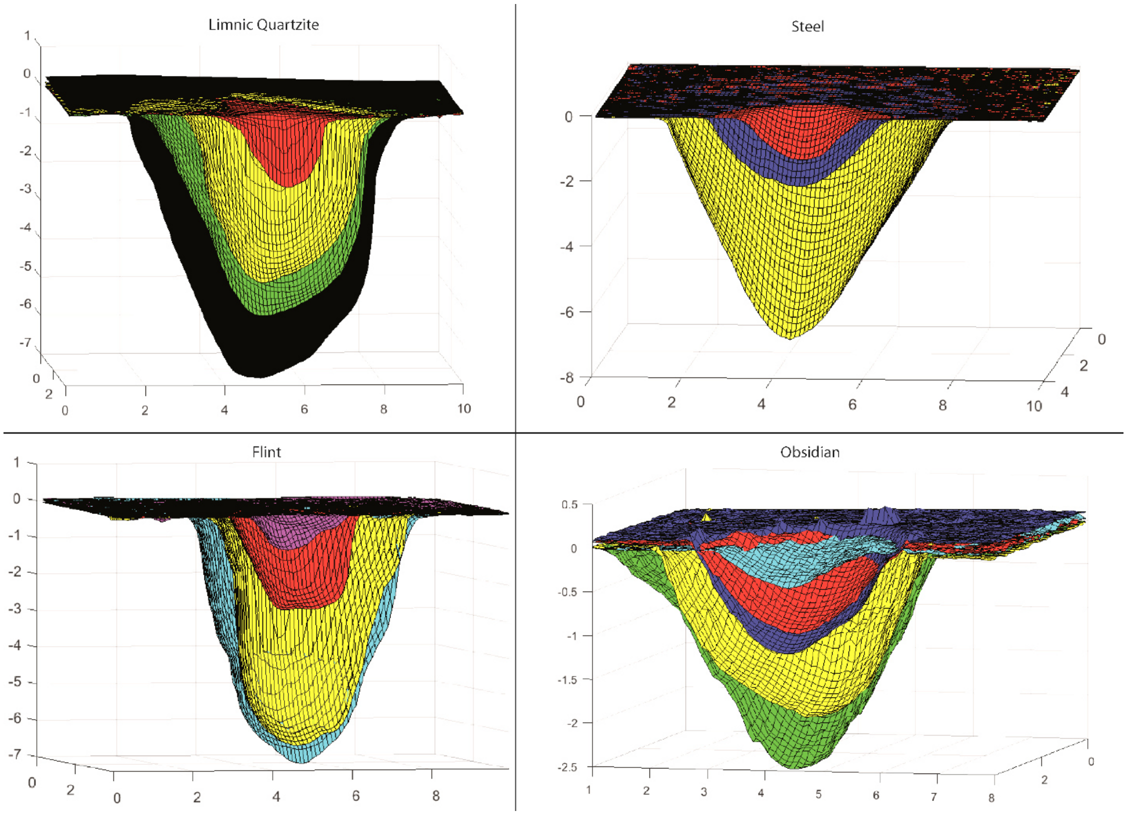


Figure 8.2: Three-dimensional mesh models of obsidian, flint, limnic quartzite and antler at different moments.

Discs drilled with the steel blade and the antler tip do not leave any rotational striations on the ceramic material. This is also observable in the normals plots (Figure 8.3). Using the original surface of the ceramic disc as a reference, the coloured dots represent the topography of the perforation wall from different angles, with blue representing completely flat surfaces and red completely vertical ones. The coloured curves around the perforation wall represent rotational striations. They are caused by the irregularities of the perforator's edge as it abrades through the ceramic disc. The normals plot of perforations made with steel blades, show no ring-like patterns, due to the smooth edge of the blade. Thus, the angles are similar across the perforation surface, generating a peak in the distribution of angles (histogram in Figure 8.3). The yellow curves (Figure 8.4), highlight marked points of inflexion in the perforation wall, and are indicative of the perforator's irregular shape. As can be seen, there are no contrasting yellow curves in perforations created with a steel blade or antler tool.

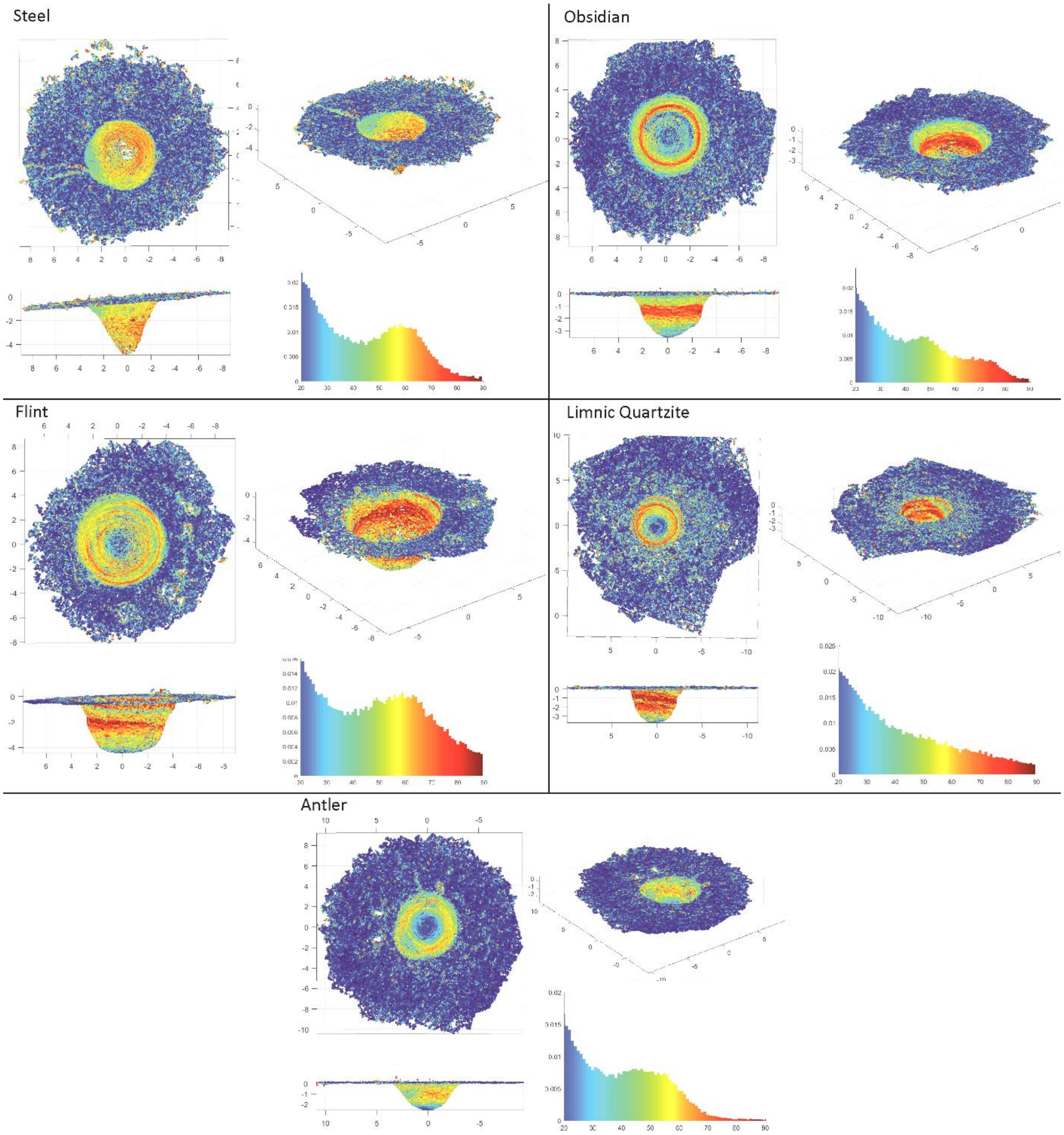


Figure 8.3: Normals plot comparing perforations made with a steel blade, antler, and type A flint, limnic quartzite and obsidian perforators.

In contrast, perforations made with lithic and glass tools all produce clear semi-circular patterns, which are displayed as platykurtic distributions in the histograms (Figure 8.3). Variation of depth plots also show rotational striations, *i.e*. the yellow curves (Figure 8.4). Distinguishing between flint, limnic quartzite and obsidian perforators is more difficult. While obsidian is a more brittle material and quickly chips at the edge when perforating materials like ceramics, and flint/limnic quartzite are harder rocks that tend to get their edges round rather than flaked, the parameters presented do not show any difference in the perforations.

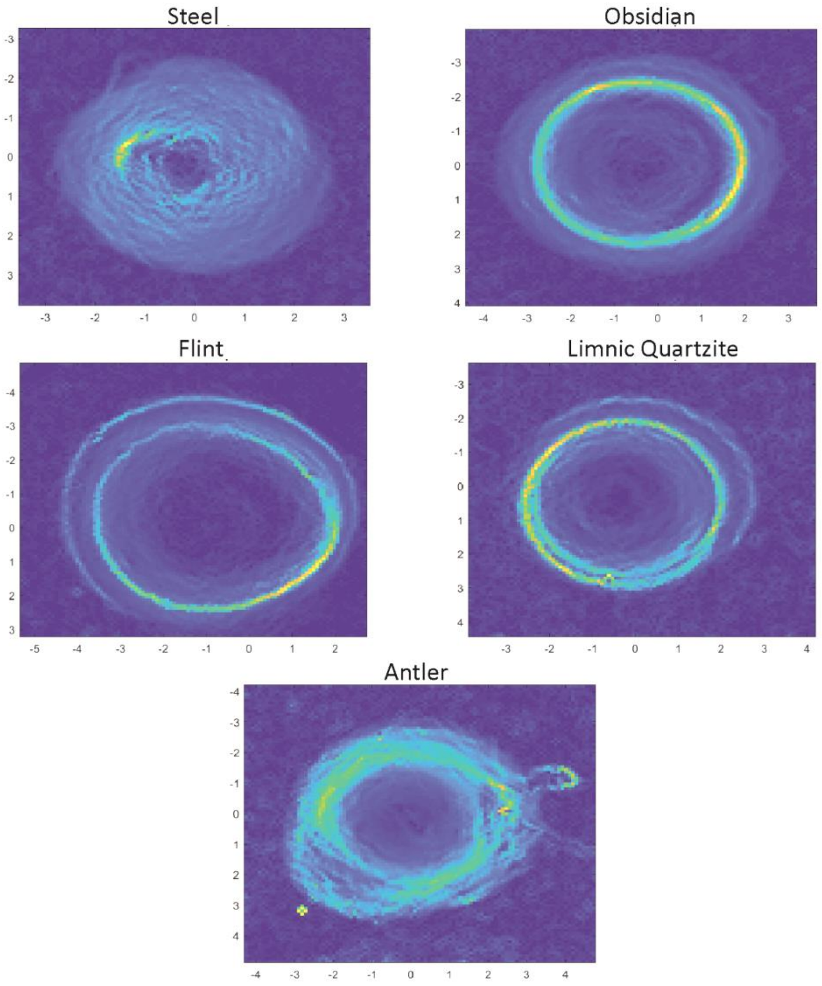


Figure 8.4: Variation of depth of perforations for steel blade, antler, and type A flint, chert, and obsidian perforators.

8.1.2 Hand-drilled and rod-drilled perforations

Two parameters were used to detect differences between rod- and hand-drilled perforations on flint perforators (section 6.2.3.2): the centre and aspect ratio of the perforation in plan view at different depths. The former is a measure of the inclination of the central axis of the tool in relation to the worked surface, while the latter indicates the consistency of rotational movement of the perforator. Thus, both parameters indicate differences between these drilling techniques that can be observed regardless of perforator shape.

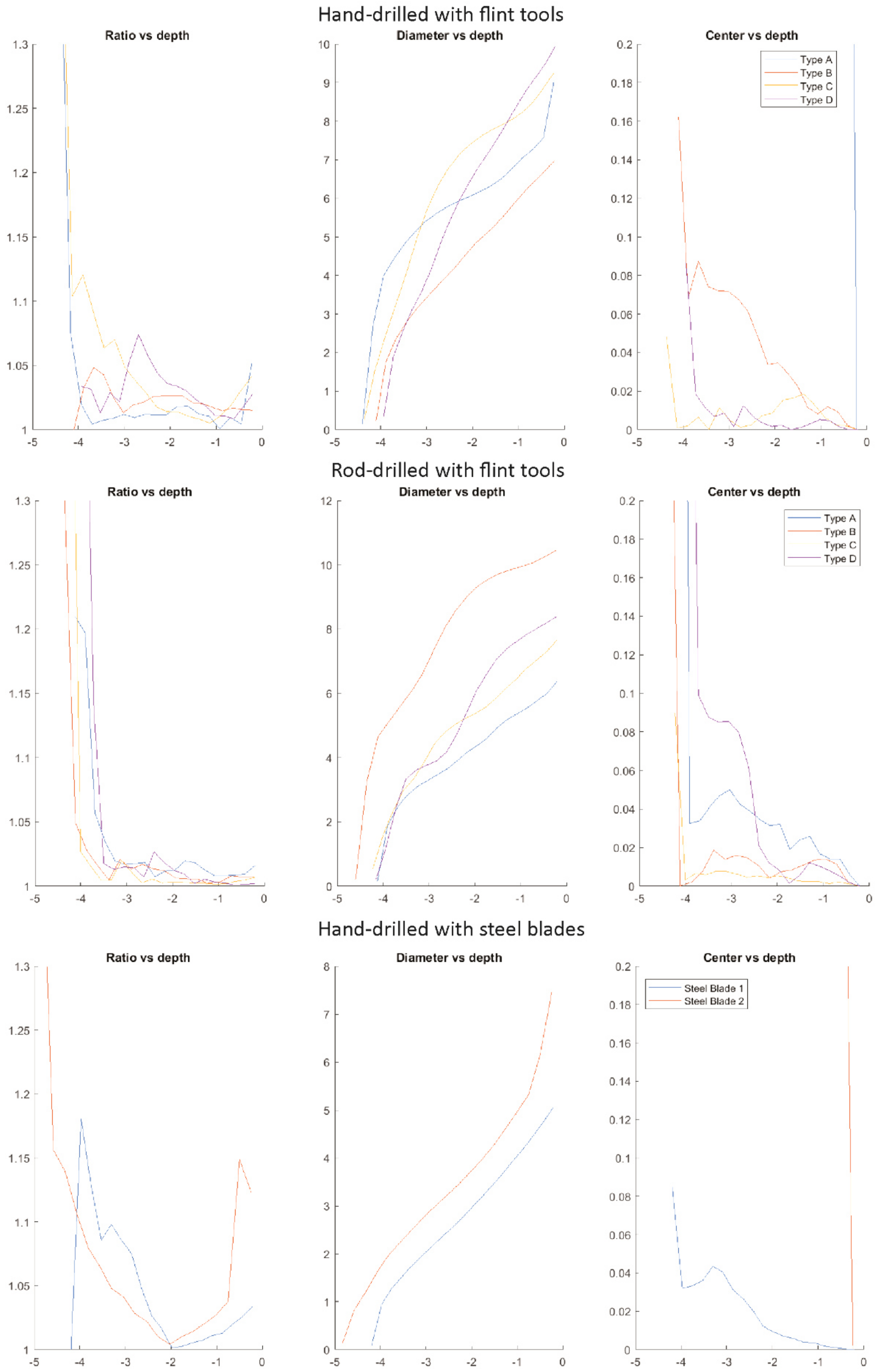


Figure 8.5: Differences observed between rod- and hand-drilled specimens according to the centre (left) and aspect ratio (right) of their perforations by depth.

In rod-drilled specimens the curve representing the centres according to depth of perforation tends to remain stable or flat (Figure 8.5). While there is some minor variation according to perforator shape (up to 0.1mm deviation), the trend is consistent. Hence, once the perforation begins to form, the rod-drill allows for less deviation of the central axis of the tool against the worked surface. In contrast, the perforations that are formed by holding the perforator by hand produce more variable curves, as there is more room for jiggling around despite the craftsman’s best efforts. This is even visible in specimens drilled with the steel blade, which tentatively rules out the influence of perforator shape and composition.

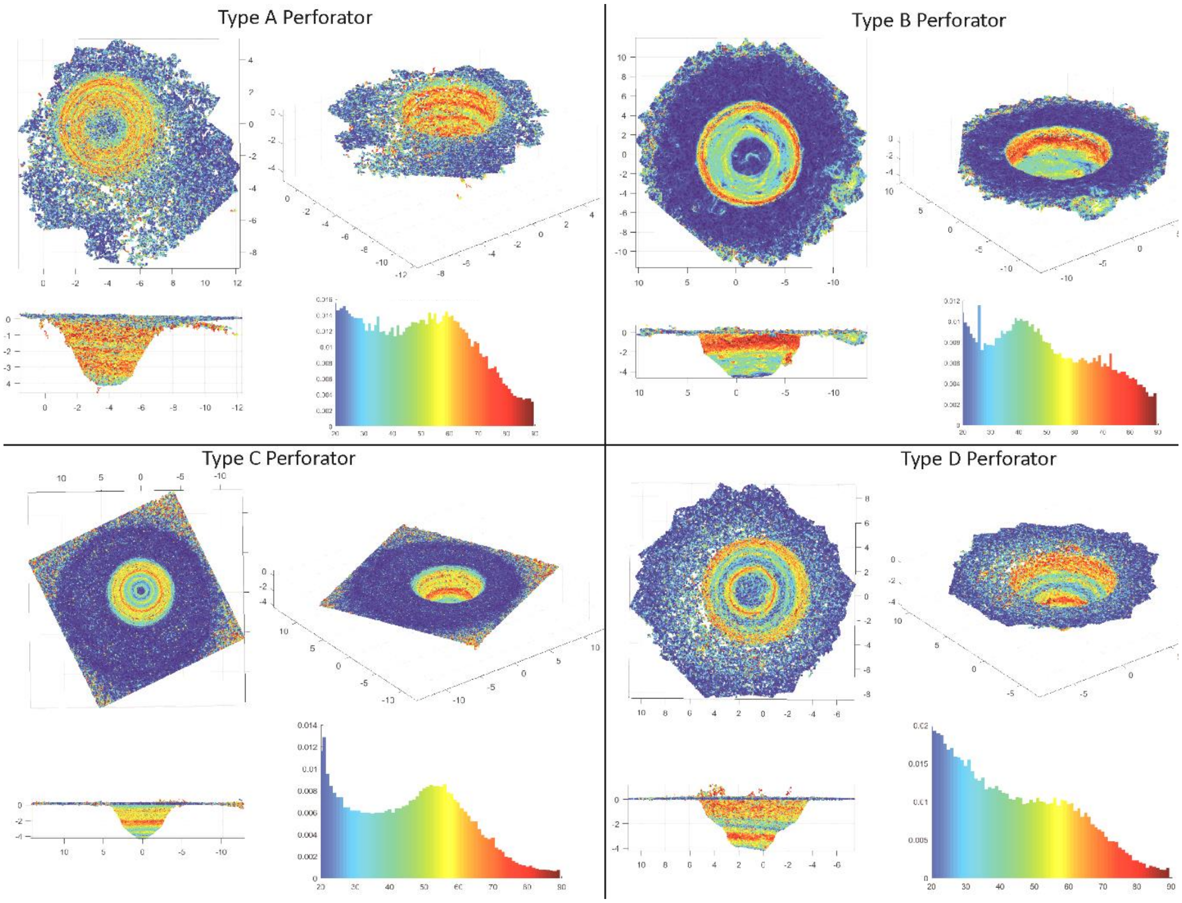


Figure 8.6: Normals plot and histograms of angle distributions highlighting characteristics of rod-drilled specimens.

Similarly, the aspect ratio of hand-drilled specimens according to depth show a lot more variation than rod-drilled perforations (Figure 8.5). While centre of perforation by depth monitors the inclination of the perforator against the worked surface, the aspect ratio shows the consistency of the rotational movement of the tool. Rotating the perforator to make 360° turns, which would approximate a stable or flat curve in the ratio vs. depth plot in Figure 8.5, is harder to achieve consistently by hand than using an instrument like a rod-drill.

The rotational striations in Figures 8.3 and 8.6, show that hand- and rod-drilled discs are different. In Figure 8.6, rotational striations are more evenly spaced and form complete rings in rod-drilled specimens. In contrast, the striations made in hand-drilled discs are rather sporadic, localized, and form semi-circular patterns (Figure 8.3 and 8.4). Variation of the depth plots confirm this finding, the points of inflexion in rod-drilled specimens produce regularly spaced rings (Figure 8.7).

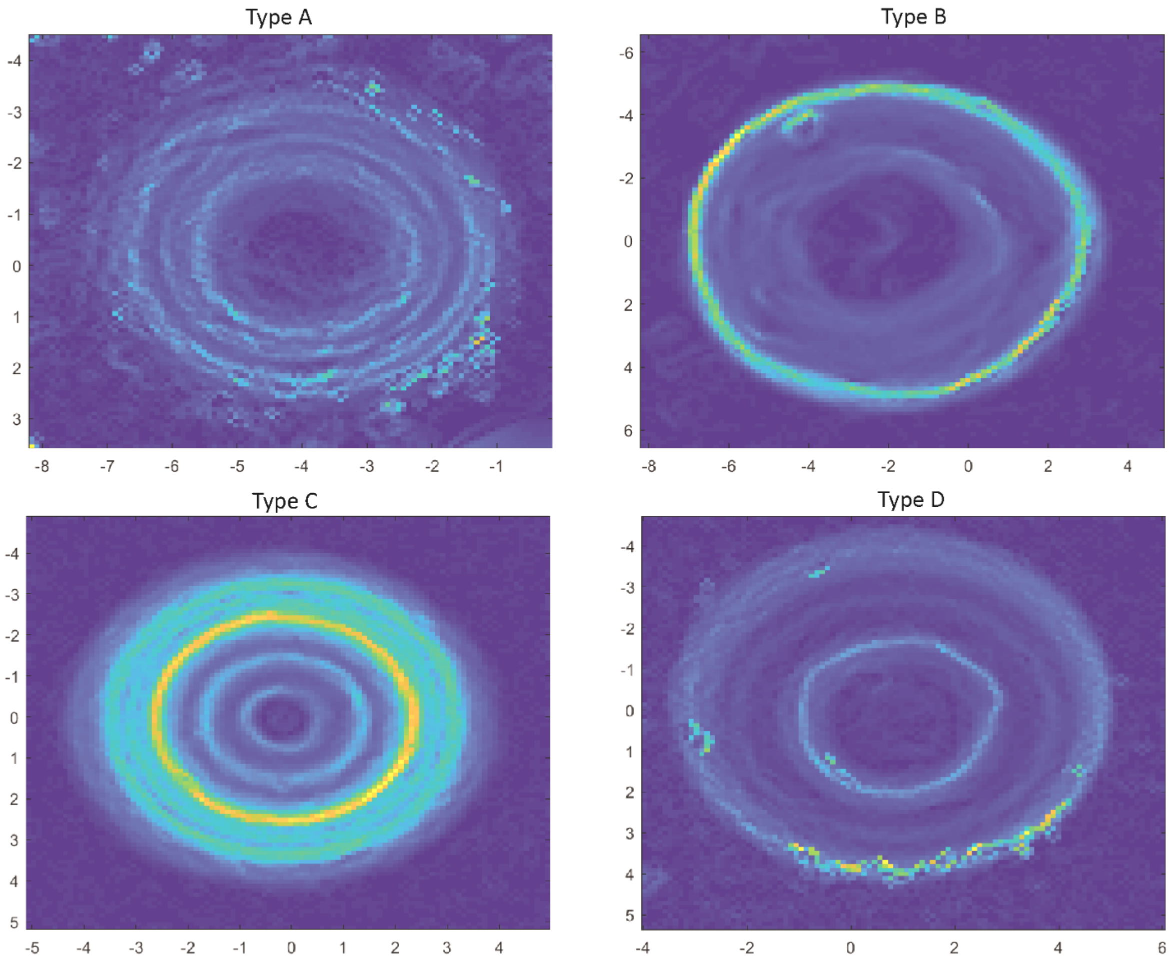


Figure 8.7: Variation of depth of perforations drilled using a rod-drill.

8.1.3 Main results from drilling tests

Microphotogrammetric tests have allowed identifying crucial indicators for understanding how perforations are formed in potsherds. Due to their breakage patterns, a first clear pattern observed was the difference between lithic/glass drills and perforators with smooth edges (*i.e*. steel and antler). The former tools generate very clear rotational striations on the perforation wall, while the latter simply leave smooth sections due to the lack of irregularities on their edges. This debunked our initial assumption that the debris being dragged by the perforator as it drills through the specimen (auto-abrasion *sensu* Cotterell and Kamminga 1990, 158), would be a significant contributor to the formation of rotational striations. Unfortunately, even though obsidian should in principle show differences, as was partly observed with time-limited tests, the parameters used do not allow us to detect these differences. Nonetheless, the high degree of effort to drill ceramics with obsidian and antler perforators was probably discouraging, and we would not expect these tools to have been used for this task.

A second fundamental result is the clear difference between drilling by hand and with an instrument that stabilizes movement, like a rod-drill, top-drill, bow-drill or pump-drill (Gurova and Bonsall 2017, 162; *e.g*. McGuire 1896, 693, 718, 720, 733). In the latter, curves from centre and aspect ratio vs. depth tend to be flat and with little deviation, regardless of perforator shape. Even if the craftsperson can skillfully stabilise the tool by hand at a fixed inclination, it is anatomically impossible to make 360° rotational movements. Namely, the rotation of our radius and ulna restrict the movement of our wrists. In contrast, the rod-drill provides a complete 360° rotation (Figure 8.8). These two main findings form the basis of the examinations carried out on archaeological samples detailed below.

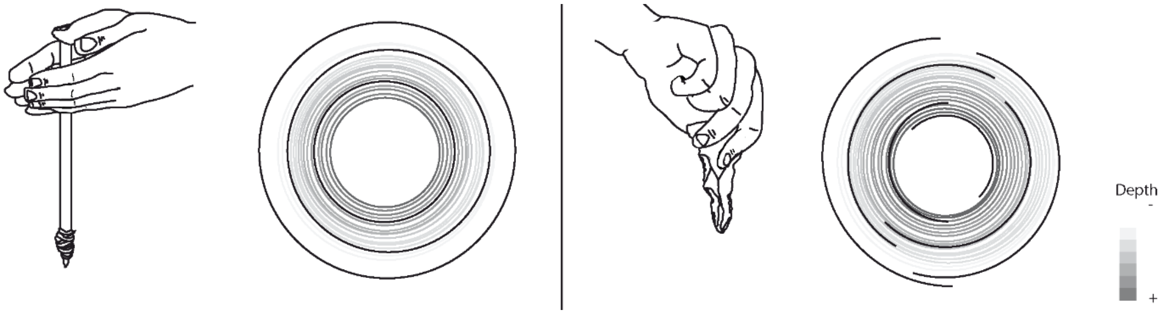


Figure 8.8: Creation of rotational striations in hand and rod-drilled specimens.

8.2 Results from Early Neolithic sites

Before continuing with the results for each site analysed, a few clarifications must be made. Wear traces on sherds were identified at three sites: Tăşnad Sere and Méhtelek-Nádas from the UTB, and Eitzum from NHF. The lack of clear evidence at the other sites is mostly due to the preservation problems with organic-tempered ceramics, which are more sensitive to abrasion, and finds processing methods already discussed (Chapter 5). Because of these preservation issues, the comparison made between sites conducted in the last section of this chapter is more about *quality than quantity*. Lastly, microphotogrammetry techniques could only be applied on blind- or through-holes that had not been fractured, as measurements (such as centre of ellipse and aspect ratio) from these fractured perforations could not be made. This does not mean this is task cannot be accomplished, only that more work is needed to adjust our modelling. A full description of wear traces on sherds is presented in Appendix 10.

8.2.1 Tăşnad Sere

Table 8.1 displays the information recorded for all fragments displaying traces of wear at Tăşnad Sere, which add up to 20 sherds. Categories A, E, K, L, H, and U are represented in the assemblage from C2/2005, with a clear predominance of the first of these categories. In comparison, only category A fragments were identified in contexts from UCLT1.

Category	C2/2005	7/UCLT1	H1/UCLT1	Total
A	6	2	5	13
E	1			1
K	1			1
L	2			2
H	1			1
U	2* (146)	(8)	(78)	2
Total	13	2	5	20

*Table 8.1: Number of fragments per wear category for each context in Tăşnad Sere. *These are fragments that showed traces linked to sherd use. The numbers in brackets represents the total amount of refired fragments.*

8.2.1.1 Percussion: Category K

Percussion have been inferred from a single pedestal fragment 774, which appears to have been purposely rounded. Its rough edges were formed by chipping or retouching of a pedestal base, as indicated by the negative scars around the edges of the potsherd (Figure 8.9a). The position of the negative scars suggests the sherd was struck from different directions. Unfortunately, no traces of use-related wear were found, and so its role in social practices is hard to determine.

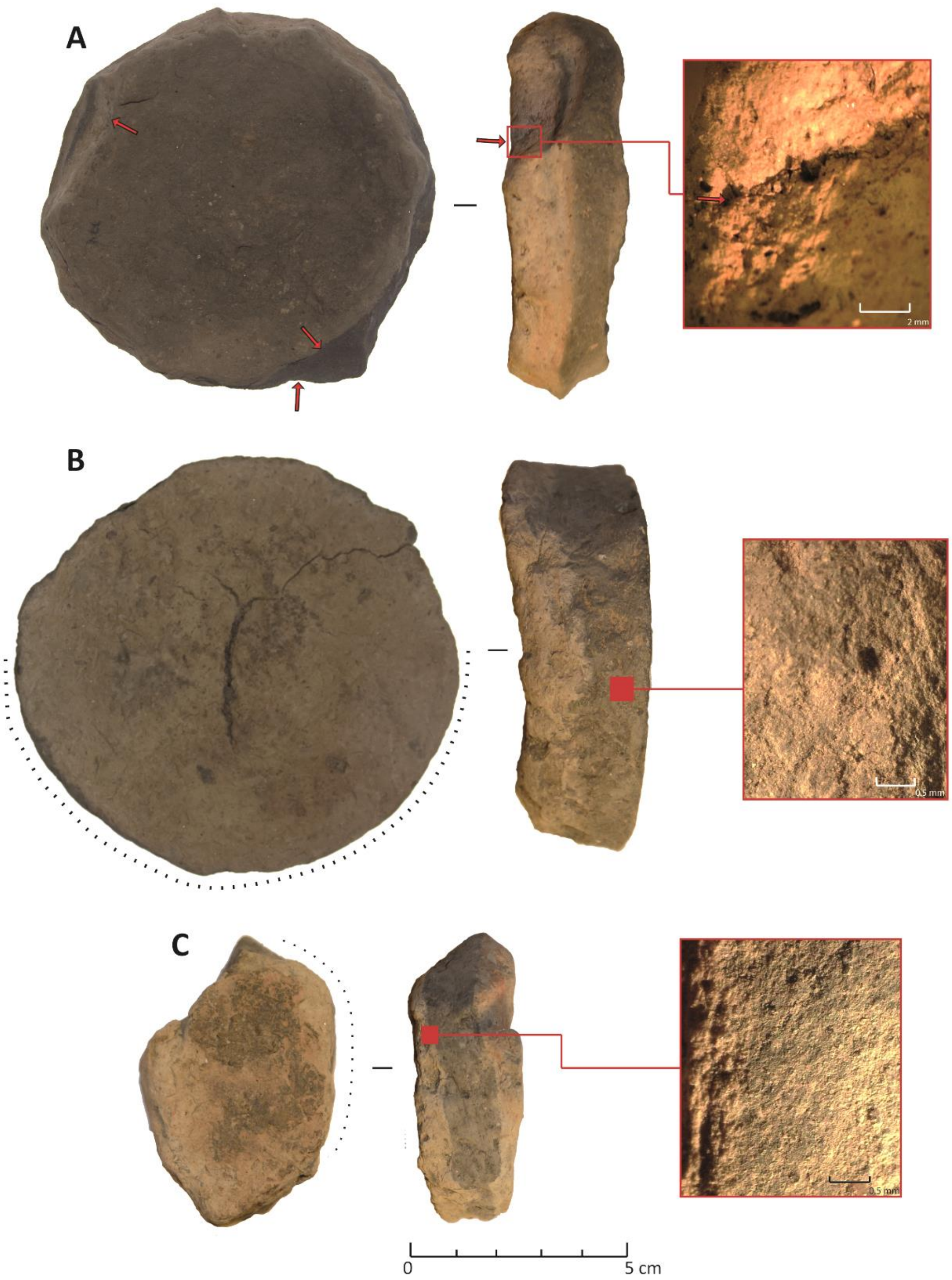


Figure 8.9: Rounded fragments 773 (A), 774 (B), and 1762 (C) found in C2/2005 at Tășnad Sere.

8.2.1.2 Smoothing, scraping or sliding: Categories A, H and L

Fragments were also found abraded to form rounded shapes (Figure 8.9b and c; category L). Base fragments 773 and 1762 show abrasion on parts of their fracture surfaces (Figure 8.9b and c). While the methods of manufacturing of these potsherds is clear, their uses are difficult to determine, as no use-related wear was observed. Potential uses include a support for potting or use as an anvil or hammer during pottery manufacture (*e.g.* Gosselain 2010, 679–680); if paddle-and-anvil techniques were used at the site as seen in some *Starčevo* sites in west Hungary (Gomart 2016).

Five fragments in context C2/2005 (fragments 743, 380, 633, 645, 725, 772, 1681) and five at UCLT1 (fragments 3807, 4319, 4811, 5642, 11840, 15825, 16914) exhibit use-wear traces on their exterior or fracture surfaces, which correspond to categories A and H. These sherds do not present traces of manufacturing or reformatting, meaning fragments were not pre-prepared before use and their concave edges should be attributed to either use or their breakage pattern. Of particular note is the fragment from category H (fragment 743), which was abraded on its exterior surface with clear striations showing direction of use perpendicular to the vessel's mouth (arrows in Figure 8.10a1). The pedestalled inclusions (Figure 8.10a2) present on the active surface suggest the abrader was finer than the distance between the mineral inclusions (Skibo 1992, 109), such as clays or fine-grained rocks. The fragment was interpreted as a pottery smoother.

Nine category A fragments (633, 725, 772, 1681, 3807, 4319, 5642, 11840, and 16914) were interpreted as scrapers used for pottery manufacture. The main traces observed included diffuse boundaries between worn and unworn areas (blue square in Figure 8.11; red square in Figure 8.12), grain pullouts (arrows in Figure 8.10c), striations (red square in Figure 8.11; blue square in Figure 8.12) and rounded sections (Figure 8.10c and red square in Figure 8.11), these sherd scrapers seem to have been used against soft materials like wet clay. With the exception of fragment 1681, which was worn exclusively between interior and fracture surfaces, these sherd scrapers seem to have been used at a wide variety of angles.

The remaining category A fragments (380, 645, 4811, 15825) were categorised as pottery smoothers for surface finishing of pots. The characteristics of these fragments, such as their straight sections (Figure 8.10b) and clear boundaries (Figure 8.12), highlight the fact that relatively hard materials must have been worked, such as pots in leather-hard state. Their straight sections were also informative of the gestures involved in the use of these fragments. The straight section implies positioning the fragment at a 90° angle to the worked surface (Vieugué 2010, 718).

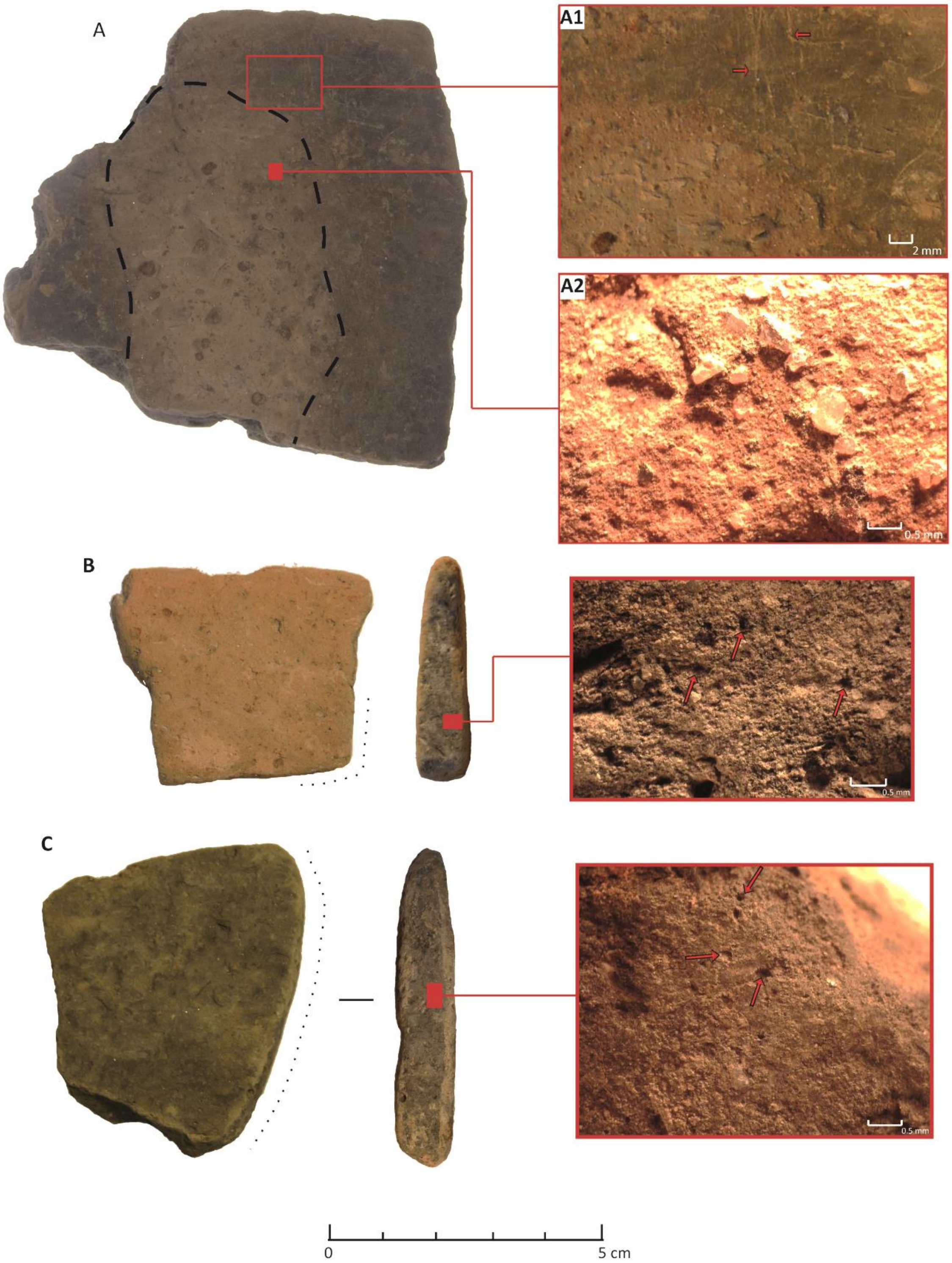


Figure 8.10: Some examples of category A and H fragments from C2/2005 at Tășnad Sere: (a) 743, (b) 645, and (c) 725. Red arrows indicate grain pullouts.

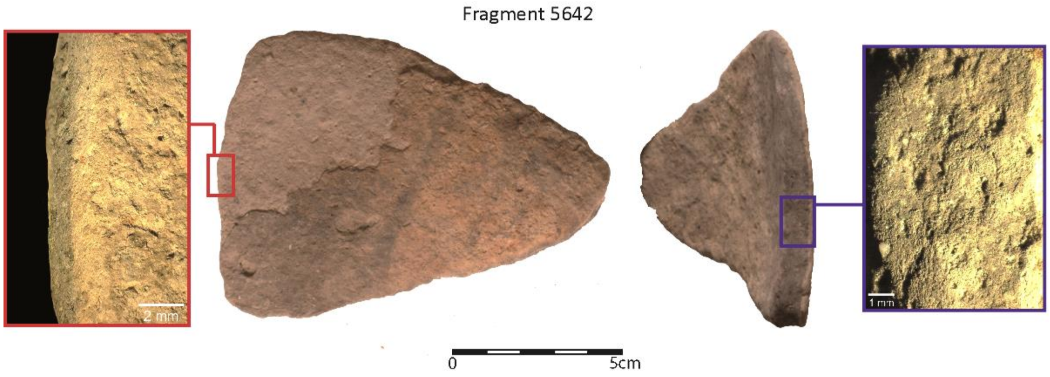


Figure 8.11: Characteristics of a sherd scraper found in house H1/UCLT1.

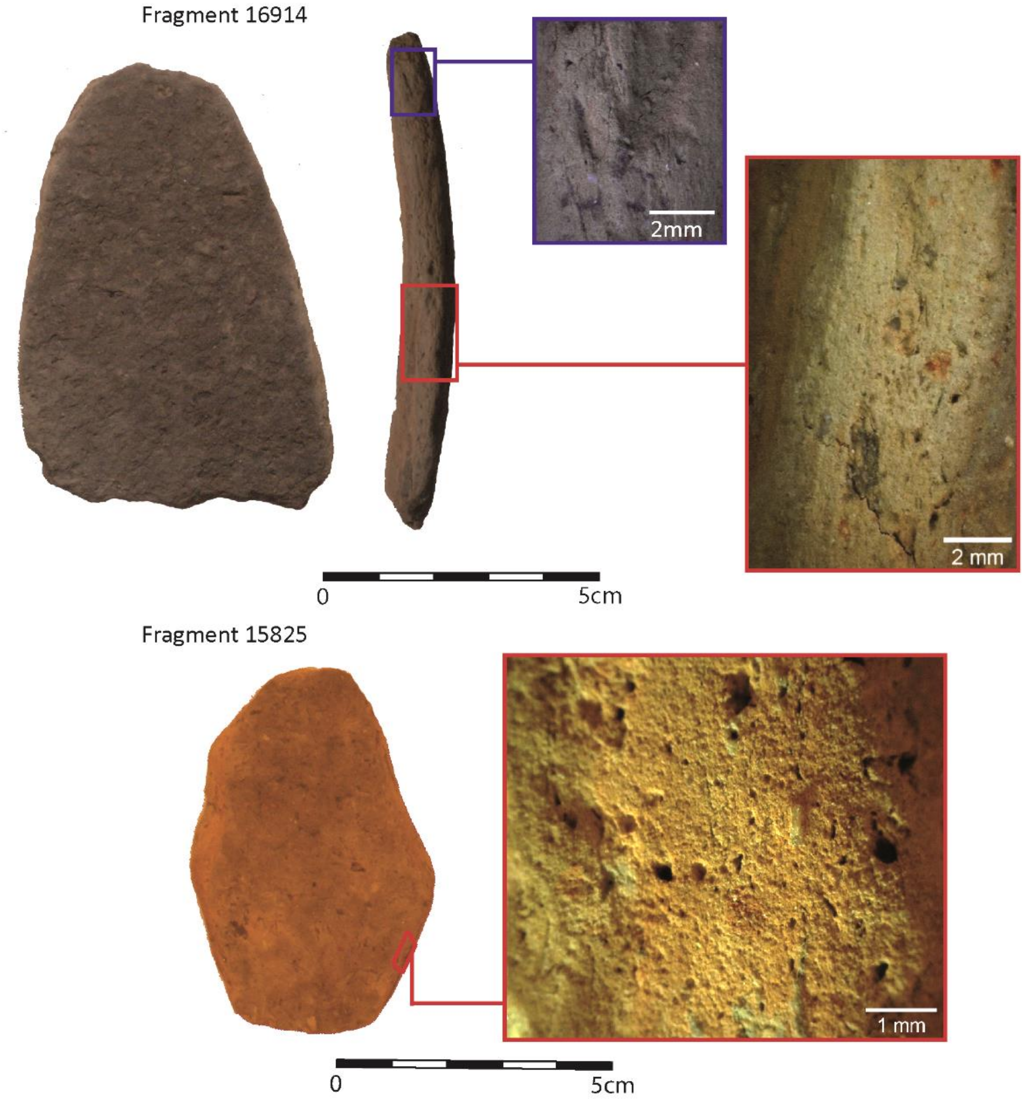


Figure 8.12: Traces observed in smoother 15825 and scraper 16914 from pit fill 7/UCLT1.

8.2.1.3 Drilling: Category E

Fragment 1 had both blind- and through-holes (category E). The blind-hole was found at the centre of the fragment (Figure 8.13a). Striations viewed in the normals plot are regularly spaced and make up a complete ring-shaped pattern across the perforation wall (Figure 8.14). The latter is also visible in the graph displaying the variation of depth (Figure 8.15). The presence of rotational striations indicates the use of a glass or lithic perforator, and the way they are spaced suggests some support could have been used, such as a rod-drill. On the lower part of this outer rim two cracks were also visible, suggesting an origin from the drilling process. At the bottom of the blind-hole, four lateral cracks are found emanating radially from a centre, which suggests a point of crack origin (Figure 8.13a2). These types of cracks are characteristic of an indentation with a sharp object, and are commonly observed in most standardized indentation tests (McColm 1990, 146, 148). Lastly, plots of the centre and the aspect ratio of the perforation according to depth display very flat curves (Figure 8.16), which supports the contention that the perforation was made with a rod-drill.

The second perforation (Figure 8.13b) completely pierces the fragment and has a biconical section, showing a mismatch between perforations. However, the through-hole was fractured in half. Some striations are visible on the perforation wall, suggesting a lithic or glass perforator was utilised for drilling. While the 3D model could not be rendered for reasons mentioned above, the mismatch between perforations is suggestive of hand-drilling.

In sum, the perforations in fragment 1 shows two different processes during drilling of both perforations. Traces of the through-hole on the edges of the fragment suggested it was created during vessel repair. However, the blind-hole in the centre of the internal surface of the fragment seems to be the product of a later operation once the repaired pot had broken. This is suggested by the overall stability shown in the drilling of this perforation, which would require the use of a rod-drill and would, therefore, be difficult if the pot were still in one piece. Therefore, the fragment shows how a vessel was repaired, and upon breakage fragment 1 was salvaged for the manufacture of another tool, maybe a spindle whorl. This is suggested by the central location the perforation occupies in the fragment, and the flatness of the sherd.

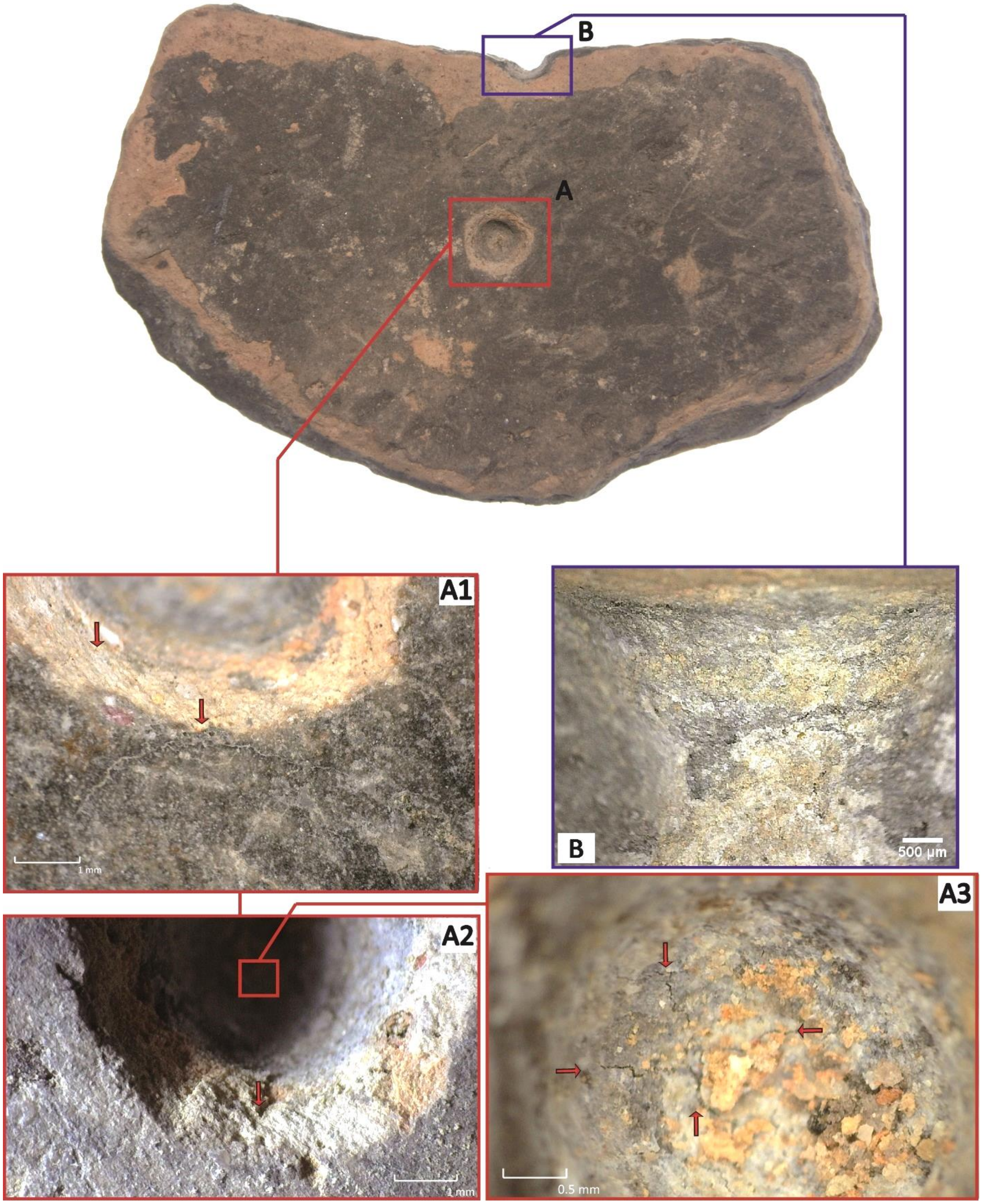


Figure 8.13: Some features observed on the blind-hole (A) and the fractured through-hole on the edge (B) of fragment 1 from C2/2005 at Tășnad Sere. Red arrows highlight the features mentioned in the text.

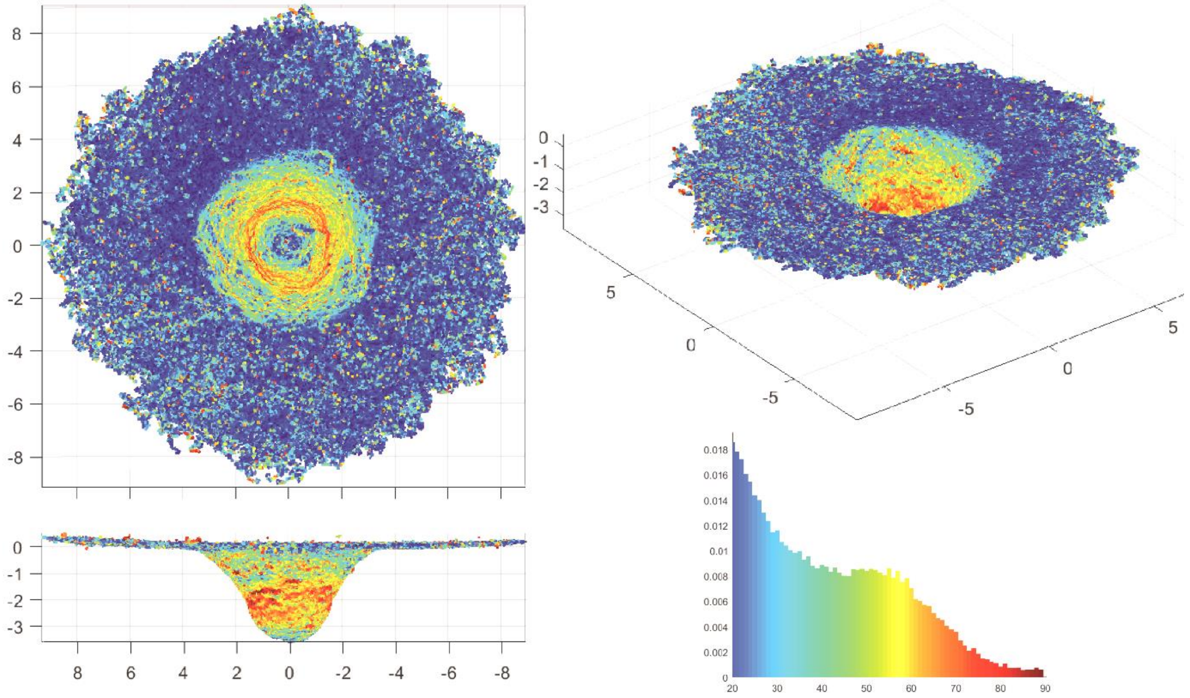


Figure 8.14: Normals plots of the blind-hole drilled in fragment 1 found at C2/2005.

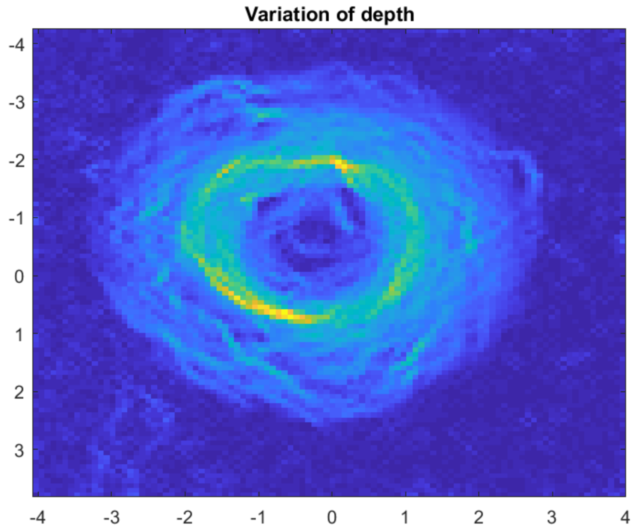


Figure 8.15: Variation of depth plot of blind-hole drilled in fragment 1 found at C2/2005.

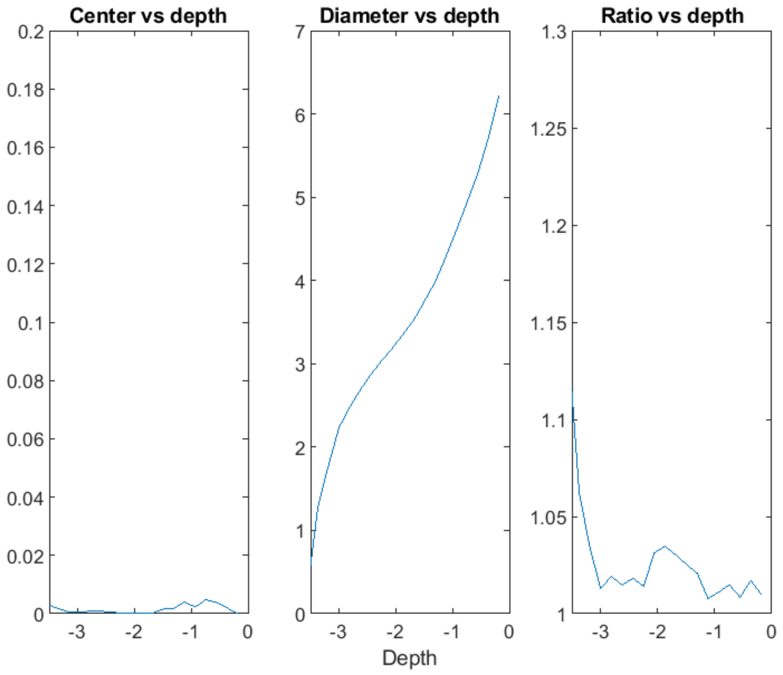


Figure 8.16: Centre and aspect ratio of blind-hole in fragment 1 according to depth.

8.2.1.4 Refired fragments: Category U

Around 145 fragments from C2/2005, and 79 fragments from UCLT1 (67 from H1/UCLT1 and only 12 in or slightly above pit 7/UCLT1) show traces of refiring, such as: clear change in colouration, bloating and deformation (Figures 8.17). The colour of fragments was the main indicator of refiring (Figure 8.17), of which 202 displayed a reddish colouration and only 22 fragments were completely grey. Grey fragments from Tășnad Sere reflect temperatures above 1000°C (Sommer *et al.* 2019, Figure 5). Other high temperature signatures were relatively infrequent, and include sherds with pumiceous texture, signs of bloating, and a single case of thermal-elastic deformation (Figure 8.18b). These results suggest only a small number of fragments were submitted to very high temperatures.

Of significant note was a complete pedestal (fragment 878) entirely refired, as indicated by its reddish colour, and several radial cracks on its bottom (blue arrows in Figure 8.18a). The extent of the colour indicates the whole fragment was submitted to firing after the vessel had broken. The cracks can also result from thermal stresses when bases are unevenly heated (Chapter 9). When the base is unevenly heated at its centre, a temperature gradient is created towards the periphery, between an expanding central area being heated and a cooler periphery. Radial cracks are formed relieving these stresses (section 9.2). The thickness of the pedestal might also be another contributing factor, as this can make this temperature gradient much worse. The radial cracks would suggest that the pedestal formed part of a vessel that was unevenly heated, and the extent of its colouration change suggests that at some point after the vessel had broken it was entirely positioned over a fire.

It is possible that many of the fragments provided some containment of heat or served as supports over fires near hearths or ovens. Powdered X-ray diffraction and thin-section analysis of four pieces of hearth from pit C2/2005 and UCLT1 indicate temperatures around 700°C were reached (Figure 9.3), which is just around the temperatures at which some colouration changes in fragments can occur. For example, one of the dung-tempered specimens in thermal shock tests discussed in Chapter 9 (Figure 9.7f), which was fired at a peak temperature of 800°C, showed colouration changes when repeatedly heated close to that temperature. It is also not uncommon that parts of vessels are found *in situ* inside ovens, for example at Alsónyék-Bátaszék (Bánffy *et al.* 2010, 42) or at Lepenski Vir (Borić and Dimitrijević 2007, 61), but unfortunately no contextual information from C2/2005 is available to support this claim.

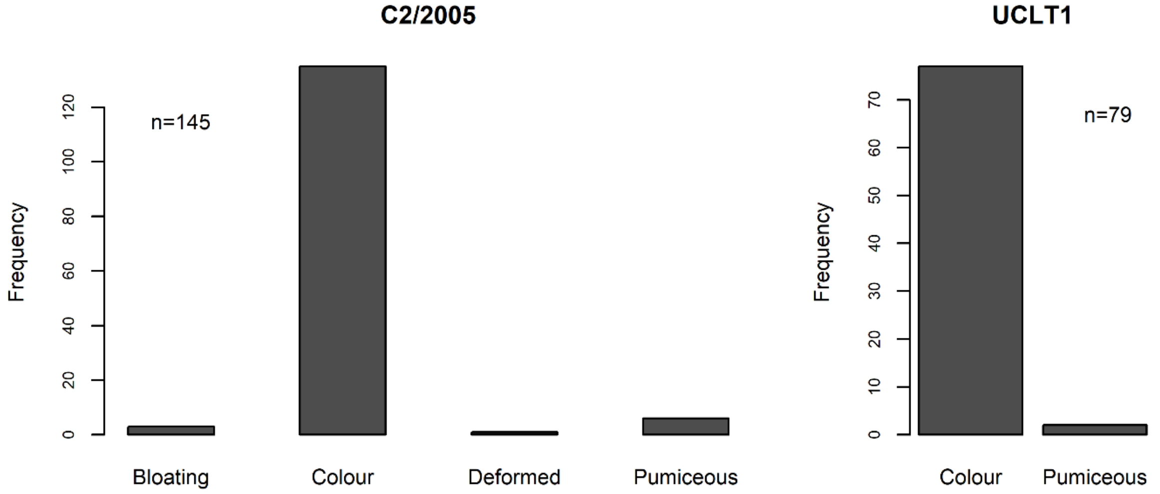


Figure 8.17: Frequencies of main traits of refired fragments from C2/2005 and UCLT1.

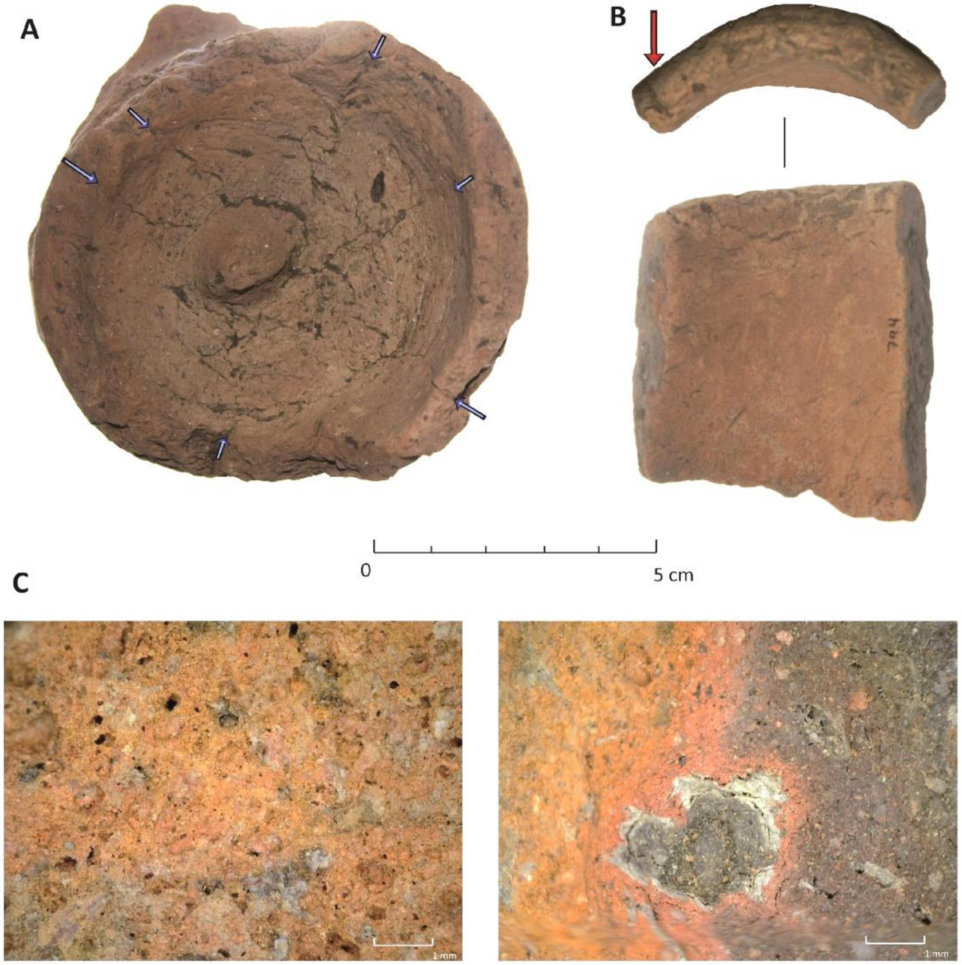


Figure 8.18: Refired fragments in C2/2005 at Tășnad Sere: (a) pedestal entirely altered by refiring (fragment 878) with radial cracks, (b) pedestal fragment 794 showing thermo-elastic deformation (indicated by arrow), and (c) reddish-pink colourations observed on several refired fragments.

8.2.1.5 Other evidence of reuse and repair of pots

There is also evidence for the reuse of larger portions of vessels. Two pots were stacked above each other and placed at the boundary between squares ZZ4 and A4 inside H1/UCLT1 (Figure 8.19; Plate VIII, 3). Above both these pots was a single fragment that did not refit with either of the vessels. The fragment could be an orphan sherd, *i.e*. the only remaining evidence of the parent vessel (Chapman 2013, 15; Schiffer 2014, 76). Examples of reused vessels are sometimes found in SKC sites, such as Szarvas 8/23 (Makkay and Starnini 2008, Figure 18). At UCLT1, the way the pots broke signals the possibility of reusing the vessels, and the location of these potsherds inside the central sector of the house suggests these were deliberately placed for either a food processing activity or as a specific depositional practice. Thus, it is hard to determine if these pots constitute *de facto* refuse or a structured deposit.

Figure 8.19: An orphan sherd and two broken vessels found in situ in the central sector of H1/UCLT1 (photograph by Harry Platts).

A flattened pedestal found in the lower levels of the pit fill 7/UCLT1 (Figure 8.20). The pedestal measuring between 8-10cm diameter was fractured into three fragments (16965, 16966, and 16967), representing around 90% of the pot's base according to EVE values. The intensity and uniformity of the abrasive process performed on the pedestal's edge indicate it was abraded purposefully against a hard material. One possibility is that the pedestal was used as a lid. Reused pedestals or bases as lids have been documented in the Early Neolithic site of Kovačevo (Vieugué 2012, 254). Due to its size, there is a restricted number of vessels that this potential lid could cover, mostly vessels with closed shapes. It is also possible that the pedestal was flattened to work some other material or as a support for holding other vessels.

A fragment from C2/2005 was found with a sign of repair during manufacturing process. Body fragment 731 (Figure 8.21) had a piece of fired clay attached, which would probably have been added to an already dried vessel. The piece of clay must have been added to mend what would have been perceived as some problem or irregularity, potentially a crack, formed on a dried pot. The vessel was then obviously fired, and the added piece of clay stayed in one piece. An X-ray radiograph of this fragment might shed light on the reason behind the repair.

Figure 8.20: A reused pedestal from pit 7/UCLT1.

Figure 8.21: A potential repair during drying of vessel manufacture of sherd 731 from pit C2/2005. Red arrow indicates the added piece of clay.

8.2.1.6 Summary and discussion of results from Tășnad Sere

Pit C2/2005 was filled by sherds used for potting, such as scrapers and smoothers. Other fragments, like pedestal fragment 878 and body fragment 1, were potentially used in cooking. A sherd spindle whorl, together with the dozens of complete clay weights and two other spindle whorls in C2/2005 (section 5.1.1.2.1), also suggests textile production was carried out in this area. This supports the claim that structures with ovens must have been areas where multiple activities were carried out. Alternatively, it could also suggest that the area was used for storage of potting equipment and tools for textile production.

Despite the higher number of finds from UCLT1, only seven fragments were diagnosed with distinctive wear patterns. The dominant use was scraping soft materials, potentially wet clay. Only two specimens were used for working harder surfaces like hardened clay. The worked sherds were found in areas considered 'inside the house': in the central and northern sectors. In the area around squares A3/A4 there seems to be a cluster of refired fragments, stacked pottery and two reused fragments (*i.e.* 3807 and 5642; Figure 8.22), which is where there are indications of a hearth (section 7.2.1.3). Enzyme activity detected in the area could suggest that food was processed (see discussion in section 7.2.1.4). While it is a still tentative interpretation, evidence from UCLT1 suggests that fragment reuse was frequent in indoor settings.

Sommer *et al.* (2019, 10) claim that most of these refired fragments were formed in house fires, but bulk soil sample analysis at the site discourages this interpretation. The magnetic susceptibility (χ) of the analysed portions of the trench in general was rather low, ranging between 15 to 25 $\times 10^{-8}$ m^3kg^{-1} (Appendix 4). Expectations for a burned house horizon would entail values closer to those obtained from the Early Neolithic site of Ecsegfalva 23 at around 717×10^{-8} m^3kg^{-1} (Goldberg and Macphail 2006, 351). Thus, the preliminary findings from bulk soil sample analysis discourages the interpretation of refired material being the product of the intentional burning of house H1/UCLT1 after its occupation.

Scrapers were mostly used in two distinct fashions at Tăşnad Sere when working soft materials, like wet clays. A first type involved applying the fracture surface of fragments at a wide variety of angles to the clay, following the curvature of the worked pot (Figure 8.23, 1b). Examples of these fragments are 633, 725, 772, 1681, 3807, 4319, 5642, 11840, 16914. The second type involved applying only the interstices between exterior or interior and the fracture surfaces of scrapers (Figure 8.23, 1a; fragments 1681 and 4811). Two different strategies of fragment use were also identified for smoothers, namely either using the exterior surface or the fracture surface of the potsherd. The former (fragment 745), involved grabbing the fragment by the edges and using its exterior surface in a bidirectional motion against the leather-hard or even dry clay (Figure 8.23, 2a). The latter involved holding the fragment at a straight angle and sliding its fracture surface on the clay (Figure 8.23, 2b; fragments 380, 645, and 15825).

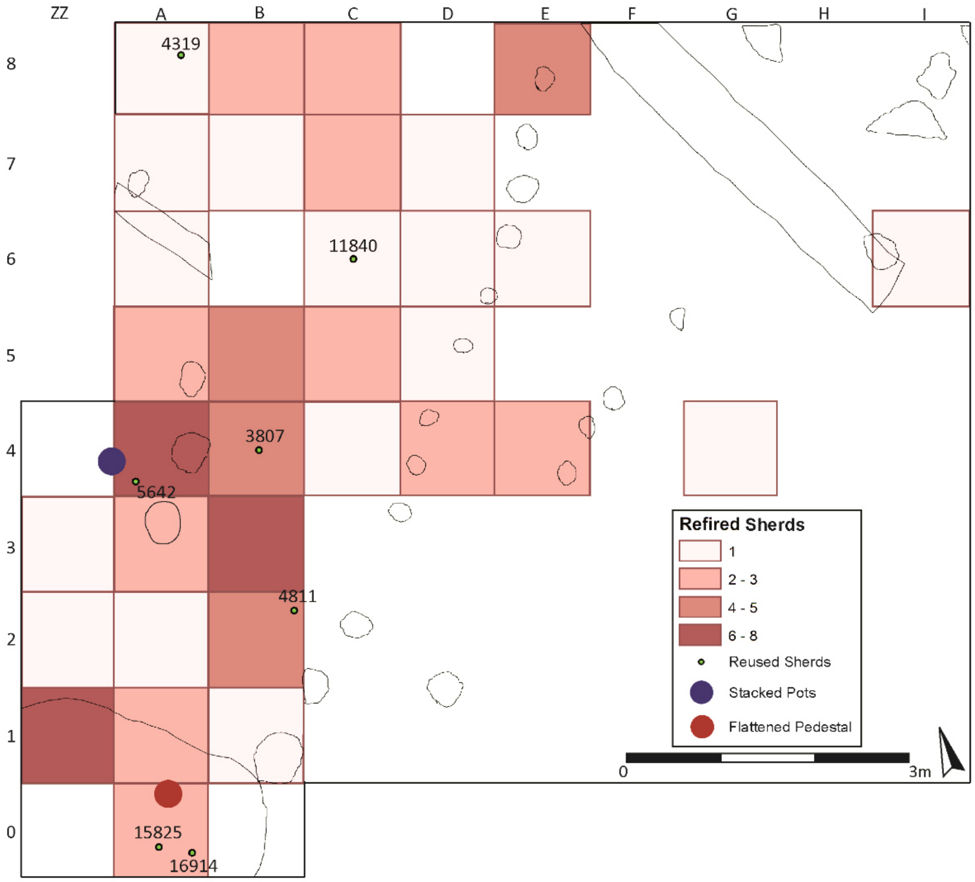


Figure 8.22: Distribution of refired fragments, stacked pots and reused fragments in UCLT1. N = 79

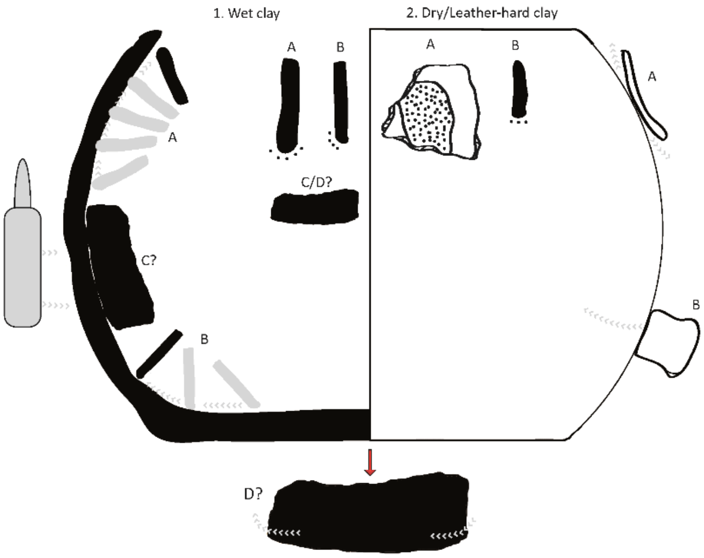


Figure 8.23: Potential uses of sherds at Tășnad Sere according to their wear traces. Scrapers, smoothers and rounded sherds used for working clays. Scrapers were used in two ways (1): by manipulating the scraper at a variety of angles (A) or at a fixed angle (B). Smoothers used for surface finishing of pots (2) also show two types of use: by using the exterior surface of the fragments (A) or the fracture surface of fragments at a 90° angle (B).

Evidence of animal bone reuse has been also found at the site (El Susi 2018, 53; Figure 8.24). While a detailed analysis of the bone fragments has yet to be performed, the presence of use-related wear indicates bones mostly from cattle and horse were used for polishing (Figure 8.24, 2 and 4) or scraping (Figure 8.24, 1 and 3), and informs us of the interconnectivity of materials and crafts (*sensu* van Gijn 2012) at the site.

Figure 8.24: Used bone fragments from contexts Gr.2/2001 (1-3), Gr.1/2001 (4), and Sup.IV/2002 (5) from Tășnad Sere (with permission by Astaloș). Scraper from fragment of large fauna bone (1, 3, 5), first phalanx of cattle with traces of polishing (2), and polished metapodium from cattle (4).

Other evidence of sherd reuse at Tășnad Sere may be related to cooking and house heating (Figure 8.26). This was observed by the refiring traces in pedestal fragment 878, and possibly the flattened pedestal used as a lid or as a support for cooling down other vessels. There was also evidence of fragment 1 used as an unfinished spindle whorl, which would link it to textile production activities. Other sherd spindle whorls at the site come from context 216 from Su.XIII/2009, which is also a 'flat' fragment (Virag 2015b, Figure 23, 11).

Fragment 1 also showed traces of pottery repair, as suggested by its through-hole. No other repair holes have been identified at UCLT1. However, there are repair holes in fragments from house 101 Su.X/2009, located just a few metres to the west on the opposite bank of the modern Cehal channel, and in context 216 from Su.XIII/2009 (Virag 2015b, Figure 12, 10). Therefore, it does not seem an activity restricted to C2/2005. Furthermore, Sherd 731 had an added piece of clay, possibly indicating that mending occurred also during pottery manufacturing stages (as has been recorded in other SKC sites (section 8.3).

Many reused potsherds were not submitted to a manufacturing stage before being used. Most of these potsherds were scrapers or smoothers and were almost exclusively found indoors. Fragments appear to have been mostly used as they were 'picked up', without any further modification.

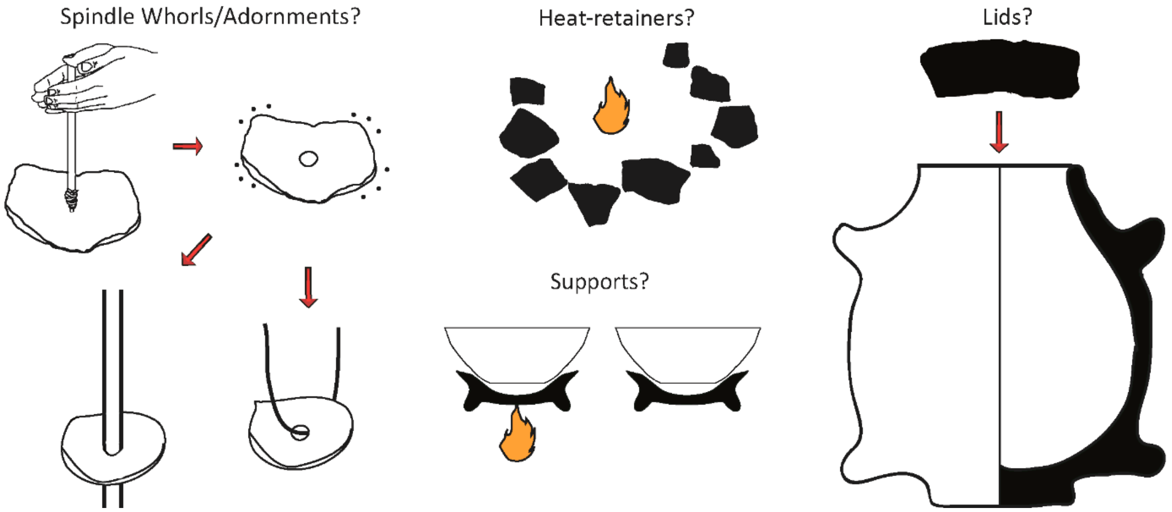


Figure 8.25: Uses of sherds as supports of pots over fires, lids, heat-retainers, and spindle whorls.

8.2.2 Méhtelek-Nádas

The only wear traces detected in samples from Méhtelek-Nádas were perforations, *i.e.* through- and blind-holes (category D), from twelve fragments: two of them from pit III and ten from pit 1-3 α. While some of the perforated sherds analysed were already published (Kalicz 2011, 69, 85; Makkay 2007, 206), others were discovered during my analysis of non-diagnostic materials (Figure 8.26).

8.2.2.1 Drilling: Category D

All fragments analysed showed traces of being drilled with flint, limnic quartzite or obsidian perforators. This was mostly determined by the presence of rotational striations, clearly observable in normals plots and the marked inflexion points in variation of depth plots (see figures below). Based on the location of perforations at the edges of sherds, repair holes were identified in eight sherds from pit 1-3α (fragments 10331, 10516, 10791, 10849, 10850, 10851, 10852, 10853; Figure 8.26) and one from pit III (11188). A single sherd spindle whorl in pit 1-3α (fragment 16616) and two so-called ring fragments were also examined (10847 from pit 1-3α and 10848 from pit III).

Repair holes from sherds 10331, 10791, 11188, 10849, 10852, and 10853 showed clear indications of being hand-drilled. Perforations in these fragments all possessed biconical sections, showing they were drilled from both sides and mostly with considerable mismatch. For example, rim fragment 11188 even had three pitted areas showing multiple attempts to drill from the exterior surface (red arrows in Figure 8.27). Furthermore, the perforations made from interior surfaces of hand-drilled fragments were always substantially wider than their counterpart. Variation of depth plots display unevenly spaced yellow curves that form incomplete ring patterns (Figures 8.29, 8.33, and 8.37), which is also observable in normals plots (Figures 8.28, 8.32, 8.36, 8.39). Centre and aspect ratio of perforations according to depth (Figures 8.30, 8.34, 8.38, 8.40) also show there was little stability in the drilling of these perforations, as curves are not flat. In fragments 10852 and 10853 there were also grooved areas extending from the edges of perforations to nearest fracture surfaces (red arrow in 8.36; Figure 8.41), indicating the area worn by some fibre or leather strap. The fact that these fragments were hand drilled, suggests the vessels were probably still in one piece when the perforations were made.

Nonetheless, in fragments 10849 and 10853, black residues were also found on fracture surfaces being repaired (Figure 8.35). Because the residues were located uniquely on these surfaces, it is likely they correspond to some kind of adhesive used during repair, rather than a substance prepared inside the vessel. It is possible then, that some fragments had been detached at the time of repair, and then glued onto the vessel. Considering that perforations were hand-drilled, it would seem in this case that fragments 10849 and 10853 were part of a largely complete fractured vessel from which a few sherds had detached.

Fragments 10850 and 10851 represented a unique sample to study drilling and repairing of Early Neolithic pottery, as they are conjoining fragments with through-holes (Figure 8.26). Repair holes from these sherds were manufactured using a support like a rod-drill. Rotational striations were regularly spaced and formed complete ring patterns in perforations from both fragments (Figure 8.42/8.43). The centre and aspect ratio of perforations according to depth (Figure 8.44) also showed that there was a great amount of stability in all perforations of both fragments, except the one made from the exterior surface of fragment 10850. Reasons for this slight discrepancy in an overall uniform pattern is mostly due to the post-drilling wear created by material used to strap fragments together. Moreover, the almost identical curves in all three plots from Figure 8.44, probably indicate the use of the same tool with a support for drilling. In this particular case, drilling from the interior of vessels would be certainly possible, as it has an open V-shaped profile, but judging by the level of uniformity of the drilling sherds must have been detached from the vessel. Unfortunately, the sherds were glued during finds processing, which impaired the identification of residues on the fracture surface that would confirm this claim. Moreover, both on the exterior surface of fragment 10850 and the interior surface of fragment 10851 grooves were identified extending towards the nearest fracture surface (red arrows in Figure 8.42), which show places where fibres or leather were used to tie both sherds together.

Two so-called 'rings' (Makkay 2007, 206) were also examined. The latter showed traces of heavy abrasion in both the fracture surface and perforation wall of the ring (Figure 8.45, b), which erased most traces of the manufacturing process, such as rotational striations. In contrast, fragment 10847 has a clear biconical section at the perforation, and abrasion is limited to the fracture surface of the fragment. The edges of both fragments are polished, suggesting formation during use (Figure 8.45, a, c-d). It is very difficult to ascertain what role these fragments fulfilled. The polished surface would suggest some rubbing with skin, but the diameter of these fragments is too small to fit an adult's finger. Thus, it could have been part of a necklace, bracelet or maybe earrings.

Lastly, rim fragment 16616 was interpreted as an unfinished spindle whorl perforated with a rod-drill. This was suggested by the central location of the perforation, the evenly rotational striations forming rings on perforation walls (Figures 8.46 and 8.47), and the stable curves displayed in centre of ellipse and aspect ratio of perforations according to depth (Figure 8.48). While there is a certain inclination detected in the centres of perforation according to depth, the values fall well within the range of rod-drilled tools, suggesting the rod-drill used was slightly tilted. The almost identical curves in all the plots from Figure 8.48 was suggestive that the exact same tool was used for drilling perforations from the exterior and interior surfaces of the fragment.

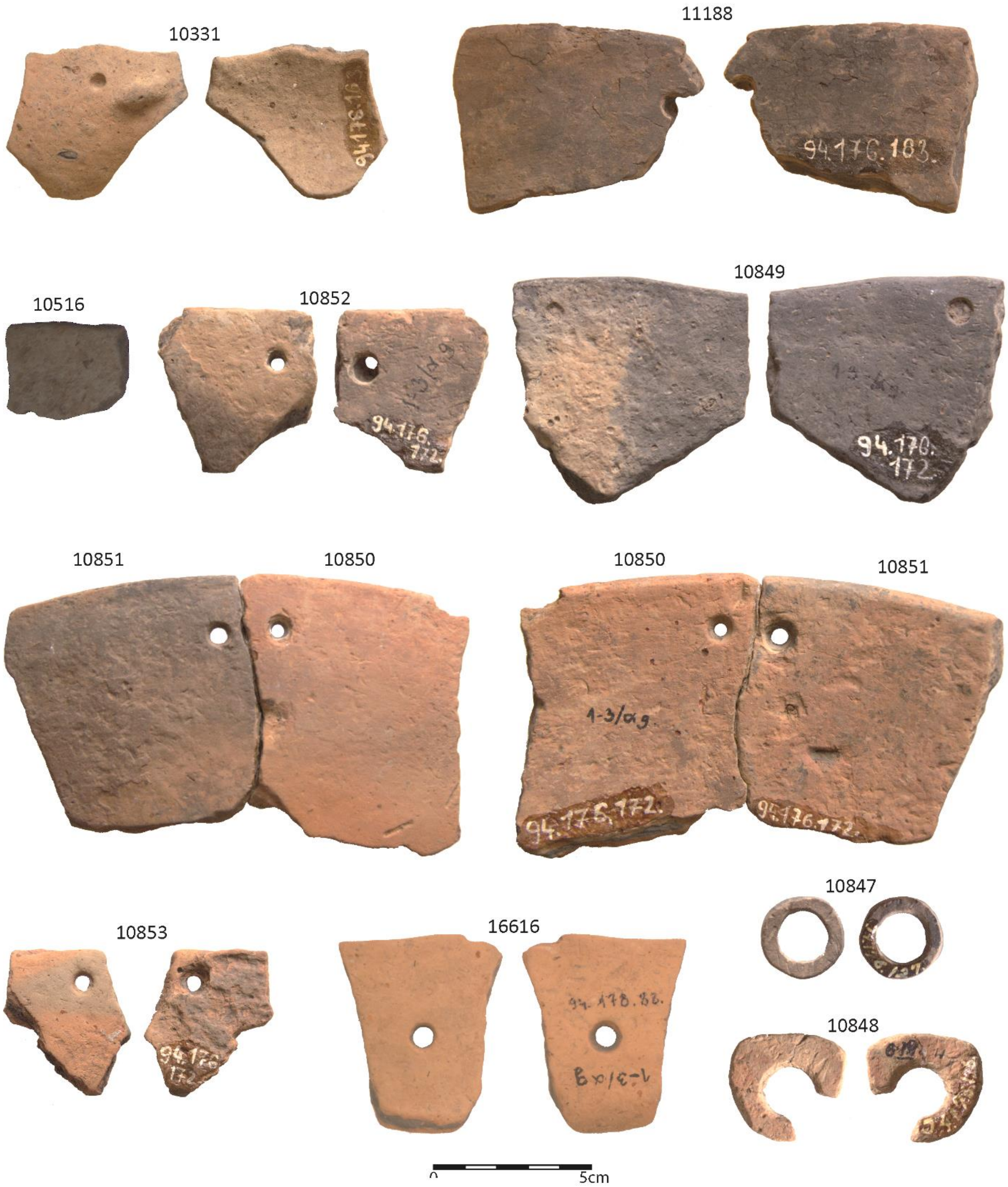


Figure 8.26: Category D fragments from Méhtelek-Nádas.

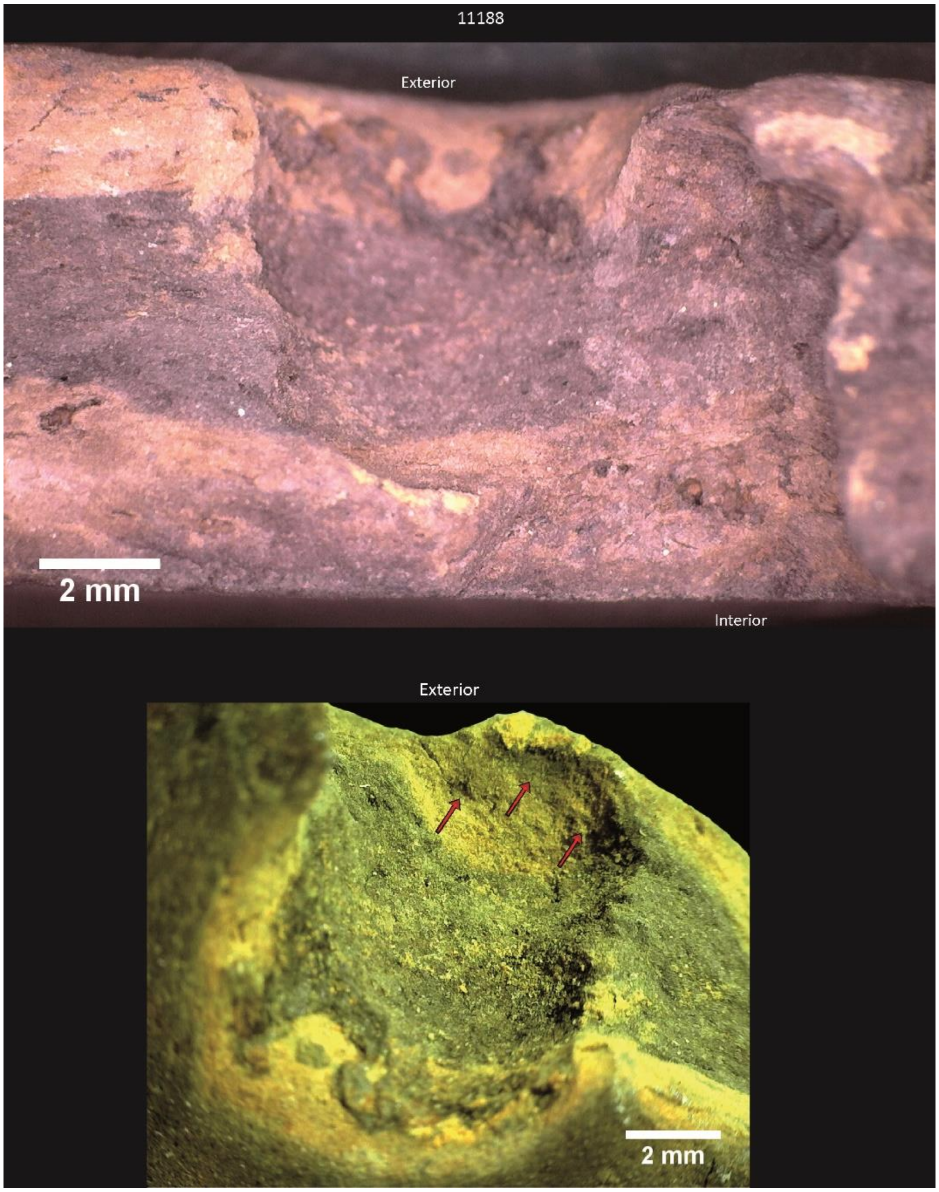


Figure 8.27: The mismatching perforations in fragment 11188 (top) and a detail of the hole from the exterior surface of fragment (bottom), arrows indicate pitted areas made by the tip of a perforator.

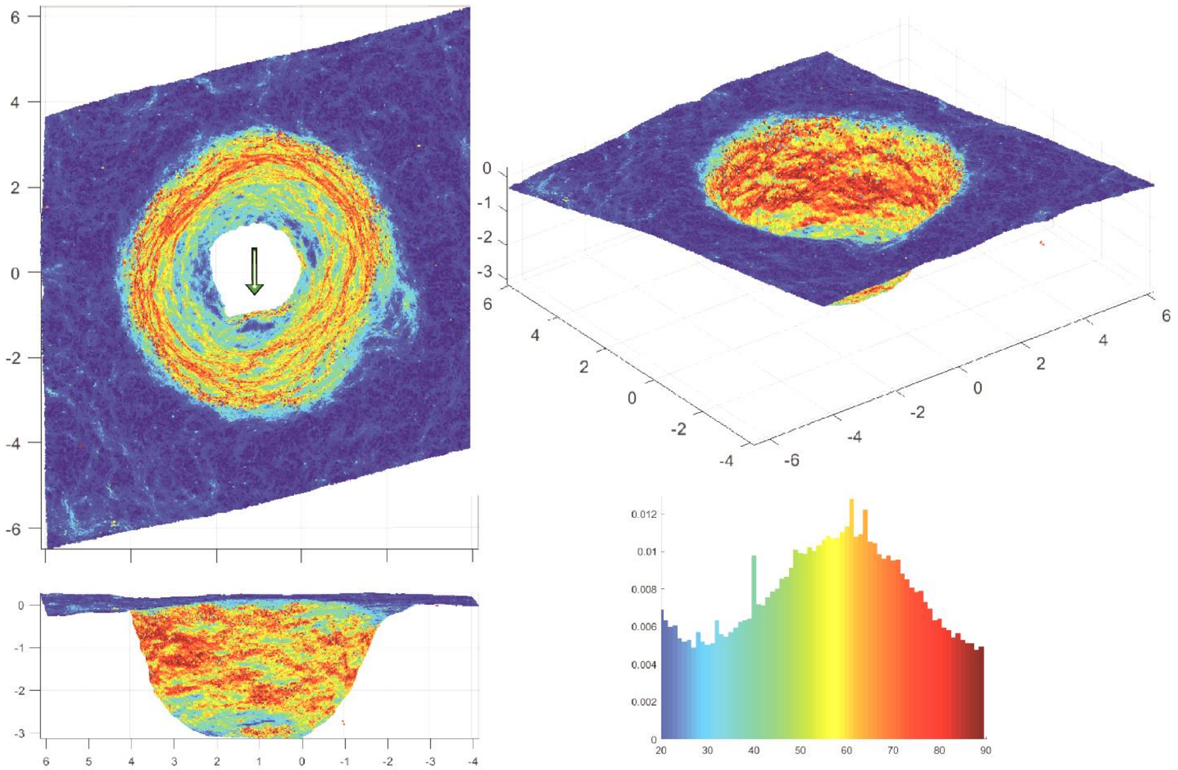


Figure 8.28: Normals plots obtained for through-hole in fragment 10331. Green arrows indicate the crack or fracture repaired.

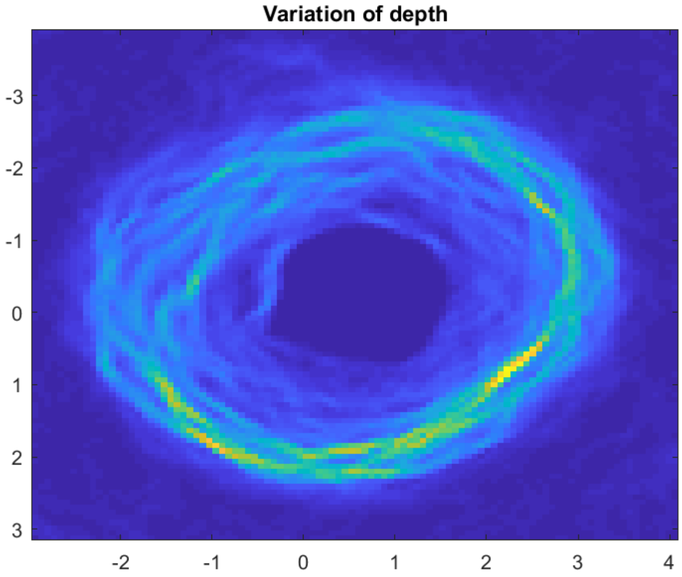


Figure 8.29: Variation of depth plot from through-hole in fragment 10331.

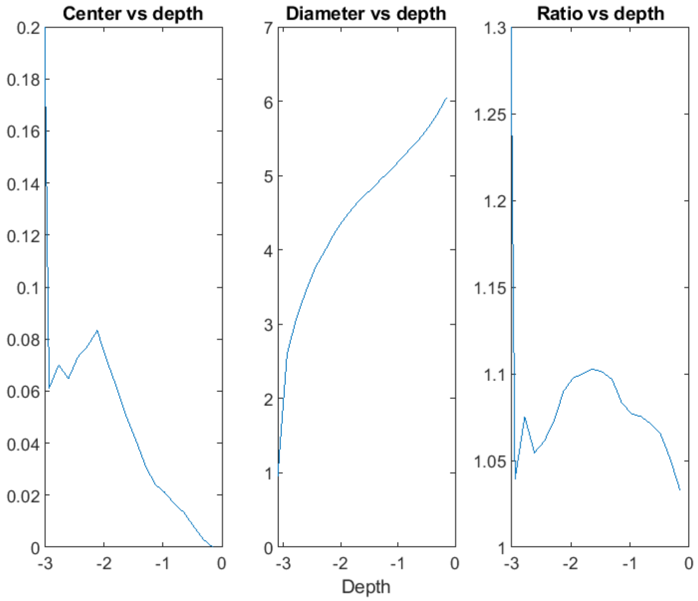


Figure 8.30: Centre, diameter and aspect ratio per depth of perforation from fragment 10331.

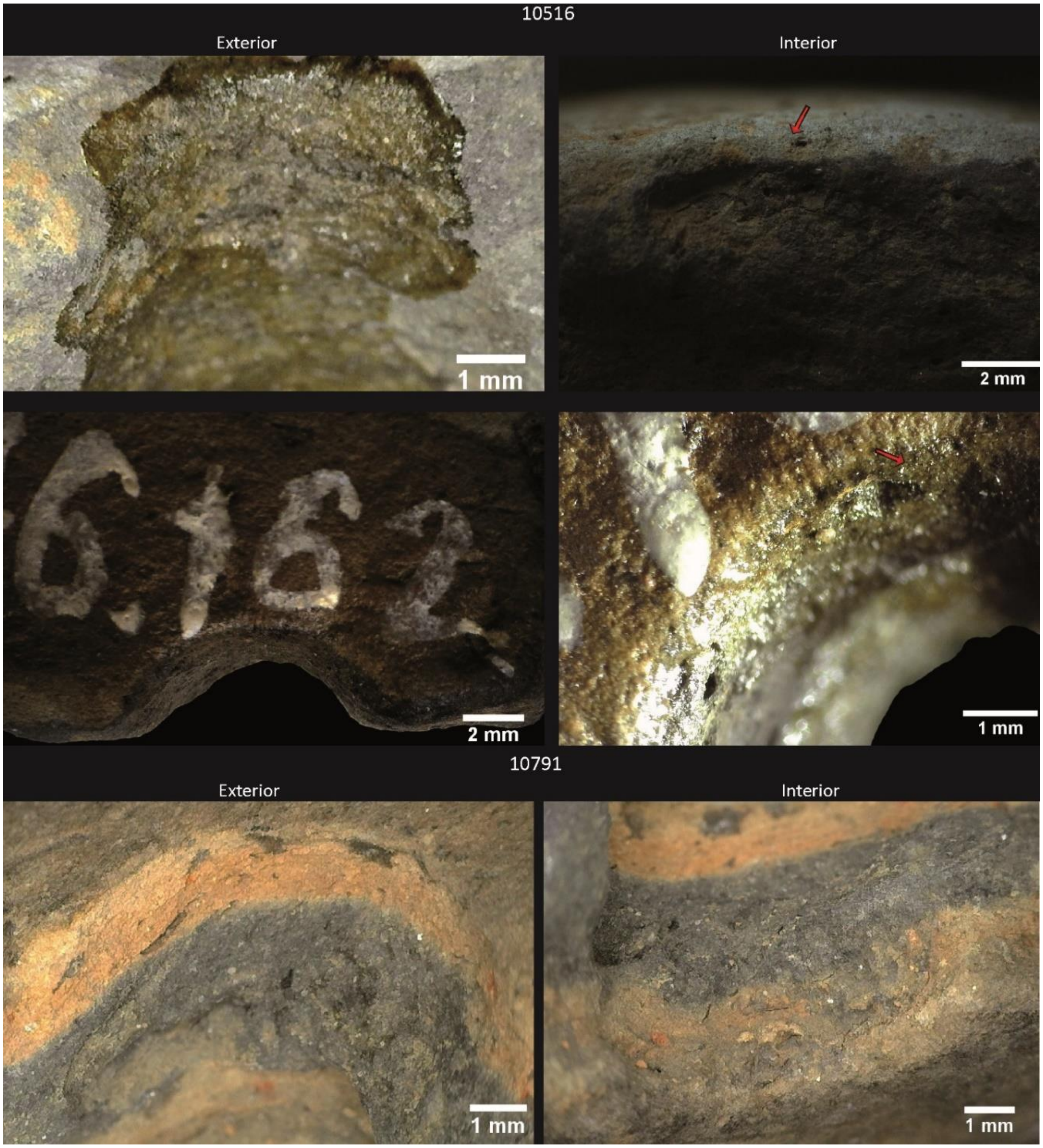


Figure 8.31: Rim fragments 10516 and 10791. Red arrows indicate the rotational striations.

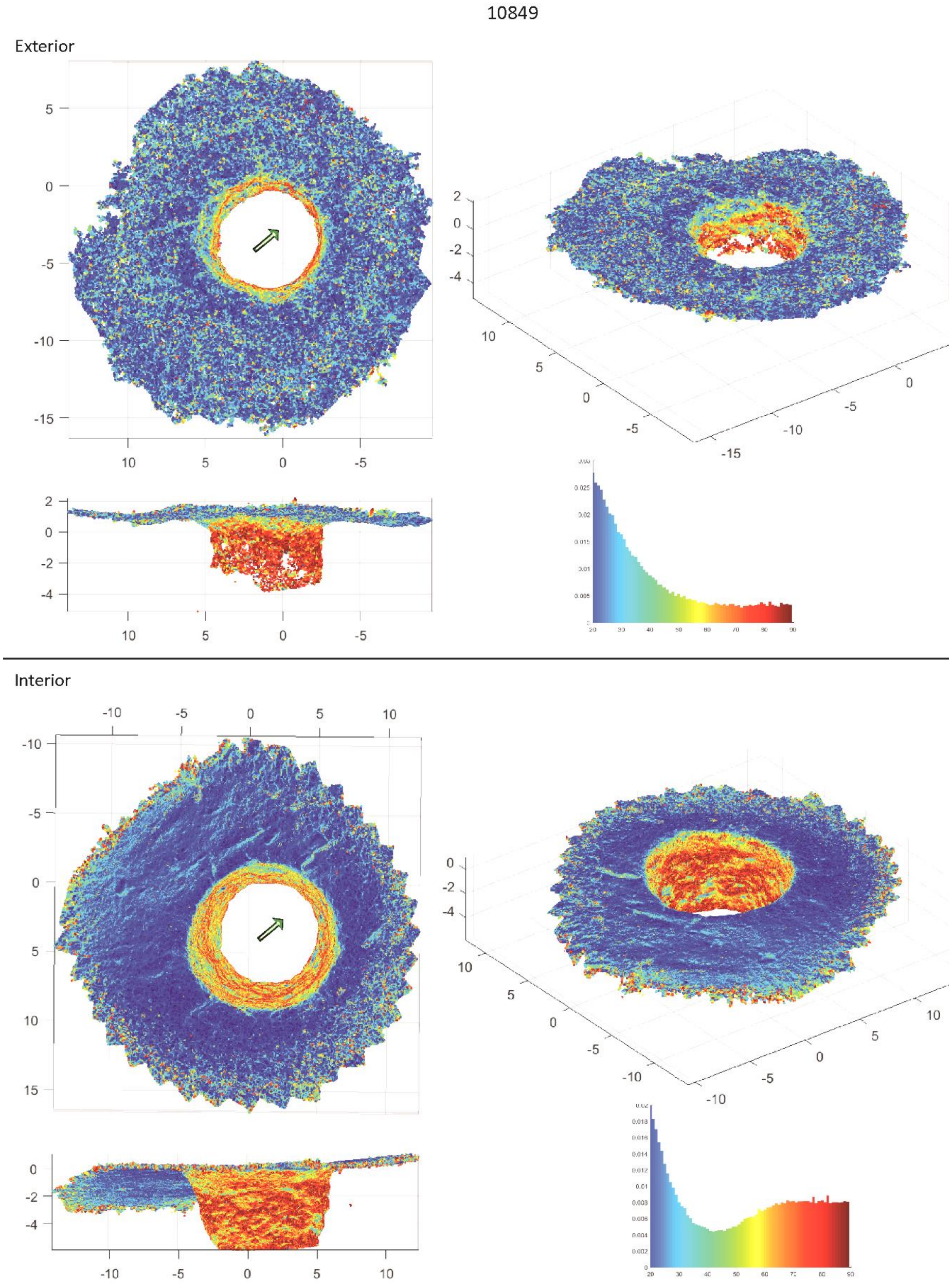


Figure 8.32: Normals plot of perforations drilled from exterior and interior surface of fragment 10849. Green arrows point towards the crack or fracture being repaired.

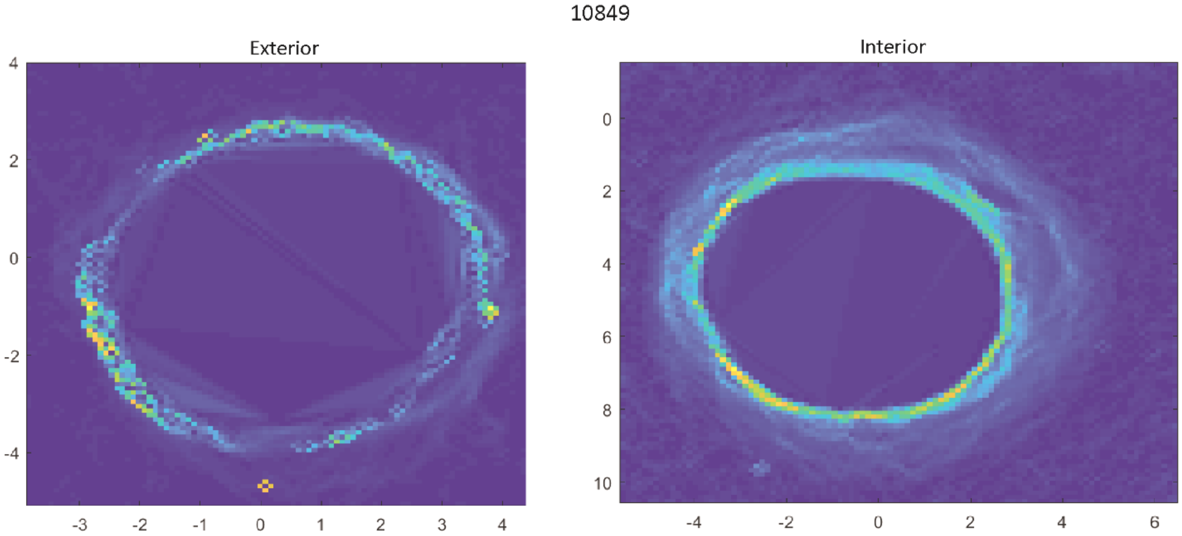


Figure 8.33: Variation of depth plot of perforations drilled from exterior and interior surface of fragment 10849.

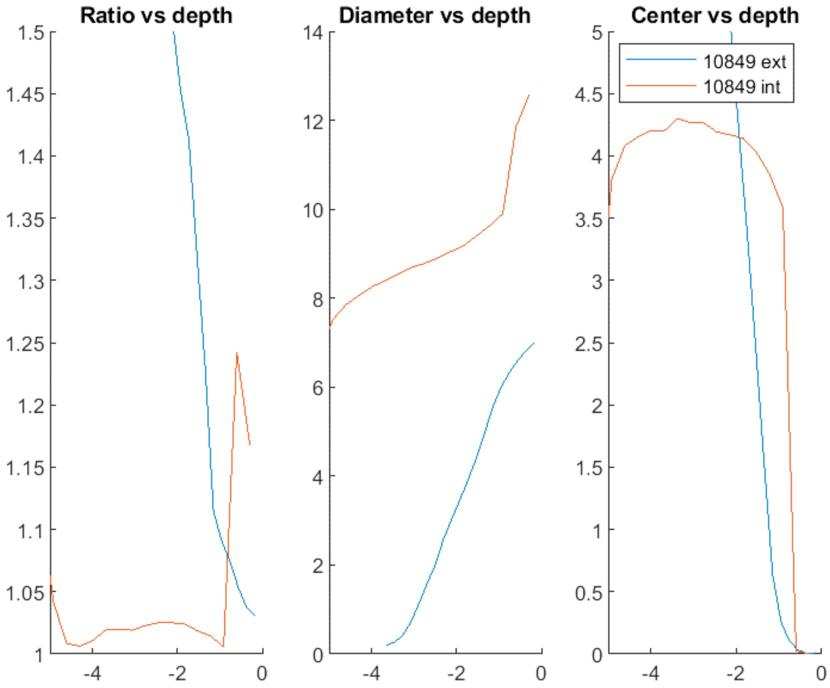


Figure 8.34: Centre, diameter and aspect ratio according to depth of perforations drilled from exterior and interior surface of fragment 10849.

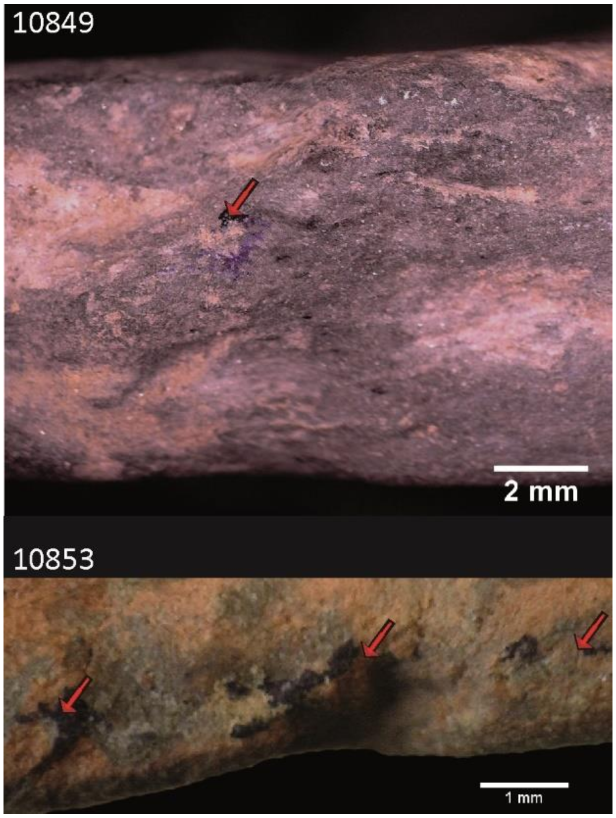


Figure 8.35: Potential residue found on fracture surface of fragments 10849 and 10853, as signaled by red arrows.

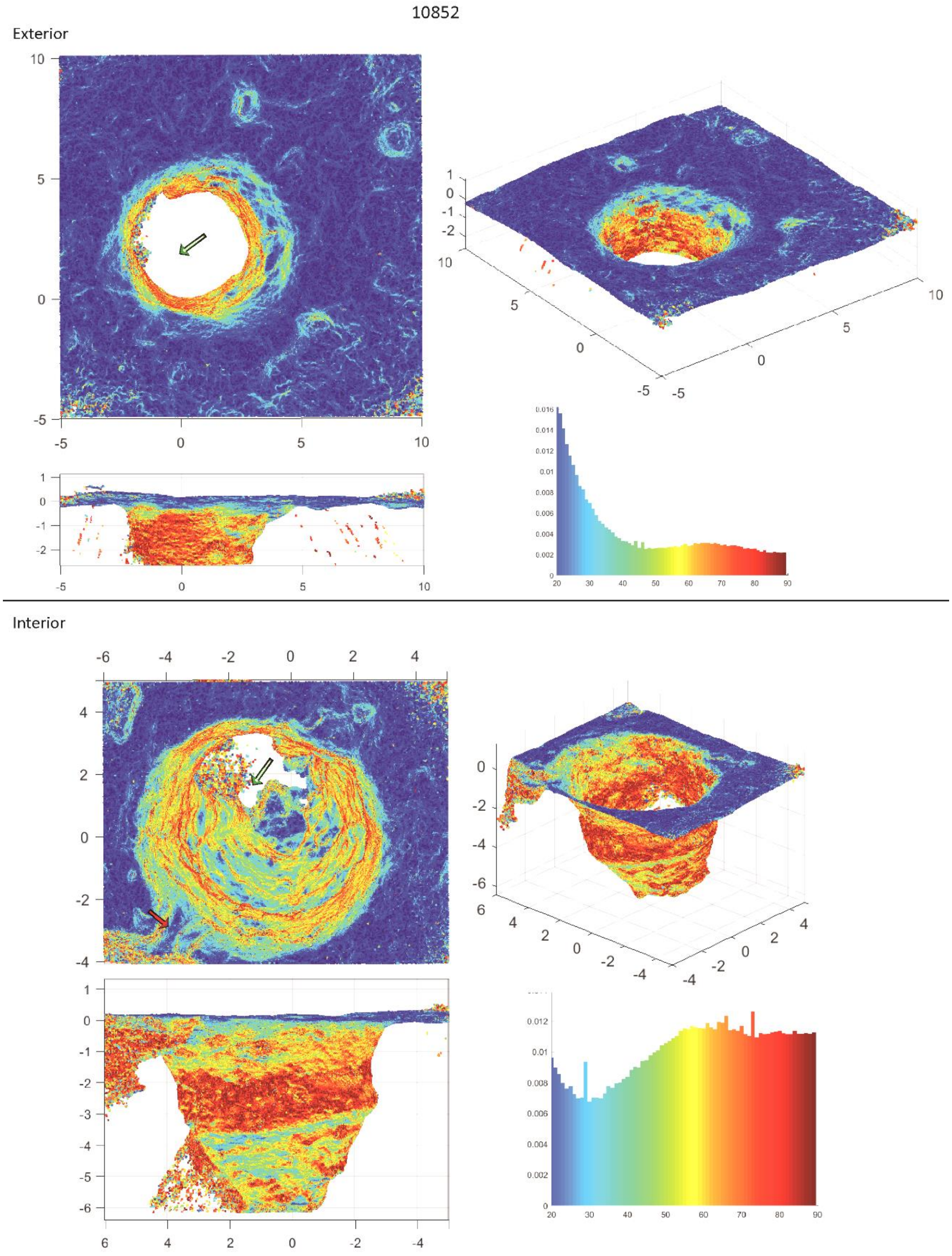


Figure 8.36: Normals plot of perforations drilled from exterior and interior surfaces of fragment 10852. Green arrows point towards the crack or fracture being repaired. The red arrow indicates grooves formed by fibres or leather being used.

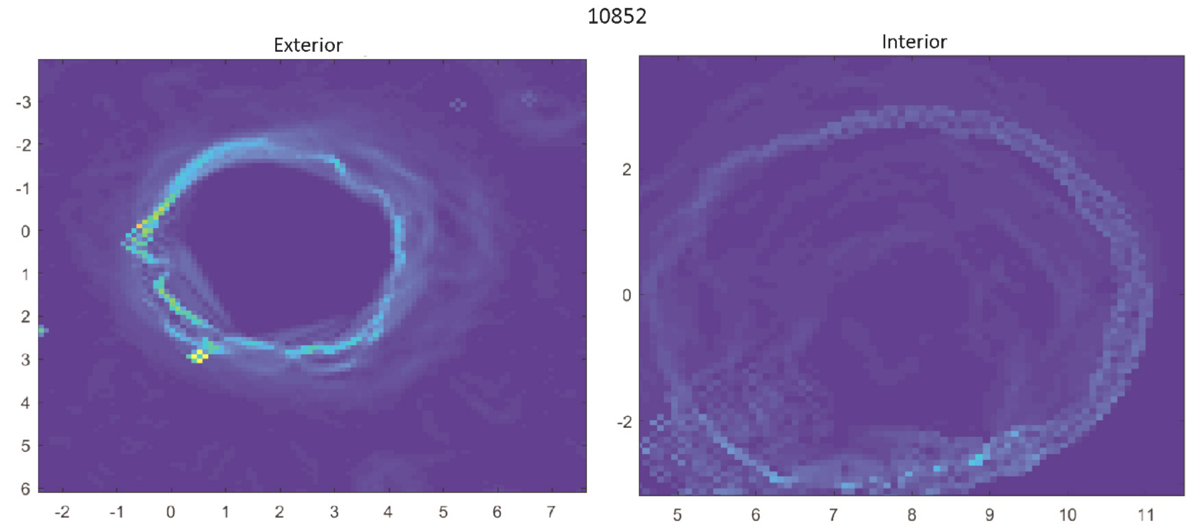


Figure 8.37: Variation of depth of perforations drilled from exterior and interior surfaces of fragment 10852.

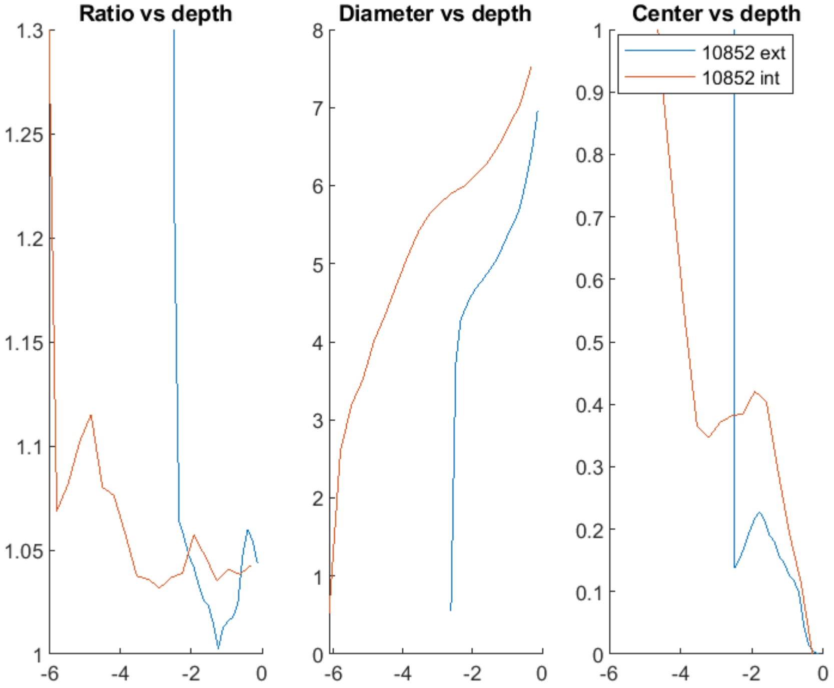


Figure 8.38: Centre, diameter, and aspect ratio according to depth of perforations drilled from exterior and interior surfaces of fragment 10852.

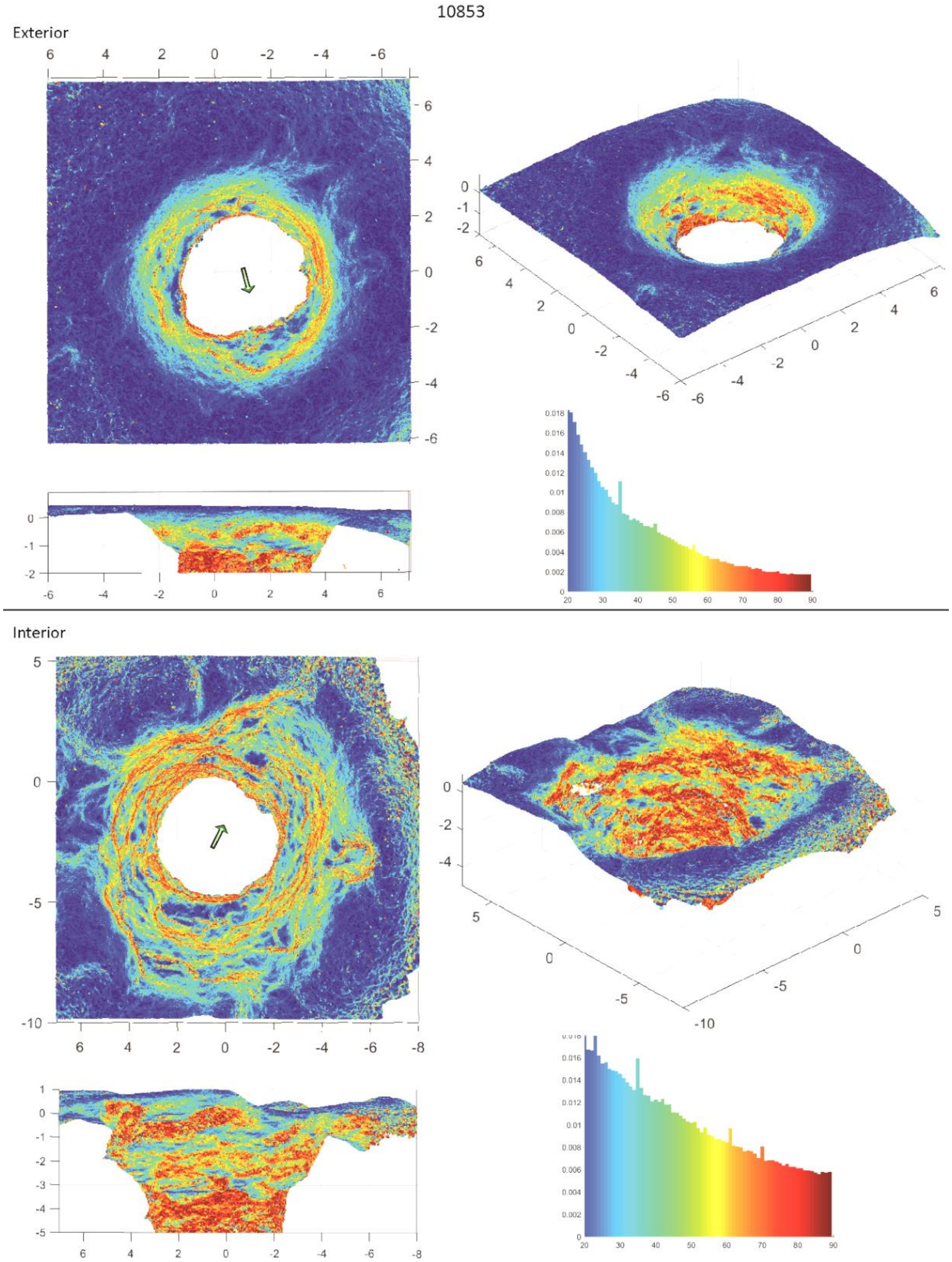


Figure 8.39: Normals plot of perforations drilled from exterior and interior surfaces of fragment 10853. Green arrows point towards the crack or fracture being repaired.

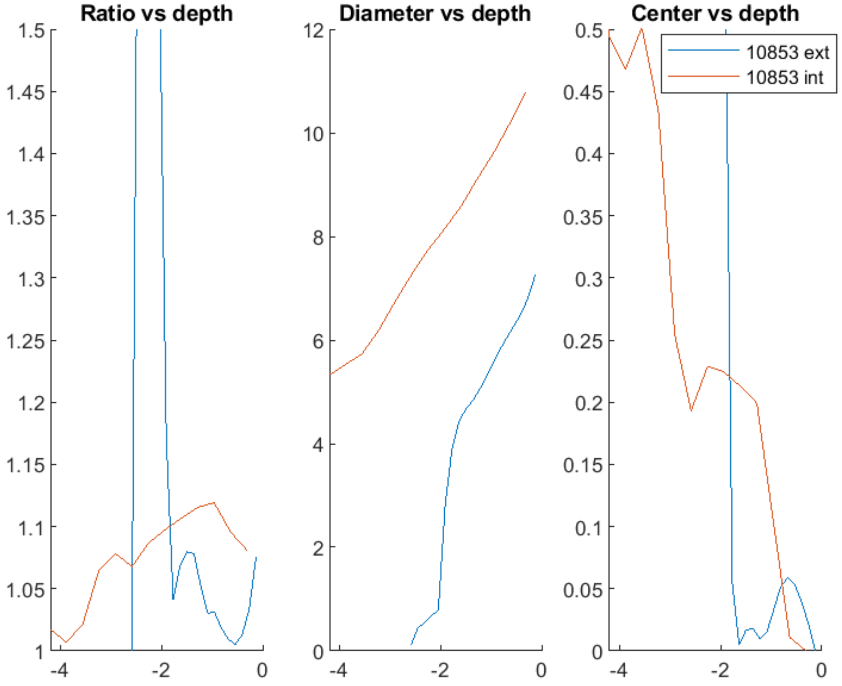


Figure 8.40: Centre, diameter, and aspect ratio according to depth of perforations drilled from exterior and interior surfaces of fragment 10853.

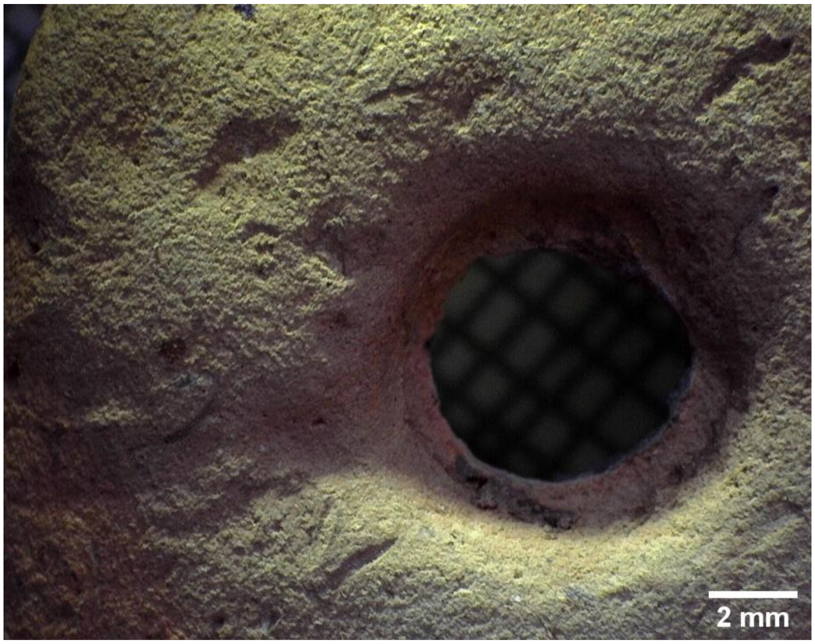
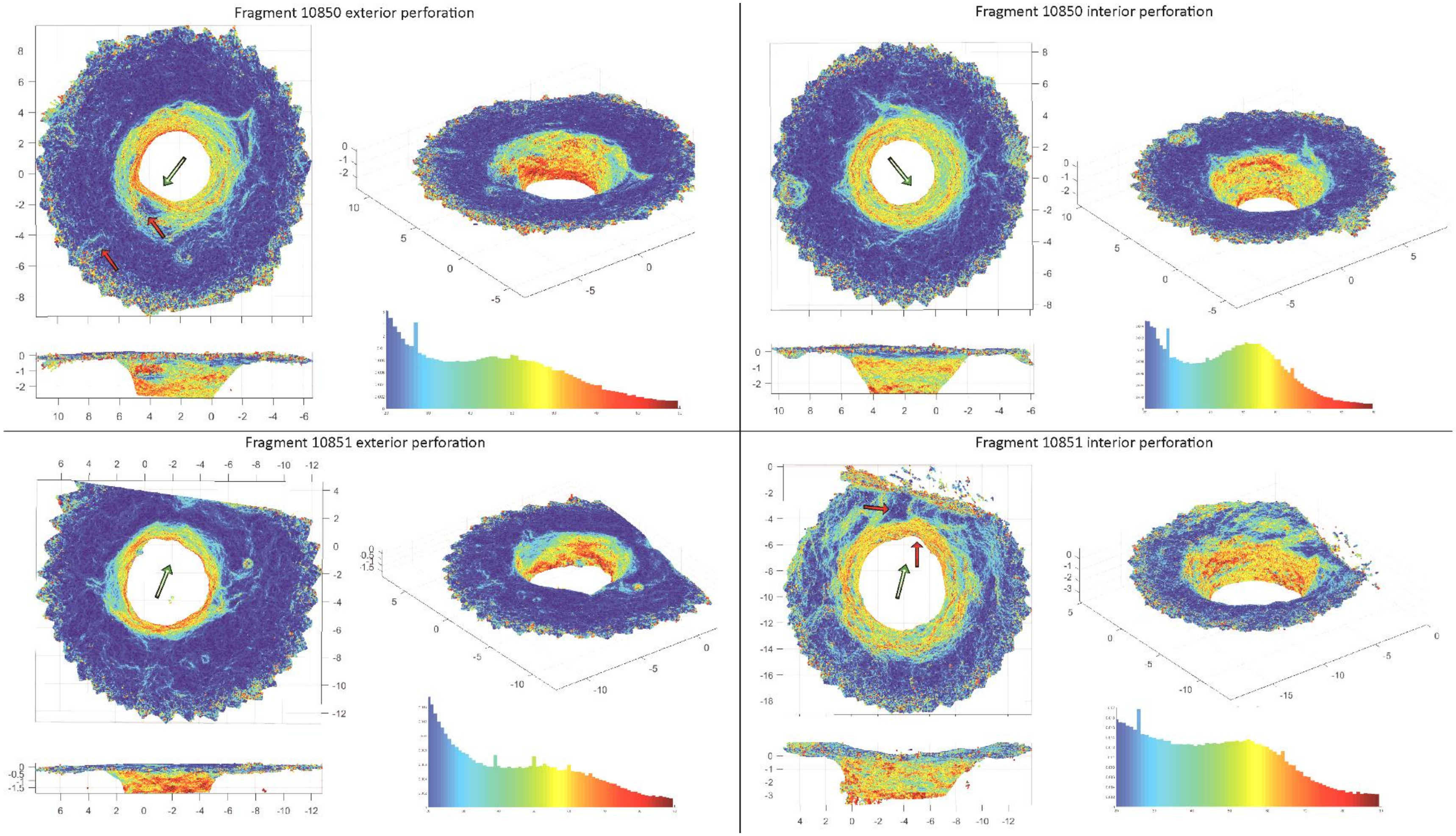


Figure 8.41: Detail of grooved area connecting perforation from the exterior surface of fragment 10853 to the repaired fracture surface.


Fragment 10850 exterior perforation

Fragment 10850 interior perforation

Fragment 10851 exterior perforation

Fragment 10851 interior perforation

Figure 8.42: Normals plot of perforations drilled from exterior and interior surfaces of fragments 10850 and 10851. Green arrows point towards the crack or fracture being repaired. Red arrows indicate grooves formed by fibres or leather being used.

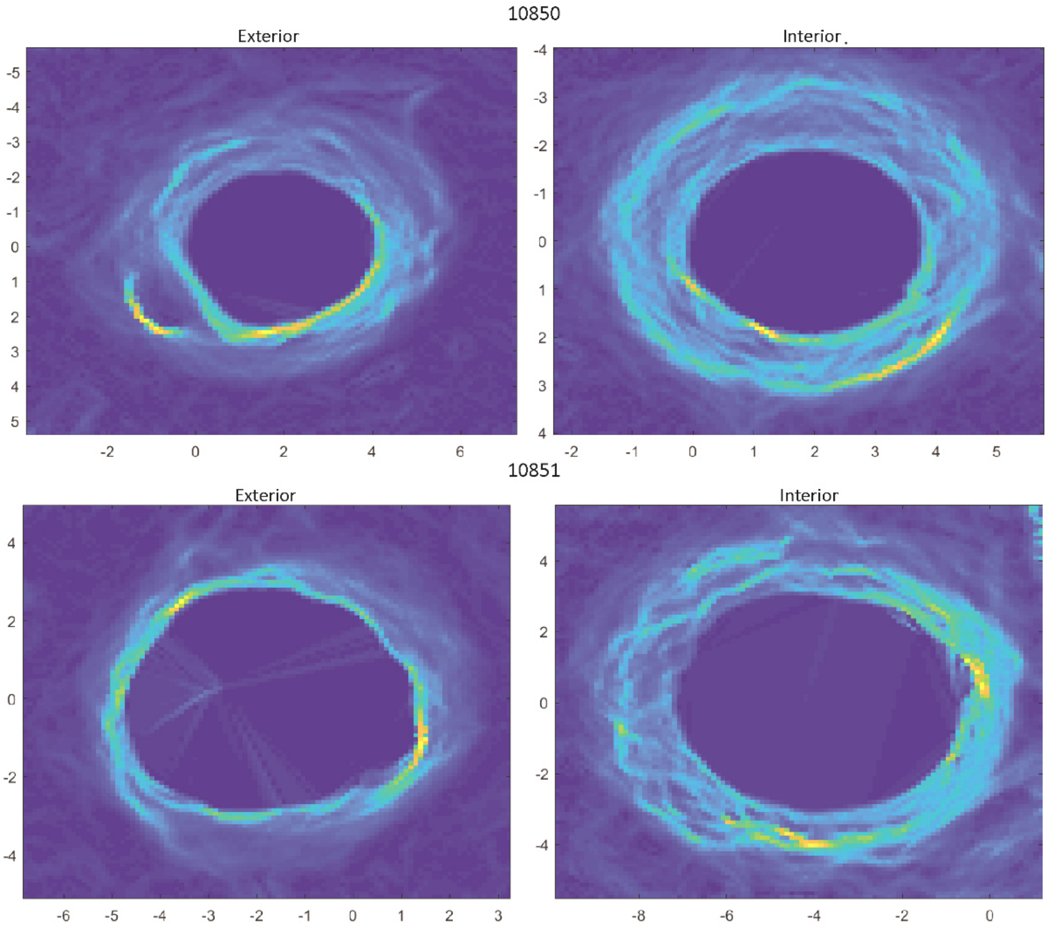


Figure 8.43: Variation of depth of perforations drilled from exterior and interior surfaces of fragments 10850 and 10851.

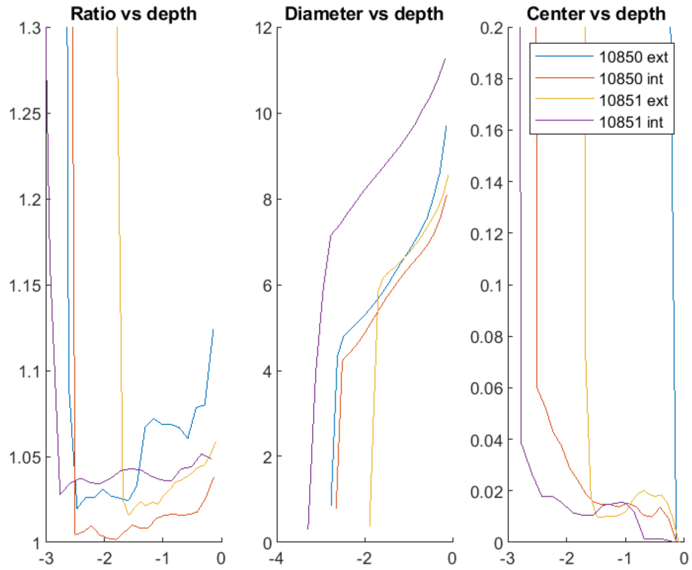


Figure 8.44: Centre, diameter, and aspect ratio according to depth of perforations drilled from exterior and interior surfaces of fragments 10850 and 10851.

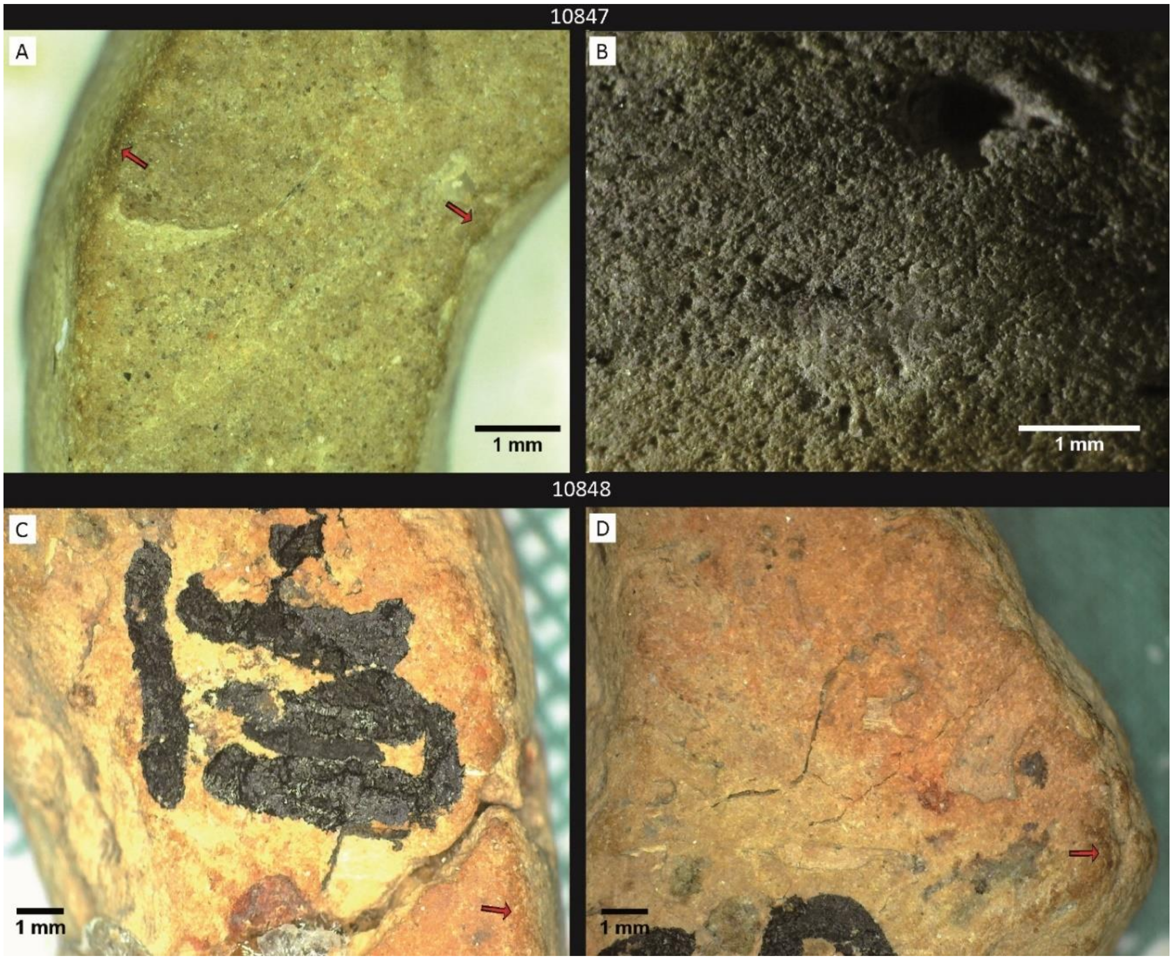
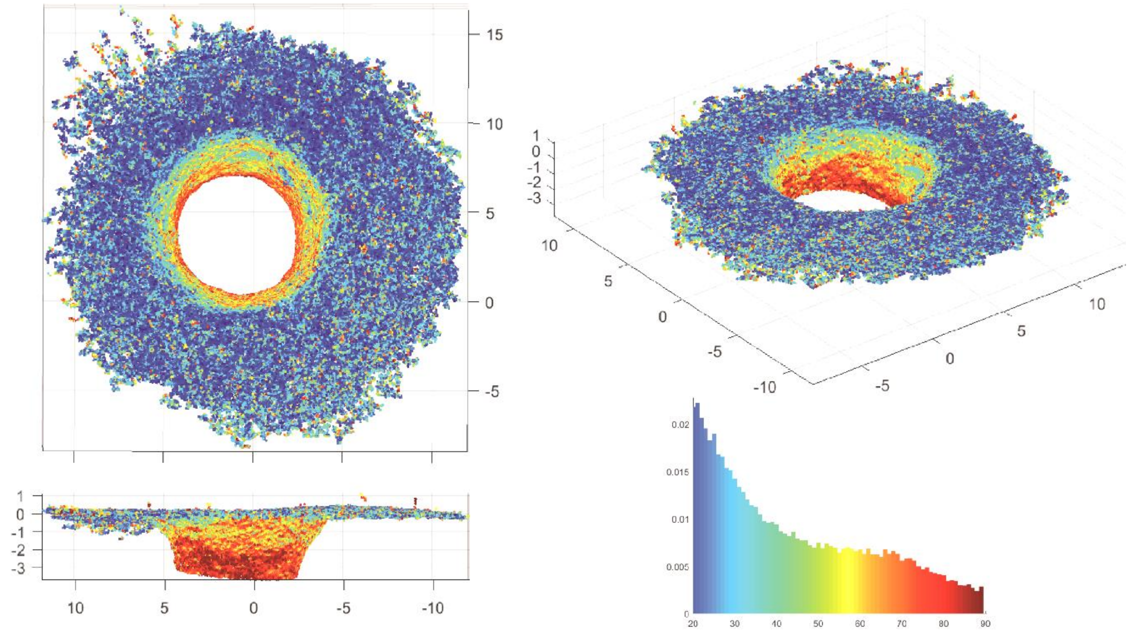


Figure 8.45: Wear traces on ring fragments from Méhtelek-Nádas: glossy surfaces (a, c-d) and heavy abrasion (b).

16616

Exterior



Interior

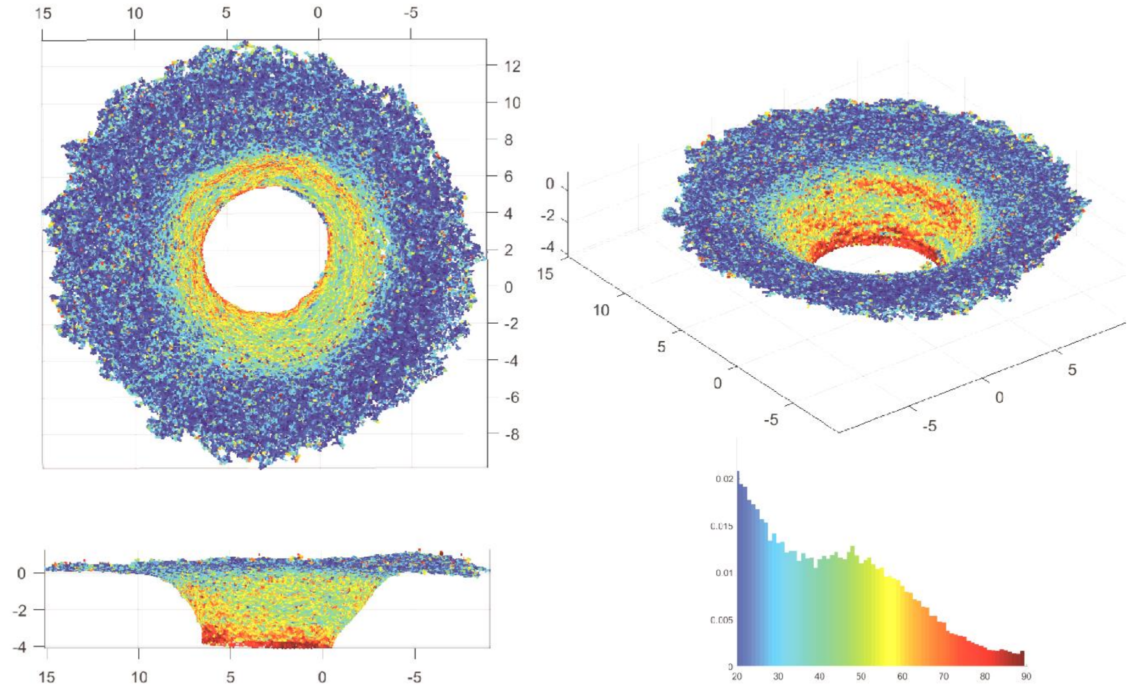


Figure 8.46: Normals plot of perforations drilled from exterior and interior surfaces of fragment 16616. Green arrows point towards the crack or fracture being repaired.

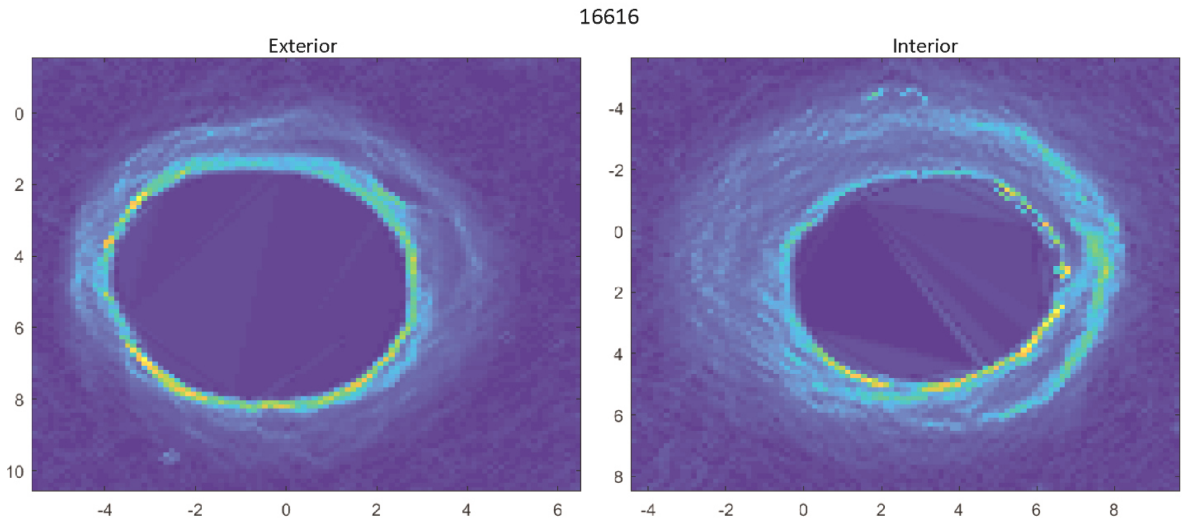


Figure 8.47: Variation of depth of perforations drilled from exterior and interior surfaces of fragment 16616.

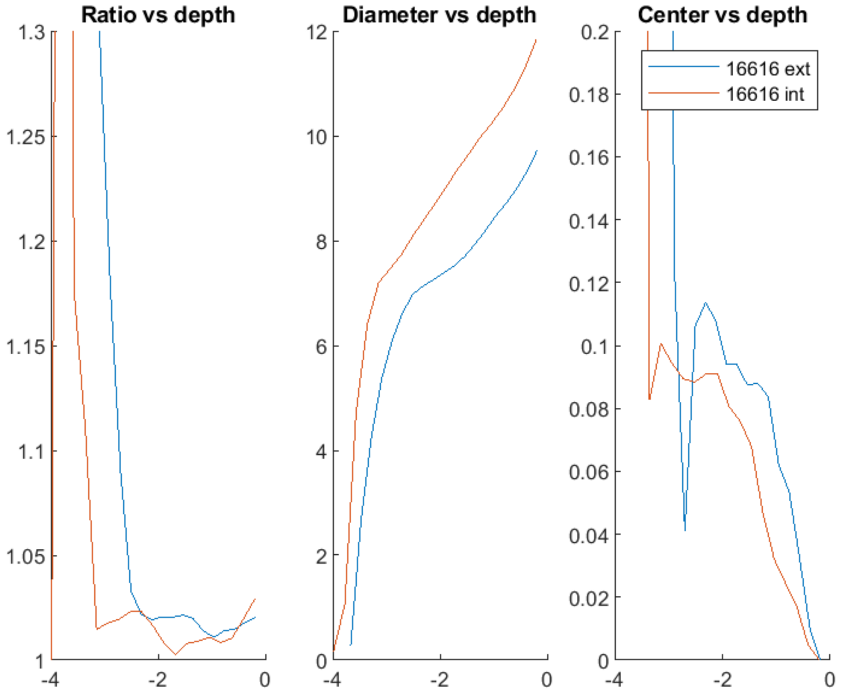


Figure 8.48: Centre, diameter, and aspect ratio according to depth of perforations drilled from exterior and interior surfaces of fragment 16616.

8.2.2.2 Summary and discussion of results from Méhtelek-Nádas

There seems to be two different reasons for drilling fragments at Mehtelek-Nadas: pottery repair and modification of sherds for other uses (Figure 8.49). In the two supposed ring fragments, the only evidence of polish was seen on the edges of the fragments' interior and exterior surfaces, which could be the result of contact with skin (Langley 2018, 160), but also with threads (Falci *et al.* 2019; Mărgărit 2016, 69). Thus, these pieces perhaps could have been beads for necklaces, bracelets, earings or ear expanders. The unfinished spindle whorl (fragment 16616) was drilled in the same way from both ends with a lithic or obsidian perforator hafted to a rod-drill.

Evidence of repair shows at least two different drilling techniques were used, both using 'type A' lithic or obsidian perforators. A first method involved hand-drilling both perforations. This was exemplified by fragments 10331, 10791, 11188, 10849, 10852, and 10853. Another drilling technique for repairing pottery was signalled by fragments 10850 and 10851. In this case, perforations were carefully manufactured with the help of a rod or bow-drill, which would involve a different hand gesture. Regardless of which technique was being used, perforations created in the interior surface of fragments are usually deeper and wider, which would seem logical to suggest that these were manufactured first. This was attested in all sherds except fragment 10331. After the first perforation, in occasions probably piercing through to the other side, there was an attempt to match these by drilling from the opposing exterior surface. This process appears to have been difficult in hand-drilled specimens, often creating some severe mismatches between the joins of both holes like in fragments 11188, 10791 and 10852. In contrast, matching appears to be done rather effortlessly and effectively in rod-drilled fragments, *i.e*. 10850, 10851 and in spindle whorl fragment 16616. However, it is possible that the perforation from the exterior surface of fragment 10850 was hand-drilled.

It would seem the choice of drilling method was partly influenced by how vessels were broken. Vessels that did not completely fracture, and hence made rod-drilling a very difficult task, may have been drilled by hand (Figure 8.49a). In contrast, when some portions of the vessel were completely detached, rod-, pump- or bow-drilling could have been used (Figure 8.49c). These detached fragments could have then been glued to the vessel with birch bark tar (fragments 10849 and 10853). This adhesive has been documented in various Mesolithic and Neolithic sites for hafting lithic tools or as gum (Jensen *et al.* 2019; Rageot *et al.* 2019; Regert 2004), and has also been identified in repaired pottery from later LBK sites (Elburg 2015; Tegel *et al.* 2012). Hand-drilled fragments 10849 and 10853, which could be stained with this adhesive, might be an exception to the abovementioned repair sequences. The adhesive could be firstly added to the fragment, attached to the vessel and then hand-drilled; or part of the vessel was completely broken, then partly hand-drilled and finally refitted with the adhesive (Figure 8.49b and d).

After drilling had been performed a fibre or piece of leather was used to strap fragments together. Grooved areas identified in fragments 10850, 10851, 10852 and 10853 show this binding material would have not been more than 2mm thick. The wider perforation on the interior surface of the fragments also suggests that whatever fibre or leather used to strap the repair holes together, it was introduced from the exterior side of the vessel and then secured from the interior. The wider perforation made on the interior of the vessel could also serve to hide and secure the knots of the fibres/leather. Figure 8.49 presents the reconstruction of some of the potential sequences of repair.

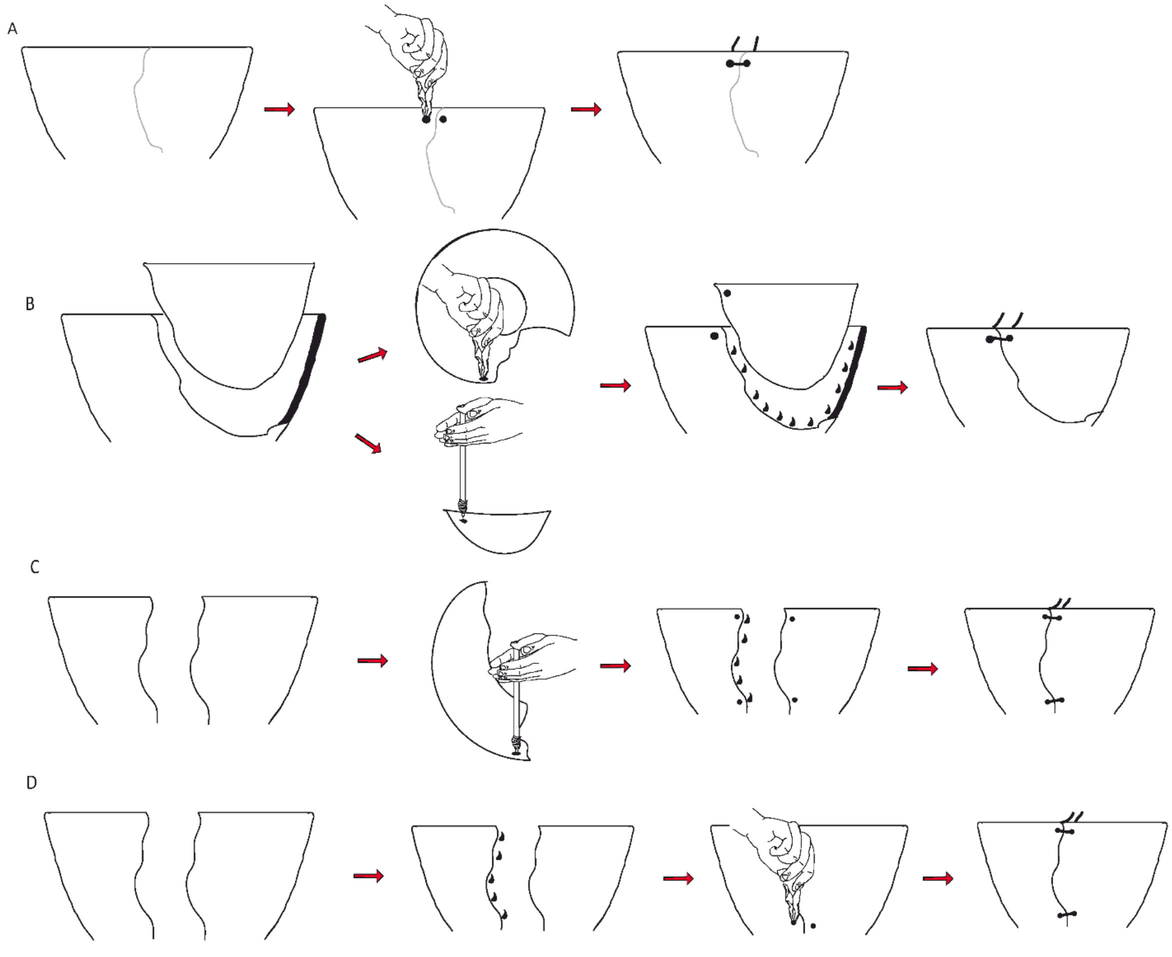


Figure 8.49: Reconstruction of drilling techniques used for repairing pottery from Méhtelek-Nádas.

8.2.3 Eitzum

Among the 3247 sampled, 17 fragments had wear traces and most of them falling into category A (Table 8.2). No pattern was identified in terms of sherd composition or selection of vessel portions.

Category	Zone A	Zone B				Zone D					Total
	WLH1	13	14	15	16	7	10	11	26	Unknown	
A	3						1	1	1	1	7
D						1					1
K					1						1
L				1					1		2
H	1										1
J	1	1	1	1							4
U	1(1)		(1)			(1)					1
Total	6	1	1	2	1	1	1	1	2	1	17

Table 8.2: Number of fragments per wear category for each context at Eitzum.

8.2.3.1 Percussion: Category K

Fragment 7546 is a rounded body sherd attributed to category K. The potsherd bears several scars from knapping (Figure 8.50). Knapping of the sherd's edges seems to have occurred from several directions in both its interior and exterior surfaces. No use-related wear was identified. Due to the fragment's curvature it could have been intended as a support for rotating pots during potting (*e.g.* Mayor 2010, 651–652).

Figure 8.50: Fragment 7546 with scars (arrows) from retouch around the edges of the exterior and interior surfaces.

8.2.3.2 Scraping, smoothing or sliding: Categories A, L and H

Fragments 7100 and 8734 were rounded by abrasion (category L). Both fragments have a smooth texture and clear outline of wear on fracture surfaces, highlighting that surfaces were abraded against hard materials. 8734 also showed traces of levelled or flattened inclusions in several portions of its fracture surface (Figure 8.51). These traces suggest that both fragments were shaped as the result of manufacture and not the consequence of use. The intended use of the fragments could not be inferred.

Figure 8.51: Fragments 7100 and 8734 (category L). The arrows highlight inclusions that have been levelled or flattened.

Category A (fragments 6086, 6133, 6409, 7003, 8446, 8559, 8560) and the only fragment in this site identified as category H (fragment 8002) were found at WLH1. The latter fragment functioned as a smoother on clay in leather-hard state. Striations on the exterior surface of the fragment (blue box in Figure 8.52) and on a mineral inclusion in this active surface run perpendicular to the vessel mouth, suggesting the direction of movement was from top to bottom of fragment (red box in Figure 8.52; see also Figure 8.59). While the worn area shows a diffuse boundary, indicative of abrasion against soft materials, the marked striations mentioned above show hard materials must have been worked show. Thus, the diffuse boundary is most likely due to the limited use given to the fragment (*i.e*. use-time).

Fragments 8446 and 8559 from WLH1 in zone A and fragments 6409 and 7003 from features 11 and 26 in zone D show traces of being used as scrapers on soft materials, most likely for working wet clay during pottery manufacture. Common traces included the diffuse boundary between worn and unworn areas, smooth surface textures, rounded section shapes, and on one occasion striations visible (fragment 6409; red box in Figure 8.55). Differences between these scrapers lie mostly in the areas of the fragment used, suggesting different movements. For example, fragments 7003 and 8559 were used at different angles, as shown by their rounded section (Figures 8.53 and 8.55), and fragments 6409 and 8446 were used at a sharp angle to the worked surface, as suggested by striations (6409; red box in Figure 8.55) or faceting (8446; Figure 8.53) between interior and fracture surfaces. Therefore, while fragments 7003 and 8559 appear to have been used following the curvature of pots, fragments 6409 and 8446 were likely used for drawing up excess clays in pottery forming stages.

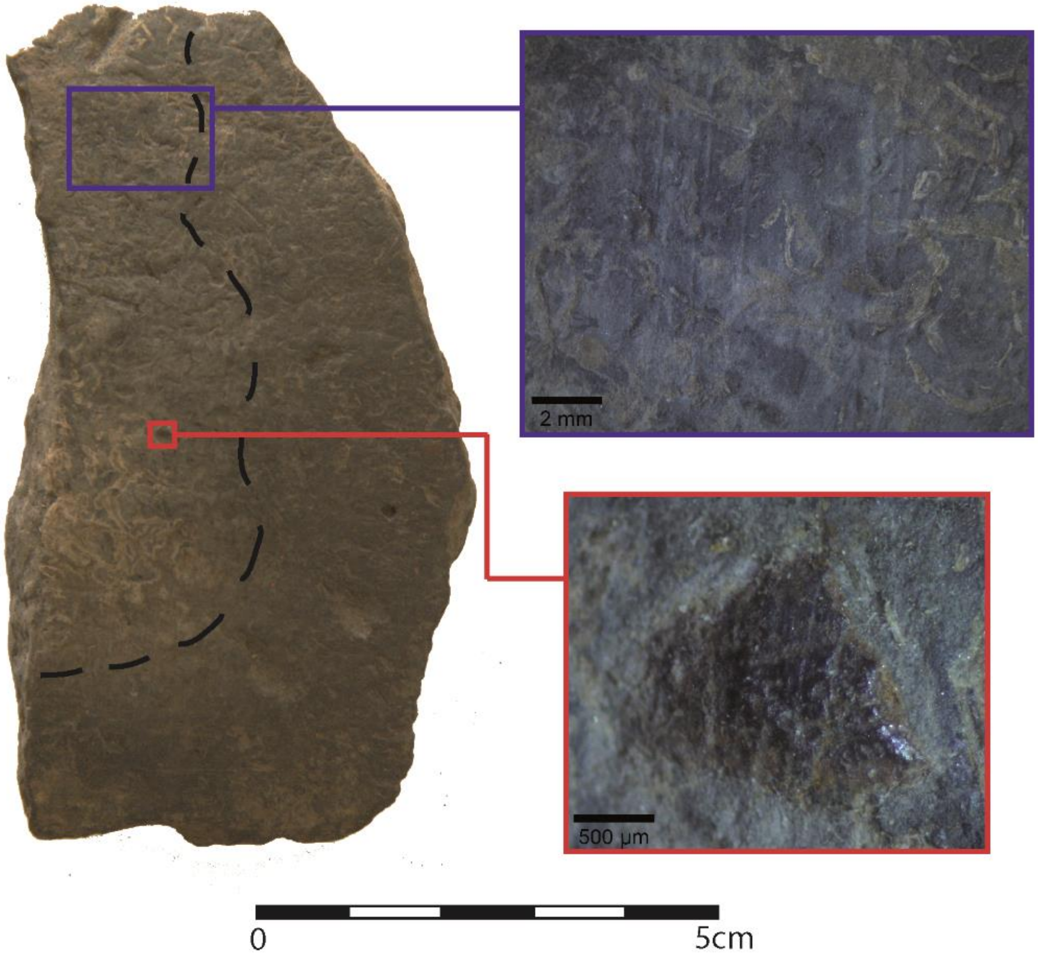


Figure 8.52: Traces in fragment 8002 at WLH1 (zone A) at Eitzum.

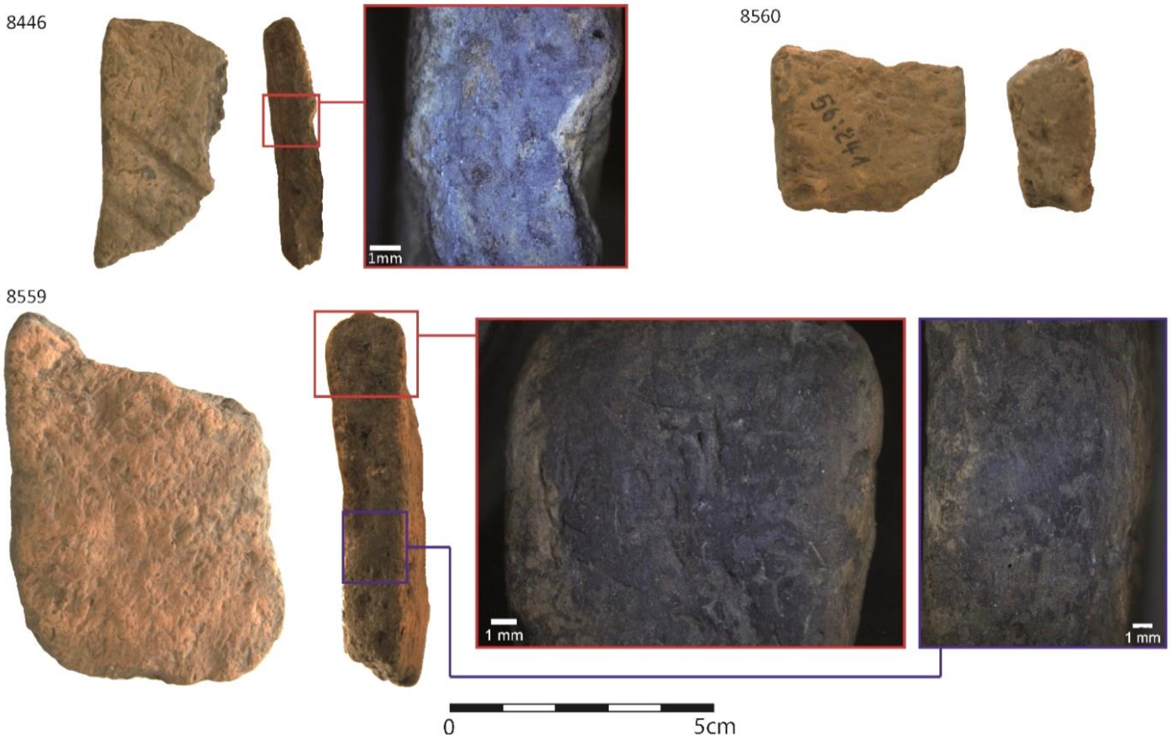


Figure 8.53: Category A fragments at WLH1 (zone A) at Eitzum.

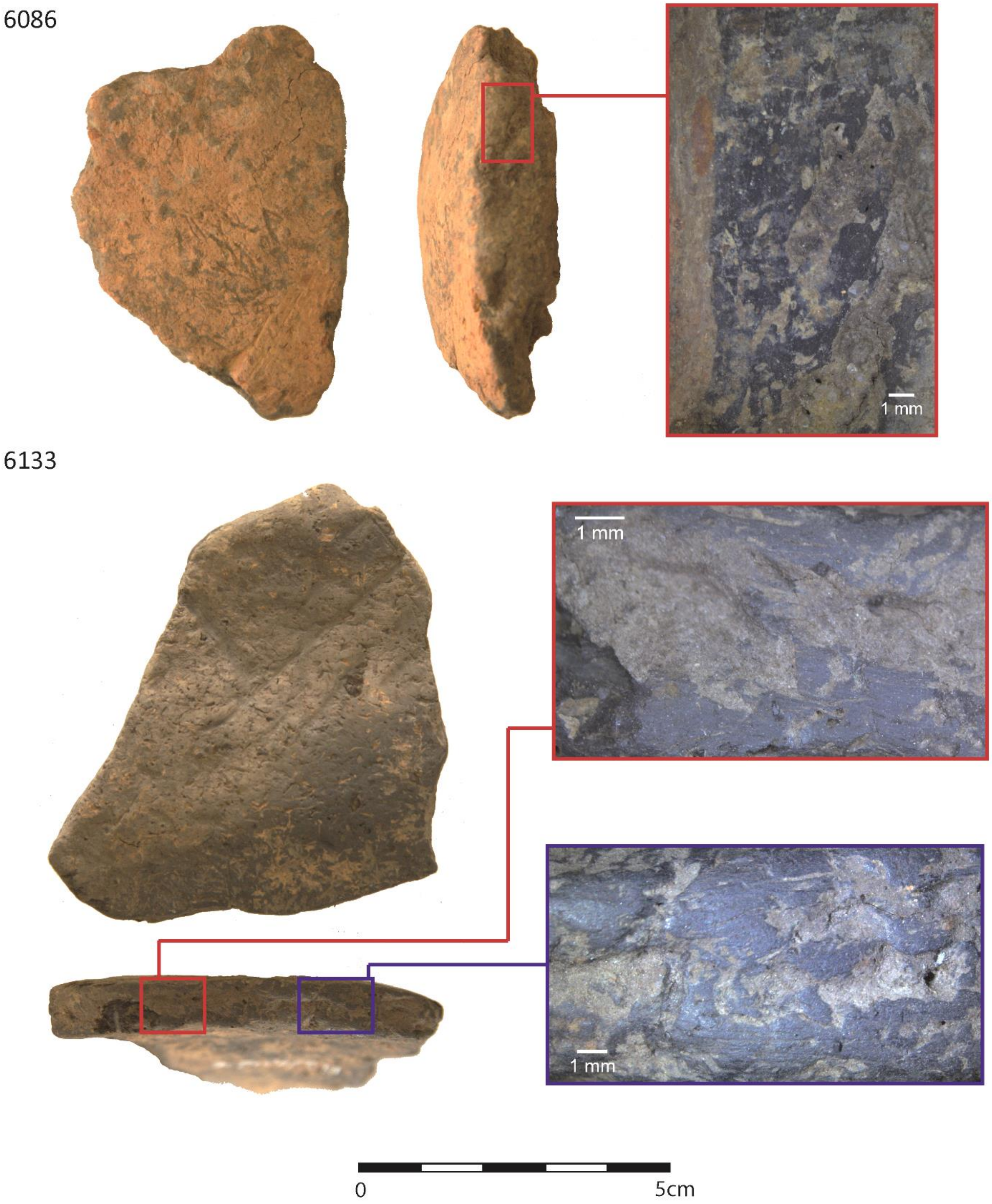


Figure 8.54: Other pottery smoothers found in different contexts at Eitzum.

Other fragments (6086 from an unknown feature and 6133 from feature 10 in zone D, and 8560 from WLH1 in zone A) were probably used as smoothers on leather-hard or even already dry pots but were used in different directions. Fragments 6086 and 6133 possess a very clear boundary between worn and unworn areas in their fracture surface and a straight section (Figure 8.54). While the former showed striations running perpendicular to vessel wall (red box in Figure 8.54), in the latter striations ran in opposite direction, *i.e.* parallel to vessel wall (blue box in Figure 8.54). Fragment 8560 differs in that its active surface was so worn out that the outline of between worn and unworn areas is unclear and no striations were visible (Figure 8.53).

Figure 8.55: Scraper fragments used in pottery manufacture found in different contexts at Eitzum.

8.2.3.3 Drilling: Category D

There was only a single perforated fragment present at Eitzum. The wear trace consisted of a through-hole with biconical section suggesting the sherd was drilled from both exterior and interior surfaces. Due to the size of the fragment and the location of the perforation in a marginal area of the sherd, it is likely this fragment was drilled for repair or was broken during manufacture of a tool. Some rotational striations visible on the perforation made from the exterior surface of the fragment, suggest the use of a lithic perforator. No trace of use was visible. The mismatch between perforations would suggest the specimen was drilled by hand.

Figure 8.56: Detail of sherd 6202 with two through-holes found in feature 7/zone D at Eitzum.

8.2.3.4 Grooving or cutting: Category J

Cutmarks were found on at least four fragments (Table 8.2). These short parallel cutmarks were found around the edges of the interior surfaces of fragments 7482, 8322, 8695, and 8980 (Figure 8.57), and in certain cases run deep into the sherd. It is possible that more fragments were cut in similar ways at Eitzum and even at Klein Denkte, but these traces were sometimes difficult to distinguish from the eroded elongated pores left by the burnt fibres composing these ceramics. As these grooves are located at the edges of the interior surface and in occasions extending to the fracture surface of fragments, this rules out the possibility of these traces being the result of the manufacture or use of the parent vessels (*i.e*. before primary rupture).

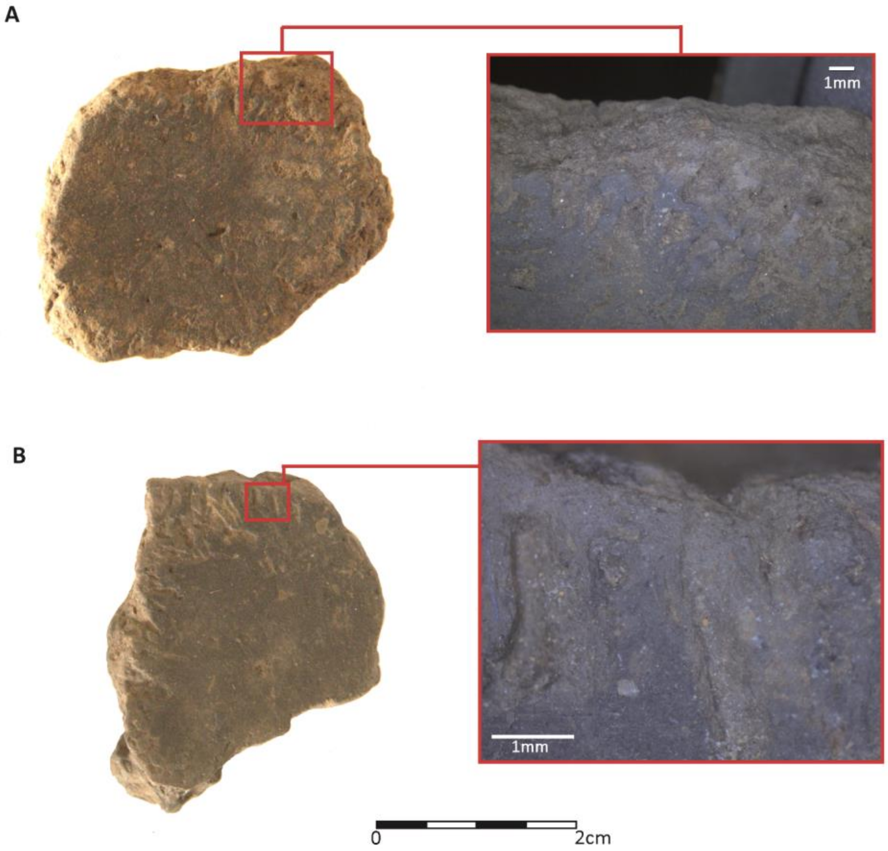


Figure 8.57: Cutmarks on fragments 7482 and 8695.

8.2.3.5 Refiring: Category U

Five fragments bore traces of refiring, all were identified by their colour change. Only one fragment (7570) had extensive colour changes by fire, showing some possibility of use as a heat retainer, support, or cover in firing processes. Thus, there is little evidence suggesting the use of potsherds as heat retainers, supports or covers in fires.

Figure 8.58: Fragment 7570 with signs of refiring.

8.2.3.6 Summary and discussion of results from Eitzum

At Eitzum, worn fragments do not appear to be signaling specific activity areas, as was seen in the previous sites, as used fragments appear in a great variety of locations. Scraping was the most common use of sherds. Scrapers were worked mostly soft materials like wet clay, and their wear traces suggest two ways of use. A first way of use was by moving scrapers along the entire curved surface of pots. This tended to produce round sections on fragments and on occasion some striations running perpendicular to vessel wall (Figure 8.59, wet clay ‘a’). Examples of this type of use include fragments 8559 and 7003. A second way of using scrapers was at a sharp angle to the worked surface, such as in drawing up clays during forming stages in pottery manufacturing (Figure 8.59, wet clay ‘b’). This use tended to affect only the interstices between exterior or interior and fracture surfaces of the worn fragments. Fragments 6409 and 8446, show clear examples of this process.

Another common use for potsherds was smoothing clays during surface finishing stages in pottery manufacture, which means fragments were worked against clays in leather-hard or completely dry state. As for the scrapers, two different ways of smoothing were identified. A first one consisted of placing fracture surface of the potsherd at a right angle against the pot, and then moving it either parallel or perpendicular to the sherd’s wall (Figure 8.59, dry clay ‘b’ and ‘c’). Sherds 6086, 6133, and 8560 show wear traces consistent with these gestures. A second type of smoothing technique involved pressing the curved exterior surface of the fragment against the clay, and then sliding the sherd in two directions (Figure 8.59, dry clay ‘a’). Fragment 8002 was the only evidence of this type of smoothing technique.

Rounded sherds are also frequent, and one potential use is a support for rotating vessels during pottery manufacture (Figure 8.59, wet clay ‘c’). This interpretation fits well with the attributes of fragment 7546 but does not explain use of fragments 7100 and 8734, which is difficult to discern. Another use given to sherds at Etzum were as supports for cutting, as seen in Early Neolithic Karanovo sherds (Vieugué 2014, 107–109); however, the specific activities are hard to unravel. There was only one case of a sherd maybe being used as a heat retainer or as a cover during firing processes but interpreting its uses without any nearby firing or heating structures is a difficult task.

A single case of drilling was identified at the site, and it would seem to be repair related. This could suggest that drilling was not frequent or perhaps a repair method was devised not involving perforations. Repair holes do seem to occur at other äLBK sites (as mentioned below). Only sherds from categories D, K and L were shaped for use, which suggests that the great majority of fragments were probably used in the shape they were picked up.

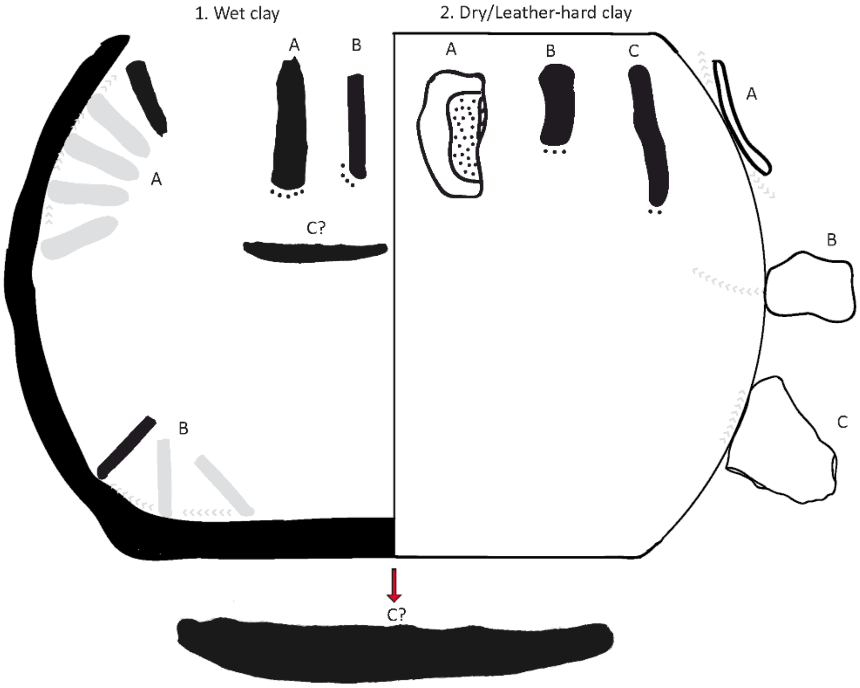


Figure 8.59: Summary of the different sherds used during pottery manufacture at Eitzum.

8.3 Discussion

Before moving on to discussing results, a few limitations of the study must be articulated. There are limitations on the use of photogrammetry for creating three-dimensional models and then extracting information from these models. An important one is the preservation of fragments. Concretions or postdepositional formation of calcium carbonate or post-drilling wear produced on the surface of ceramics can create problems. This was particularly the case with fragment 10853 at Méhtelek-Nádas. Nonetheless, these postdepositional traces were carefully monitored to avoid drawing the wrong conclusions. Secondly, there is an important difference between archaeological and experimental samples, as the preservation conditions creates some problems, which is why I have selected different diagnostic parameters. In the microscopic examination of wear, the soapy texture of LBK sherds in NHF and general abrasion of fragments by washing in UTB sites made the identification of worn sherds difficult. For this reason, I have been cautious with my sampling strategy, and have only selected fragments where this was not considered problematic. Thus, the number of fragments presented in this chapter is most likely an underrepresentation of worn fragments in these sites. For example, the only diagnostic trait on hide scrapers that has been documented in the literature is the distinctive glossy polish that is formed on the active surface

(Shamanaev 2001, 145; Vieugué 2015, Table 3), and due to the washing these are rarely preserved. Lastly, due to the embryonic state of use-wear studies of potsherds, there is an undeniable bias at the moment towards potting activities. Possibly there is an underrepresentation of other activities or that similar traces can be left by other activities. For instance, it is possible sherds were being used for processing food or in cooking (apart from the ones detected in this chapter), but there are no studies yet.

Despite these caveats, microphotogrammetry techniques have allowed the visualization and quick measurement of distinct features created by drilling mechanisms, which would have been impossible by simple visual inspection. The tests provide a strong basis for further work on any kind of perforation in ceramics. The two main results included the distinction of tools with rough surface texture, such as flint, limnic quartzite and obsidian, from perforators with a smooth texture, like antler or steel. There is also potential for singling out obsidian perforators, but further work is required. The second important finding from these tests was the identification of distinctive traces from different drilling methods. Several parameters like the regularly spaced ring patterns showed by rotational striations, the stability of the central axis and the consistent circular shape of the perforation according to depth were identified.

Moving on to the archaeological material, the sites from the Upper Tisa/Tisza Basin showed a rich repertoire of reused sherds and repair strategies. At Tășnad Sere, there was evidence of reuse of sherds for scraping and smoothing clay in different ways and at various stages of pottery manufacture. Reused sherds for potting were found mostly in workshop/storage and household areas, and less in adjacent pits. We have also found some *tentative* evidence of the reuse of potsherds in cooking activities or for heating houses, as was shown with lids, supports and heat-retainers, which are linked to either ovens or hearths. While only a single instance of repair by drilling was observed, it was also an example of use of fragments. This last fragment links to the use of sherds as spindle whorls, which appears to be a common occurrence in SKC sites like Becsehely I (Kalicz 1990, Plate 45, 1), Ghiroc "Balastiera Vest" (Sava *et al.* 2015, Plate 23, 13), Gura Baciului (Lazarovici and Maxim 1995, Figure 30 and 31), Lánycsók-Bácsfapuszta (Kalicz 1990, Plate 17, 7), Szarvas site 8/56 (Makkay and Starnini 2008, Figure 358, 17 and 18), Tiszacsege (*Idem*., Figure 366, 2-6), and Turia-“La Silozuri” (Ciută 1997, Plate VI, 6 and 7). At Méhtelek-Nádas, fragments seem to also be shaped for personal adornments either as part of necklaces, bracelets or maybe earrings or ear expanders.

The material from Méhtelek-Nádas helps to fill in the picture of mending or repair of pottery vessels. Repair observed at this site suggests there is a general cookbook for how to do this, but that individual decisions needed to be made on the spot as well. So, while drilling, the possible addition of an adhesive, and strapping holes with fibres was a common process, these were tailored to how the vessel had broken. If the pot was cracked, hand-drilling might have been the better choice, as making the perforation from the inside could not be done by using rod-drills. In contrast, if the pot had fractured, drilling with the use of a support on at least one of the sides of the fragment is easier and more accurate for matching perforations from both sides of the fragments' surfaces. More work needs to be performed on the grooves that could indicate how the holes were then strapped. Another very different type of repair was observed in Tășnad Sere by applying wet clay to a cracked formed on a vessel when drying. This type of repair was also recorded in a pot found in the so-called sacrificial pit 4 at Endrőd 119. Makkay (1992, 140) describes the pot was likely cracked during drying stages, and the potter had attempted to mend this by filling the cracks with wet clay (Figure 8.60). Thus, in SKC sites there are several types of repair tailored to the specific scenario of breakage. This illustrates the point made in Chapter 2, on how breakage happens at any time.

[redacted]

Figure 8.60: A pot repaired during drying and then fired. The pot was retrieved from sacrificial pit 4 in Endrőd 119 (Makkay 1992, Plate 17,2 and Plate 25, 1).

The äLBK site of Eitzum in the Northern Harz Foreland showed use of fragments mostly for pottery manufacture, and only one possible repair attempt. Scraping and smoothing appear to be almost identical in both regions. Unfortunately, the distribution of these reused sherds cannot be fully compared to sites from the UTB, as all material comes from pits. Contrary to the evidence from SKC sites studied, it would appear these activities were performed mostly outdoors, but this assertion should be taken with caution considering the poorly preserved occupation layers in LBK sites.

A clear difference between Eitzum and the SKC sites analysed is the fire management, and the place of sherds in these processes. There was only one sherd displaying evidence of use in a firing structure (*e.g.* hearth, oven or bonfire), suggesting this was not a common use for sherds in daily fires. However, this could be due to preservation as well, as features indicating firing processes like hearths are rarely found at LBK sites. An exception is the äLBK House XVII at the multiperiod site of Rosdorf-Mühlengrund, which showed high concentrations of charred grains in the central portions of the house (Kirleis and Willerding 2008, 143). There is also a rare example from later LBK site of Klein-Auheim where hearths have been preserved inside and outside houses (Sommer 2006). However, there are no refired sherds found at this site. Ovens, however, have been found in several LBK sites, and potsherds are sometimes found accompanying them (Bernhardt 1986; Boelicke 1988; Kaufmann and Heege 1991; Lenneis 1995, 18; Modderman 1988, 104; Petrasch 1986; Tichý 1962). For example, sherds and groundstones at Mohelnice were found as part of the ground surface or 'pavement' of ovens (Thér *et al.* 2019, 1146). At Borovce several ovens were documented and potsherds were found inside at least one of them (Staššíková-Štukovská 2002). Thus, there is evidence that sherds occupied some role in firing processes, but perhaps their use was more restricted than in the SKC, where they seem ubiquitous.

Another difference with the SKC sites analysed from the UTB was the presence of cutmarks on the edges of fragments, which perhaps signal their use as supports for cutting other materials. To my knowledge, this type of trace has not been recorded in LBK sites before, and so more work is required. Grooving on the surfaces of fragments have been studied at the Early Neolithic site of Kovačevo (Bulgaria), and their traces also appear to be the unintended outcome of processing some other unknown material (Vieugué 2014, 108).

Figure 8.61: Three-dimensional model of an LBK pot from Eythra dated to 5196 ± 10 BC repaired with birch bark tar (©Landesamt für Archäologie Sachsen / T. Reuter and R. Elburg).

Unfortunately, evidence of repair is scant at Eitzum, with only one perforated fragment, and without a 3D model to reconstruct the drilling process and draw a comparison. Yet, it seems perforations were done in the same sequence from the interior surface of fragments and then from the exterior. It would be easy to conclude that repair was not all that common in äLBK sites, with some sporadic evidence observed at Schwanfeld (Cladders 2001, Plate 48, 3-5). However, the astonishing finds in later LBK wells, such as in Eythra and Altscherbitz, should make us reconsider this statement, as in these sites the refitting of pots with birch bark was apparently the preferred method of repair, most often without use of repair holes (Elburg 2015, 240; Figure 8.61). In many cases birch bark pitch completely covers pots including repair holes, and a complete redecoration is made (see Einicke 2014 for a comprehensive review). While this evidence stems from younger/youngest LBK sites, where these types of repair appear more common (Einicke 2014, 164), birch bark could have been used for repair in the earliest LBK, as processing of this adhesive has been recently documented in the Early LBK site of Brunn am Gebirge on Lower Austria (Puchinger *et al.* 2019). Another possibility is that repair was a practice restricted to water carrying vessels, or perhaps that well deposits consist of structured deposits (in the sense of 'ritual'), as suggested by one of the excavators (Elburg 2010, 6), where unique or personally important vessels were deposited. Whatever the reason, repair holes are undoubtedly more frequent in SKC pottery, suggesting this was an essential part of the repair process. Therefore, there is likely a difference in repair methods chosen by social groups in these two regions.

Lastly, we have seen from both SKC and LBK sites analysed, that most used fragments do not go through a 'manufacturing phase' *per se*. This was particularly clear for scrapers and smoothers used in potting activities, which appear to have been used as they were picked up. Therefore, since there is no production process, they cannot be considered tools *sensu stricto*, as defined in section 2.2.1. For this reason, a large part of section 10.1.3 discusses these objects and all their implications for our understanding of Early Neolithic societies' social knowledge of breakage. For now, we can state that an important implication of these objects, is that they indicate the awareness of SKC and LBK populations of the surrounding broken cultural material. A last fascinating point to highlight, is that LBK and SKC scrapers and smoothers in most cases were extensively used, which could suggest that these objects were passed through by several generations. Some potters in Falémé valley in eastern Senegal inherit reused sherds from their parents (Julien Vieugué, personal communication 2019). However, while it is tempting to consider these as transgenerational objects, there is still much work to be done in the study of potsherd wear to corroborate this interpretation further.

Chapter 9. Thermal shock resilience and strength test results

This chapter constitutes the last part of my results section, where the main results of the materials science testing methods are presented. The chapter is divided into three sections, starting with the presentation of results of the characterisation of Early Neolithic cooking activities. The next section presents and discusses the main results from thermal shock resilience and strength tests of experimental ceramic discs. The limitations of these tests and future line of work are presented in the following section. The chapter ends with some concluding remarks regarding my main research questions.

9.1 Preliminary characterisation of cooking activities

An important part of the experiment design was determining how Early Neolithic cooking activities could have taken place. For this task, I used the most well-preserved pottery bases available, which were the SKC vessels from C2/2005 Tăşnad Sere and the LBK ceramics from Eitzum, and determined how the vessels might have been positioned in hearths during cooking or other activities requiring heating (*e.g.* production of birch bark tar). This was accomplished by the examination of sooting patterns. In second place, I sampled hearth fragments from C2/2005 and UCLT1 (Tăşnad Sere) for powdered X-Ray Diffraction (pXRD) and thin-section analysis, in order to estimate cooking temperatures.

9.1.1 Sooting patterns

As shown in ethnoarchaeological studies (Longacre 1981; Skibo 1992; 2013), the adherence of soot to pottery vessels is a common occurrence in open hearth cooking, and sooting patterns produced are indicative of how pots were positioned on hearths or fires. Unless there is evidence of long-term exposure to fire, sooting patterns on the exterior surface of pots from cooking activities mostly reflect the last episode of exposure to fire (Skibo 2013, 92). Thus, while some patterns can be ascribed to vessel firing during manufacture, soot is mostly related to the use of vessels.

Soot and burnt patterns were identified on pot bases from Eitzum and Tăşnad Sere, signalling how they might have been positioned on fires (Figure 9.1 and 9.2). Given the predominance of small and medium-sized pots in both sites (see sections 7.2.1.1 and 7.2.4.1), it was unsurprising that soot and other (re)firing traces were mostly found in vessel of these sizes. Of note in C2/2005 was that most of these small and medium vessels with soot or traces of refiring had pedestals. It is difficult, however, to assess quantitatively how much of the ceramic assemblage was involved in cooking, as these correspond to almost ten percent of pedestalled bowls and pots were found with some indication of being exposed to fire. This is partly because the clayey soil matrix tends to erode the surfaces of pots throughout the site (section 5.1.4.1.1), affecting the preservation of soot, and so any estimation would be inaccurate. For instance, there were cases where carbonised remains were found inside pots but no soot nor burning patterns preserved on the pots' exterior surface. At Eitzum, in contrast, all the vessels with signs of being used for cooking or heating food and other substances were medium-sized globular vessels. Furthermore, from the 38 most refitted vessel bases in the site, at least twelve show signs of having been exposed to fire during their use, which gives us an idea of how common this practice was in this LBK settlement.

With regards to the soot and burning patterns identified at these sites, most base fragments had faded white to grey oxidised patches in the central parts of bases and black soot in their margins (Figure 9.1, 1-3; Figure 9.2, 2-3). Nonetheless, some pottery fragments had black sooted and burnt areas on their walls (Figure 9.1, 5; Figure 9.2, 1, 4-5). Most of these patterns can be explained by the pot being located slightly over the fire rather than put directly into it (Rice 1987, 235). Thus, several materials could have been used to hold pots slightly above fires, like pedestals from broken pots (as suggested in section 8.2.1.1.4) or rocks of different sizes. For example, a completely sooted pot at Eitzum had an unburnt area, indicating the use of some support to hold the vessel in place at a fire (Figure 9.2, 1). Sooting and burning patterns suggest that pots were probably elevated over fires in some way. Furthermore, some vessels appear to be heated exclusively on their bases while others were heated sideways. The patterns on pedestalled pots are different, as burnt areas appeared distributed uniformly (Figure 9.1, 4). Maybe these vessels did not require any supports and were put directly into the fire.

Figure 9.1: SKC sooted pottery bases from C2/2005 at Tăşnad Sere.

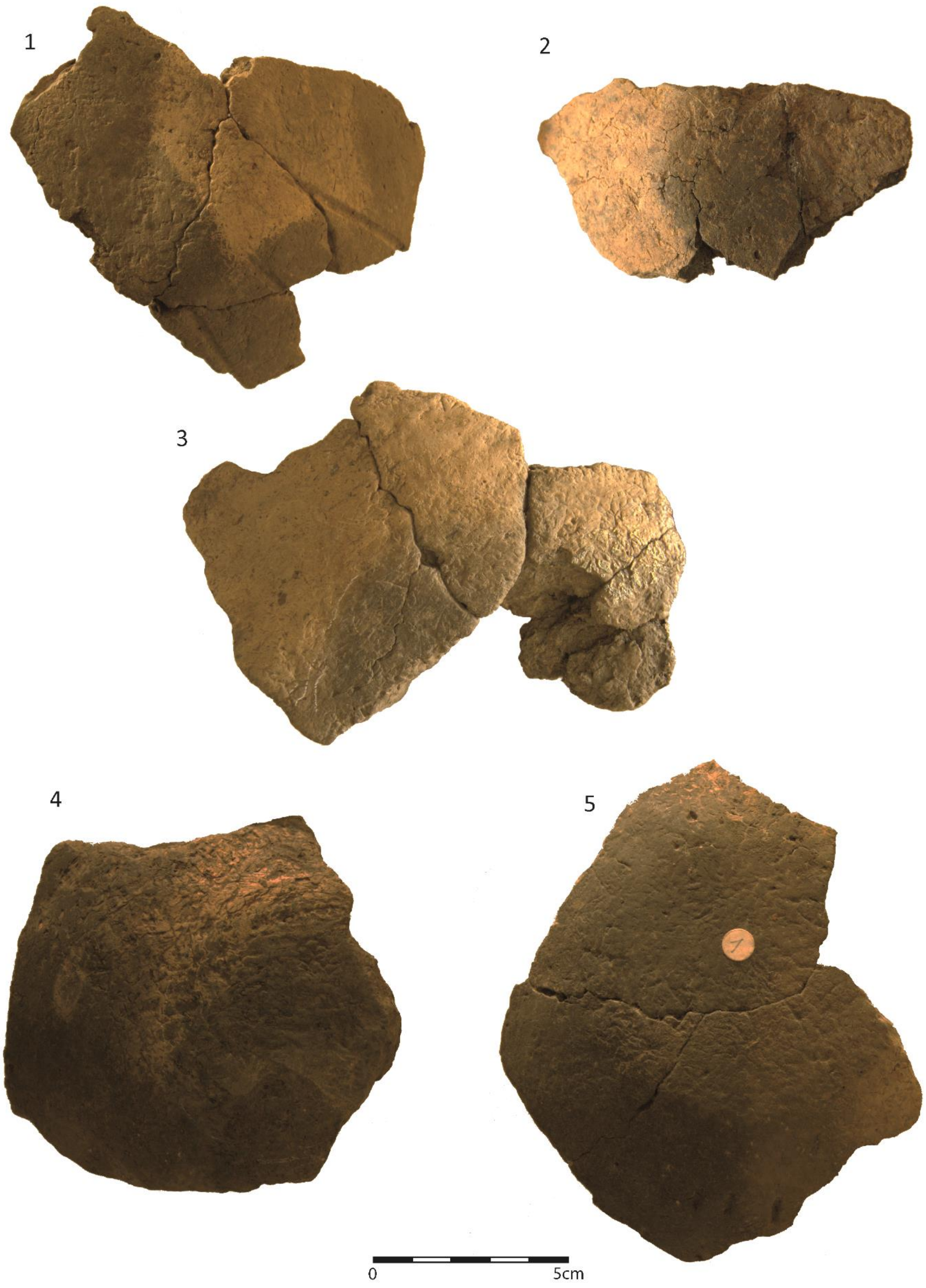


Figure 9.2: LBK sooted pottery bases at Eitzum.

9.1.2 Temperature estimations

Three hearth fragments were sampled from trench UCLT1 with ID code TS1, TS2, and TS3, and one from C2/2005, sample ID TS4. PXRD was conducted using a Rigaku MiniFlex 600 Benchtop X-ray Diffraction System with copper-K-alpha radiation (λ = 1.54059 Å) functioning at 40kV and

15mA. Patterns were obtained in the range of angles between 5-90° in 2θ and using 0.02° of step size. This data was then analysed using Match! Software version 3.11.1.183. The X-ray diffraction curves were obtained from the three fragments retrieved from UCLT1 (*i.e.* TS1, TS2 and TS3), which show extremely similar results (Figure 9.3). For this reason, these patterns are described as a group.

Three mineral components were identified: quartz (COD 7103014), heat-treated low albite (ICSD 87660), muscovite (COD 9016477), and illite (COD 9009665). Quartz can be commonly found in clays fired at low and high temperatures and does not provide any information in terms of temperature estimation. Low albite is a plagioclase feldspar, and in the specific XRD pattern detected the mineral was heat treated (Meneghinello *et al.* 1999, 1145). This match provides some indication that the temperatures reached were at least not lower than 700°C, which is when low albite begins to melt (with some variation depending on specific heating and pressure conditions, see Goldsmith and Jenkins 1985). Lastly, illite is a type of clay minerals, commonly derived from the weathering of muscovite mica. The temperature at which illite degrades can be highly dependent on the type of mineral mixture (Aras 2004). In a XRD study on loam samples from Satu Mare county (Romania), where Tășnad Sere site is located, illite remained stable only until 750°C, after which it started degrading (Nagy *et al.* 2015, 27). Considering these results, the temperatures according to pXRD analysis can be estimated around 700-750°C.

Thin sections of hearth fragments TS1 and TS4 gave more indication of the maximum temperature range at which the hearth was heated. In both samples, the clay matrix was optically active, in other words the clay minerals exhibit extinction when rotated under cross-polarised light (XP). Below 850°C clay minerals are anisotropic and display this property (Whitbread 1995, 394; Rice 1987, 431), but above this temperature they vitrify and become optically inactive. Amphiboles were identified in all three samples, mostly green in XP. However, in areas of the thin sections closer to the hearth's surface amphiboles exhibited a reddish colouration. Amphiboles, such as hornblende, start breaking down just over 700°C at the lowest due to iron oxidation (Quinn 2013, 191; Spear 1981), which indicates some areas of the heart must have reached this temperature. Melted plagioclase feldspars were also present. If we consider the type of plagioclase identified through pXRD was low albite, this indicates temperatures must have reached at least 700-750°C. In short, the thin-section analysis provided estimation of temperatures between 700-850°C.

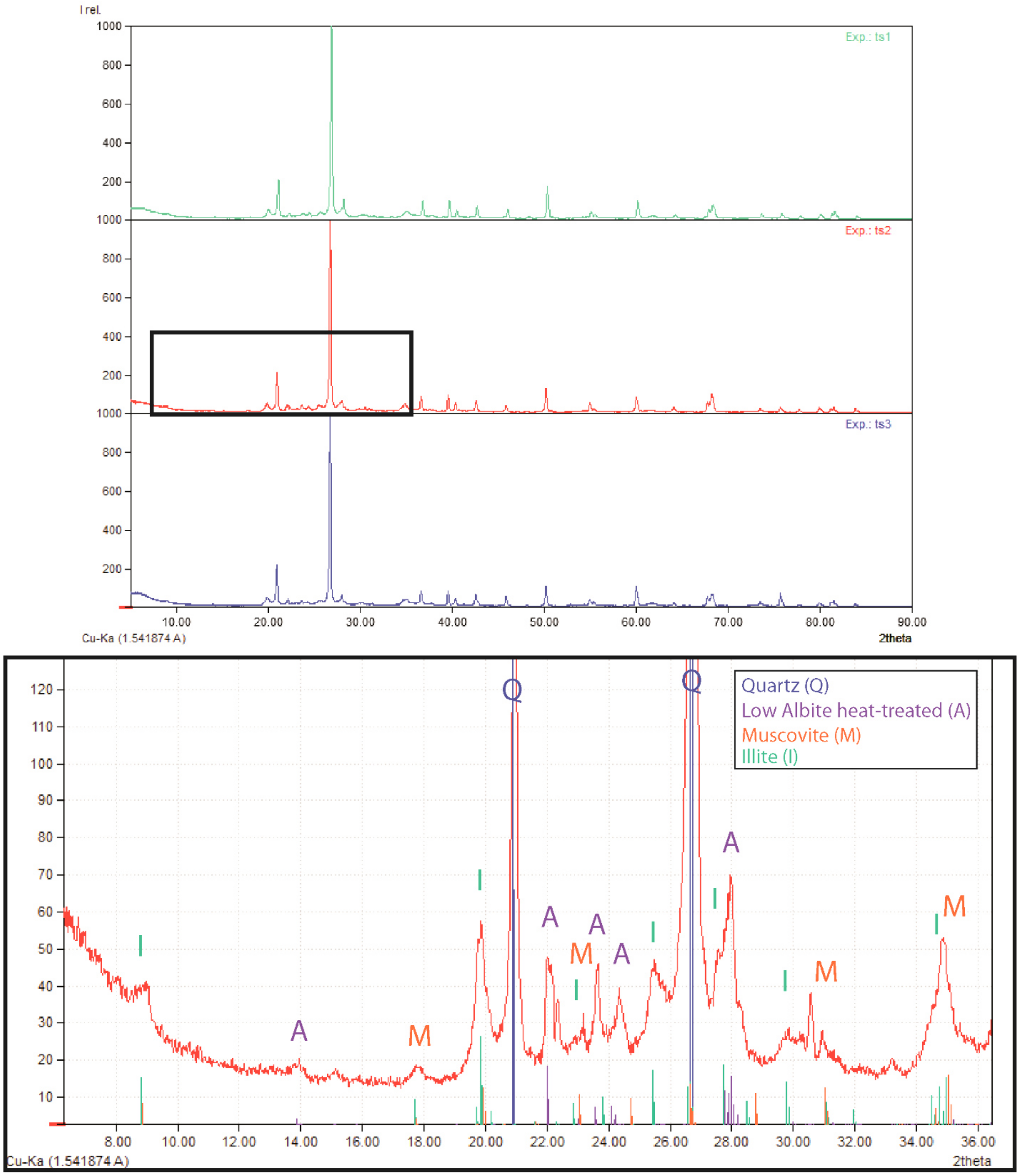


Figure 9.3: Results from pXRD of hearth fragments TS1, TS2 and TS3 from UCLT1 at Tăşnad Sere.

In sum, according to pXRD and thin section analysis of hearth fragments, the maximum temperatures reached in the fragments of hearth sampled were likely around 700-750°C. This is consistent with experiments on daub fragments. In order for these fired clays to preserve, temperatures must at least reach 700°C (Leineweber 1999, 37; Strutzberg 2004 in Carneiro and Mateiciucová 2007). Nonetheless, a few clarifications must be made. In contrast to the pXRD samples, the thin sections cut through all areas of the hearth fragments, and thus provide more information on the mineralogy of the entire fragment. This can explain why amphiboles were not identified in the pXRD samples. Estimated temperatures of course do not indicate the actual cooking temperatures but provide a maximum temperature which clay minerals were exposed to. As shown in experimental and ethnographic cooking scenarios (Duričić 2014, 269; Gur-Arieh *et al.* 2013, 4338; Portillo *et al.* 2017, 141), fires created in preparation for cooking activities can reach up to 600/700°C near the fuel source. Temperatures would not be the same in all areas of the hearth. Lastly, it is important to note that this was not a systematic study on the Neolithic uses of hearths and was only performed to inform the thermal shock experiment design. Nonetheless, the information obtained also helps assess the possibility of the use of sherds in hearths discussed in the previous chapter (section 8.2.1.4).

9.2 Thermal shock experiments

In accordance with these estimated temperatures, thermal shock cycles with our heat apparatus reached an average maximum temperature of 721°C. For the shocking to not be too extreme during the cooling stage, temperatures on average did not go below 300°C until a thousand cycles were completed. In other words, the temperature shock was on average around 420°C (Figure 9.4; section 6.3.2.3).

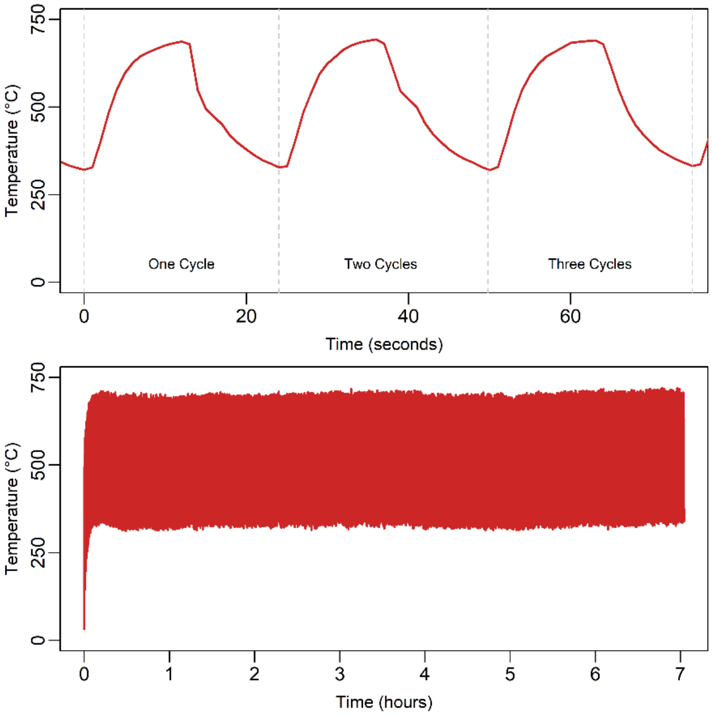


Figure 9.4: Temperature curves of untempered coiled specimen recorded for three cycles at the 300th minute (top) and 1000 cycles (bottom) during thermal shock experiments.

At a thousand cycles, the untempered coiled (specimen 22), chaff-tempered coiled (specimen 61) and both pinched and coiled dung-tempered (specimen 70 and 73) samples had developed radial cracks, which were the result of the tension between the expansion of the centre of the specimen and the much cooler periphery. At two thousand cycles, none of the specimens had failed or fractured, but all except the untempered pinched specimen displayed radial cracks that extended from the edges to the centre of the discs (Figure 9.5).

Figure 9.5: Cracks from the different specimen after 2000 cycles (photographs by Adam Wojcik): untempered coiled (a), chaff-tempered pinched (b), chaff-tempered coiled (c), dung-tempered pinched (d) and dung-tempered coiled (e).

Disc ID	Parameter	Crack length (mm)		Tortuosity
		1000 cycles	2000 cycles	
1	Untempered pinched	0	0	0
22	Untempered coiled	17.54	25.62	1.24
47	Chaff-tempered pinched	0	15.58	1.27
61	Chaff-tempered coiled	15.15	17.26	1.31
70	Dung-tempered pinched	21.57	22.28	1.35
73	Dung-tempered coiled	28.77	28.77	1.27

Table 9.1: Summary of data from thermal shock tests.

Since none of the specimens failed, crack length and crack path tortuosity are the other estimations of resilience to thermal shock (section 6.3.1.4). Measurements of the longest crack show that coiled specimens were more affected by thermal shock than pinched discs, regardless of composition (Figure 9.6 and Table 9.1). Untempered and dung-tempered coiled specimens exhibited the longest cracks. According to crack length measurements, the parameters that would arguably be most resilient to thermal shock are pinching with untempered clays, as no cracks were developed in these specimens.

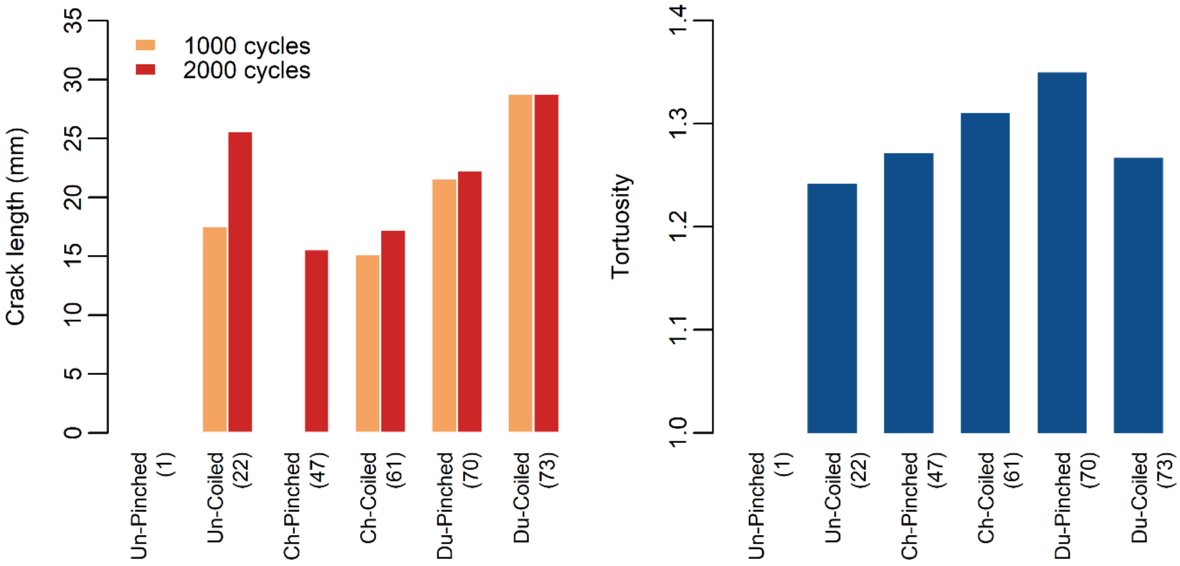


Figure 9.6: Crack length measurements on specimens after 1k and 2k cycles of thermal shock. Un = untempered, Ch = chaff, Du = dung.

However, this is only half the picture, as measurements of crack growth and crack path tortuosity give us other cues regarding thermal shock resilience. As seen in Figure 9.7, crack growth was observed in specimens that had cracked at 1000k, *i.e.* untempered pinched (disc 22), coiled chaff (dic 61), pinched dung (disc 70), and coiled dung (disc 73). There is significant crack growth in the untempered disc (22), while organic-tempered specimens display a very low (61 and 70) or even no increase (73) in crack length. These differences show that crack growth was more stable in organic-tempered specimens. Crack path tortuosity calculations, as a measure of energy dissipation (Figure 9.67 section 6.3.1.4), highlight that coiled chaff and pinched dung specimens developed the most tortuous cracks. More tortuous crack paths induced by fibres indicate that these materials are tougher, as the energy needed for crack propagation is much higher. Considering energy dissipating mechanisms, it appears that chaff-tempered coiled and dung-tempered pinched specimens would be the most resilient to thermal shock.

Cracks in Figure 9.7 show differences in how cracks propagated in these specimens. There is some directional change in crack paths on coiled specimens due to the weak interface between coils, but this only appears to be significant in chaff coiled discs (Figure 9.7c). A first energy dissipation mechanism observed was crack tip deflection (Figure 9.7b and e). In contrast to the cracked untempered specimen (Figure 9.7a), the fibres in the dung-tempered disc seem to divert crack paths (Figure 9.7b). This was also observed in sample 47, *i.e*. the chaff-tempered pinched specimen (Figure 9.7e). Micro-cracking is another potential energy dissipating mechanism observed (Kreher and Pompe 1981, 701), where cracks pre-existing loading conditions redirect macrocracks. While technically not small enough to be considered ‘micro’-cracks, some cracks developed in specimen 61 at a thousand cycles seem to have worked in this way when reheated for two thousand cycles (Figure 9.7c and d). This mechanism could also explain the highly tortuous path of its longest crack. Lastly, recolouration of the central area of specimen 73 shows how secondary firing occurs on ceramics with a prolonged exposure to thermal stresses (Figure 9.7f). The recolouration occurred within the first 1000 cycles, and it is restricted to the area directly exposed to the light beam.

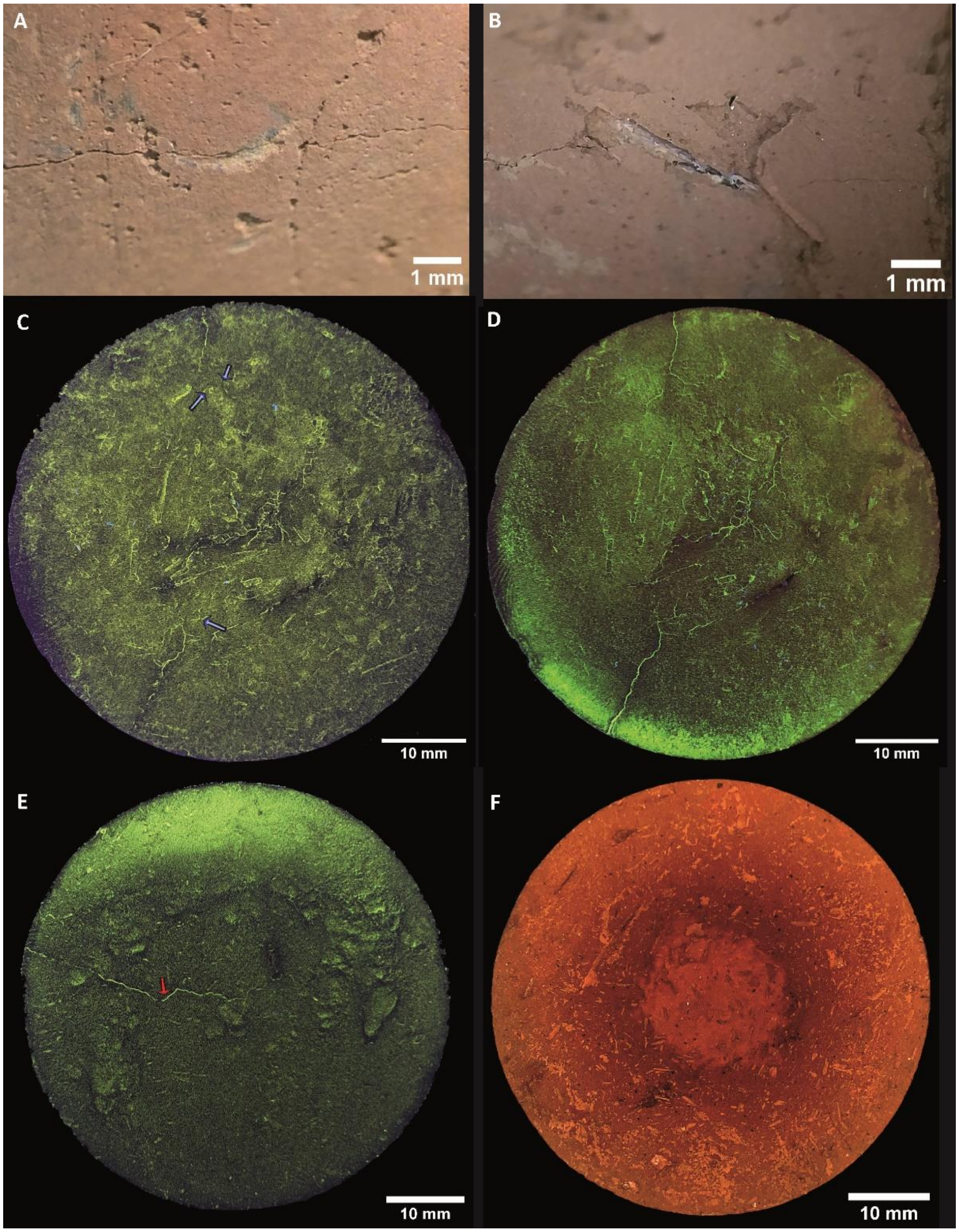


Figure 9.7: Traces of energy dissipating mechanisms and recolouration on organic-tempered fragments submitted to thermal shock: detail of untempered (a) and dung-tempered (b) cracks after 1k cycles, chaff-tempered coiled specimen at 1k (c) and 2k (d) cycles, example of crack deflection on chaff-tempered pinched specimen at 1k cycles (e), and detail of colour change by secondary firing on specimen 73 (f). Red arrows indicate crack deflection, and blue arrows highlight evidence of microcracking mechanisms.

9.2.1 Discussion

Thermal shock would seem to be a favourable condition for crack growth. Results are not entirely comparable to other studies (*e.g.* Müller *et al.* 2014; Skibo *et al.* 1989; West 1992), as thermal shock was much less severe and estimations of thermal shock resilience were conducted through different parameters. The heat apparatus is applied in a non-uniform way at a specific area, which would approximate cooking scenarios. We have also measured crack growth and crack path tortuosity for two thousand cycles– which provides a direct estimation of thermal shock behaviour of ceramics– and have directly observed energy dissipating mechanisms.

Because heating is restricted to the discs' centre, this central area expands and applies considerable stress on the discs' periphery. In order to relieve these stresses, the periphery progressively cracks towards the centre until conditions are stabilised and the cracks are arrested. It is possible that the specimens will not entirely fail if more cycles are performed, as crack propagation could be sufficient to relieve the thermal stresses. For example, the crack in specimen 73 may have already arrived at a stable state at a thousand cycles and did not continue propagating.

For organic temper, the hypothesis was that organic temper (chaff or dung) would divert cracks, and therefore increase the toughness of specimens, as more energy is required to propagate cracks (Tite *et al.* 2001, 304). High crack path tortuosity and stable crack growth of all organic-tempered specimens corroborate this hypothesis, which are evidence of toughening or energy dissipating mechanisms. The mechanisms observed included crack tip deflection and micro-cracking. Nonetheless, for pre-existing cracks or flaws, such as voids left by burnt organic material, to dissipate energy, these must be oriented in specific ways.

At the opposite end, the untempered pinched specimen also shows high thermal shock resilience, but not through toughening mechanisms. In this case, there is less chance for crack initiation because of the minimisation of flaws per volume and the lack of stresses resulting from the differential expansion of clay and other components like added temper, which makes the fabric resilient to thermal shock. However, once a crack would form in untempered specimens, these are severe and can quickly lead to failure, as was shown in crack growth changes of the untempered coiled specimen between 1-2k cycles of thermal shock. Another important variable to take into consideration is thermal conductivity. As the porosity of organic-tempered materials is higher than in untempered ones, it is likely that the thermal gradient, and thus the thermal stresses, are larger under thermal shock. This in turn would have required the material to create longer cracks to mitigate the stresses being applied.

Our initial hypothesis regarding the effects of coiling on thermal shock resilience was twofold: (i) in untempered specimens, joins between coils would provide more room for the heated clays to expand, preventing crack initiation; and (ii) in organic-tempered specimens coils would effectively increase the capacity of the material to withstand crack propagation by interfering with the radial crack path. Evidence so far seems to disprove our first hypothesis. In the untempered coiled specimen, a radial crack had initiated within the first thousand cycles of thermal shock, in contrast to the pinched disc. The results obtained regarding our second hypothesis are ambiguous. On the one hand, coiled chaff specimens showed more resilience to thermal shock through effective energy dissipating mechanisms like crack tip deflection. On the other hand, despite the lack of crack growth, the dung-tempered coiled specimen did not develop a high crack path tortuosity, which means that the coils did not toughen the material. Differences in temper size could explain the differences between coiled chaff and coiled dung. Fibres introduced in chaff specimens were slightly longer than in the dung, because of difficulties in sieving of wheat. Thus, it appears coils become effective energy dissipators when fibres are long and fine, because these tend to align along the interface between coils (as observed in radiographs), which toughens these areas of the discs. Further testing is required, and a plan to continue this work is given below. Other reasons for the ambiguous results may be that the thermal stresses were too severe, which did not provide the material with enough time to release stresses, or that the size of coils were too large for the size of the discs.

In sum, two types of thermal shock behaviour could be determined from replicas of Early Neolithic ceramics. Not adding temper and making bases by pinching a large lump of clay could make pots highly resilient to failure from thermal shock. In stark contrast, the addition of fine organic temper to bases, as seen in the pinched dung specimen, makes the pot resilient by allowing stresses to be relieved through crack tip deflection. Similarly, the coiling of longer chaff fibres to make pottery bases could potentially add another dimension to this type of behaviour, as tortuosity of crack path shows these can be quite a resilient ceramic composite through microcracking, but further testing would be required to substantiate this claim.

9.3 Flexural strength tests (three-point-bend)

Load-displacement curves in Figure 9.8, illustrate that the dung-tempered pinched specimens consistently reached a higher critical load than all the other parameters. Some residual strength was also observed in at least two chaff-tempered specimens: 51 (pinched) and 62 (coiled). The final calculations for flexural strength are presented in Figure 9.9 and Table 9.2. Pinched or pressed specimens corroborate that the addition of organic matter can improve the flexural strength of the ceramic, although in chaff-tempered specimens the difference is almost negligible. In coiled specimens, however, the addition of organic temper appears to be detrimental for flexural strength. When we compare our results with the literature, there is a clear contrast. Published results indicate the addition of temper reduces the flexural strength of specimens (Figure 9.10), while our results show dung-tempered pinched specimens are among the strongest specimens.

The Weibull modulus normally requires around 20 or 30 specimens to be tested per parameter. However, the modulus does provide us with an idea of the distribution of flaws in the different materials. Values highlight the more consistent distribution of weak areas in dung-tempered specimens, while the difference between chaff-tempered and untempered specimens is negligible (Figure 9.9).

Specimen ID	Parameter	Maximum load (N)	Flexural strength (MPa)	Weibull modulus
9	Untempered pinched	1928.17	10.14	1.32
11	Untempered pinched	395.17	2.82	
12	Untempered pinched	614.75	4.23	
13	Untempered coiled	1447.42	9.87	2.44
16	Untempered coiled	693.25	5.55	
18	Untempered coiled	745.17	5.18	
43	Chaff-tempered pinched	896.50	6.48	2.46
51	Chaff-tempered pinched	453.25	3.30	
52	Chaff-tempered pinched	1075.75	6.84	
55	Chaff-tempered coiled	572.58	3.65	3.58
58	Chaff-tempered coiled	730.58	5.76	
62	Chaff-tempered coiled	387.33	2.90	
63	Dung-tempered pinched	1093.92	8.76	5.52
64	Dung-tempered pinched	1039.92	7.38	
65	Dung-tempered pinched	1463.08	8.72	
77	Dung-tempered coiled	686.25	5.44	5.54
78	Dung-tempered coiled	526.83	4.03	
80	Dung-tempered coiled	791.45	5.93	

Table 9.2: Results from flexural strength tests.

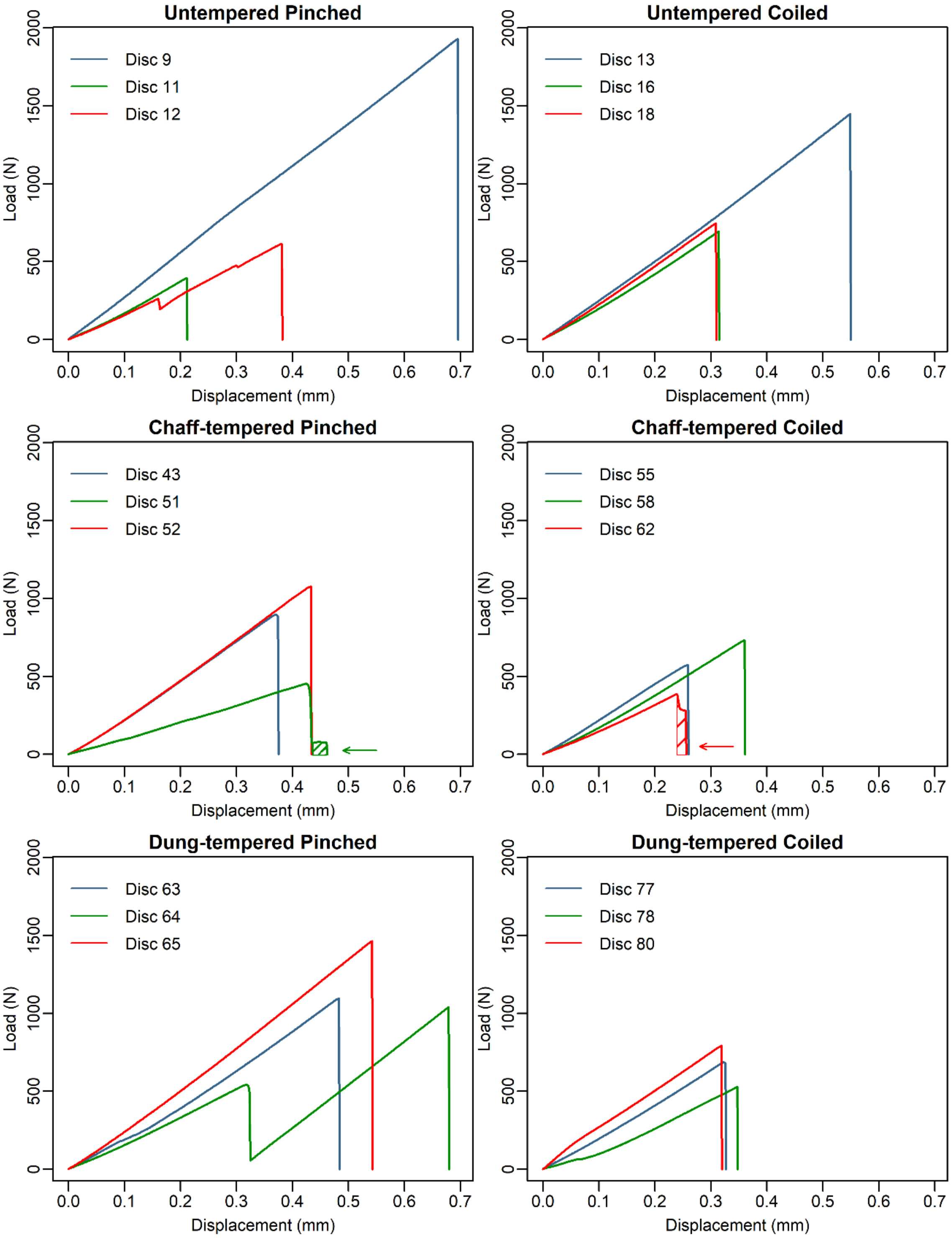


Figure 9.8: Load-displacement curves for all specimens tested. Arrows/shaded areas potentially indicate residual strength from specimens.

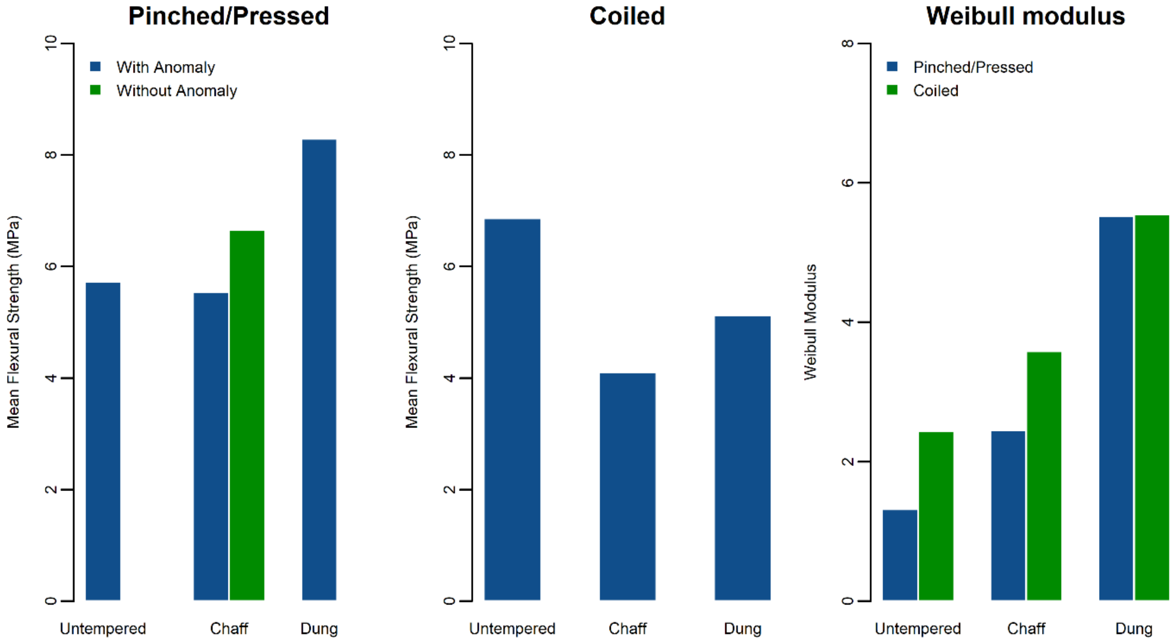


Figure 9.9: Mean values of flexural strength (a.k.a. transverse rupture strength) from pinched/pressed (left) and coiled specimens (centre), and Weibull modulus for all parameters (right).

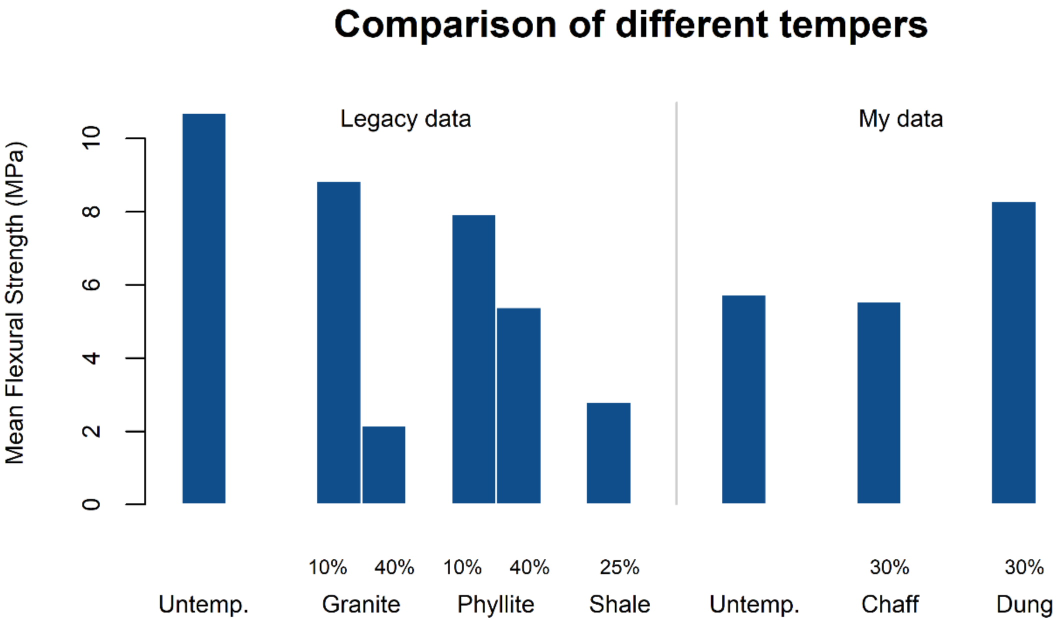


Figure 9.10: Comparison of flexural strength from pinched discs with literature (Müller et al. 2015; Warfe 2015). Values are estimations for specimens fired between 750-800°C.

In order to understand the seemingly contradictory evidence of extensive cracking, as attested in the crack path tortuosity values, and the higher flexural strength of organic-tempered specimens, comparison between the crack path tortuosity and the mean flexural strength of organic-tempered discs is presented in Figure 9.11. While sample size is small, the results indicate that there is a direct relationship between these parameters. In comparison to untempered discs, the higher flexural strength of organic-tempered specimens is likely the result of the toughness of the material, *i.e*. the resilience to crack propagation.

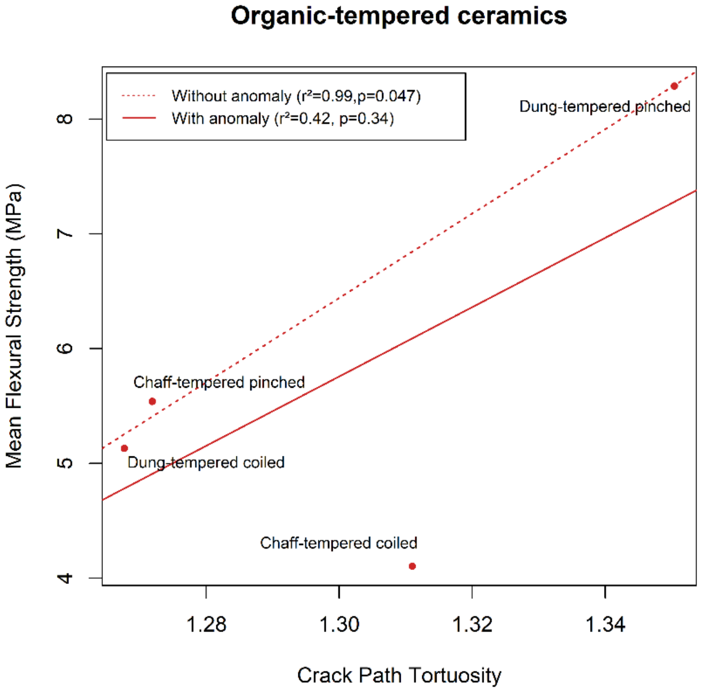


Figure 9.11: Comparison of results from thermal shock and three-point bend tests according to the crack path tortuosity and mean flexural strength of the discs.

Many fibres protruding from the fracture surface of organic-tempered specimens are observable by naked eye (Figure 9.12). As the carbon from the disc was potentially all burnt out during its firing at 800°C, the fibres could be silica, potentially calcium silicate, which forms at 700°C (Dodson *et al.* 2011, 525). These fibres could increase the fracture energy of the specimens as they hold both sides of the cracks together. This mechanism, known as crack-bridging (Becher 1991; West 1992, 24), could explain some of the residual strength observed in specimens highlighted in Figure 9.9. The ceramic matrix is the first part of the discs to crack, while the more ductile fibrous temper survives longer and briefly holds the specimen together before failure. Alternatively, the residual strength may be the result of how fragments of specimens broke, as they can sometimes form an arch and generate some resistance to the machine.

Figure 9.12: Remaining chaff fibres potentially acting as crack bridges.

9.3.1 Discussion

These three-point-bend tests were designed to obtain information on the material properties of the ceramics and corroborate our claim that the addition of organic matter to clays can increase the toughness of ceramics. As mentioned in Chapter 6, organic-tempered specimens possess more flaws and increased chances of crack initiation than untempered specimens. Considering that in three-point-bend tests the application of stresses is progressive, energy dissipating mechanisms would have little effect on the strength values of organic-tempered discs. The expectation was that organic-tempered ceramics, much like any other tempered ceramic, would have lower strength than untempered specimens, as shown in most studies (Müller *et al.* 2015; Shepard 1956, 131; Skibo *et al.* 1989).

To our surprise, we have found the exact opposite. The tested specimens are likely to have had intrinsic microcracks before the testing. These microcracks would have formed during drying and firing (*e.g.* Kilikoglou *et al.* 1998, 270) and, due to their microscopic size, would have been undetectable in our X-ray radiographs. Energy dissipating mechanisms, like crack tip deflection, crack bridging or microcracking, would have then had some effect on the fracture strength of specimens. This would mean that the flexural strength values we obtain from the three-point-bend tests are likely to reflect the toughness of the ceramics, which means that these tests independently corroborate findings from thermal shock tests.

Contrary to the literature, the addition of organic temper seems to strengthen the ceramic. In terms of its mechanical properties, it would seem dung is a particularly well-suited additive for ceramics. Dung-tempered discs are shown to be *consistently* stronger, as they also showed the least variation in fracture strength per specimen (see Weibull Modulus in Figure 9.9). Reasons for the strength can be that the fibres bond to the clay matrix quite well, the distribution of pores or flaws is even, and the bifurcation of the fibres allow for greater crack deflection. It was observed that reproductions of pots in the field using the same local clays used in the experiments, that during firing the survival rate of dung-tempered pots was significantly higher than chaff-tempered or untempered vessels. This may suggest that cow dung as an additive to clay can serve to enhance the survival rate of pots during firing as well as in post-firing activities but needs further testing.

Three-point-bend tests showed that only in the absence of organic temper does coiling actually increase the flexural strength of the ceramic. When the organic-tempered clays are rolled into coils, the fibres tend to align near the edges of the coil, weakening the interface with conjoining coils. This can cause the lower flexural strength of organic-tempered coiled specimens. In contrast, in untempered specimens the bonding between coils appears to be much better, while specimens still benefit by the alignment of clay particles perpendicular to the applied stress.

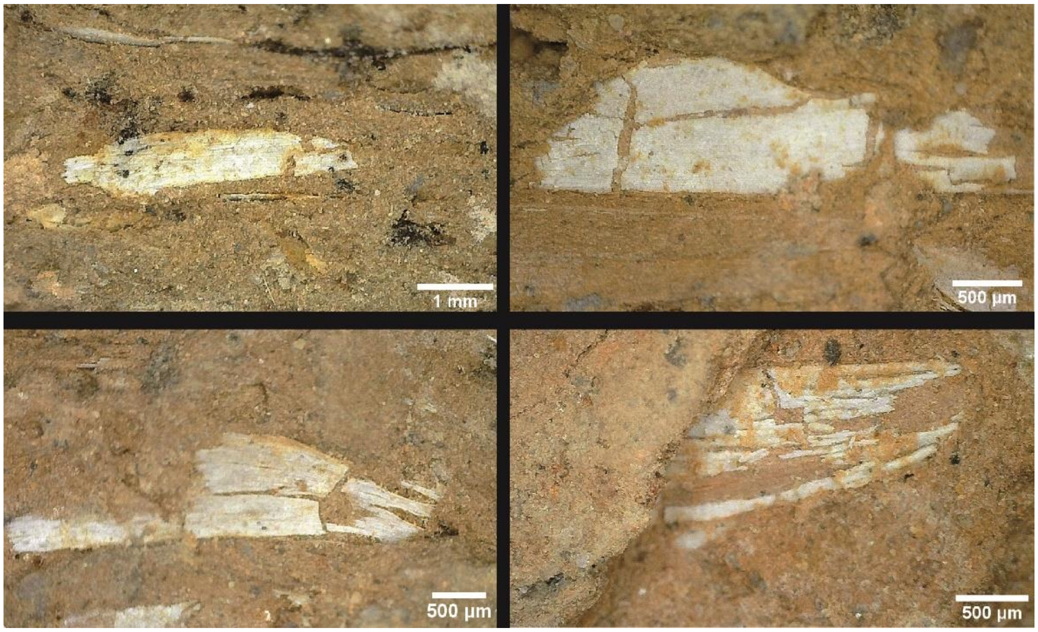


Figure 9.13: Example of fibres preserved in fragments from Tăşnad Sere.

A last factor to discuss is the role of silica fibres in the mechanical performance of organic-tempered ceramics. These fibres, which are the remnants of the burning of wheat chaff or hay (the dung was from a hay-fed cow), may have enhanced energy dissipation through crack bridging mechanisms. These fibres were frequently encountered in many potsherds from the UTB sites (Figure 9.13). Furthermore, dark areas were observed in the section of some of our experimental discs, even if these were fired in completely oxidised conditions. Thus, it is likely that not all the carbon in the composite was burnt out and leaves the possibility that not only silica, but carbon fibres have been produced by pyrolysis in these darker areas. These fibres have a substantially high tensile strength and are used in modern times to reinforce various materials. This, of course, would require further confirmation.

9.4 Limitations and further work

The control of particle size during specimen manufacture proved to be difficult for chaff temper. During sieving, long and thin fibres passed through the mesh in some instances and could have caused the lower strength values observed in comparison to dung temper. In case of the cow dung, we did not want to remove other components in this material by sieving it. Thus, particle size had to be observed in the post-manufacture stages. Future work will have to include a comparison with undigested hay chopped into the same particle sizes as observed to understand the influence of these organic fibres on the mechanical properties of the specimens. Other comparisons should include dung from grass-fed cows, as grasses possess less silica than wheat or hay.

Another complication relates to the sample size used for both tests. Our thermal shock protocol was severely delayed due to repeated equipment malfunction, so the number of specimens tested could not be increased in the proposed timeframe. Therefore, at least ten samples per parameter will be tested in the near future to corroborate our findings. Similarly, the sample size for strength test need to be increased substantially in order to undertake a more robust statistical analysis. As mentioned above, these would need to be around 20 or 30 specimens per parameter.

One must also take into account the post-firing processing of ceramics, like the application of organic coatings like beeswax, tar, oil or other substances that can block pores. These coatings and surface treatments could help mitigate thermal stresses by reducing thermal gradient (*i.e*. improving thermal conductivity). These additives can also reduce vessel permeability (Rice 1987, 163). Therefore, the specimens used for testing are not exactly as they might be when used for cooking practices.

A possible further line of work is to increase thermal cycling of specimens up to five thousand. This would provide better indication of the thermal shock resilience of untempered and organic-tempered specimens. A last line of work would be focused on determining if these fibres are purely silica or if carbon fibre is actually produced by pyrolysis. This could be accomplished through Atomic Absorption Spectroscopy (AAS) or X-ray Fluorescence (XRF).

Lastly, as briefly mentioned in section 6.3, it is highly likely that impact-related stresses accounted for the other causes of breakage like pots being dropped, knocked over, or hit against surfaces when cleaning them (DeBoer and Lathrap 1979, 129–133; Longacre 1981, 64; Skibo 1992; 2013). Furthermore, during cooking or food processing activities thermal and bend stresses account for a portion of the breaking process, yet these activities can also involve impact-related stresses, such as pots hit with kitchen utensils and lids (*e.g.* Longacre 1981, 64; Skibo 2013, 135). The study of the effects of these stresses on organic-tempered ceramics could be tested through falling-weight experiments (Mabry *et al.* 1988) or by using a pendulum tester (Müller *et al.* 2016). However, given the variation of practices where impacting a pot can occur, it is much more difficult to reproduce impact stresses in a 'realistic' setting.

9.5 Concluding remarks

Our study innovates on materials science techniques to answer questions about the mechanical behaviour of Early Neolithic ceramics. For thermal shock tests, the heat apparatus provided a unique way of conducting a large quantity of thermal cycles in a relatively short period and retain control over temperature curves. The use of imaging techniques provided a direct way of measuring crack growth, as well as crack path tortuosity (a crucial parameter for determining the toughness of the material). This method certainly is better than heating and quenching methods, where crack growth must be measured indirectly through standardised tests (*e.g*. three- or four-point-bend tests; section 6.3.1.4), and thermal shock conditions can be so severe that specimens often fail before these tests. With further work, our crack growth calculations could be performed live with Digital Correlation Imaging (DCI), which would enrich the understanding of crack propagation.

Despite the limitations mentioned, our results are very promising, particularly for the effects of organic fibres on the thermal shock resilience of low-fired ceramics. Under conditions of thermal shock (*ca.* 400°C) chaff and dung-tempered ceramics produce stable crack growth, which means cracking is an essential component of the performance of these pots in different heat-related activities. The materials used for Early Neolithic SKC and LBK pots offered two strategies to attain thermal shock resilience. Firstly, untempered pots, although rare in the archaeological assemblages studied, would have been resilient to heating processes, as our results show pinched specimens did not develop any visible cracks. In this case, under the somewhat mild conditions tested their thermal shock resilience is tied to the material's ability to withstand crack initiation (*i.e*. strength). Following the modern logic of ceramic production, untempered specimens would seem pertinent.

Another way of attaining thermal shock resilience was through the addition of organic temper, particularly cow dung. In this case, ceramics do not withstand crack initiation but restrict their propagation. In other words, their thermal shock resilience is tied to their toughness by various energy dissipating mechanisms, which may relate to remaining silica or carbon fibres in the clay. We have observed this fact in the high flexural strength, stable crack growth and high crack path tortuosity values of organic-tempered specimens. Part of the reason why cracks do not seem to be an issue, is their stable growth. What we do not know yet is the effect of this cracking behaviour for the storing liquids.

In sum, we observe two strategies, one that seeks to avoid cracking and another one that embraces a specific type of cracking behaviour. Given the sheer abundance of organic-tempered pots in the sites studied, it would seem that Neolithic people were more acquainted with the latter approach. Whether this was intended or unintended was not the ultimate aim of this study. However, we could state that these Early Neolithic populations were adding tempers that helped pots survive for long periods of time, and it is *partly* because these pots survived that people likely kept fabricating them in this fashion. This is an important clarification as it does not follow a rationalist utilitarian explanation, *e.g.* potters wanted long-lasting pots so they planned a way to make them this way, but one that can be explained by a historical process of emergent causation. What is most interesting is that the strength of the Early Neolithic pottery technology is paradoxically tied to cracking behaviour. Thus, these tests confirm that organic-tempered pots can remain cracked for quite some time without completely fracturing, which has enormous implications for our question about the social knowledge of breakage (highlighted in section 10.1.5). Early Neolithic pottery was in a way a ‘cracking technology’, which ensured that people had a prolongued exposure to breaking/breakage during vessel use.

Lastly, in response to our broader question regarding how could pots have broken in Early Neolithic times, results indicate that crack formation would have been a common occurrence in cooking scenarios, but specimens were likely to have maintained their shape for a long time before breakage.

Chapter 10. Conclusions: The social knowledge of breakage, the Early Neolithic 'Broken World', and the waste crisis

This dissertation started by assessing the statement that waste brings forward the limits of knowledge (Allen 2007, 206). While under the current technocratic regime we find waste as an enigmatic entity without any known use, *i.e*. a disutility (Illich 1992, 45), rather than equating this with the limits of knowledge, it is perhaps more pertinent to state that waste brings to light the limits of the particular manner in which we have chosen to construct knowledge: through the technical apprehension of nature (as indicated by the Enlightenment project). The modern waste crisis is an epistemological crisis.

What we need to understand are other forms of knowledge, other epistemes responsive to what we call waste accumulation. We must "[…] return to the world of everyday existence, but armed with a scientific thought that is sufficiently aware of itself and its limits to be capable of thinking practice without destroying its object" (Bourdieu 2000, 50). Following this need to become self-aware of the analytical concepts that we have inherited, as well as the fear of falling prey to the same functionalism that has resurfaced in the mist of the self-proclaimed new materialisms, I have enquired on the effect of waste in daily life through negative dialectics. By inverting categories of the philosophy of human control over nature, *i.e*. the philosophy that has hijacked knowledge since the Enlightenment, I posed breakage as the negation of this philosophy for its power to resist human technical control. In so doing, I established a first dialectical movement for my analysis. Through this conjecture I envisaged a theory of breakage and gave a rough guide on to how to study this process, including three dimensions from which we could study the social response to object breakage.

Considered by many as the cradle or dawn of European civilisation and, as such, a particularly powerful symbol of human mastery over nature, but paradoxically a moment of material accumulation (*sensu* Robb 2013), investigating the Neolithic provided the perfect opportunity to both disrupt the technocratic regime and begin understanding forms of knowledge surrounding the breakage of objects. Under this umbrella, I proposed the idea of the 'Early Neolithic Broken World' as the negation of the Neolithic world of productivity and control, which has been the pervasive narrative about the Neolithic since the time of Gordon Childe. This would correspond, in short, to a world where people conducted their daily lives in response to material accumulation, particularly to material resistances like breakage. The dialectical relation between these resistances and social responses gave shape to different practices, as we shall see in this chapter, and even, on occasions, motivated practices entirely devoted to this relation. Since the *Starčevo-Körös-Criş* and

Linearbandkeramik are in line with the so-called Neolithic productive package originating in the Near East, they were particularly suited for analysing their broken world. When reading the literature from these Early Neolithic groups, I realised a particularly problematic analogy was continually used: the 'landfill analogy'. This seemed in line with the very same philosophy of control I have attempted to challenge. Thus, I started my quest by attempting to destabilise this analogy and constructed my own set of methods to study the social knowledge of breakage of Early Neolithic SKC and LBK groups, particularly those located in the Upper Tisza/Tisa Region and the Northern Harz Foreland. Through the combination of failure, wear and archaeo-morphometric analyses, I have collected a wide range of data related to the social responses to breakage. With the risk of oversimplifying daily life in the Neolithic, I now finally attempt to reconstruct this practical knowledge of breakage, and present what I see as an Early Neolithic Broken World.

10.1 On the *Starčevo-Körös-Criş* and *Linearbandkeramik* social knowledge of breakage

To accomplish the crucial task of building a storyline from the huge variety of data collected, I will begin by answering my main research question: what was the role of breakage and broken pots in the Early Neolithic? As suggested by my main theoretical construct, *i.e.* the social knowledge of breakage (section 2.3.4), the answer is provided by exploring each dimension of this practical form of knowledge. Only when each of these dimensions are threaded together, does an idea of an Early Neolithic Broken World come to light.

10.1.1 The first dimension

The first dimension of breakage is a very refined one, and probably the hardest to study archaeologically. As detailed in section 2.3.4.1, it refers to how human agents perceive the breaking object and how they work to prevent, encourage or simply allow it to unfold. The socialised signs of breakage are *protentions*[1] or anticipations developed in practice. The forthcoming (breakage), as part of the agents' perception and in relation to which they position themselves to respond, is present *in* the practice itself, even if the pot is not actually broken. It is not that breakage "may happen or not happen, but something which is already there" (Bourdieu 2000, 208). This perception of risk, so to say, is the power of this first dimension of the social knowledge of breakage, as it moulds practices and disposes agents towards further action.

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[1] An aspect of Bourdieu's work developed from Husserl's Of the Phenomenology of the Consciousness of Internal Time (1991).

We can infer this dimension from our experimental study of organic-tempered ceramics, which were designed to allow an analogous comparison to Early Neolithic pottery. In Chapter 9, we learned, that the resilience of organic-tempered pottery paradoxically lies in cracking behaviour. Cracks, in this sense, are an important part of these objects. While they are formed by the inherent flaws left by some of the burnt organic component of plant fibres that work as stress concentrators, they become stable because of these same flaws and some remaining mineralised fibres (or perhaps carbon fibres) through mechanisms like crack-bridging, micro-cracking and crack tip deflection. This cracking behaviour not only prolongs the so-called 'use-life' of the pot, but, more importantly, extends its breakage history and with it, the opportunity for human agents to learn how cracks are formed. In other words, these types of pots were particularly suitable for developing this first dimension of the social knowledge of breakage. Of course, more work on the study of cracks in different mineral tempers might shed light on the differences to later societies like *Stichbandkeramik* (SBK) in the NHF, and *Alföldi Vonaldíszes Kerámica* (AVK) and *Pişcolt II* in the UTB. As discussed in Chapter 9, cooking is an activity where crack growth can occur and it is quickly detectable, as the stresses are not as severe as in impact. This also shows how cooks must have been well-versed in sensing cracks.

There were traces of the human response to signs of breakage in several types of repair-work in SKC sites. This type of work could be described as 'schematically improvised'. We observed how drilling methods at Méhtelek-Nádas were probably linked to the state broken pots were in. The way in which a vessel cracked or completely fractured would have restricted some drilling techniques and enabled others, which would be tailored by the person repairing the pot. While the schematic way to repair a pot in SKC groups was by adding two holes on either side of a crack and then strapping them with some form of fibre or leather, the contingent nature of how the pot would break required for some leeway or improvisation. So, the SKC craftsperson would have had to decide: if drilling with a support was pertinent or if this would risk further damaging the vessel; if the addition of an adhesive was necessary[2]; in what specific areas of the pot should these perforations be placed; among many other options. The variety of processes involved in this work probably also means that these pots were removed from the original practices where the cracks were formed and then repaired. In this sense, repairing became a practice-in-itself, meaning that

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[2] That is, if we can determine that residue stains on fragments 10849 and 10853 are indeed some form of adhesive like birch bark tar.

breakage, as a resistance to human will, not only can shape practice but also encourage the generation of other previously unintended practices.

We have also briefly documented a different repair process performed on dried vessels during pottery manufacture in SKC sites like at Endrőd 119 and Tăşnad Sere. In this scenario, clay is added to areas perhaps considered fragile, which is founded on the contingent relation between craftsperson and the pot being formed. The organic fibres in the wet clay would have reduced shrinkage, which prevented the added clay from falling off, as it is usually the differential of greater shrinkage of the added clay which causes them to break off. Some modern potters utilise this technique with paper clay (Graham Hay, personal communication 19 June 2020), which is an avenue for further investigation. In contrast to the previous type of repair, pots are mended on the spot. In other words, this type of mending would be just another resource from the potter's repertoire. Regardless of the method, the schematic knowledge of pottery repair is based on the sensing of irregularities, cracks and fractures. Because of the brittle nature and cracking behaviour of these ceramics, pottery repair know-how is inextricably linked to what people know of how pots break. We could say that it is this uncertainty which gives the game, in this case related to pottery craftwork, its 'charm' (Bourdieu 1990, 99).

10.1.2 The second dimension

A second dimension corresponds to how pots actually break in specific practices (section 2.3.4.2). This dimension refers to a latent and pervasive element of the knowledge of breakage, how breakage evokes a series of dispositions based on previous experience. These are often expressed as precautions and included in proverbs, myths, tales, etc. This pervasive dimension of breakage is in its most concrete nature related to the question of the stresses to which the object was submitted, and that is partly the task that was set in this dissertation.

In my rather unconventional quest to determine how exactly pottery would have broken in Early Neolithic times, thermal shock and strength tests provided a place to start. In the previous chapter it was concluded that organic temper adds to the toughness of ceramics through energy dissipating mechanisms, but also that it would take a considerable exposure to high temperatures to actually break these Early Neolithic pots purely through thermally induced stresses. This is excluding the effect of variables like the thickness, porosity, thermal conductivity, geometry and firing temperatures of pots.

However, when breakage does occur by thermal shock, it has similar results. The non-uniform heating of the bases of vessels, produces the radial cracks we observed in our disc specimens. Thus, if pottery bases were positioned directly over fires, as was observed in some of the pottery bases with sooting patterns, then it is likely radial cracks would have been a significant contributor to the breakage of cooking pots in the Early Neolithic sites studied. Experience of this consistent cracking pattern could have developed past knowledge of pottery breakage, potentially forming part of the more latent aspect of this dimension. 'Careful how you position pots over the fire, or else!'

Thermal stresses are not the only stresses occurring in cooking activities; continued knocking and hitting with utensils and other pots can occur to even the most skilled of cooks. Moreover, the cleaning of pots adds further wear and impact stresses and was probably an important activity for assessing the state of pots after cooking. While the resilience of pots to impact was not a parameter tested, the toughness of organic-tempered ceramics shows pots were probably not easy to break as their fracture strength was comparatively high.

10.1.3 The third dimension

No matter how strong ceramics are or how skilled the person repairing the pot is, pots will eventually break. This is where the third dimension of the social knowledge of breakage operates. In this dimension, it is the reaction or response to broken objects that is taken into account. The third dimension is the most straightforward dimension to study archaeologically and, for that reason, a considerable amount of data was obtained. While it is commonly assumed that objects were simply disposed of in pits shortly after breakage, which I have referred to as the 'landfill analogy', results discussed in Chapter 7 and 8 corroborate that this is more of an exception rather than a rule. Non-tools, or objects that are not put towards human intent in accordance to a production design, are considered solely as waste by modern accounts, but they encapsulate a wide variety of things. The varied performance of non-tools in practice shows the richness of this dimension in the Early European Neolithic social knowledge of breakage.

I have outlined in Chapter 8 how in the light of breakage, non-tools were on occasions shaped into tools. In both SKC and LBK, some fragments were rounded through abrasion or percussion for multiple purposes. The choice of forming could be related to the shape of the fragments created during vessel breakage. In C2/2005 at Tăşnad Sere, a base fragment was broken at the junction of the spiralled coils, forming a round fragment, and then simply abraded to produce a new tool. In this same context, a pedestal formed by a single mass of clay was knapped around the edges, because the parent vessel had broken somewhere else. Larger rounded fragments could have served as supports for pottery manufacture, while smaller rounded sherds have been interpreted as tokens. We also witnessed the abrasion of a pedestal at Tăşnad Sere for use as a lid or as a support. Lastly, sherd spindle whorls also appear in SKC and LBK sites, and their manufacture, based on the evidence gathered so far, seems to be restricted to a particular type of drilling technique using a rod- or bow-drill. Thus, these objects undergo a socially informed transformation from non-tools to tools.

However, most of the reused potsherds in both LBK and SKC sites had no trace of being purposely shaped or 'manufactured', and these objects are most rewarding for the research questions posed in this dissertation. These types of fragments cannot be termed 'tools' *sensu stricto* (section 2.2.1), for the latter designation is restricted to objects put towards human intent *as defined by its rationalised design*. As mentioned, however, most fragments were not shaped by a pre-designed manufacture process, and their form is attributed to the breakage of the pot (an unintended process). These non-tools cannot be designated as 'expedient' nor opportunistic, as both these types of tools involve some manufacturing stage and design process (Nelson 1991, 65). Another consideration is the distinction introduced by Choyke (2007) between class 1 and class 2 bone artefacts. The former would correspond to the re-working of bones acquired for other purposes into a preconceived image of a tool, while the latter are considered mostly *ad hoc,* where "a simple fortunate break was taken advantage of, with little or no surface modification" (Tóth 2012, 172). The description of class II objects moves in the right direction for what we observe in our potsherd assemblages, but for some reason they are lumped into what is termed a 'manufacturing continuum', which entirely misses the point. As it is still considered a manufacturing process, the contingent form, which is the result of the breakage of these objects, risks being somehow attributed to the rational human actor. Therefore, in order to put this terminological unrest to sleep, I will use the term accidentally formed artefacts (AFAs) to designate these types of non-tools. At first glance, this term is somewhat of an oxymoron: how could objects be formed without intent and still be considered artefacts? If we acknowledge there are other forces in play than the rational human actor, however, this becomes a term that starts to make sense. If we can renounce the philosophy of human mastery over nature, we may also start to see that these objects are a common occurrence. For example, van Gijn and Lammers-Keijsers state that:

> "*tools for pottery production in various archaeological contexts were used in a relatively ad hoc way, using readily available sherds and unmodified pieces of other materials, such as shell, coral and bone, lying around the potters' working area"* (2010, 755)

In this sense, accidentally formed artefacts are an interesting contrast with skeuomorphic objects. The latter describes objects made to mimic the shape or design of another object with different composition. The term is perhaps best known from Gordon Childe's use of the term to highlight the capacity of clays to imitate any shape (Childe 1956, 13, 37; 1985, 57). A clear example are the gourd-imitating vessels that Childe attributes to so-called Danubian cultures (Figure 10.1). Indeed, this construct works well with Childe's observation of the Neolithic as a form of mastery over matter, as the skeuomorphic capacity of clays are an important outlet of human ability to produce, *i.e.* to mould matter into any mental template. However, the prevalence of accidentally formed artefacts in SKC and LBK sites show a different picture, and indeed poses a threat to the hypostatised Neolithic world of productivity. It is not the control over matter, but the humble perception of the material's contingent expression in daily life which is of importance for the human agent. It is ultimately the accidentality of the material creation of AFAs, and the dispositions of Neolithic people guided by an historically acquired knowledge on the breakage of objects, that turn these objects into artefacts. As such, breakage once more invites purpose.

[redacted]

Figure 10.1: The skeuomorphic power of pottery for imitating other containers, in this case a gourd (after Childe 1956).

Nonetheless, most non-tools had no traces of being used and are effectively left lying around in both SKC and LBK sites. This indicates that daily life was more about living *with* fragments than keeping them out of sight. However, there were different approaches to this conviviality. The level of erosion and fragmentation of most sherds from SKC shows that final deposition in pits was only a small part within long history of fragment life, and that pots were rarely deposited soon after breakage. Moreover, the distribution of these materials inside and outside houses indicates social attitudes welcomed broken objects. Such attitudes are apparent in the reuse of pits observed at Călineşti-Oaş-D.S.M and Tăşnad Sere. The re-visitation of these features resonates McNiven's (2013) interpretation of middens of Torres Strait Islanders as structuring structures, as they still possess a generative dimension in social life. Middens can work as "visual anchors to the past and social beacons for normative behaviour by framing, constraining and structuring future social acts and interactions” (McNiven and Wright 2008, 145). In other words, a structured living with broken objects influences the design and use of space.

In LBK sites, this picture was different, as it was not erosion but fragmentation, presumably by trampling, which gave some indication of an extended history of sherds. However, the level of exposure of potsherds appears to be lower than in SKC sites. More importantly, variation in depositional patterns within LBK sites was different from SKC ones. It would seem certain areas of longpits were designated for placing or discarding freshly broken pots, while most of the other adjacent pits appear to be sporadically filled with fragments that were lying around. Areas of deposition for freshly broken fragments seem far more structured (in the sense of ‘consistently reproduced’) in LBK sites. These deposits must have had some role in delineating household boundaries (Last 1995, 278–280), and perhaps even formed part of strategies for differentiating these houses.

The different *modus operandi* in the deposition of broken pots is also linked to the degree of material accumulation observed in both Early Neolithic groups. In SKC groups, accumulation of broken pots appears to be much higher than what is witnessed in LBK sites. Potsherds are everywhere in SKC sites. However, this does not mean space was not structured or that there were no designated areas for depositing broken objects. At LBK sites broken objects are comparatively less frequent and their deposition more localised, and different types of sherd deposits seem to be demarcating household space in a different way (as seen with the tripartite division of longpits; section 7.3.1). This line of argumentation leads us towards the conclusion that broken pots were probably not considered “matter out of place” (Douglas 2002, 50), and secondly that depositing sherds in pits was only one way of dealing with broken objects among many others. As shown by Sommer (1990, 51), the social categorisation of bodily substances and so-called ‘refuse’ as dirt can be linked historically to the beginning of industrial capitalism in Europe with the stigmatisation of manual labour (see also section 1.1).

Despite differences observed between SKC and LBK depositional practices, it can be stated that there was general acceptance of broken objects near or within households. This attitude of living with broken objects provided these populations with a certain ‘resourcefulness’ (*i.e*. a *bricoleur*-like behaviour) and thus the creation of a wealth of knowledge about the breakage of objects. Therefore, our instrumental ‘landfill logic’ appears to have a blind sight for the place of broken objects in shaping social practices.

10.1.4 Interpreting two Early Neolithic scenarios: Potting and cooking practices

After elucidating several aspects of the social knowledge of breakage from the main results of this dissertation, I would like to illustrate how these dimensions come into play in practice. Enough information has been gathered on two practices where the social knowledge of breakage was objectified: potting and cooking.

A summary of pottery manufacturing processes in SKC and LBK from the point of view of breakage is presented in Figure 10.2, but firstly I must advise a bit of caution. We cannot just assume this knowledge operates in a sequential fashion, even if retrospectively practices follow this flow. The diagram does not give justice to the complexity of how this knowledge operates in practice. For example, the latency of the social knowledge of breakage in the design process was not fully integrated. Having stated these precautions, in the diagram we observe how the integration of the different dimensions of breakage come into play at different stages of pottery production. During forming, several types of AFAs from sherds or bones and pre-formatted tools like large rounded sherds were incorporated from the breakage of other objects. These in turn were available from various locations. In SKC sites, these sherds were commonly found inside structures like workshops or houses, while in LBK sites these were likely left in areas just outside longhouses. Cracks commonly occur right after pots are formed as it enters the drying stages of manufacture (cf. manuals on potting like Fraser 1986), and it would seem some of these were considered a threat by Early Neolithic potters. In some cases, wet clay was added to mend them on the spot. Others, like S-shaped cracks of bases were not considered threatening, at least for SKC groups from the UTB, possibly because of the thickness of bases and the toughness of the material. These cracks, mended or not, would not disappear, but are retained by the perceiving human agent, which may fuel further action. After pots had reached leather-hard state, several other AFAs were incorporated to smoothen their surface. Pots would then be fired, that is, if cracking had not been considered too severe. In the case of SKC groups it is possible other sherds were utilised as covers or heat retainers in this process. Lastly, despite the help of organic temper in stabilising crack propagation, firing was certainly an untameable process and some pots were probably broken. At this point, some SKC potsherds could have been partly reincorporated as covers for future fires.

The reconstruction of the social knowledge of breakage in relation to pottery manufacture raises questions on approaches like the *chaîne opératoire*. A technical act has been defined by this school of thought as “the transformation of matter from a state A to a state A + x, which is the product of it” (Balfet 1991, my (rather crude) translation), where state A is not necessarily restricted to raw materials (*Ibid*.). Others, like Pierre Lemonnier, give a broader definition as “everything that concerns the action of man on matter” (Lemonnier 1983, 50). In the former definition, there is nothing stopping us from including tools, AFAs, and gestures generated by the social knowledge of breakage in pottery manufacture. Thus, their exclusion from pottery studies marks some unspoken arbitrary decision. The latter definition by Lemonnier seems to explicitly restrict the social knowledge of breakage, as the effect of “matter on man” is not included in the definition, despite the fact that the author has repeatedly emphasised that technical processes are indeed constrained by matter (Lemonnier 1993, 3). In other words, the dialectic between contingency and structure, and between humans and materials is nullified. As van der Leeuw states, “it is that tendency to split off change from stability which is ultimately responsible for the dichotomy between matter and mind” (1993, 242). The point is that there are a set of non-technological choices that Neolithic potters made, which were inspired by the contingency of breakage. This does not mean that these choices are a one-off individual reaction, but they constitute ‘regulated improvisations’, a term I borrow from Pierre Bourdieu. As such, some of these decisions may comply with the intentionality of the practice at hand, in this particular case making a pot, while others may slightly change the aims or perhaps even completely interrupt the practice.

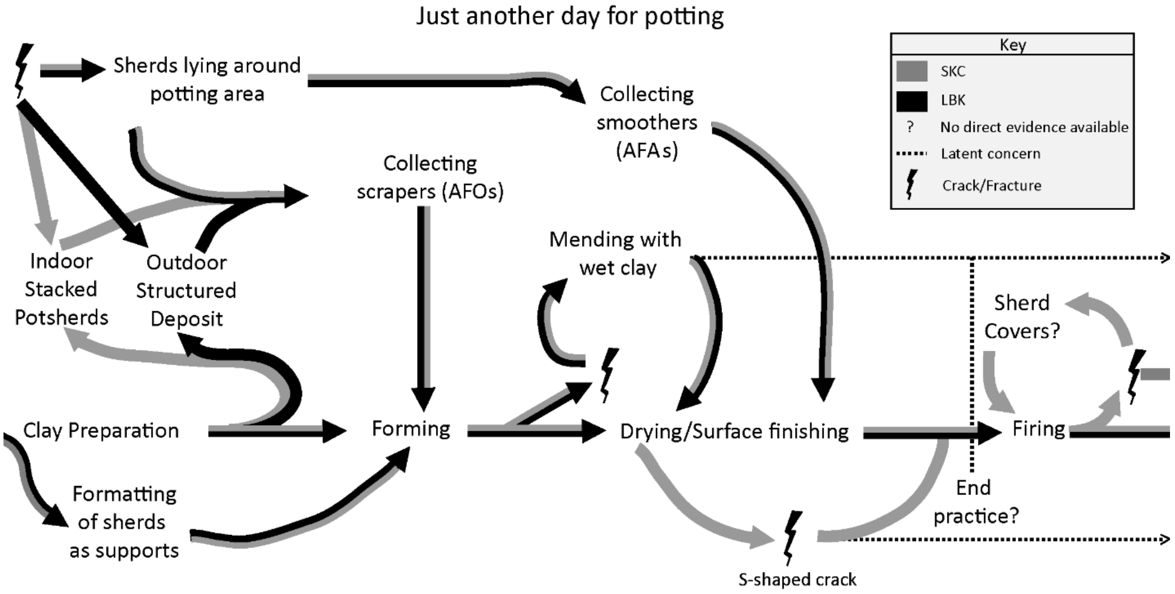

Figure 10.2: Early Neolithic pottery manufacturing scenarios taking into account the social knowledge of breakage.

Cooking was discussed in this dissertation. Most evidence of the social knowledge of breakage connected to this practice has come from SKC sites, which means I will focus on these groups for this reconstruction. From temperature estimations of hearths (Chapter 9) and in accordance to some ethno- and experimental studies (Gur-Arieh *et al.* 2013; Portillo *et al.* 2017), it would seem fire preparation is where temperatures related to cooking probably reached their highest point (*ca*. 700°C; section 9.1.2). This process poses a risk to vessels, as the thermal gradient formed by quickly expanding clays on vessel bases enhances stresses and is a potential reason for cracking. However, as shown by experiments, the cracking behaviour of organic-tempered pots is key to their toughness. The refired pedestal found in C2/2005 at Tăşnad Sere is a good example of how thermally induced radial cracks were formed on its exterior that were not conducive to the specimen breaking. Thus, it may take several hundred more cycles for the cracked pot to actually 'resist human will'. In other words, cracks form in various ways and are not necessarily conducive to disrupting practice. Nonetheless, once the crack forms it is also probable that there is careful monitoring of the pots. During the actual cooking, sooting patterns revealed some pots were placed over the fire directly, which also applies considerable stress to vessels. Thus, there must have been constant evaluation of when was the time the pot had had enough. As shown in Chapter 9, thermal stresses were especially suitable for stimulating crack growth even in untempered low-fired ceramics. After cracking was considered a threat, a range of responses were inferred from SKC sherds, particularly revolving around the decision to remove the cracked pot from practice for repair or placing them in hearths or ovens for other purposes like supports over the fire or retaining heat.

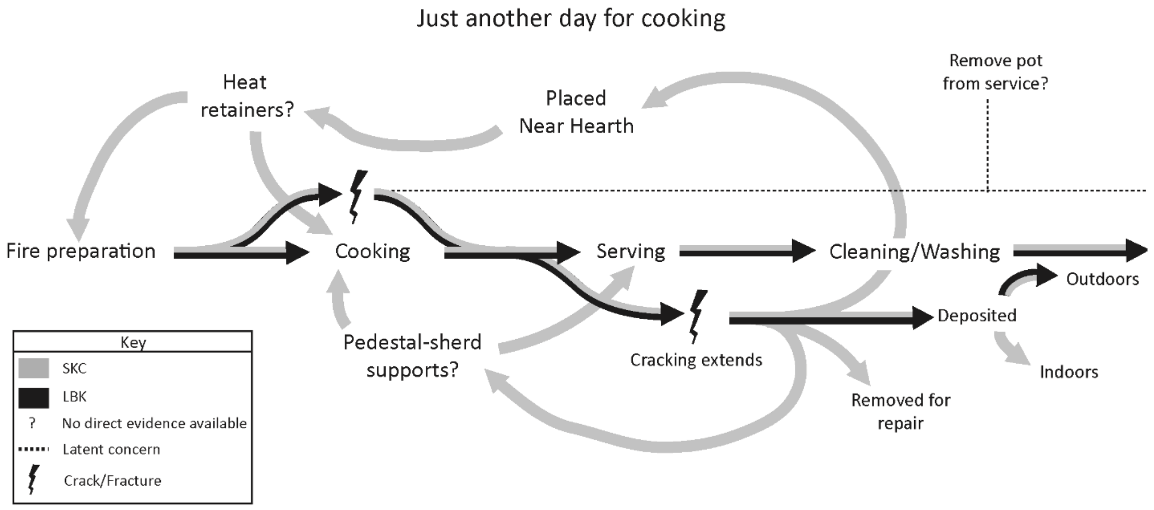

Figure 10.3: Early Neolithic cooking scenarios accounting only for the social knowledge of breakage.

From these scenarios, it seems clear that the social knowledge of breakage is practical knowledge that allows agents to adapt to the contingency of the object 'failing'. To make this point clearer, I borrow another of Bourdieu's cleverly articulated terms: 'regulated improvisations'. Bourdieu's *habitus* can be defined as a series of regulated improvisations (1990, 57). The 'regulated' aspect of the concept refers to the disposition of agents to reproduce a tacitly known *modus operandi* in specific tasks at hand. It is, in a way, the weight of history borne upon the agent. The ‘improvisation’ aspect refers to the agent’s response to contingent situations in practice, which leaves a window for the structuring structures constituting the *habitus* to actually transform. Regulated improvisations introduce the notion that there is no such thing as an entirely free improvisation or complete uniformity in social practice (no matter how orthodox a social group is). By studying breakage, we observe how those small regulated and improvised practical decisions take place, following a practical and not a functional logic[3]. These regulated improvisations are the core of practical life.

10.1.5 Some conclusions on the Early Neolithic Broken World

In our understanding of the Early Neolithic in south-eastern and central Europe we observed two processes of emergent causation related to the mechanical behaviour of organic-tempered pots. A first one related to the resilience of pots to breakage, refers to the fact that the resilience of these pots created a motivation for the reproduction and use of these items (see section 9.5). Linked to this resilience is these pots’ cracking behaviour. At the same time, while pots were good for staying in one piece, as cracks developed stably, they also demanded practitioners to be watchful. They can, after all, threaten the vessels’ form and role in practice. Organic-tempered pots, thus, demanded the need for a specific social knowledge of breakage, while at the same time this bodily knowledge (conservative as it is) disposed agents towards the reproduction and use of these pots. Therefore, pots were resilient also because of the attentive care given to these objects.

We have also witnessed how broken objects were categorised in both studied regions. In a first ‘practical’ category, we see objects that were considered needing mending in both areas of the European continent, albeit at a much more frequent scale (from the evidence gathered) in the SKC. Mending was performed during the manufacturing of pots but also in their use. Another category includes those broken pots ‘saved for later’, which are sherds that have been shaped into other objects and some of the AFAs. Also in this category are those larger parts of broken vessels ‘structurally deposited’ (or placed with care) in (SKC) or near (LBK) houses. In the last category identified, we find sherds that were not considered useful and could be labelled tentatively as waste. Here we observe some fundamental categorical differences between south-eastern and central European inhabitants. In SKC settlements, the accumulation of materials of this category is substantial and is allowed to be scattered around the settlement, including the *domus*. We could

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[3] On the difference between practical and functional we can simply state that while the former is relative to the characteristics of the practice at hand (which needs to be determined by the analyst before stating something like “this is why people did A or B”), the latter refers to a universalised category imposed *apriori*. In other words, function is a reified category.

say that, as the Dogon in Mali (see section 2.3.4.3), exposing this waste was a sign of ‘doing well’, of prosperity, which is probably an attitude inherited from their ancestors down south (*e.g.* tell settlements), albeit at a much smaller scale. The effects of these ‘useless’ broken objects might have been unintentionally beneficial for insulating houses and allowing drainage of soils in a wetland environment. People in the LBK, in contrast, seem to be a lot more concerned about the accumulation of these materials around settlement areas and potentially also inside houses. They had designed areas for their disposal and the scattering observed in other areas seems to be an unintended consequence of nearby activities. Yet, it is likely some of this disposed material was still intentionally reincorporated, and it is possible some of the AFAs are evidence of this process. Nonetheless, it would seem the social response to this category of broken objects substantially changed from what is seen in SKC settlements. Regardless of these differences, the attitude towards living with rather than without broken objects provided Early Neolithic populations with opportunity to learn from these materials. This reflects how the Broken World was far more complex than we give it credit for.

Can we speak of the Neolithic as a period of mastery over nature? It would seem rather that some of the most mundane practices like potting and cooking were shaped by an uncontrollable force to an extent that the resulting social adjustments actually became part of an embodied knowledge. Furthermore, the effect of the brittleness of pottery had a strong influence on the construction of domestic spaces. Through the extensive research conducted, we have forced the Neolithic immovable symbol of productivity to actually gain traction towards its negation: a Broken World. What has been illustrated throughout the dissertation is that Neolithic knowledge was probably not oriented by the control or domination over nature, as shown by the range of non-technological choices. Some of these choices were forged from recurrent social response to breakage as a material resistance. This forces us to understand knowledge can be constructed from the uncertain contingencies of social and material life.

10.2 The waste crisis revisited

I have yet to come to terms with one final and crucial research objective: to revisit what has been labelled the ‘waste crisis’. It would seem that I have burdened myself with a monstrous task, and one where my expertise reaches its limit. For this task to be accomplished, I do not feel obliged nor compelled to provide a ‘solution’ to this socially-constructed problem, as that is not at all the intent of this dissertation; for that would imply that I have already accepted the framing of waste as a problem without further question. On the contrary, the path of my research leads me to expose the fallacy that waste, and our tendency of discard or removal of unwanted materials from sight, are absolutes. This I believe I *can* do. Yet, before moving towards my analysis on this topic, I will abstain from any direct comparison between modern practical logics and Neolithic ones, for each "depends on the social conditions of its formation and exercise […]" (Bourdieu 2000, 64). My use of Neolithic examples, derived from my analysis of potsherds, aim to demonstrate what I have already started through a negative dialectics of waste: to expose the reification of waste and waste management, which are categorisations resulting from our modern administered world.

A central premise of this dissertation has been the role of the social responses to breakage, as non-technological choices, in shaping even the most seemingly 'technological' of practices, *e.g.* the design and manufacture of pottery. What we have seen in Early Neolithic societies in Europe is that practice-specific responses were commonly performed, up to the point of becoming part of the schematics of those practices. In a modern scenario, technological practices (section 2.2.1), are linked to the division between design and execution, producers and consumers, which is particularly the case in industrial developments. The designer is not only not exposed to the actual breakage of the material but sees it as something to be avoided. Thus, the social knowledge of breakage is oriented towards preventing breakage at all costs and creates the illusion of control over matter. Yet, the designer also knows that whatever object is being designed, it will come to the point that it will effectively break or deform. So, when the object is finally (deemed) broken (sometimes not even then!) the broken object in this case is removed from sight (burned, buried or thrown into the ocean). Consequently, this behaviour leads to the reproduction of the concept of waste, and its view as a problem.

Let me present an example. I have recently attended a talk on reinforced carbon-fibre polymers designed for the airline industry. In this talk, a nice summary on the material properties of carbon-fibres, such as its high tensile strength (off the charts!), was given. A problem mentioned was that depending on the direction of the stress applied, these materials could also be extremely weak, which is why engineers claim there is a need to reinforce them with other fibres. Absorbed by my PhD, I immediately thought that in this case while increasing the strength of a material might be a technological choice (related to the fulfillment of the object's intended use in practice), trying to avoid the object from breaking is a non-technological one too, as it is partly based on the previous knowledge that carbon fibre breaks easily under certain conditions and the social convention that breakage has to be 'tamed'. The talk continued with testing of the strength of this new polymer and concluded with the profitable conclusion that this material would be fantastic for manufacturing airplanes. But what happens when the material shows signs of breaking in service or does effectively reach the point of breakage? While the presenters were aware that these materials easily crumble when broken, much like many cars sold today, it can be safely inferred that the response is always the same: they are dumped. This is also a non-technological choice, but it does not concern the engineer; the material is strong, and it will fulfill its intended function of making people arrive safely at their destination. Whatever happens to the aircraft once it breaks is someone else's responsibility. Thus, even in the practices most seemingly endowed with technological knowledge there are elements of the social knowledge of breakage. There is no control over matter, and thus the "project of technology chases a target that recedes as fast as it is approached" (Ingold 2011, 62).

Unlike modern materials, Early Neolithic pottery seems to enable the social knowledge of breakage, and rather than improving strength by avoiding breakage it is allowing cracks to initiate which was the chosen 'strategy'. In other words, the contingent nature of crack formation is acknowledged and built into the social practice surrounding the making and use of pottery. What is exposed by this strategy is the modern technological fallacy that avoiding breakage is the only way objects can be useful and shows that this decision partly follows a non-technological choice (*i.e*. a social choice). However, Neolithic pottery technology cannot be divorced from its social context. As I showed in Chapter 2, breakage always occurs within a social environment. A bodily knowledge had to be constantly in play for these objects to perform in practice. The daily gestures that arise from breakage as a resistance to our control followed a different *ethos*. Unfortunately, industrial productivity does not leave room for this creative input, partly because materials are not really designed for people to reconfigure them.

A last point I wish to make is that an accumulation of materials should not be equated with being 'wasteful', that would be an anachronism, and it is an important lesson learned from Neolithic societies. This does not mean that accumulation of slowly degrading materials is restricted to the present. The fact that we automatically think so is evidence of how engrained these notions are in our daily life. Unlike plastics in modern times, organic-tempered pottery and potsherds in the Neolithic, as a material reproduced for almost a thousand years, had a place in social life. I cannot imagine these broken objects having been "matter out of place". After all the idea of waste management *per se* is a modern invention (Illich 1992, 79), not a universal constant.

References

Adams, J.L. 2002. *Ground Stone Analysis: A Technological Approach*. Salt Lake City: University of Utah Press.

Adams, J.L. 2014. Ground stone use-wear analysis: a review of terminology and experimental methods. *Journal of Archaeological Science*, 48, pp. 129–138.

Adorno, T.W. 2004. *Negative Dialectics*. London: Routledge.

Adorno, T.W. 2017. *An Introduction to Dialectics*. C. Ziermann, ed. Cambridge: Polity Press.

Adorno, T.W. 2019. *Ontology and Dialectics*. Cambridge: Polity Press.

Akhavan, A., Shafaatian, S.-M.-H. & Rajabipour, F. 2012. Quantifying the effects of crack width, tortuosity, and roughness on water permeability of cracked mortars. *Cement and Concrete Research*, 42, pp. 313–320.

Alexander, C. & Reno, J. 2012. Introduction. In: C. Alexander and J. Reno, eds. *Economies of Recycling. The Global Transformation of Materials, Values and Social Relations*. London: Zed Books, pp. 1–32.

Alinei, M. 2014. Europe: Mesolithic-Neolithic Transition. In: C. Smith, ed. *Encyclopedia of Global Archaeology*. New York, NY: Springer, pp. 2580–2586.

Allaby, M. (ed.) 2013. *A Dictionary of Geology and Earth Sciences*. 4th ed. Oxford: Oxford University Press.

Allard, P., Hamon, C., Bonnardin, S., Cayol, N., Chartier, M., Coudart, A., Dubouloz, J., Gomart, L., Hachem, L., Ilett, M., Meunier, K., Monchablon, C., & Thevenet, C. 2013. Linear Pottery domestic space: taphonomy, distribution of finds and economy in the Aisne valley settlements. In: C. Hamon, P. Allard and M. Ilett, eds. *The Domestic Space in LBK Settlements*. Rahden/Westfalen: Marie Leidorf GmbH, pp. 9–28.

Allegretta, I., Eramo, G., Pinto, D., & Hein, A. 2014. The effect of temper on the thermal conductivity of traditional ceramics: Nature, percentage and granulometry. *Thermochimica Acta*, 581, pp. 100–109.

Allen, J.R.L. 1989. A quantitative technique for assessing the roundness of pottery sherds in water currents. *Geoarchaeology*, 4, pp. 143–155.

Altuhafi, F., O'Sullivan, C. & Cavarretta, I. 2013. Analysis of an image-based method to quantify the size and shape of sand particles. *Journal of Geotechnical and Geoenvironmental Engineering*, 139, pp. 1290–1307.

Amberg, C.R. & Hartsook, J. 1946. Effect of design factors on thermal-shock resistance of cooking ware. *American Ceramic Society Bulletin*, 25, pp. 448–452.

Amicone, S. 2019. Introduction: Tracing Pottery-Making Recipes in the Prehistoric Balkans, 6th-4th Millennia BC. In: S. Amicone, P. S. Quinn, M. Marić, N. Mirković-Marić and M. Radivojević, eds. *Tracing Pottery-Making Recipes in the Prehistoric Balkans 6th–4th Millennia BC*. Oxford: Archaeopress, pp. 1–7.

Ammerman, A.J. 1985. Plow-Zone Experiments in Calabria, Italy. *Journal of Field Archaeology*, 12, pp. 33–40.

Ammerman, A.J. 2003. Looking Back. In: A. J. Ammerman and P. Biagi, eds. *The Widening Harvest. The Neolithic Transition in Europe: Looking Back, Looking Forward*. Boston: Archaeological Institute of America, pp. 3–23.

Ammerman, A.J. & Cavalli-Sforza, L.L. 1979. The Wave of Advance Model for the Spread of Agriculture in Europe. In: C. Renfrew and K. L. Cooke, eds. *Transformations: Mathematical Approaches to Culture Change*. New York: Academic Press, pp. 275–293.

Ammerman, A.J. & Cavalli-Sforza, L.L. 1984. *The Neolithic Transition and the Genetics of Populations in Europe*. Princeton: Princeton University Press.

Anderson-Gerfaud, P. 1983. L'utilisation de certains objets en céramique de tell el-'Oueili (Obeid 4): Rapport préliminaire sur les microtraces. In: J. L. Huot, ed. *Larsa et 'Oueili, Travaux de 1978-1981*. Paris: ERC, pp. 177–191.

Andreescu, R. *et al.* 2003. *Situl Arheologic de La Măgura Buduiasca - Teleor 003*. Bucureşti: CIMEC - Institutul de Memorie Culturală.

Andreescu, R. & Mirea, P. 2008. Teleorman Valley. The beginning of the Neolithic in southern Romania. *Acta Terrae Septemcastrensis*, VII, pp. 57–75.

Arandjelović-Garašanin, D. 1954. *Starčevačka Kultura*. Ljublijana: Univerza v Ljubljani, Arheološki seminar.

Aras, A. 2004. The change of phase composition in kaolinite- and illite-rich clay-based ceramic bodies. *Applied Clay Science*, 24, pp. 257–269.

Ariès, P. 1981. *The Hour of Our Death*. London: Allen Lane.

Van As, A. 2010. 'How and Why?' The Neolithic Pottery from Teleor 003, Teleor 008 and Magura-Bran, Teleorman River Valley, Southern Romania. *Buletinul Muzeului Judeţean Teleorman*, 2, pp. 29–43.

Van As, A., Jacobs, L. & Thissen, L. 2004. Preliminary data on Starčevo-Criş and Dudeşti pottery from Teleor 003, Teleorman River Valley, Southern Romania. *Leiden Journal of Pottery Studies*, 20, pp. 121–128.

Astaloş, C. 2005. *Cronica Cercetărilor Arheologice Din România. Campania 2004*. Bucureşti: CIMEC - Institutul de Memorie Culturală.

Astaloş, C., Sommer, U. & Virag, C. 2013. Excavations of an Early Neolithic Site at Tăşnad, Romania. *Archaeology International*, 16, pp. 47–53.

Băcueț-Crişan, S. 2008a. *Cultura Starčevo-Criş în Depresiunea Şimleului*. Cluj-Napoca: MEGA.

Bader, T. 1968. Despre figurinele antropomorfe în cadrul culturii Criş [Beitrage zur Kenntnis anthropomorpher Figurinen aus der Cris-Kultur]. *Acta Musei Napocensis*, V, pp. 381–388.

Bailey, D. & Whittle, A. 2005. Unsettling the Neolithic: breaking down concepts, boundaries and origins. In: D. Bailey, A. Whittle and V. Cummings, eds. *(Un)Settling the Neolithic*. Oxford: Oxbow Books, pp. 1–7.

Bailey, D.W. 2000. *Balkan Prehistory. Exclusion, Incorporation and Identity*. London: Routledge.

Balesta, B. & Zagorodny, N. 2002. La restauración alfarera en la funebria arqueológica: Observación y estudios experimentales sobre la Colección Muñiz Barreto. *Bulletin de l'Institut français d'études andines*, 31, pp. 373–395.

Balfet, H. 1991. Des chaîne opératoire, pour quoi faire? In: H. Balfet, ed. *Observer l'action Technique. Des Chaîne Opératoire, Pour Quoi Faire?* Paris: Centre National de la Recherche Scientifique, pp. 11–20.

Balista, C., Levi, S.T., Vanzetti, A., & Vidale, M. 1991. The Use of Potsherds for Interpreting Alluvial Deposits: A Case Study in the Adige River Basin. *Materials Research Society Proceedings*, 185, pp. 561–570.

Bánffy, E. 2004. *The 6th Millenium BC Boundary in Western Transdanubia and Its Role in the Central European Neolithic Transition. The Szentgyörgyvölgy-Pityerdomb Settlement*. Budapest: Varia Archaeologica Hungarica.

Bánffy, E. 2006. Eastern, Central and Western Hungary – variations of Neolithisation models. *Documenta Praehistorica*, XXXIII, pp. 125–142.

Bánffy, E. 2013. Tracing the Beginning of Sedentary Life in the Carpathian Basin. The Formation of the LBK House. In: D. Hofmann and J. Smyth, eds. *Tracing the Neolithic House in Europe*. New York: Springer, pp. 117–149.

Bánffy, E., Marton, T. & Osztás, A. 2010. Early Neolithic settlement and burials at Alsónyék-Bátaszék. In: J. K. Kozlowski and P. Raczky, eds. *Neolithization of the Carpathian Basin: Northernmost Distribution of the Starčevo/Körös Culture*. Kraków: Polska Akademia Umiejętności, pp. 37–51.

Bánffy, E. & Oross, K. 2009. Three successive waves of Neolithisation: LBK development in Transdanubia. *Documenta Praehistorica*, XXXVI, pp. 175–189.

Barker, G. 2006. *The Agricultural Revolution in Prehistory: Why Did Foragers Become Farmers?* Oxford: Oxford University Press.

Barley, N. 1994. *Smashing Pots: Works of Clay from Africa*. Washington D.C.: Smithsonian Institution Press.

Barrett, J.C. 2016. The new antiquarianism? *Antiquity*, 90, pp. 1681–1686.

Barrett, P.J. 1980. The shape of rock particles, a critical review. *Sedimentology*, 27, pp. 291–303.

Battaglia, V., Fornarino, S., Al-Zahery, N., Olivieri, A., Pala, M., Myres, N.M., King, R.J., Rootsi, S., Marjanovic, D., Primorac, D., Hadziselimovic, R., Vidovic, S., Drobnic, K., Durmishi, N., Torroni, A., Santachiara-Benerecetti, A.S., Underhill, P.A., Semino, O. 2009. Y-chromosomal evidence of the cultural diffusion of agriculture in southeast Europe. *European Journal of Human Genetics*, 17, pp. 820–830.

Baudrillard, J. 1975. *The Mirror of Production*. St. Louis: Telos Press.

Baudrillard, J. 1981. *For a Critique of the Political Economy of the Sign*. New York: Telos Press.

Becher, P.F. 1991. Microstructural Design of Toughened Ceramics. *Journal of the American Ceramic Society*, 74, pp. 255–269.

Beck, M.E., Skibo, J.M., Hally, D.J., & Yang, P. 2002. Sample Selection for Ceramic Use-alteration Analysis: The Effects of Abrasion on Soot. *Journal of Archaeological Science*, 29, pp. 1–15.

Becker, W.T. & Shipley, R.J. (eds.) 2002. *Failure Analysis and Prevention, ASM Handbook, Vol. 11*. Materials Park: American Society for Materials.

Behrens, H. & Rüster, B. 1981. Kalibrierte C14-Daten für das Neolithikum des Mittelelbe-Saale-Gebietes. *Archäologisches Korrespondenzblatt*, 11, pp. 189–193.

Beldiman, C. & Sztancs, D.-M. 2011. Technology of skeletal materials of the Starčevo-Criş Culture in Romania. Some considerations. In: S. A. Luca and C. Suciu, eds. *The First Neolithic Sites in Central/South-East European Transect. Volume II: Early Neolithic (Starčevo-Criş) Sites on the Territory of Romania*. Oxford: Archaeopress, pp. 57–70.

Bennet, J. 2005. The Agency of Assemblages and the North American Blackout. *Public Culture*, 17, pp. 445–465.

Bentley, R.A., O'Brien, M.J., Manning, K., & Shennan, S. 2012. Community differentiation and kinship among Europe's first farmers. *Proceedings of the National Academy of Sciences*, 109, pp. 9326–9330.

Berg, I. 2008. Looking through pots: recent advances in ceramics X-radiography. *Journal of Archaeological Science*, 35, pp. 1177–1188.

Bernhardt, G. 1986. Die linearbandkeramische Siedlung von Köln-Lindenthal: eine Neuarbeitung. *Kölner Jahrbuch für Vor- und Frühgeschichte*, 18/19, pp. 9–165.

Bertemes, F. 2002. Die mitteleuropäische Archäologie: eine Standortbestimmung zwischen Ost und West. In: F. Biehl, A. Gramsch and A. Marciniak, eds. *Archaeologies of Europe. History, Methods and Theories*. Münster: Waxmann, pp. 99–118.

Bertemes, F. 2011. Prehistoric Archaeology in Central Europe. In: A. Gramsch and U. Sommer, eds. *A History of Central European Archaeology. Theory, Methods, and Politics*. Budapest: Archaeolingua, pp. 41–56.

Biagi, P. 2011. Some aspects of the earliest Neolithic chipped stone assemblages of Transylvania and the Banat (Romania). In: S. A. Luca and C. Suciu, eds. *The First Neolithic Sites in Central/South-East European Transect. Volume II: Early Neolithic (Starčevo-Criş) Sites on the Territory of Romania*. Oxford: Archaeopress, pp. 71–78.

Biagi, P., Shennan, S. & Spataro, M. 2005. Rapid rivers and slow seas? New data for the radiocarbon chronology of the Balkan Peninsula. In: L. Nikolova, J. Fritz and J. Higgins, eds. *Prehistoric Archaeology and Anthropological Theory and Education, Reports of Prehistoric Research Projects 6–7*. Salt Lake City & Karlovo: International Institute of Anthropology, Argosy University, pp. 41–50.

Biagi, P. & Spataro, M. 2005. New observations on the radiocarbon chronology of the Starčevo-Criş and Körös cultures. In: L. Nikolova, J. Fritz and J. Higgins, eds. *Prehistoric Archaeology and Anthropological Theory and Education, Reports of Prehistoric Research Projects 6–7*. Salt Lake City & Karlovo: International Institute of Anthropology, Argosy University, pp. 35–40.

Bickle, P. 2020. The structure of chaos: decay and deposition in the Early Neolithic. In: D. Hofmann, ed. *Magical, Mundane or Marginal? Deposition Practices in the Early Neolithic Linearbandkeramik Culture*. Leiden: Sidestone Press, pp. 181–204.

Binder, D., Gassin, B. & Sénépart, I. 1994. Éléments pour la caractérisation des productions céramiques néolithiques dans le Sud de la France. L'exemple de Giribaldi. In: Centre de recherches archéologiques, ed. *Terre Cuite et Société. La Céramique, Document Technique, Économique, Culturel.* Juan-les-Pins: Éditions APDCA, pp. 255–267.

Binford, L.R. 1962. Archaeology as Anthropology. *American Antiquity*, 28, pp. 217–225.

Binford, L. 1978. Dimensional Analysis of Behavior and Site Structure: Learning from an Eskimo Hunting Stand. *American Antiquity*, 43, pp. 330-361.

Biró, K.T. 2018. More on the State of Art of Hungarian Obsidians. *Archeometriai Műhely*, XV, pp. 213–224.

Bitter, J.G.A. 1963. A study of erosion phenomena: Part I. *Wear*, 6, pp. 5–21.

Blackham, M. 2000. Distinguishing bioturbation and trampling using pottery sherd measures, Tell Fendi, Jordan. *Geoarchaeology*, 15, pp. 469–497.

Blair, T.C. & McPherson, J.G. 1999. Grain-size and Textural Classification of Coarse Sedimentary Particles. *Journal of Sedimentary Research*, 69, pp. 6–19.

Blanco-González, A. 2015. Past fragments: From ceramics to social practices in later prehistoric Iberia. *Journal of Social Archaeology*, 15, pp. 342–365.

Boaz, N.T. & Behrensmeyer, A.K. 1976. Hominid taphonomy: Transport of human skeletal parts in an artificial fluviatile environment. *American Journal of Physical Anthropology*, 45, pp. 53–60.

Bode, R., Lehmkuhl, F., Reinecke, V., Hilgers, A., Dresely, V., & Radtke, U. 2003. Holozäne fluviale Geomorphodynamik und Besiedlungsgeschichte in einem kleinen Einzugsgebiet am nördlichen Harzrand. *Eiszeitalter und Gegenwart*, 53, pp. 74–93.

Boelicke, U. 1982. Gruben und Häuser: Untersuchungen zur Struktur bandkeramischer Hofplätze. In: B. Chropovský, ed. *Siedlungen Der Kultur Mit Linearkeramik in Europa: Internationales Kolloquium*. Nitra: Archaeological Institute of the Slovakian Academy of Sciences, pp. 17–28.

Boelicke, U. 1988. Gruben. In: J. Lüning, P. Stehli and A. Zimmermann, eds. *Der Bandkeramische Siedlungsplatz Langweiler 8, Gemeinde Aldenhoven. Kreis Düren*. Köln: Rheinland-Verlag, pp. 300–394.

Boelicke, U. & Aniol, R.W. (eds.) 1988. *Der Bandkeramische Siedlungsplatz Langweiler 8: Gemeinde Aldenhoven, Kreis Düren (Rheinische Ausgrabungen)*. Köln: Rheinland-Verlag.

Bogaard, A. (ed.) 2011. *Plant Use and Crop Husbandry in an Early Neolithic Village: Vaihingen an Der Enz, Baden-Württemberg*. Bonn: Habelt.

Bogaard, A., Krause, R. & Strien, H.-C. 2011. Towards a social geography of cultivation and plant use in an early farming community: Vaihingen an der Enz, south-west Germany. *Antiquity*, 85, pp. 395–416.

Bogdanović, M. 1988. Architecture and structural features at Divostin. In: A. McPherron and D. Srejović, eds. *Divostin and the Neolithic of Central Serbia*. Pittsburgh: Department of Anthropology, University of Pittsburgh, pp. 35–142.

Boggs, S. 2011. *Principles of Sedimentology and Stratigraphy*. Fifth Edition. Upper Saddle River: Pearson Prentice Hall.

Bogucki, P. 1988. *Forest Farmers and Stockherders. Early Agriculture and Its Consequences in North-Central Europe*. Cambridge.

Bogucki, P. 1996. The Spread of Early Farming in Europe. *American Scientist*, 84, pp. 242–253.

Borič, D. 2005a. Deconstructing essentialisms: unsettling frontiers of the Mesolithic-Neolithic Balkans. In: D. Bailey, A. Whittle and V. Cummings, eds. *(Un)Settling the Neolithic*. Oxford: Oxbow Books, pp. 16–31.

Borič, D. 2005b. Fuzzy Horizons of Change: Orientalism and the Frontier Model of the Meso-Neolithic Transition. In: N. Milner and P. C. Woodman, eds. *Mesolithic Studies at the Beginning of the 21st Century*. Oxford: Oxbow Books, pp. 81–105.

Borič, D. 2008. First Households and 'House Societies' in European Prehistory. In: A. Jones, ed. *Prehistoric Europe: Theory and Practice*. Oxford: Blackwell, pp. 109–142.

Borić, D. & Dimitrijević, V. 2007. When did the 'Neolithic package' reach Lepenski Vir? Radiometric and faunal evidence. *Documenta Praehistorica*, XXXIV, pp. 53–72.

Bosquet, D. 2013. Chronological signification of Linear Pottery waste assemblages and waste management at the village scale: spatial analysis of Remicourt 'En Bia Flo' II (Liege province, Belgium). In: C. Hamon, P. Allard and M. Ilett, eds. *The Domestic Space in LBK Settlements*. Rahden/Westfalen: Marie Leidorf GmbH, pp. 29–41.

Bosquet, D., Salaverta, A. & Golitko, M. 2010. Chronological signification of LBK waste assemblages: the contribution of anthracological, typological, and stratigraphic data from three LBK sites in the Hesbaye (Liége Province, Belgium). In: I. Théry-Parisot, L. Chabal and S. Costamagno, eds. *The Taphonomy of Burned Organic*

Residues and Combustion Features in Archaeological Contexts. Proceedings of the Round Table, Valbonne, May 27-29 2008. Valbonne, pp. 39–57.

Bourdieu, P. 1977. *Outline of a Theory of Practice. (Esquisse d’une Théorie de La Pratique). Transl. by Richard Nice. (Repr.)*. Cambridge University Press.

Bourdieu, P. 1990. *The Logic of Practice*. Stanford: Stanford University Press.

Bourdieu, P. 2000. *Pascalian Meditations*. Cambridge: Polity Press.

Bourdieu, P. & Wacquant, L.J.D. 1992. *An Invitation to Reflexive Sociology*. Chicago: The University of Chicago Press.

Bradley, R. 2001. Orientations and origins: a symbolic dimension to the long house in Neolithic Europe. *Antiquity*, 75, pp. 50–56.

Bradley, R. & Fulford, M. 1980. Sherd Size in the Analysis of Occupation Debris. *Bulletin of the Institute of Archaeology London*, 17, pp. 85–94.

Braidwood, R.J. 1962. *The Near East and the Foundations for Civilization*. Eugene: Oregon State System of Higher Education.

Bramanti, B. Bramanti, B., Thomas, M.G., Haak, W., Unterlaender, M., Jores, P., Tambets, K., Antanaitis-Jacobs, I., Haidle, M.N., Jankauskas, R., Kind, C.J., Lueth, F., Terberger, T., Hiller, J., & Matsumura, S. 2009. Genetic discontinuity between local hunter-gatherers and Central Europe’s first farmers. *Science*, 326, pp. 137–140.

Bronitsky, G. 1986a. Archaeologists Study Thermal Shock. *Thermochimica Acta*, 98, pp. 37–47.

Bronitsky, G. 1986b. The Use of Materials Science Techniques in the Study of Pottery Construction and Use. *Advances in Archaeological Method and Theory*, 9, pp. 209–276.

Bronitsky, G. & Hamer, R. 1986. Experiments in Ceramic Technology: The Effects of Various Tempering Materials on Impact and Thermal-Shock Resistance. *American Antiquity*, 51, pp. 89–101.

Bronk, C., Higham, T., Whittle, A., & Bartosiewicz, L. 2007. Radiocarbon chronology. In: A. Whittle, ed. *The Early Neolithic on the Great Hungarian Plain. Investigations of the Körös Culture Site of Ecsegfalva 23, County Békés*. Budapest: Instituti Archaeologici, Academiae Scientiarum Hungaricae, pp. 173–188.

Bruner, E.M. 1993. Epilogue: Creative Persona and the Problem of Authenticity. In: S. Lavie, K. Narayan and R. Rosaldo, eds. *Creativity/Anthropology*. Ithaca: Cornell University Press, pp. 321–334.

Buchanan, R.A. 1992. *The Power of the Machine*. London: Viking.

Buckley, D.H. & Miyoshi, K. 1984. Friction and Wear of Ceramics. *Wear*, 100, pp. 333–353.

Buessem, W.R. & Bush, E.A. 1955. Thermal Fracture of Ceramic Materials Under Quasi-Static Thermal Stresses (Ring Test). *Journal of the American Ceramic Society*, 38, pp. 27–32.

Burri, O. & Guiet, R. 2016. Max Inscribed Circles. *ImageJ Plugins*.

Buttler, W. & Haberey, W. 1936. *Die Bandkeramische Ansiedlung Bei Köln- Lindenthal*. Berlin: De Gruyter.

Byrd, J.E. & Owens, D.D. 1997. A Method for Measuring Relative Abundance of Fragmented Archaeological Ceramics. *Journal of Field Archaeology*, 24, pp. 315–320.

Cahen, D. & Gilot, E. 1983. Chronologie radiocarbone du néolithique Danubien. *Dissertationes archaeologicae Gandenses*, XXI, pp. 21–40.

Calame, C. 1999. The Rhetoric of Mythos and Logos: Forms of Figurative Discourse. In: R. G. A. Buxton, ed. *From Myth to Reason? Studies in the Development of Greek Thought*. Oxford: Oxford University Press, pp. 119–144.

Cameron, C. M. (2002). Sacred earthen architecture in the northern Southwest: The Bluff Great House Berm. *American Antiquity*, 67(4), 677–695.

Campaña, I., Benito-Calvo, A., Pérez-González, A., Bermúdez de Castro, J.M., & Carbonell, E. 2016. Assessing automated image analysis of sand grain shape to identify sedimentary facies, Gran Dolina archaeological site (Burgos, Spain). *Sedimentary Geology*, 346, pp. 72–83.

Carneiro, A. & Mateiciucová, I. 2007. Daub fragments and the question of structures. In: *The Early Neolithic on the Great Hungarian Plain. Investigations of the Körös Culture Site of Ecsegfalva 23, County Békés*. Budapest: Instituti Archaeologici Academiae Scientiarum Hungaricae, pp. 255–286.

Carr, C. 1990. Advances in Ceramic Radiography and Analysis: Applications and Potentials. *Journal of Archaeological Science*, 17, pp. 13–34.

Carson, M.A. & Kirkby, M.J. 1972. *Hillslope Form and Process*. Cambridge: Cambridge University Press.

Castetter, E.F. & Underhill, R.M. 1935. The Ethnobiology of the Papago Indians. *The University of New Mexico Bulletin, Biological Series*, 4, pp. 3–84.

Cavalli-Sforza, L.L. 2003. Returning to the Neolithic Transition in Europe. In: A. J. Ammerman and P. Biagi, eds. *The Widening Harvest. The Neolithic Transition in Europe: Looking Back, Looking Forward*. Boston: Archaeological Institute of America, pp. 297–314.

Chapman, J. 1983. Meaning and illusion in the study of burial in Balkan prehistory. In: C. Burgess, P. Topping and D. Mordant, eds. *Ancient Bulgaria, Vol 1.* Oxford: Archaeopress, British Archaeological Reports, pp. 1–45.

Chapman, J. 1994. The living, the dead, and the ancestors: time, life cycles and the mortuary domain in later European prehistory. In: J. Davies, ed. *Ritual and Remembrance: Responses to Death in Human Societies*. Sheffield: Sheffield Academic Press, pp. 40–85.

Chapman, J. 2000a. *Fragmentation in Archaeology: People, Places, and Broken Objects in the Prehistory of South Eastern Europe.* London: Routledge.

Chapman, J. 2000b. Pit-digging and Structured Deposition in the Neolithic and Copper Age. *Proceedings of the Prehistoric Society*, 66, pp. 61–87.

Chapman, J. 2003. From Franchti to the Tiszazug: two Early Neolithic worlds. In: E. Jerem and P. Raczky, eds. *Frühe Etappen Der Menschheitsgeschichte in Mittel- Und Südosteuropa. Festschrift Für Nándor Kalicz Zum 75*. Budapest: Archaeolingua, pp. 89–108.

Chapman, J. 2013. Pottery fragmentation in archaeology: Picking up the pieces. *Annales Universitatis Apulensis Series Historica*, 17, pp. 7–16.

Chapman, J. & Gaydarska, B.I. 2007. *Parts and Wholes: Fragmentation in Prehistoric Context*. Oxford: Oxbow Books.

Chapman, R. 1981. The emergence of formal disposal areas and the ‘problem’ of megalithic tombs in prehistoric Europe. In: R. Chapman, I. Kinnes and K. Randsborg, eds. *The Archaeology of Death*. Cambridge: Cambridge University Press, pp. 71–81.

Chase, P.G. 1985. Whole Vessels and Sherds: An Experimental Investigation of Their Quantitative Relationships. *Journal of Field Archaeology*, 12, pp. 213–218.

Chernysheva, E., Korobov, D. & Borisov, A. 2017. Thermophilic microorganisms in arable land around medieval archaeological sites in Northern Caucasus, Russia: Novel evidence of past manuring practices. *Geoarchaeology*, 32, pp. 494–501.

Childe, V.G. 1929. *The Most Ancient East: The Oriental Prelude to European Prehistory*. London: Kegan Paul.

Childe, V.G. 1939. The Orient and Europe. *American Journal of Archaeology*, 43, pp. 10–26.

Childe, V.G. 1944. *Progress and Archaeology*. London: Watts.

Childe, V.G. 1956. *Piecing Together the Past*. London: Routledge & Kegan Paul.

Childe, V.G. 1964. *The Dawn of European Civilization*. 6th ed., rev. New York: Vintage.

Childe, V.G. 1981. *Man Makes Himself*. Bradford on Avon: Moonraker.

Childe, V.G. 1985. *What Happened in History*. Harmondsworth: Penguin Books.

Chmielewski, T.J. 2009. Early Neolithic Chipped Stone Assemblage from Seini-Dagas, District of Maramureş, Romania/Ansamblul de pietre cioplite din neoliticul timpuriu de la Seini-Dagas, judeţul Maramureş, România. *Marmatia*, 9, pp. 23–57.

Chmielewski, T.J. 2012. *Developed Neolithic Chipped Stone Industry in the Upper Tisza Basin*. Lucian Blaga University of Sibiu.

Chmielewski, T.J. & Astaloş, C. 2015. Floating stones down the Tur river. Comparative study of chipped stone assemblages from Călineşti-Oaş-Dâmbul Sfintei Mării and Méhtelek-Nádas. In: C. Virag, ed. *Neolithic Cultural Phenomena in the Upper Tisa Basin*. Satu Mare: Muzeul Județean Satu Mare, pp. 29–74.

Cho, G.-C., Dodds, J. & Santamarina, C. 2006. Particle Shape Effects on Packing Density, Stiffness, and Strength: Natural and Crushed Sands. *Journal of Geotechnical and Geoenvironmental Engineering*, 132, pp. 591–602.

Cho, S.-J., Huh, Y.-H., Yoon, K., & Ogawa, T. 1994. Aspects in Grinding of Ceramics. *Journal of the American Ceramic Society*, 77, pp. 2443–2444.

Choyke, A.M. 2007. Objects for a lifetime - tools for a season: the bone tools from Ecsegfalva 23. In: A. Whittle, ed. *The Early Neolithic on the Great Hungarian Plain. Investigations of the Körös Culture Site of Ecsegfalva 23, County Békés*. Budapest: Instituti Archaeologici Academiae Scientiarum Hungaricae, pp. 641–666.

Çilingiroğlu, Ç. 2005. The concept of ‘Neolithic package’: considering its meaning and applicability. *Documenta Praehistorica*, XXXII, pp. 1–13.

Ciută, M. 1997. Contribuţii la repertoriul arheologic al Neoliticului timpuriu în depresiunea Braşovului. *Apulum*, 34, pp. 5–35.

Ciută, M. 2005. *Începuturile Neoliticului Timpuriu În Spaţiul Intracarpatic Transilvănean*. Alba Iulia: Aeternitas.

Cladders, M. 2001. *Die Tonware Der Ältesten Bandkeramik. Untersuchung Zur Zeitlichen Und Räumlichen Gliederung*. Bonn: Habelt.

Cladders, M. & Stäuble, H. 2003. Das 53. Jahrhundert v. Chr.: Aufbruch und Wandel. In: J. Eckert, U. Eisenhauer and A. Zimmermann, eds. *Archäologische Perspektiven. Analysen Und Interpretationen Im Wandel*. Rahden/Westfalen: Marie Leidorf GmbH, pp. 491–503.

Clark, J.F.M. 2014. John Lubbock, Science and the Liberal Intellectual. *Notes & Records. The Royal Society Journal of the History of Science*, 68, pp. 65–87.

Clarke, D. 1968. *Analytical Archaeology*. London: Methuen.

Claßen, E. 2005. Siedlungsstrukturen der Bandkeramik im Rheinland. In: J. Lüning, C. Frirdich and A. Zimmermann, eds. *Die Bandkeramik Im 21. Jahrhundert: Symposium in Der Abtei Brauweiler Bei Köln Vom 16.9.-19.9.2002*. Rahden: Marie Leidorf GmbH, pp. 113–124.

Claßen, E. 2009. Settlement history, land use and social networks of early Neolithic communities in western Germany. In: D. Hofmann and P. Bickle, eds. *Creating Communities: New Advances in Central European Neolithic Research*. Oxford: Oxbow Books, pp. 95–110.

Claßen, E. 2010. Some technological aspects of LBK and non-LBK pottery in the Rhineland. In: B. Vanmontfort, L. Louwe Kooijmans, L. Amkreutz and L. Verhart, eds. *Pots, Farmers and Foragers. Pottery Traditions and Social Interaction in the Earliest Neolithic of the Lower Rhine Area*. Leiden: Leiden University Press, pp. 115–124.

Cleal, R. 1988. The Occurrence of Drilled Holes in Later Neolithic Pottery. *Oxford Journal of Archaeology*, 7, pp. 139–145.

Coble, R.L. & Kingery, W.D. 1955. Effects of Porosity on Thermal Stress Fracture. *Journal of the American Ceramic Society*, 38, pp. 33–37.

Cohen, M. 1980. Materials in human affairs. In: L. H. Van Vlack, ed. *Elements of Materials Science and Engineering*. 4th edition. Reading: Addison-Wesley, pp. vii–xix.

Commenge, C. 2009. Techniques séquentielles appliquées aux argiles: résonances orientales dans le Néolithique de Macédoine. In: *De Méditerranée et d'ailleurs... Mélanges Offerts à Jean Guilaine*. Toulouse: Archives d'Écologie Préhistorique, pp. 205–220.

Comte, A. 1988. *Introduction to Positive Philosophy*. Indianapolis: Hackett Publishing Company.

Connerton, P. 1989. *How Societies Remember*. Cambridge: Cambridge University Press.

Cotterell, B. & Kamminga, J. 1990. *Mechanics of Pre-Industrial Technology*. Cambridge: Cambridge University Press.

Coudart, A. 1998. *Architecture et Société Néolithique: L'unité et La Variance de La Maison Danubienne*. Paris: Éditions de la Maison des Sciences de l'Homme.

Courty, M.-A., Goldberg, P. & Macphail, R. 1989. *Soils and Micromorphology in Archaeology*. Cambridge: Cambridge University Press.

Courty, M.A. & Roux, V. 1995. Identification of wheel throwing on the basis of ceramic surface features and microfabrics. *Journal of Archaeological Science*, 22, pp. 17–50.

Cox, M.R. & Budhu, M. 2008. A practical approach to grain shape quantification. *Engineering Geology*, 96, pp. 1–16.

Craig, O.E., Heron, C., Willis, L.H., Yusof, N., & Taylor, G. 2007. Organic residue analysis of pottery vessels. In: A. W. R. Whittle, ed. *The Early Neolithic on the Great Hungarian Plain. Investigations of the Körös Culture Site of Ecsegfalva 23, County Békés*. Budapest: Instituti Archaeologici Academiae Scientiarum Hungaricae, pp. 349–359.

Crandell, O. 2014a. Knappable lithic resources of North-Western Romania: A mineralogical study. *Journal of Lithic Studies*, 1, pp. 73–84.

Crandell, O. 2014b. Knappable materials in the Criș Valley, Romania. *Journal of Lithic Studies*, 1, pp. 47–62.

Crowther, J. 2007. Chemical and magnetic properties of soils and pit fills. In: A. Whittle, ed. *The Early Neolithic on the Great Hungarian Plain. Investigations of the Körös Culture Site of Ecsegfalva 23, County Békés*. Budapest: Instituti Archaeologici Academiae Scientiarum Hungaricae, pp. 227–253.

Cruz, P. 2006. Complejidad y heterogeneidad en los Andes meridionales durante el Período de Integración Regional (siglos IV–X d.C.). *Bulletin de l'Institut français d'études andines* 35: 121–48.

Danzer, R., Lube, T., Supancic, P., & Damani, R. 2008. Fracture of ceramics. *Advanced Engineering Materials*, 10, pp. 275–298.

Davidge, R.W. 1979. *Mechanical Behaviour of Ceramics*. Cambridge: Cambridge University Press.

De Certeau, M., Giard, L. & Mayol, P. 1998. *The Practice of Everyday Life. Volume 2: Living and Cooking*. Minneapolis: University of Minnesota Press.

Deal, M. 1985. Household pottery disposal in the Maya highlands: An ethnoarchaeological interpretation. *Journal of Anthropological Archaeology*, 4, pp. 243–291.

Deal, M. & Hagstrum, M.B. 1995. Ceramic Reuse Behavior among the Maya and Wanka: Implications for Archaeology. In: J. M. Skibo, W. H. Walker and A. E. Nielsen, eds. *Expanding Archaeology*. Salt Lake City: University of Utah Press, pp. 111–125.

DeBoer, W.R. & Lathrap, D.W. 1979. Making and Breaking of Shipibo-Conibo Ceramics. In: C. Kramer, ed. *Ethnoarchaeology: Implications of Ethnography for Archaeology*. New York: Columbia University Press, pp. 102–138.

Descola, P. 2013. *Beyond Nature and Culture*. Chicago: University of Chicago Press.

Dizdar, M. & Krznarić Škrivanko, M. 2001. Prilog poznavanju arhitekture starčevačke kulture u Vinkovcima. *Vijesnik Arheološkog muzeja u Zagrebu*, 32–33, pp. 7–22.

Dodds, E.R. 1951. *The Greeks and the Irrational*. Berkeley: University of California Press.

Dodson, J.R., Hunt, A.J., Budarin, V.L., Matharu, A.S., & Clark, J.H. 2011. The chemical value of wheat straw combustion residues. *RSC Advances*, 1, pp. 523–530.

Dolukhanov, P., Shukurov, A., Gronenborn, D., Sokoloff, D., Timofeev, V., & Zaitseva, G. 2005. The chronology of Neolithic dispersal in Central and Eastern Europe. *Journal of Archaeological Science*, 32, pp. 1441–1458.

Domanska, E. 2010. Beyond Anthropocentrism in Historical Studies. *Historein*, 10, pp. 118–130.

Domboróczki, L. 2010a. Neolithisation in Northeastern Hungary: old theories and new perspectives. In: D. Gronenborn and J. Petrasch, eds. *Die Neolithisierung Mitteleuropas: Internationale Tagung, Mainz 24. Bis 26. Juni 2005*. Budenheim: RGZM, pp. 175–187.

Domboróczki, L. 2010b. Report on the excavation at Tiszaszőlős-Domaháza-puszta and a new model for the spread of the Körös Culture. In: J. K. Kozlowski and P. Raczky, eds. *Neolithization of the Carpathian Basin: Northernmost Distribution of the Starčevo/Körös Culture*. Kraków: Polska Akademia Umiejętności, pp. 137–176.

Domboróczki, L. 2012. Research at Ibrány-Nagyerdő in 2008-2009. In: A. Anders and Z. Siklósi, eds. *The First Neolithic Sites in Central/South-East European Transect. Volume III: The Körös Culture in Eastern Hungary*. Oxford: Archaeopress, pp. 125–128.

Domboróczki, L. & Raczky, P. 2010. Excavations at Ibrány-Nagyerdő and the northenmost distribution of the Körös Culture in Hungary. In: J. K. Kozlowski and P. Raczky, eds. *Neolithization of the Carpathian Basin: Northenmost Distribution of the Starčevo/Körös Culture*. Kraków: Polska Akademia Umiejętności, pp. 191–218.

Domínguez-Solera, S. 2010. An Experiment on the Vertical Migration of Archaeological Materials in Clay Deposits. *Journal of Taphonomy*, 8, pp. 69–74.

Dooijes, R. & Nieuwenhuyse, O.P. 2009. Ancient repairs in archaeological research: a Near Eastern perspective. In: J. Ambers, C. Higgitt, L. Harrison and D. Saunders, eds. *Holding It All Together: Ancient and Modern Approaches to Joining, Repair and Consolidation*. London: Archetype Publications Ltd, pp. 8–12.

Dorren, L.K.A. 2003. A review of rockfall mechanics and modelling approaches. *Progress in Physical Geography*, 27, pp. 69–87.

Douglas, M. 2002. *Purity and Danger*. London: Routledge.

Douny, L. 2007. The Materiality of Domestic Waste: The Recycled Cosmology of the Dogon of Mali. *Journal of Material Culture*, 12, pp. 309-331.

Drazin, A. 2019. Brokenness and Normality in Design Culture. In: F. Martínez and P. Laviolette, eds. *Repair, Brokenness, Breakthrough: Ethnographic Responses*. London: Berghahn, pp. 297–312.

Dreibrodt, S., Lubos, C., Terhorst, B., Damm, B., & Bork, H.-R. 2010. Historical soil erosion by water in Germany: Scales and archives, chronology, research perspectives. *Quaternary International*, 222, pp. 80–95.

Dubreuil, L. & Savage, D. 2014. Ground stones: a synthesis of the use-wear approach. *Journal of Archaeological Science*, 48, pp. 139–153.

Dunnell, R.C. & Simek, J.F. 1995. Artifact Size and Plowzone Processes. *Journal of Field Archaeology*, 22, pp. 305–319.

Duričić, A. 2014. The Construction and Usage of the Neolithic Oven: Experimental Archaeology. In: S. Vitezović and D. Antonović, eds. *Archaeotechnology: Studying Technology from Prehistory to the Middle Ages*. Belgrade: Srpsko arheološko društvo, pp. 257–276.

Ehrich, R.W. 1977. Starčevo revisited. In: V. Markotić, ed. *Ancient Europe and the Mediterranean*. Warminster: Aris and Phillips, pp. 59–67.

Einicke, R. 2014. Einige Bemerkungen zu den klebeverzierten Gefäßen der jüngeren Linienbandkeramik. In: H. J. Beier, R. Einicke and E. Biermann, eds. *"Material – Werkzeug: Werkzeug – Material" & "Klinge, Messer, Schwert & Co – Neues Aus Der Schneidenwelt"- Aktuelles Aus Der Neolithforschung. Beiträge Der Tagungen Der Arbeitsgemeinschaft Werkzeuge Und Waffen Pottenstein (Fränkische Schweiz) 2011 & Herxheim Bei Landau in Der Pfalz 2012*. Langenweißbach: Beier & Beran, pp. 163–172.

El Susi, G. 2018. Preliminary report on the faunal remains form the Early Neolithic site (Starčevo-Criş IIIB-IVA) at Tăşnad-Sere, Satu Mare County. *Studii de Preistorie*, 15, pp. 51–71.

Elburg, R. 2010. A Neolithic Treasure Chest. *The European Archaeologist*, pp. 4–6.

Elburg, R. 2013. Bandkeramiek anders: een Vroeg-Neolithische waterput uit altscherbitz (Saksen, Duitsland). *Archeologie*, 14, pp. 5–28.

Elburg, R. 2015. Keramik: flicken, kleben, reparieren. In: T. Otten, J. Kunow, M. M. Rind and M. Trier, eds. *Revolution Jungsteinzeit: Archäologische Landesausstellung Nordrhein-Westfalen*. Darmstadt: Theiss, pp. 240–241.

Engelbrecht, T. & Lüning, J. 2005. Die Keramik der Bandkeramiker. In: J. Lüning, ed. *Die Bandkeramiker. Erste Steinzeitbauern in Deutschland*. Rahden/Westfalen: Marie Leidorf GmbH, pp. 169–176.

Engels, F. 1902. *The Origin of the Family, Private Property, and the State*. Chicago: Charles H. Kerr & Company.

Engels, F. 1976. *Dialectics of Nature*. New York: International Publishers.

Eramo, G., Aprile, A., Muntoni, I.M., & Zerboni, A. 2014. Textural and Morphometric Analysis Applied to Holocene Pottery from Takarkori Rock Shelter (SW Libya, Central Sahara): A Quantitative Sedimentological Approach. *Archaeometry*, 56, pp. 36–57.

van Erp, J. & Huisman, W. 2010. Smart regulation and enforcement of illegal disposal of electronic waste. *Criminology & Public Policy*, 9, pp. 579–590.

Evans-Pritchard, E.E. 1937. *The Notion of Witchcraft Explains Unfortunate Events*. Oxford: Oxford University Press.

Falci, C.G., Cuisin, J., Delpuech, A., van Gijn, A., & Hofman, C.L. 2019. New Insights into Use-Wear Development in Bodily Ornaments Through the Study of Ethnographic Collections. *Journal of Archaeological Method and Theory*, 26, pp. 755–805.

Fansa, M. & Thieme, H. 1985. Eine Siedlung und Befestigungsanlage der Bandkeramik auf dem 'Nachtwiesen-Berg' bei Esbeck, Stadt Schöningen, Ldkr. Helmstadt. In: K. Wilhelmi, ed. *Ausgrabungen in Niedersachsen: Archäologische Denkmalpflege 1979-1984*. Stuttgart: Konrad Theiss, pp. 87–92.

Ferguson, R., Hoey, T., Wathen, S., & Werritty, A. 1996. Field evidence for rapid downstream fining of river gravels through selective transport. *Geology*, 24, pp. 179–182.

Ferreira, T. & Rasband, W. 2012. *ImageJ User Guide. IJ 1.46r*. http://imagej.nih.gov/ij/docs/guide/user-guide.pdf. Accessed October 2015.

Filipović, M. 1951. *Primitive Ceramics Made by Women among the Balkan Peoples*. Belgrade: Naučna knjiga.

Folk, R. 1966. A review of grain-size parameters. *Sedimentology*, 6, pp. 73–93.

Folk, R. & Ward, W. 1957. Brazos River bar: a study in the significance of grain size parameters. *Journal of Geology*, 62, pp. 344–359.

Foucault, M. 1975. *The Birth of the Clinic: An Archaeology of Medical Perception*. New York: Vintage.

Foucault, M. 1977. *Discipline and Punish: The Birth of the Prison*. London: Allen Lane.

Fowler, C., Harding, J. & Hofmann, D. 2015a. (eds.). *The Oxford Handbook of Neolithic Europe*. Oxford: Oxford University Press.

Fowler, C., Harding, J. & Hofmann, D. 2015b. The Oxford Handbook of Neolithic Europe: An Introduction. In: C. Fowler, J. Harding and D. Hofmann, eds. *The Oxford Handbook of Neolithic Europe*. Oxford: Oxford University Press, pp. 3–23.

Fowler, P.J. & Swanton, G. 1996. Background, Overton. In: M. Bell, P. J. Fowler and S. W. Hillson, eds. *The Experimental Earthwork Project, 1960-1992*. York: Council for British Archaeology, pp. 8–12.

Fowles, S. 2010. People Without Things. In: M. Bille, F. Hastrup and T. K. Sørensen, eds. *An Anthropology of Absence: Materialities of Transcendence and Loss*. London: Springer, pp. 23–41.

Franklin, J.A. 1998. Linear and Stichbandkeramik Pottery Technololgy from the Neolithic Site of Bylany (Czech Republic). In: I. Pavlů, ed. *Bylany Varia 1*. Praha: Archeologický ústav AV ČR, pp. 3–16.

Fraser, H. 1986. *Ceramic Faults and Their Remedies*. London: A & C Black.

Fréchette, V.D. 1990. *Failure Analysis of Brittle Materials*. Westerville: The American Ceramic Society.

Freeman, H.J. 2013. The Neolithic Revolution and Subsequent Emergence of the Celiac Affection. *International Journal of Celiac Disease*, 1, pp. 19–22.

Fröhlich, N. 2012. Bandkeramische Hofplätze und ihre Auffindbarkeit im Fundgut. In: *Siedlungsstruktur Und Kulturwandel in Der Bandkeramik. Beiträge Der Internationalen Tagung „Neue Fragen Zur Bandkeramik Oder Alles Beim Alten?!“. Leipzig 23. Bis 24. September 2010*. Dresden: Landesamt für Archäologie, pp. 311–315.

Gaastra, J.S., de Vareilles, A. & Vander Linden, M. 2019. Bones and Seeds: An Integrated Approach to Understanding the Spread of Farming across the Western Balkans. *Environmental Archaeology*.

Garašanin, M. 1983. *The Stone Age in the Central Balkans*. Cambridge: Cambridge University Press.

García-Granero, J.J., Arias-Martorell, J., Madella, M., & Lancelotti, C. 2016. Geometric morphometric analysis of Setaria italica (L.) P. Beauv. (foxtail millet) and Brachiaria ramosa (L.) Stapf. (browntop millet) and its implications for understanding the biogeography of small millets. *Vegetation History and Archaeobotany*, 25, pp. 303–310.

Garrow, D. 2012. Odd deposits and average practice. A critical history of the concept of structured deposition. *Archaeological Dialogues*, 19, pp. 85–115.

Gâţă, G. 1994. Caracterizarea tehnologică a ceramicii Starčevo-Criş de la Dulceanca. *Analele Banatului*, 3, pp. 41–43.

Gâţă, G. 1998. Caracterizarea tehnologiei de pastă a ceramicii Starcevo-Criş de la Şimnic. (The paste technology of Starcevo-Criş pottery from Şimnic). *Cercetări Arheologice*, 11, pp. 599–607.

Gheorghiu, D. 2008. The Emergence of Pottery. In: A. Jones, ed. *Prehistoric Europe. Theory and Practice*. Oxford: Wiley-Blackwell, pp. 164–192.

van Gijn, A. 2012. New perspectives for microwear analysis. *Analecta Praehistorica Leidensia*, 43/44, pp. 275–282.

van Gijn, A. & Hofman, C.L. 2008. Were they used as tools? An exploratory functional study of abraded potsherds from two pre-colonial sites on the island of Guadeloupe, northern Lesser Antilles. *Caribbean Journal of Science*, 44, pp. 21–35.

van Gijn, A. & Lammers-Keijsers, Y. 2010. Toolkits for ceramic production: informal tools and the importance of high power use-wear analysis. *Bulletin de la Société préhistorique française*, 107, pp. 755–762.

Gillespie, S.D. 2001. Personhood, Agency, and Mortuary Ritual: A Case Study from the Ancient Maya. *Journal of Anthropological Archaeology*, 20, pp. 73-112.

Girardet, H. 1993. Versuchsbohrungen an Originalscherben von Zürich-Mozartstrasse. In: E. Bleuer and B. Hardmeyer, eds. *Zürich-"Mozartstrasse" Band 3: Die Neolithische Keramik*. Zürich: FO Publishing, pp. 343–344.

Godon, M. & Lepere, C. 2006. Les estèques en céramique du Chasséen provençal: des outils simples? In: L. Astruc, F. Bon, V. Léa, P.-Y. Milcent and S. Philibert, eds. *Normes Techniques et Practiques Sociales. De La Simplicité Des Outillages Pré- et Protohistoriques*. Antibes: Éditions APDCA, pp. 1–8.

Gogotsi, G.A., Primak, L.P., Stepanenko, V.A., & Zakharov, A.I. 1977. Fracture characteristics of ceramic materials during thermal impact loading. *Strength of Materials*, 9, pp. 877–882.

Goldberg, P. & Macphail, R.I. 2006. *Practical and Theoretical Geoarchaeology*. Oxford: Blackwell.

Goldsmith, J.R. & Jenkins, D.M. 1985. The hydrothermal melting of low and high albite. *American Mineralogist*, 70, pp. 924–933.

Golitko, M. & Keeley, L.H. 2007. Beating ploughshares back into swords: warfare in the Linearbandkeramik. *Antiquity*, 81, pp. 332–342.

Gomart, L. 2014. *Traditions, Techniques et Production Céramique Au Néolithique Ancien. Étude de Huit Sites Rubanés Du Nord Est de La France et de Belgique*. Leiden: Sidestone Press.

Gomart, L. 2016. What factors of emergence of the first Neolithic in temperate Europe? Contribution of the anthropological aproach of ceramic assemblages from the early and middle Neolithic in Hungary. *Annales de la Fondation Fyssen*, 29, pp. 153–160.

Gomart, L., Anders, A., Kreiter, A., Marton, T., Oross, K., & Raczky, P. 2020. Innovation or inheritance? Assessing the social mechanisms underlying technological change in Early Neolithic pottery assemblages in Central Europe. In: M. Spataro and M. Furholt, eds. *Detecting and Explaining Technological Innovation in Prehistory*. Leiden: Sidestone Press, pp. 49–72.

Gomart, L., Hachem, L., Hamon, C., Giligny, F., Ilett, M. Household integration in Neolithic villages: A new model for the Linear Pottery Culture in west-central Europe. *Journal of Anthropological Archaeology*, 40, pp. 230–249.

Gomart, L. & Ilett, M. 2017. From potters' hands to settlement dynamics in the Early Neolithic site of Cuiry-les-Chaudardes (Picardy, France). *Archeologické rozhledy*, LXIX, pp. 209–226.

Gordillo, I. 2007. Detrás de las paredes ... Arquitectura y espacios domésticos en La Rinconada (Ambato, Catamarca). In: A. Nielsen, M.C. Rivolta, V. Seldes, M. Vázquez and P. Mercolli, eds. *Procesos sociales prehispánicos en los Andes Meridionales: perspectivas desde la casa, la comunidad y el territorio*. Córdoba: Brujas, pp. 65–98.

Gordillo, I. & Vindrola-Padrós, B. 2017. Destruction and abandonment practices at La Rinconada, Ambato Valley (Catamarca, Argentina). *Antiquity*, 91, pp. 155–172.

Gosden, C. 2005. What Do Objects Want? *Journal of Archaeological Method and Theory*, 12, pp. 193–211.

Gosden, C. & Marshall, Y. 1999. The cultural biography of objects. *World Archaeology*, 31, pp. 169-178.

Gosselain, O.P. 1992. Bonfire of the enquiries. Pottery firing temperatures in archaeology: What for? *Journal of Archaeological Science*, 19, pp. 243–259.

Gosselain, O.P. 2010. Ethnographie comparée des trousses à outils de potiers au sud du Niger. *Bulletin de la Société préhistorique française*, 107, pp. 667–689.

Graeber, D. 2011. "Consumption". *Current Anthropology*, 52, pp. 489–511.

Graeber, D. 2012. Afterword: the apocalypse of objects - degradation, redemption and transcendence in the world of consumer goods. In: C. Alexander and J. Reno, eds. *Economies of Recycling. The Global Transformation of Materials, Values and Social Relations*. London: Zed Books, pp. 277–290.

Graeber, D. & Wengrow, D. 2018. How to change the course of human history (at least, the part that's already happened). *Eurozine*.

Gräslund, B. 1974. *Relativ Datering. Om Kronologisk Metod i Nordisk Arkeologi*. Uppsala: Almqvist & Wiksell.

Gräslund, B. 1981. The background to C.F. Thomsen's Three Age System. In: G. Daniel, ed. *Towards a History of Archaeology. Being the Papers Read at the First Conference on the History of Archaeology in Aarhus, 29 August - 2 September 1978*. London: Thames and Hudson, pp. 45–50.

Gräslund, B. 1987. *The Birth of Prehistoric Chronology: Dating Methods and Dating Systems in Nineteenth-Century Scandinavian Archaeology*. Cambridge: Cambridge University Press.

Green, D.J. 1998. *An Introduction to the Mechanical Properties of Ceramics*. Cambridge: Cambridge University Press.

Greene, K. & Moore, T. 2010. *Archaeology. An Introduction*. Fifth edition. London: Routledge.

Greenfield, H.J. & Jongsma Greenfield, T. 2014. Subsistence and settlement in the Early Neolithic of temperate SE Europe: a view from Blagotin, Serbia. *Archaeologica Bulgarica*, XVIII, pp. 1–33.

Greenfield, H.J. & Lawson, K.S. 2020. Defining activity areas in the Early Neolithic (Starčevo-Criş) of southeastern Europe: A spatial analytic approach with ArcGIS at Foeni-Salaş (southwest Romania). *Quaternary International*, 539, pp. 4–28.

Griffith, A.A. 1920. The Phenomena of Rupture and Flow in Solids. *Philosophical Transactions of the Royal Society of London*, 221A, pp. 163–198.

Grote, K. 1998. Laubach 7. Eine spätmesolithische Station im unteren Werratal (Südniedersachsen). In: N. J. Conard and C. J. Kind, eds. *Aktuelle Forschungen Zum Mesolithikum. Current Mesolithic Research*. Tübingen: Marie Leidorf GmbH, pp. 203–221.

Guldager Bilde, P. & Handberg, S. 2012. Ancient Repairs on Pottery from Olbia Pontica. *American Journal of Archaeology*, 116, pp. 461–481.

Gur-Arieh, S., Mintz, E., Boaretto, E., & Shahack-Gross, R. 2013. An ethnoarchaeological study of cooking installations in rural Uzbekistan: development of a new method for identification of fuel sources. *Journal of Archaeological Science*, 40, pp. 4331–4347.

Gurova, M., Anastassova, E., Bonsall, C., Bradley, B., & Cura, P. 2014. Experimental approach to prehistoric drilling and bead manufacturing. In: S. Cura, J. Cerezer, M. Gurova, B. Santander, L. Oosterbeek and J. Cristóvão, eds. *Technology and Experimentation in Archaeology*. Oxford: Archaeopress, pp. 47–55.

Gurova, M. & Bonsall, C. 2017. Experimental Replication of Stone, Bone and Shell Beads from Early Neolithic Sites in Southeast Europe. In: M. D. Bar-Yosef, C. Bonsall and A. M. Choyke, eds. *Not Just for Show: The Archaeology of Beads, Beadwork and Personal Ornaments*. Oxford: Oxbow Books, pp. 159–167.

Guzman, M.J. de 2004. *Bandkeramik Pit Contents and Stratification: A Relational Analysis Investigating Structured Deposition*. Unpublished MA Thesis, Durham University.

Gwinnett, J. & Gorelick, L. 1987. The Change from Stone Drills to Copper Drills in Mesopotamia. An Experimental Persective. *Expedition*, 29, pp. 15–24.

Haak, W., Balanovsky, O., Sanchez, J.J., Koshel, S., Zaporozhchenko, V., Adler, C.J., Sarkissian, C.S.I.D., Brandt, G., Schwarz, C., Nicklisch, N., Dresely, V., Fritsch, B., Balanovska, E., Villems, R., Meller, H., Alt, K.W., Cooper, A., & Consortium, the G. 2010. Ancient DNA from European Early Neolithic Farmers Reveals Their Near Eastern Affinities. *PLOS Biology*, 8. Retrieved on 29 October 2018 from World Wide Web: journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.1000536

Hachem, L. 2000. New observations on the Bandkeramik house and social organization. *Antiquity*, 74, pp. 308–312.

Hachem, L. & Hamon, C. 2014. Linear Pottery Culture Household Organisation: An Economic Model. In: A. W. R. Whittle and P. Bickle, eds. *Early Farmers: The View from Archaeology and Science*. Oxford: Oxford University Press, pp. 159–180.

Hágó, A.N. & Németi, J. 2013. Archaeological Researches at Pişcolt-Lutărie. *Acta Terrae Septemcastrensis*, XII, pp. 21–36.

Hardy-Smith, T. & Edwards, P.C. 2004. The Garbage Crisis in prehistory: artefact discard patterns at the Early Natufian site of Wadi Hammeh 27 and the origins of household refuse disposal strategies. *Journal of Anthropological Archaeology*, 23, pp. 253–289.

Harman, G. 2010. *Towards Speculative Realism: Essays and Lectures*. Winchester: Zero Books.

Harrison, R. 2003. 'The Magical Virtue of these Sharp Things'. Colonialism, Mimesis and Knapped Bottle Glass Artefacts in Australia. *Journal of Material Culture*, 8, pp. 311–336.

Hasselman, D.P.H. 1969. Unified Theory of Thermal Shock Fracture Initiation and Crack Propagation in Brittle Ceramics. *Journal of the American Ceramic Society*, 52, pp. 600–604.

Hattingh, J. & Illenberger, W.K. 1995. Shape sorting of flood-transported synthetic clasts in a gravel bed river. *Sedimentary Geology*, 96, pp. 181–190.

Hauzeur, A. 1991. Outils en céramique du Néolithique ancien. *Anthropologie et Préhistoire*, 102, pp. 55–59.

Hawkins, G. 2006. *The Ethics of Waste: How We Relate to Rubbish*. Oxford: Rowman & Littlefield.

Hayden, B. & Cannon, A. 1983. Where the garbage goes: Refuse disposal in the Maya Highlands. *Journal of Anthropological Archaeology*, 2, pp. 117–163.

Heidegger, M. 1962. *Being and Time*. Oxford: Blackwell.

Heilbronner, R. & Barrett, S.D. 2014. *Image Analysis in Earth Sciences*. Berlin: Springer.

Hein, A., Müller, N.S., Day, P.M., & Kilikoglou, V. 2008. Thermal conductivity of archaeological ceramics: The effect of inclusions, porosity and firing temperature. *Thermochimica Acta*, 480, pp. 35–42.

Hein, A., Müller, N.S. & Kilikoglou, V. 2015. Heating efficiency of archaeological cooking vessels: computer models and simulations of heat transfer. In: M. Spataro and A. Villing, eds. *Ceramics, Cuisine and Culture: The Archaeology and Science of Kitchen Pottery in the Ancient Mediterranean World*. Oxford: Oxbow Books, pp. 49–54.

Heinemann, R. 2014. Drilling. In: L. Laperrière and G. Reinhart, eds. *CIRP Encyclopedia of Production Engineering*. Berlin and Heidelberg: Springer, pp. 416–421.

Heinen, M. 1998. Mèche de foret - eine charakteristische, aber weitgehend unbekannte Werkzeugform des Mesolithikums. In: N. Conrand and C. J. Kind, eds. *Aktuelle Forschungen Zum Mesolithikum. Current Mesolithic Research*. Tübingen: Mo Vince Verlag, pp. 133–146.

Hertelendi, E., Kalicz, N., Raczky, P., Horváth, F., Veres, M., Svingor, E., Futó, I., & Bartosiewicz, L. 1995. Re-evaluation of the Neolithic in Eastern Hungary based on calibrated radiocarbon dates. *Radiocarbon*, 37, pp. 239–244.

Hesser, A. 2003. The Torch is Passed, Handle First. In: H. Hughes, ed. *Best Food Writing 2003*. New York: Marlow, pp. 15–18.

Hildebrand, J.A. & Hagstrum, M.B. 1999. New Approaches to Ceramic Use and Discard: Cooking Pottery from the Peruvian Andes in Ethnoarchaeological Perspective. *Latin American Antiquity*, 10, pp. 25–46.

Hodder, I. 1982. *Symbols in Action. Ethnoarchaeological Studies of Material Culture*. Cambridge: Cambridge University Press.

Hodder, I. 1987. The meaning of discard: ash and domestic space in Baringo. In: S. Kent, ed. *Method and Theory for Activity Research*. New York: Columbia University Press, pp. 424-448.

Hodder, I. 1990. *The Domestication of Europe: Structure and Contingency in Neolithic Societies*. Oxford: Basil Blackwell.

Hodder, I. 2006. *Çatalhöyük: The Leopard's Tale*. London: Thames and Hudson.

Hodder, I. 2014. The Asymmetries of Symmetrical Archaeology. *Journal of Contemporary Archaeology*, 1, pp. 228–230.

Hodder, I. 2017. Things and the Slow Neolithic: The Middle Eastern Transformation. *Journal of Archaeological Method and Theory*, 24, pp. 1–23.

Hodder, I. 2018. *Where Are We Heading? The Evolution of Humans and Things*. New Haven: Yale University Press.

Hofmann, D. 2020. LBK structured deposits as magical practices. In: D. Hofmann, ed. *Magical, Mundane or Marginal? Deposition Practices in the Early Neolithic Linearbandkeramik Culture*. Leiden: Sidestone Press, pp. 113–147.

Hofmann, D. 2015a. The burnt, the whole and the broken: funerary variability in the Linearbandkeramik. In: Z. Devlin and E. J. Graham, eds. *Death Embodied: Archaeological Approaches to the Treatment of the Corpse*. Oxford: Oxbow, pp. 109–128.

Hofmann, D. 2015b. What Have Genetics Ever Done for Us? The Implications of aDNA Data for Interpreting Identity in Early Neolithic Central Europe. *European Journal of Archaeology*, 18, pp. 454–476.

Hofmann, D. & Smyth, J. 2013. Introduction: Dwelling, Materials, Cosmology—Transforming Houses in the Neolithic. In: D. Hofmann and J. Smyth, eds. *Tracking the Neolithic House in Europe*. Springer New York, pp. 1–17.

Holt, B.M. 2003. Mobility in Upper Paleolithic and Mesolithic Europe: evidence from the lower limb. *American Journal of Physical Anthropology*, 122, pp. 200–215.

Horkheimer, M. 1947. *The Eclipse of Reason*. New York: Continuum.

Horkheimer, M. 2012. *Critique of Instrumental Reason*. London: Verso Books.

Horkheimer, M. & Adorno, T.W. 2002. *Dialectic of Enlightenment. Philosophical Fragments*. G. Schmid Noerr, ed. Stanford: Stanford University Press.

Hoselitz, Virginia. 2007. *Imagining Roman Britain: Victorian Responses to a Roman Past*. Woodbridge: The Boydell Press.

Huisman, D.J., Brounen, F., Lohof, E., Machiels, R., de Moor, J., van Os, B.J.H., van de Velde, P., Rensink, E., & van Wijk, I.M. 2014. Micromorphological study of Early Neolithic (LBK) soil features in the Netherlands. *Journal of Archaeology in the Low Countries*, 5, pp. 107–133.

Husserl, E. 1991. *Of the Phenomenology of the Consciousness of Internal Time*. 1st ed. Dordrecht: Springer.

Hutson, S.R. & Stanton, T.W. 2007. Cultural Logic and Practical Reason: the Structure of Discard in Ancient Maya Houselots. *Cambridge Archaeological Journal*, 17, pp. 123-144.

Iercoşan, N. 1994. Săpături arheologice în aşezarea neolitică aparţinând culturii Starčevo – Criş de la Tăşnad (jud. Satu Mare). *Studii şi Comunicări Satu Mare*, 11–12, pp. 9–32.

Ignat, D.F. 1998. *Grupul Cultural Neolitic Suplacu de Barcău*. Timişoara: MIRTON.

Illich, I. 1992. *In the Mirror of the Past. Lectures and Addresses 1978-1990*. London: Marion Boyars Publishers.

Ingold, T. 1986. *The Appropriation of Nature. Essays on Human Ecology and Social Relations*. Manchester: Manchester University Press.

Ingold, T. 1993. The art of translation in a continuous world. In: G. Pálsson, ed. *Beyond boundaries: understanding translation and anthropological discourse*. Oxford: Berg, pp. 210-230.

Ingold, T. 2007a. Materials against materiality. *Archaeological Dialogues*, 14, pp. 1–16.

Ingold, T. 2007b. Writing texts, reading materials. A response to my critics. *Archaeological Dialogues*, 14, pp. 31–38.

Ingold, T. 2000. *The Perception of the Environment. Essays on Livelihood, Dwelling and Skill*. London: Routledge.

Ingold, T. 2011. *Being Alive: Essays on Movement, Knowledge and Description*. London: Routledge.

Ingold, T. 2018. Back to the future with the theory of affordances. *HAU: Journal of Ethnographic Theory*, 8, pp. 39-44.

Ingold, T. & Hallam, E. 2007. Creativity and Cultural Improvisation: An Introduction. In: E. Hallam and T. Ingold, eds. *Creativity and Cultural Improvisation*. Oxford: Berg, pp. 1–24.

Jackson, S.J. 2011. Rethinking Repair. In: T. Gillespie, P. Boczkowski and K. Foot, eds. *Media Technologies: Essays on Communication, Materiality and Society*. Cambridge: MIT Press, pp. 221–239.

Jensen, T.Z.T., Niemann, J., Iversen, K.H., Fotakis, A.K., Gopalakrishnan, S., Vågene, Å.J., Pedersen, M.W., Sinding, M.-H.S., Ellegaard, M.R., Allentoft, M.E., Lanigan, L.T., Taurozzi, A.J., Nielsen, S.H., Dee, M.W., Mortensen, M.N., Christensen, M.C., Sørensen, S.A., Collins, M.J., Gilbert, M.T.P., Sikora, M., Rasmussen, S., &

Schroeder, H. 2019. A 5700- year-old human genome and oral microbiome from chewed birch pitch. *Nature Communications*, 10, pp. 5520.

Jewell, P. & Dimbleby, G.W. 1966. The experimental earthwork on Overton Down, Wiltshire, England: the first four years. *Proceedings of the Prehistoric Society*, 32, pp. 313–342.

Johnsen, J. 1976. Comments on relative chronology. *Norwegian Archaeological Review*, 9, pp. 105–108.

Jones, A.M. & Sibbesson, E. 2013. Archaeological Complexity: Materials, Multiplicity, and the Transitions to Agriculture in Britain. In: B. Alberti, A. M. Jones and J. Pollard, eds. *Archaeology after Interpretation: Returning Materials to Archaeological Theory*. Walnut Creek: Left Coast Press, pp. 151–172.

Jordan, P. & Zvelebil, M. (eds.) 2010. *Ceramics Before Farming: The Dispersal of Pottery Among Prehistoric Eurasian Hunter-Gatherers*. London: Routledge.

Jovanović, B. 1991. Arhitektonska plastika u Starcevackoj kulturi. *Zbornik Narodnog muzeja*, XIV, pp. 53–64.

Kaczanowska, M. & Kozlowski, J.K. 1994. Environment and highland zone exploitation in the Western Carpathians (VII-VI Millennium BP). In: P. Biagi and J. Nandris, eds. *Highland Zone Exploitation in Southern Europe*. Brescia: Museo civico di storia naturale di Brescia, pp. 49–71.

Kaczanowska, M. & Kozlowski, J.K. 2012. Körös lithics. In: A. Anders and Z. Siklósi, eds. *The First Neolithic Sites in Central/South-East European Transect. Volume III: The Körös Culture in Eastern Hungary*. Oxford: Archaeopress, pp. 161–170.

Kadrow, S. & Rauba-Bukowska, A. 2017a. The selection of raw material: convenience or a technological idea? A case study of the Danubian cultures north of the Carpathians. *Archeologické rozhledy*, LXIX, pp. 261–280.

Kadrow, S. & Rauba-Bukowska, A. 2017b. The Technology of Neolithic Pottery North and South of the Western Carpathians. In: T. Pereira, X. Terradas and N. Bicho, eds. *The Exploitation of Raw Materials in Prehistory: Sourcing, Processing, and Distribution*. Newcastle upon Tyne: Cambridge Scholars Publishing, pp. 414–431.

Kalicz, N. 1965. Siedlungsgeschichtliche Probleme de Koros- und der Theiss-Kultur. *Acta Antiqua et Achaeologica*, VIII, pp. 27–40.

Kalicz, N. 1990. *Frühneolithische Siedlungsfunde Aus Südwestungarn: Quellenanalyse Zur Geschichte Der Starčevo-Kultur*. Budapest: Magyar Nemzeti Múzeum.

Kalicz, N. 1998. Das Frühneolithikum im Karpatenbecken. In: J. Preuß, ed. *Das Neolithikum in Mitteleuropa, Kulturen – Wirtschaft – Umwelt Vom 6. Bis 3. Jahrtausend v. u. Z.* Weissbach: Beier and Beran, pp. 257–262.

Kalicz, N. 2011. *Méhtelek : The First Excavated Site of the Méhtelek Group of Early Neolithic Körös Culture in the Carpathian Basin*. Oxford: Archaeopress.

Kalicz, N. 2012. Méhtelek-Nádas – The First Excavated Site of the Mehtelek Facies of the Early Neolithic Körös Culture in the Carpathian Basin. In: A. Anders and Z. Siklósi, eds. *The First Neolithic Sites in Central/South-East European Transect. Volume III: The Körös Culture in Eastern Hungary*. Oxford: Archaeopress, pp. 113–123.

Kalicz, N. & Makkay, J. 1976. Frühneolithische Siedlung in Méhtelek-Nádas (Vorbericht). *Mitteilungen des Archäologischen Instituts der Ungarischen Akademie der Wissenschaften*, 6, pp. 13–24.

Kalicz, N. & Raczky, P. 1980. Siedlung der Körös-Kultur in Szolnok-Szanda. *Mitteilungen des Archäologischen Instituts der Ungarischen Akademie der Wissenschaften*, 10–11, pp. 13–24.

Karmanski, S. 2005. *Donja Branjevina: A Neolithic Settlement near Deronje in the Vojvodina, Serbia*. Trieste: Società per la preistoria e protostoria della regione Friuli-Venezia Giulia.

Kato, K. & Adachi, K. 2001. Wear Mechanisms. In: B. Bhushan, ed. *Modern Tribology Handbook. Volume One: Principles of Tribology*. Boca Raton: CRC Press, pp. 273–300.

Kaufmann, D. 1983. Die ältestlinienbandkeramischen Funde von Eilsleben, Kr. Wanzleben, und der Beginn des Neolithikums im Mittelelbe-Saale-Gebiet. *Nachrichten aus Niedersachsens Urgeschichte*, 52, pp. 177–202.

Kaufmann, D. 1997. Zur Funktion linienbandkeramischer Erdwerke. *Niederbayerischer Archäologentag*, 15, pp. 41–87.

Kaufmann, D. & Heege, E. 1991. Der linienbandkeramische Backofen von Eisleben, Ldkr. Wanzleben: Der archäologische Befund und sein Nachbau im Experiment. *Experimentelle Archäologie in Deutschland*, 6, pp. 185–196.

Kazdová, E. 1984. *Těšetice-Kyjovice. 1, Starší Stupeň Kultury s Moravskou Malovanou Keramikou*. Brno: Universita J.E. Purkyně.

Keefer, E. 1993. *Steinzeit*. Stuttgart: Konrad Theiss.

Keerl, V. 2015. *A River Runs through It - Ancient DNA Data on the Neolithic Populations of the Great Hungarian Plain*. Unpublished PhD thesis, Johannes Gutenberg-Universität Mainz.

Kehrberg, I. 1992. Flaked Glass and Pottery Sherd Tools of the Late Roman and Byzantine Periods from the Hippodrome at Jerash. *Syria*, 69, pp. 451–464.

Kenyon, K.M. 1954. Excavations at Jericho. *The Journal of the Royal Anthropological Institute of Great Britain and Ireland*, 84, pp. 103–110.

Kenyon, K.M. 1969. The Origins of the Neolithic. *The Advancement of Science*, 26, pp. 144–160.

Kertész, R. & Sümegi, P. 2001. Theories, critiques and a model: Why did the expansion of the Körös-Starčevo Culture stop in the centre of the Carpathian Basin? In: R. Kertész and J. Makkay, eds. *From the Mesolithic to the Neolithic. Proceedings of the International Archaeological Conference Held in the Damjanich Museum of Szolnok, September 22-27, 1996*. Budapest: Archaeolingua, pp. 225–246.

Kilikoglou, V. & Vekinis, G. 2002. Failure Prediction and Function Determination of Archaeological Pottery by Finite Element Analysis. *Journal of Archaeological Science*, 29, pp. 1317–1325.

Kilikoglou, V., Vekinis, G., Maniatis, Y., Day, P.M. 1998. Mechanical Performance of Quartz-Tempered Ceramics: Part I, Strength and Toughness*. *Archaeometry*, 40, pp. 261–279.

Kingery, W.D. 1955. Factors Affecting Thermal Stress Resistance of Ceramic Materials. *Journal of the American Ceramic Society*, 38, pp. 3–15.

Kingery, W.D. 1963. Effects of microstructure on the properties of ceramics. In: C. Klingsberg, ed. *The Physics and Chemistry of Ceramics*. New York: Gordon and Breach, pp. 286–305.

Kingery, W.D., Bowen, H.K. & Uhlmann, D.R. 1976. *Introduction to Ceramics*. 2nd Edition. New York: John Wiley & Sons.

Kirkby, A. & Kirkby, M.J. 1974. Surface wash at the semi-arid break in slope. *Zeitschrift für Geomorphologie*, 21, pp. 151–176.

Kirkby, A. & Kirkby, M.J. 1976. Geomorphic processes and the surface survey of archaeological sites in semi-arid areas. In: D. Davison and M. Shackley, eds. *Geoarchaeology*. London: Duckworth, pp. 229–253.

Kirkby, M.J. & Statham, I. 1975. Surface Stone Movement and Scree Formation. *The Journal of Geology*, 83, pp. 349–362.

Kirleis, W. & Willerding, U. 2008. Die Pflanzenreste der linienbandkeramischen Siedlung von Rosdorf-Mühlengrund, Ldkr. Göttingen, im südöstlichen Niedersachsen. *Prähistorische Zeitschrift*, 83, pp. 133–178.

Kiss, A. 2009. Floods and weather in 1342 and 1343 in the Carpathian Basin. *Journal of Environmental Geography*, II, pp. 37–47.

Kiss, T., Hernesz, P., Sümeghy, B., Györgyövics, K., & Sipos, G. 2015. The evolution of the Great Hungarian Plain fluvial system – Fluvial processes in a subsiding area from the beginning of the Weichselian. *Quaternary International*, 388, pp. 142–155.

Kjærsgaard, M.S., Halse, J., Smith, R.C., Vangkilde, K.T., Binder, T., & Otto, T. 2016. Introduction: Design Anthropological Futures. In: R. C. Smith, K. T. Vangkilde, M. S. Kjærsgaard, T. Otto, J. Halse and T. Binder, eds. *Design Anthropological Futures*. London: Bloomsbury Academic, pp. 1–16.

Klindt-Jensen, O. 1975. *A History of Scandinavian Archaeology*. London: Thames and Hudson.

Kloos, U. 1990. *Die Keramik Der Ältestbandkeramischen Siedlung Bruchenbrücken, Gemeinde Friedberg/ Wetterau Wetteraukreis*. Johann Wolfgang Goethe-Universität Frankfurt.

Knappett, C. 2007. Materials with materiality? *Archaeological Dialogues*, 14, pp. 20–23.

Knappett, C. & Malafouris, L. (eds.) 2008a. *Material Agency: Towards a Non-Anthropocentric Approach*. New York: Springer.

Knappett, C. & Malafouris, L. 2008b. Material and Nonhuman Agency: An Introduction. In: C. Knappett and L. Malafouris, eds. *Material Agency: Towards a Non-Anthropocentric Approach*. New York: Springer, pp. ix–xix.

Kopytoff, I. 1986. The cultural biography of things: commoditization as process. In: A. Appadurai, ed. *The Social Life of Things: Commodities in Cultural Perspective*. Cambridge: Cambridge University Press, pp. 64-91.

Končelová, M., Midgley, M., Rulf, J., Zápotocká, M., & Pavlů, I. 2019. The Vertical Structure of Neolithic Finds in the Fills of Archaeological Features. *Interdisciplinaria Archaeologica. Natural Sciences in Archaeology*, X, pp. 29–51.

Kossinna, G. 1911. *Die Herkunft Der Germanen: Zur Methode Der Siedlungsarchäologie*. Würzburg: C. Kabitzsch.

Kovaříková, I., Szewczyková, B., Blaškoviš, P., Hodúlová, E., & Lechovič, E. 2009. Study and characteristic of abrasive wear mechanisms. *Material Science and Technology*, 1, pp. 1–8.

Kowarik, K. 2010. Die Keramikfunde der Häuser 1-4 aus der bandkeramischen Siedlung von Mold in Niederösterreich. In: E. Lenneis, ed. *Die Bandkeramische Siedlung von Mold Bei Horn in Niederösterreich. Teil 1 - Naturwissenschaftliche Beiträge Und Einzelanalysen*. Rahden/Westfalen: Marie Leidorf GmbH, pp. 33–168.

Krauß, L., Zens, J., Zeeden, C., Schulte, P., Eckmeier, E., & Lehmkuhl, F. 2016. A Multi-Proxy Analysis of two Loess-Paleosol Sequences in the Northern Harz Foreland, Germany. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 461, pp. 401–417.

Krebber, A. 2011. Anthropocentrism and Reason in Dialectic of Enlightenment: Environmental Crisis and Animal Subject. In: R. Boddice, ed. *Anthropocentrism. Human, Animals, Environments*. Leiden: Brill, pp. 321–340.

Krebber, A. 2017. Negative Dialectics of Nature: From Nature's Death to New Materialisms. In: C. Novero, ed. *Of Rocks, Mushrooms and Animals: Material Ecocriticism in German-Speaking Cultures*. Otago: Dunedin, pp. 199–222.

Kreher, W. & Pompe, W. 1981. Increased fracture toughness of ceramics by energy-dissipative mechanisms. *Journal of Materials Science*, 16, pp. 694–706.

Kreiter, A. 2010. Crafting Difference: Early Neolithic (Körös Culture) Ceramic Traditions in North-East Hungary. In: J. K. Kozlowski and P. Raczky, eds. *Neolithization of the Carpathian Basin: Northenmost Distribution of the Starčevo/Körös Culture*. Kraków: Polska Akademia Umiejętności, pp. 266–282.

Kreiter, A., Marton, T., Gomart, L., Oross, K., & Pánczél, P. 2017. Looking into houses: analysis of LBK ceramic technological change on a household level. In: *Matières à Penser. Raw Materials Acquisition and Processing in Early Neolithic Pottery Productions. Proceedings of the Workshop of Namur (Belgium), 29-30 May 2015*. Paris: Société préhistorique française, pp. 111–132.

Kreiter, A., Pető, Á. & Pánczél, P. 2013. Materialising tradition: ceramic production in Early Neolithic Hungary. In: E. Bánffy, ed. *The Early Neolithic in the Danube-Tisza Interfluve*. Oxford: Archaeopress, pp. 127–140.

Kreiter, A., Riebe, D.J., Parkinson, W.A., Pető, Á., Tóth, M., Pánczél, P., & Bánffy, E. 2014. Unique in its chaîne opératoire, unique in its symbolism: undressing a figurine from the 6th Millennium BC Körös culture, Hungary. *Journal of Archaeological Science*, 44, pp. 136–147.

Kreiter, A. & Szakmány, G.Y. 2011. Petrographic analysis of Körös ceramics from Méhtelek–Nádas. In: N. Kalicz, ed. *The First Excavated Site of Méhtelek Group of the Early Neolithic Körös Culture in the Carpathian Basin*. Budapest: Archaeolingua, pp. 113–130.

Kreuz, A. 2007. Archaeobotanical perspectives on the beginning of agriculture north of the Alps. In: S. Colledge and J. Conolly, eds. *The Origins and Spread of Domestic Plants in Southwest Asia and Europe*. Walnut Creek: Left Coast Press, pp. 259–294.

Kreuz, A. 1990. *Die Ersten Bauern Mitteleuropas - Eine Archäobotanische Untersuchung Zu Umwelt Und Wirtschaft Der Ältesten Bandkeramik*. Leiden: Sidestone Press.

Kreuz, A. & Schäfer, E. 2011. Weed finds as indicators for the cultivation regime of the early Neolithic Bandkeramik culture? *Vegetation History and Archaeobotany*, 20, pp. 333.

Krumbein, W.C. 1941a. Measurement and Geological Significance of Shape and Roundness of Sedimentary Particles. *Journal of Sedimentary Research*, 11, pp. 64–72.

Krumbein, W.C. 1941b. The Effects of Abrasion on the Size, Shape and Roundness of Rock Fragments. *The Journal of Geology*, 49, pp. 482–520.

Krumbein, W.C. & Sloss, L.L. 1963. *Stratigraphy and Sedimentation*. 2nd Edition. San Francisco and London: W.H. Freeman and Company.

Kuenen, P.H. 1959. Experimental Abrasion: 3. Fluviatile action on sand. *American Journal of Science*, 257, pp. 172–190.

Kuenen, Ph.H. 1960. Experimental Abrasion 4: Eolian Action. *The Journal of Geology*, 68, pp. 427–449.

Kuenen, Ph.H. 1964. Experimental Abrasion: 6. Surf Action. *Sedimentology*, 3, pp. 29–43.

Kuna, M. 2015. Categories of Settlement Discard. In: K. Kristiansen, L. Šmejda and J. Turek, eds. *Paradigm Found: Archaeological Theory – Present, Past and Future. Essays in Honour of Evžen Neustupný*. Oxford: Oxbow Books, pp. 278–292.

Kunst, M. 2010. 'Neolithisierung—Eine Begriffsbestimmung'. In: D. Gronenborn and J. Petrasch, eds. *The Spread of the Neolithic to Central Europe*. Mainz: RGZM, pp. 13–22.

Kuo, C.-Y. & Freeman, R. 2000. Imaging Indices for Quantification of Shape, Angularity, and Surface Texture of Aggregates. *Transportation Research Record: Journal of the Transportation Research Board*, 1721, pp. 57–65.

Kuper, R., Lohr, H., Lüning, J., & Stehli, P. 1974. Untersuchungen zur neolithischen Besiedlung der Aldenhovener Platte IV. *Bonner Jahrbücher*, 174, pp. 424–500.

Květina, P. 2010. The spatial analysis of non-ceramic refuse from the Neolithic site at Bylany, Czech Republic. *European Journal of Archaeology*, 13, pp. 336–367.

Květina, P. & Hrnčiř, V. 2013. Between archaeology and anthropology: imagining Neolithic settlements. *Anthropologie*, 51, pp. 323–347.

Květina, P. & Končelová, M. 2011. Sherds on the Map. Intra-site GIS of the Neolithic Site of Bylany (Czech Republic). In: P. Verhagen, A. G. Posluschny and Danielisová, eds. *Go Your Own Least Cost Path. Spatial Technology and Archaeological Interpretation. Proceedings of the Session at EAA 2009, Riva Del Garda*. Oxford: Archaeopress, British Archaeological Reports, pp. 55–65.

Květina, P. & Končelová, M. 2013. Neolithic LBK Intrasite Settlement Patterns: A Case Study from Bylany (Czech Republic). *Journal of Archaeology*, 2013, pp. 1–7.

Květina, P. & Pavlů, I. 2007. *Neolitické Sídliště v Bylanech – Základní Databáze / Neolithic Settlement at Bylany – Essential Database*. Praha: Archeologický ústav.

Langley, M.C. 2018. Explaining the lack of emu eggshell material culture in Australia: Experimental working and archaeological implications. *Journal of Archaeological Science: Reports*, 17, pp. 155–162.

Larsen, C.S. 2006. The agricultural revolution as environmental catastrophe: Implications for health and lifestyle in the Holocene. *Quaternary International*, 150, pp. 12–20.

Lartet, E. 1861. Nouvelles recherches sur la coexistence de l'homme et des grands mammifères fossiles réputés caractéristiques de la dernière période géologique. *Annales des sciences naturelles, Partie Zoologique*, XV, pp. 177–253.

Last, J.A. 1995. *Secondary Refuse Deposits and the Spatial Structure of Settlement in the Early and Middle Neolithic of Central Europe*. Unpublished PhD thesis, University of Cambridge.

Last, J. 1998. The Residue of Yersterdays Existence: Settlement Space and Discard at Miskovice and Bylany. In: I. Pavlů, ed. *Bylany Varia 1*. Praha: Archeologický ústav, pp. 17–46.

Last, J. 2015. Longhouse Lifestyles in the Central European Neolithic. In: C. Fowler, J. Harding and D. Hofmann, eds. *The Oxford Handbook of Neolithic Europe*. Oxford: Oxford University Press, pp. 273–290.

Latour, B. 2005. *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press.

Laviolette, P. 2019. This Mess We’re in, or Part of. In: F. Martínez and P. Laviolette, eds. *Repair, Brokenness, Breakthrough: Ethnographic Responses*. London: Berghahn, pp. 316–323.

Lazarovici, C.M. & Lazarovici, G. 2011. Architecture of the early Neolithic in Romania. In: S. A. Luca and C. Suciu, eds. *Early Neolithic (Starčevo-Criş) Sites on the Territory of Romania*. Oxford: Archaeopress, pp. 19–36.

Lazarovici, G. 1979. *Neoliticul Banatului*. Cluj-Napoca: Comitetul pentru Cultură şi Educație Socialistă al Județului Cluj.

Lazarovici, G. 1984. Neoliticul timpuriu în România. *Acta Musei Porolissensis*, VIII, pp. 48–104.

Lazarovici, G. 1998. About the Neolithization process of the second migration of the early Neolithic. In: F. Draşovean, ed. *The Late Neolithic of the Middle Danube Region*. Timişoara: Eurobit, pp. 7–38.

Lazarovici, G. & Maxim, Z. 1995. *Gura Baciului. Monografie Arheologică*. Cluj-Napoca: Biblioteca Musei Napocensis.

Lee, R.B. 1968. What Hunters Do for a Living, or, How to Make Out on Scarce Resources. In: R. B. Lee and I. DeVore, eds. *Man the Hunter: The First Intensive Survey of a Single, Crucial Stage of Human Development — Man’s Once Universal Hunting Way of Life*. New York: Routledge, pp. 30–48.

van der Leeuw, S.E. 1993. Giving the Potter a Choice. In: P. Lemonnier, ed. *Technological Choices: Transformation in Material Cultures Since the Neolithic*. London: Routledge, pp. 238–288.

Legland, D., Arganda-Carreras, I. & Andrey, P. 2016. MorphoLibJ: integrated library and plugins for mathematical morphology with ImageJ. *Bioinformatics*, 32, pp. 3532–3534.

Lehmkuhl, F., Zens, J., Krauß, L., Schulte, P., & Kels, H. 2016. Loess-paleosol sequences at the northern European loess belt in Germany: Distribution, geomorphology and stratigraphy. *Quaternary Science Reviews*, 153, pp. 11–30.

Leineweber, R. 1999. Prähistorische Öfen. In: S. Fröhlich, ed. *Archäologische Berichte Aus Sachsen-Anhalt 1997*. Halle: Landesamt für Archäeologie Sachsen-Anhalt, pp. 13–42.

Lemonnier, P. 1983. L’Étude des systèmes techniques. Une urgence en technologie culturelle. *Techniques et culture*, 1, pp. 11–26.

Lemonnier, P. 1986. The study of material culture today: Toward an anthropology of technical systems. *Journal of Anthropological Archaeology*, 5, pp. 147–186.

Lemonnier, P. 1992. *Elements for an Anthropology of Technology*. Ann Arbor: Museum of Anthropology, University of Michigan.

Lemonnier, P. 1993. Introduction. In: P. Lemonnier, ed. *Technological Choices. Transformation in Material Cultures Since the Neolithic*. London: Routledge, pp. 1–35.

Lenneis, E. 1995. Altneolithikum: die Bandkeramik. In: E. Lenneis, C. Neugebauer-Maresch and E. Ruttkay, eds. *Jungsteinzeit Im Osten Österreichs*. St. Pölten: Niederösterreichisches Presshaus, pp. 11–56.

Lenneis, E. (ed.) 2010. *Die Bandkeramische Siedlung von Mold Bei Horn in Niederösterreich. Teil 1 - Naturwissenschaftliche Beiträge Und Einzelanalysen*. Rahden/Westfalen: Verlag Marie Leidorf.

Lenneis, E. & Lüning, J. 2001. *Die Altbandkeramischen Siedlungen von Neckenmarkt Und Strögen*. Bonn: Habel.

Lenneis, E. & Schwarzäugl, J. (eds.) 2014. *Die Bandkeramische Siedlung von Mold Bei Horn in Niederösterreich. Teil 2 - Häuser, Innere Chronologie Und Siedlungsstruktur*. Rahden/Westfalen: Verlag Marie Leidorf.

Levi-Strauss, C. 1966. *The Savage Mind*. London: Weidenfeld and Nicolson.

Levi-Strauss, C. 1997. *Look, Listen, Read*. New York: Basic Books.

Lienemann, J. 1998. Phosphatkartierungen in bandkeramischen Häusern. *Bericht der Römisch-Germanischen Kommission*, 79, pp. 39–45.

Lindauer, O. 1992. Ceramic Conjoinability: Orphan Sherds and Reconstructing Time. In: J. L. Hofman and J. G. Enloe, eds. *Piecing Together the Past: Applications of Refitting Studies in Archaeology*. Oxford: Tempus Reparatum, pp. 210–216.

Link, T. 2012. 'Hofplatz' und 'Zeilensiedlung': konkurrierende Modelleoder zwei Seitenderselben Medaille? In: R. Smolnik, ed. *Siedlungsstruktruen Und Kulturwandel in Der Bandkeramik. Beiträge Der Internationalen Tagung „Neue Fragen Zur Bandkeramik Oder Alles Beim Alten?“, Leipzig 23. - 24. September 2010. Dresden, Landesamt Für Archäologie*. Dresden: Landesamt für Archäologie, pp. 43–46.

Lira, C. & Pina, P. 2009. Automated grain shape measurments applied to beach sands. *Journal of Coastal Research*, 56, pp. 1527–1531.

Livingstone Smith, A. 2001. Bonfire II: The Return of Pottery Firing Temperatures. *Journal of Archaeological Science*, 28, pp. 991–1003.

Longacre, W. 1981. Kalinga pottery: an ethnoarchaeological study. In: I. Hodder, G. Isaac and N. Hammond, eds. *Pattern of the Past. Studies in Honour of David Clarke*. Cambridge: Cambridge University Press, pp. 49–66.

López Varela, S.L., van Gijn, A. & Jacobs, L. 2002. De-mystifying Pottery Production in the Maya Lowlands: Detection of Traces of Use-Wear on Pottery Sherds through Microscopic Analysis and Experimental Replication. *Journal of Archaeological Science*, 29, pp. 1133–1147.

Lubbock, J. 1865. *Pre-Historic Times. As Illustrated by Ancient Remains, and the Manners and Customs of Modern Savages*. London: Williams and Norgate.

Lubbock, J. 1868. Editor's Introduction. In: J. Lubbock, ed. *On the Primitive Inhabitants of Scandinavia*. London: Longmans, Green and Co, pp. ix–xiv.

Lubbock, J. 1870. *The Origin of Civilisation and the Primitive Condition of Man. Mental and Social Condition of Savages*. London: Longmans, Green and Co.

Lubbock, J. 1882. *The Origin of Civilisation and the Primitive Condition of Man: Mental and Social Condition of Savages.* 4th ed. New York: Longmans, Green and Co.

Luca, S.A., Diaconescu, D. & Suciu, C. 2008. Archaeologcial research in Miercurea Sibiului - Petriş (Sibiu County, Romania): the Starčevo-Criş level during 1997-2005 (a preliminary report). *Documenta Praehistorica*, 35, pp. 325–343.

Luca, S.A. & Suciu, C. 2008. Migrations and Local Evolution in the Early Neolithic of Transylvania. The Typological-Stylistic Analysis and the Radiocarbon Data. *Acta Terrae Septemcastrensis*, VII, pp. 39–56.

Luca, S.A., Tudorie, A. & Ciută, M. 2012. Data concerning C164 feature from Turdaş-Luncă (Hunedoara County, Romania). *Acta Terrae Septemcastrensis*, XI, pp. 7–20.

Lucas, G. 2015. Debating Archaeological Empiricism. Some Closing Comments. In: C. Hillerdal and J. Siapkas, eds. *Debating Archaeological Empiricism. The Ambiguity of Material Evidence*. London: Routledge, pp. 188–192.

Lucejko, J.J., Nasa, J.L., Porta, F., Vanzetti, A., Tanda, G., Mangiaracina, C.F., Corretti, A., Colombini, M.P., & Ribechini, E. 2018. Long-lasting ergot lipids as new biomarkers for assessing the presence of cereals and cereal products in archaeological vessels. *Scientific Reports*, 8, pp. 3935.

Lucero, L.J. 2008. Memorializing Place among Classic Maya Commoners. In: B. J. Mills and W. H. Walker eds. *Memory work: Archaeologies of material practices*. Santé Fe: School of Advanced Research, pp. 187-205.

Lüning, J. 1973. Gruben. In: J. P. Farruggia, R. Kuper, J. Lüning and P. Stehli, eds. *Der Bandkeramische Siedlungsplatz Langweiler 2, Gemeinde Aldenhoven, Kr. Düren*. Bonn: Rheinland-Verlag, pp. 50–56.

Lüning, J. 1977. Gruben. In: R. Kuper, H. Löhr, J. Lüning, P. Stehli and A. Zimmermann, eds. *Der Bandkeramische Siedlungsplatz Langweiler 9, Gemeinde Aldenhoven, Kr. Düren*. Bonn: Rheinland-Verlag, pp. 41–81.

Lüning, J. 1981. Versuchsgelände Kinzweiler. *Bonner Jahrbücher*, 181, pp. 264–284.

Lüning, J. 1986. Die Ausgrabungen zum Neolithikum in Schwanfeld, Lkr. Schweinfurt. *Mainfränkische Studien*, 37, pp. 8–16.

Lüning, J. 1988. Außengräbchen als Traufabstützung bandkeramischer Häuser. In: U. Boelicke, D. von Brandt, J. Lüning, P. Stehli and A. Zimmermann, eds. *Der Bandkeramische Siedlungsplatz Langweiler 8, Gemeinde Aldenhoven, Kreis Düren*. Köln: Rheinland-Verlag, pp. 290–295.

Lüning, J. 2000. *Steinzeitliche Bauern in Deutschland: Die Landwirtschaft Im Neolithikum*. Bonn: Habelt.

Lüning, J. & Stehli, P. (eds.) 1992. *Der Bandkeramische Siedlungsplatz Lamersdorf 2, Gemeinde Inden, Kreis Düren*. Bonn: Habelt.

McColm, I.J. 1990. *Ceramic Hardness*. New York: Springer.

McGowan, G. & Prangnell, J. 2015. A method for calculating soil pressure overlying human burials. *Journal of Archaeological Science*, 53, pp. 12–18.

McGuire, J.D. 1896. *A Study of the Primitive Methods of Drilling*. Washington: G.P.O.

McNiven, I.J. 2013. Ritualized Middening Practices. *Journal of Archaeological Method and Theory*, 20, pp. 552–587.

McNiven, I.J. & Wright, D. 2008. Ritualised marine midden formation in western Zenadh Kes (Torres Strait). In: G. Clark, F. Leach and S. O'Connor, eds. *Islands of Inquiry: Colonisation, Seafaring and the Archaeology of Maritime Landscapes*. Canberra: Pandanus, pp. 133–147.

Mabry, J, Skibo, J.M., Schiffer, M.B., & Kvamme, K. 1988. Use of a Falling-Weight Tester for Assessing Ceramic Impact Strength. *American Antiquity,* 53, pp. 829-839.

MacLeod, N. 2002. Geometric morphometrics and geological shape-classification systems. *Earth-Science Reviews*, 59, pp. 27–47.

Macphail, R. 2007. Soils and Deposits: Micromorphology. In: A. Whittle, ed. *The Early Neolithic on the Great Hungarian Plain. Investigations of the Körös Culture Site of Ecsegfalva 23, County Békés*. Budapest: Instituti Archaeologici, Academiae Scientiarum Hungaricae, pp. 189–226.

Macphail, R.I., Haită, C., Bailey, D.W., Andreescu, R., & Mirea, P. 2008. The soil micromorphology of enigmatic Early Neolithic pit-features at Măgura, southern Romania. *Studii de Preistorie*, 5, pp. 61–77.

Madsen, H.B. 2009. Repairs in antiquity illustrated by examples from the prehistory of Denmark. In: J. Ambers, C. Higgitt, L. Harrison and D. Saunders, eds. *Holding It All Together: Ancient and Modern Approaches to Joining, Repair and Consolidation*. London: Archetype Publications Ltd, pp. 83–88.

Magrill, P. & Middleton, A. 1997. A Canaanite Potter's Workshop in Palestine. In: I. C. Freestone and D. Gaimster, eds. *Pottery in the Making: World Ceramic Traditions*. London: British Museum Press, pp. 68–73.

Makkay, J. 1992. Excavations at the Körös culture settlement of Endrőd - Öregszőlők 119 in 1986-1989. A preliminary report. In: S. Bökönyi, ed. *Cultural and Landscape Changes in South-East Hungary I. Reports on the Gyomaendrőd Project*. Budapest: Archaeolingua, pp. 121–194.

Makkay, J. 1996. Theories about the Origin, the Distribution and the End of the Körös Culture. In: L. Tálas, ed. *At the Fringes of Three Worlds. Hunter-Gatherers and Farmers in the Middle Tisza Valley*. Szolnok: Damjanich Múzeum, pp. 35–49.

Makkay, J. 1997. Clay spindle whorls of the Körös culture and the technology of their perforation. In: N. Tasić, ed. *Antidoron. Completis LXV Annis Dragoslavo Srejović Ab Amicis Collegis Discipulis Oblatum*. Belgrade: Centre for Archaeological Research, Faculty of Philosophy, University of Belgrade, pp. 115–122.

Makkay, J. 2000. Neolithic cultures in Pannonia and their relations with Italy. An old theory in a new perspective. In: A. Pessina and G. Muscio, eds. *La Neolitizzazione Tra Oriente e Occidente*. Udine: Museo Friulano di Storia Naturale, pp. 23–50.

Makkay, J. 2007. *The Excavations of Early Neolithic Sites of the Körös Culture in the Körös Valley, Hungary: The Final Report. Volume I. The Excavations: Stratigraphy, Structures and Graves*. E. Starnini and P. Biagi, eds. Budapest: Società per la preistoria e protostoria della regione Friuli-Venezia Giulia.

Makkay, J. & Starnini, E. 2008. *The Excavations of Early Neolithic Sites of the Körös Culture in the Körös Valley, Hungary: The Final Report. Vol. II: The Pottery Assemblages, and Vol. III: The Small Finds*. Budapest.

Maniatis, Y. & Tite, M.S. 1981. Technological examination of Neolithic-Bronze Age pottery from central and southeast Europe and from the Near East. *Journal of Archaeological Science*, 8, pp. 59–76.

Manson, J.L. 1995. Starčevo pottery and Neolithic Development in the Central Balkans. In: W. K. Barnett and J. W. Hoopes, eds. *The Emergence of Pottery. Technology and Innovation in Ancient Societies*. Washington DC: Smithsonian Institution Press, pp. 65–77.

Mantu, C.M. 1991. The Starčevo-Cris settlement from Poienesti. *Banatica*, 11, pp. 173–183.

Maran, J. 2017. Later Balkan prehistory. A transcultural perspective. In: M. Gori and M. Ivanova, eds. *Balkan Dialogues. Negotiating Identity between Prehistory and the Present*. London: Routledge, pp. 17–37.

Mărgărit, M. 2016. Testing the endurance of prehistoric adornments: Raw materials from the aquatic environment. *Journal of Archaeological Science*, 70, pp. 66–81.

Marinescu, F., Stancu, J. & Ghenea, C. 1967. Republica Socialistă România, Harta Geologică, Scara 1:200.000. L-34-V. 2, Satu Mare.

Mariotti Lippi, M. & Pallecchi, P. 2017. Organic Inclusions. In: A. Hunt, ed. *The Oxford Handbook of Archaeological Ceramic Analysis*. Oxford: Oxford University Press, pp. 565–581.

Marta, L. *et al.* 2017. Moftinu Mare, com. Moftin, jud. Satu Mare. In: *Cronica Cercetărilor Arheologice Din România. Campania 2016*. Bucureşti: Institutul Naţional al Patrimoniului, pp. 190–191.

Marx, K. 1906. *Capital: A Critique of Political Economy*. F. Engels, ed. New York: Random House.

Marx, K. 1967. *Capital: A Critique of Political Economy*. New York: International Publishers.

Marx, K. 1972. *The Ethnological Notebooks of Karl Marx: Studies of Morgan, Phear, Maine, Lubbock*. L. Krader, ed. Assen: Gorcum and Company.

Maslow, A.H. 1966. *Psychology of Science: A Reconnaissance*. New York: Harper & Row.

Mateiciucová, I. 2007. Worked Stone: Obsidian and Flint. In: A. Whittle, ed. *The Early Neolithic on the Great Hungarian Plain. Investigations of the Körös Culture Site of Ecsegfalva 23, County Békés*. Budapest: Instituti Archaeologici Academiae Scientiarum Hungaricae, pp. 677–726.

Matlova, V., Roffet-Salque, M., Pavlu, I., Kyselka, J., Sedlarova, I., Filip, V., & Evershed, R.P. 2017. Defining pottery use and animal management at the Neolithic site of Bylany (Czech Republic). *Journal of Archaeological Science: Reports*, 14, pp. 262–274.

Mauss, M. 1966. *The Gift. Forms and Functions of Exchange in Archaic Societies*. London: Cohen & West Ltd.

Maxim, Z. 1999. *Neo-Eneoliticul Din Transilvania*. Cluj-Napoca: Muzeul Naţional de Istorie a Transilvaniei.

Mayor, A. 2010. Outils de potières au Mali: chaînes opératoires et traditions techniques. *Bulletin de la Société préhistorique française*, 107, pp. 643–666.

Mecking, O., Behrendt, S., Hohle, I., & Wolfram, S. 2012. Geochemische und technologische Keramikanalysen zum Übergang von Ältester zu älterer Linienbandkeramik in Eythra und Zwenkau-Nord, Lkr. Leipzig. In: S. Wolfram and H. Stäuble, eds. *Siedlungsstruktur Und Kulturwandel in Der Bandkeramik. Beiträge Der Internationalen Tagung „Neue Fragen Zur Bandkeramik Oder Alles Beim Alten?!“ Leipzig 23. Bis 24. September 2010*. Dresden: Landesamt für Archäologie, pp. 261–273.

Médard, F. 2006. La fusaïole: au-delà des idées reçues. In: L. Astruc, F. Bon, V. Léa, P.-Y. Milcent and S. Philibert, eds. *Normes Techniques et Practiques Sociales. De La Simplicité Des Outillages Pré- et Protohistoriques*. Antibes: Éditions APDCA, pp. 274–280.

Meneghinello, E., Alberti, A. & Cruciani, G. 1999. Order-disorder process in the tetrahedral sites of albite. *American Mineralogist*, 84, pp. 1144–1151.

Meyer, C., Knipper, C., Nicklisch, N., Münster, A., Kürbis, O., Dresely, V., Meller, H., & Alt, K.W. 2018. Early Neolithic executions indicated by clustered cranial trauma in the mass grave of Halberstadt. *Nature Communications*, 9, pp. 2472.

Milisauskas, S. 2001. Linear Pottery. Linearbandkeramik (LBK) Culture. In: P. Peregrine and M. Ember, eds. *Encyclopedia of Prehistory. Vol 4: Europe*. New York: Kluwer Academic and Plenum Press, pp. 191–197.

Mill, J.S. 2004. *Principles of Political Economy with Some of Their Applications to Social Philosophy*. Indianapolis: Hackett Publishing Company.

Miller, D. 2007. Stone age or plastic age? *Archaeological Dialogues*, 14, pp. 23–27.

Mills, B.J. 2008. Remembering while Forgetting. Depositional Practices and Social Memory at Chaco. In: B. J. Mills and W. H. Walker, eds. *Memory work: Archaeologies of material practices*. Santé Fe: School of Advanced Research, pp. 81-108.

Miloglav, I. & Balen, J. 2019. Organic Residue and Vessel Function Analysis from Five Neolithic and Eneolithic Sites in Eastern Croatia. In: S. Amicone, P. S. Quinn, M. Marić, N. Mirković-Marić and M. Radivojević, eds. *Tracing Pottery-Making Recipes in the Prehistoric Balkans 6th–4th Millennia BC*. Oxford: Archaeopress, pp. 78–95.

Minichreiter, K. 1992. Peći u starčevačkom naselju kod Zadubravlja (Öfen in der Starčevo Kultur Stammenden Siedlung bei Zadubravlje). *Opvscvla archaeologica*, 16, pp. 37–49.

Minichreiter, K. 2001. The architecture of Early and Middle Neolithic settlements of the Starčevo culture in Northern Croatia. *Documenta Praehistorica*, XXVIII, pp. 199–214.

Minichreiter, K. 2012. Slavonski Brod, Galovo, arheološka istraživanja 2011. *Annales Instituti Archaeologici*, VIII, pp. 18–22.

Minter, A. 2013. *Junkyard Planet: Travels in the Billion-Dollar Trash Trade*. New York: Bloomsbury Press.

Mirabal, S., Varljen, T., Gayden, T., Regueiro, M., Vujovic, S., Popovic, D., Djuric, M., Stojkovic, O., & Herrera, R.J. 2010. Human Y-chromosome short tandem repeats: A tale of acculturation and migrations as mechanisms for the diffusion of agriculture in the Balkan Peninsula. *American Journal of Physical Anthropology*, 142, pp. 380–390.

Mitchell, J.K. & Soga, K. 2005. *Fundamentals of Soil Behavior*. 3rd ed. New York: Wiley.

Modderman, P.J.R. 1970. *Linearbandkeramik Aus Elsloo Und Stein*. Leiden: Sidestone Press.

Modderman, P.J.R. 1977. *Die Neolithische Besiedlung Bei Hienheim, Ldkr. Kelheim*. Leiden: Sidestone Press.

Modderman, P.J.R. 1982. Die Radiokarbondatierungen der Bandkeramik. In: J. Pavúk, ed. *Siedlungen Der Kultur Mit Linearbandkeramik in Europa*. Nitra: Archäologisches Institut der Slowakischen Akademie der Wissenschaften, pp. 177–183.

Modderman, P.J.R. 1988. The Linear Pottery Culture: Diversity in Uniformity. *Berichten van de Rijkdienst voor het Oudhiedkundig Bodemonderzoek*, 38, pp. 63–139.

Molleson, T. 1994. The Eloquent Bones of Abu Hureyra. *Scientific American*, 271, pp. 70–75.

Montelius, O. 1888. *The Civilisation of Sweden in Heathen Times*. London: Macmillan & Co.

Montelius, O. 1899. *Der Orient Und Europa*. Stockholm: Königliche Akademie der schönen Wissenschaften, Geschichte und Altertumskunde.

Montelius, O. 1903. *Die Typologische Methode: Älteren Kulturperioden Im Orient Und in Europa*. Stockholm: K.L. Beckmans Buchdruckerei.

Montelius, O. 1920. Pro memoria.

Moore, H. 1986. *Space, Text, and Gender: an Anthropological Study of the Marakwet of Kenya*. Cambridge: Cambridge University Press.

Moore, M.A. & King, F.S. 1980. Abrasive wear of brittle solids. *Wear*, 60, pp. 123–140.

Morgan, L.H. 1878. *Ancient Society, or Researches in the Lines of Human Progress from Savagery through Barbarism to Civilization*. New York: Holt.

Mortillet, G. de 1883. *Le Préhistorique. Antiquité de l'homme*. Paris: Reinwald.

Moskal-del Hoyo, M., Rauba-Bukowska, A., Lityńska-Zając, M., Mueller-Bieniek, A., & Czekaj-Zastawny, A. 2017. Plant materials used as temper in the oldest Neolithic pottery from south-eastern Poland. *Vegetation History and Archaeobotany*, 26, pp. 329–344.

Much, M. 1907. *Die Trugspiegelung Orientalischer Kultur in Den Vorgeschichtlichen Zeitaltern Nord- Und Mittel-Europas*. Jena: Costenoble.

Müller, N.S. 2016. Mechanical and Thermal Properties. In: A. Hunt, ed. *The Oxford Handbook of Archaeological Ceramic Analysis*. Oxford: Oxford University Press, pp. 603–624.

Müller, N.S., Kilikoglou, V., Day, P.M., & Vekinis, G. 2010. The influence of temper shape on the mechanical properties of archaeological ceramics. *Journal of the European Ceramic Society*, 30, pp. 2457–2465.

Müller, N.S., Kilikoglou, V., Day, P.M., & Vekinis, G. 2014. Thermal shock resistance of tempered archaeological ceramics. In: M. Martinon-Torres, ed. *Craft and Science: International Perspectives on Archaeological Ceramics*. Doha: Bloomsbury Qatar Foundation, pp. 263–270.

Müller, N. S., Kilikoglou, V. & Day, P.M. 2015. Home-made recipes: Tradition and innovation in Bronze Age cooking pots from Akrotiri, Thera. In: M. Spataro and A. Villing, eds. *Ceramics, Cuisine and Culture: The Archaeology and Science of Kitchen Pottery in the Ancient Mediterranean World*. Oxford: Oxbow Books, pp. 37–48.

Müller, N.S., Vekinis, G., Day, P.M., & Kilikoglou, V. 2015. The influence of microstructure and texture on the mechanical properties of rock tempered archaeological ceramics. *Journal of the European Ceramic Society*, 35, pp. 831–843.

Müller, N.S., Vekinis, G. & Kilikoglou, V. 2016. Impact resistance of archaeological ceramics: The influence of firing and temper. *Journal of Archaeological Science: Reports*, 7, pp. 519–525.

Mutihac, V. & Mutihac, G. 2010. *The Geology of Romania within the Central East-European Geostructural Context*. Bucureşti: Editura Didactică şi Pedagogică.

Nagy, E., Guttmann, M., Molnár-Kovács, Z., & Barabás, R. 2015. Multi-method analysis of Bronze Age ceramics from Satu-Mare County, Romania. *Studia Universitatis Babeș-Bolyai Chemia*, LX, pp. 21–34.

Nagy, I., Ligetvári, F. & Schweitzer, F. 2010. Tisza River Valley: future prospects. *Hungarian Geographical Bulletin*, 59, pp. 361–370.

Naumov, G. 2013. Embodied Houses: the Social and Symbolic Agency of Neolithic Architecture in the Republic of Macedonia. In: D. Hofmann and J. Smyth, eds. *Tracking the Neolithic House in Europe: Sedentism, Architecture, and Practice*. New York: Springer, pp. 65–94.

Nelson, B.A. 1985. Reconstructing ceramic vessels and their systemic contexts. In: B. A. Nelson, ed. *Decoding Prehistoric Ceramics*. Carbondale: Southern Illinois University, pp. 310–328.

Nelson, M.C. 1991. The Study of Technological Organization. *Archaeological Method and Theory*, 3, pp. 57–100.

Nelson, E.S. 2011. Revisiting the Dialectic of Enlightenment: Nature as Ideology and Ethics in Adorno and the Frankfurt School. *Telos*, 155, pp. 105–126.

Németi, J. & Astaloş, C. 2001. 39. Călineşti Oaş, com. Călineşti Oaş, jud. Satu Mare. In: M. V. Angelescu, C. Borş and I. O. Târnoveanu, eds. *Cronica Cercetărilor Arheologice Din România, Campania 2000: A XXXV-a Ediţie a Sesiunii Anuale de Cercetare Arheologică, Suceava 2001*. Bucureşti: CIMEC - Institutul de Memorie Culturală, pp. 60–61.

Németi, J., Astaloş, C. & Ilea, C. 2002. 56. Călineşti Oaş, com. Călineşti Oaş, jud. Satu Mare. In: M. V. Angelescu, C. Borş, I. Oberländer-Târnoveanu and F. Vasilescu, eds. *Cronica Cercetărilor Arheologice Din România - Campania 2001*. Bucureşti: CIMEC - Institutul de Memorie Culturală, pp. 92–93.

Neth, A. 1999. *Eine Siedlung Der Frühen Bandkeramik in Gerlingen, Kreis Ludwigsburg*. Stuttgart: Konrad Theiss.

Neumannová, K., Petřik, J., Vostrovská, I., Dvořák, J., Zikmund, T., & Kaiser, J. 2017. Variability in coiling technique in LBK pottery inferred by experiments adnd pore structure micro-tomography analysis. *Archeologické rozhledy*, LXIX, pp. 172–186.

Neupert, M.A. 1994. Strength Testing Archaeological Ceramics: A New Perspective. *American Antiquity*, 59, pp. 709–723.

Newton, I. 1999. *The Principia: Mathematical Principles of Natural Philosophy*. Berkeley: University of California Press.

Nicklisch, N., Maixner, F., Ganslmeier, R., Friederich, S., Dresely, V., Meller, H., Zink, A., & Alt, K.W. 2012. Rib lesions in skeletons from early neolithic sites in Central Germany: On the trail of tuberculosis at the onset of agriculture. *American Journal of Physical Anthropology*, 149, pp. 391–404.

Nielsen, A.E. 1991. Trampling the Archaeological Record: An Experimental Study. *American Antiquity*, 56, pp. 483–503.

Nilsson, B. 2007. An archaeology of material stories. Dioramas as illustration and the desire of a thingless archaeology. *Archaeological Dialogues*, 14, pp. 27–30.

Nilsson, S. 1868. *On the Primitive Inhabitants of Scandinavia*. Third Edition. J. Lubbock, ed. London: Longmans, Green and Co.

Niquet, F. 1963. *Die Probegrabungen Auf Der Frühbandkeramischen Siedlung Bei Eitzum, Kreis Wolfenbüttel*. Hildesheim: Verlagbuchhandlung und Buchdruckerei August Lax.

Noghani, S., Amiri, M.C. & Emami, M. 2018. A new approach to the desalination process of archaeological potteries. *Mediterranean Archaeology and Archaeometry*, 18, pp. 255–267.

O'Brien, K. 1993. Between Enlightentment and Stadial History: William Robertson on the History of Europe. *Journal for Eighteenth-Century Studies*, 16, pp. 53–64.

O'Brien, P. 1990. An experimental study of the effects of salt erosion on pottery. *Journal of Archaeological Science*, 17, pp. 393–401.

Olalde, I., Schroeder, H., Sandoval-Velasco, M., Vinner, L., Lobón, I., Ramirez, O., Civit, S., García Borja, P., Salazar-García, D.C., Talamo, S., María Fullola, J., Xavier Oms, F., Pedro, M., Martínez, P., Sanz, M., Daura, J., Zilhão, J., Marquès-Bonet, T., Gilbert, M.T.P., & Lalueza-Fox, C. 2015. A Common Genetic Origin for Early Farmers from Mediterranean Cardial and Central European LBK Cultures. *Molecular Biology and Evolution*, 32, pp. 3132–3142.

Olsen, B. 2007. Keeping things at arm's length: a genealogy of asymmetry. *World Archaeology*, 39, pp. 579–588.

Olsen, B. 2010. *In Defense of Things: Archaeology and the Ontology of Objects*. Lanham: Altamira Press.

Olsen, B., Shanks, M., Webmoor, T., & Witmore, C.L. 2012. *Archaeology: The Discipline of Things*. Berkeley: University of California Press.

Olsen, B. & Witmore, C.L. 2015. Archaeology, symmetry and the ontology of things. *Archaeological Dialogues*, 22, pp. 187–197.

Oross, K. 2007. The pottery from Ecsegfalva 23. In: A. Whittle, ed. *The Early Neolithic on the Great Hungarian Plain. Investigations of the Körös Culture Site of Ecsegfalva 23, County Békés*. Budapest: Instituti Archaeologici, Academiae Scientiarum Hungaricae, pp. 491–620.

Oross, K., Bánffy, E., Osztás, A., Marton, T., Nyerges, E.A., Köhler, K., Szécsényi-Nagy, A., Alt, K.W., Bronk, C., Goslar, T., Kromer, B., Hamilton, D. 2016. The early days of Neolithic Alsónyék: The Starčevo occupation. *Bericht der Römisch-Germanischen Kommission*, 94, pp. 93–121.

Oross, K. & Siklósi, Z. 2012. Relative and Absolute Chronology of the Early Neolithic in the Great Hungarian Plain. In: A. Anders and Z. Siklósi, eds. *The First Neolithic Sites in Central/South-East European Transect. Volume III: The Körös Culture in Eastern Hungary*. Oxford: Archaeopress, pp. 129–159.

Orton, C. & Hughes, M. 2013. *Pottery in Archaeology*. 2nd ed. Cambridge: Cambridge University Press.

Paraskova, M. 2018. *Compositional and Identifying Characteristics of Postholes from Taşnad (Romania) and Their Potential as Aids for Archaeological Interpretation: A Geoarchaeological Study*. Unpublished MSc thesis, University College London.

Paret, O. 1948. *Das Neue Bild Der Vorgeschichte*. Stuttgart: August Schröder Verlag.

Parker, G. 1991. Selective sorting and abrasion of river gravel. I: Theory. *Journal of Hydraulic Engineering*, 117, pp. 131–147.

Pavlů, I. 2000. *Life on a Neolithic Site. Bylany – Situational Analysis of Artefacts*. Praha: Archeologický ústav AV ČR.

Pavlů, I. 2013. Activity areas around Linear Pottery houses. In: C. Hamon, P. Allard and M. Ilett, eds. *The Domestic Space in LBK Settlements*. Rahden/Westfalen: Marie Leidorf GmbH, pp. 155–168.

Pavúk, J. 2004. Early Linear Pottery Culture in Slovakia and the Neolithisation of Central Europe. In: A. Lukes and M. Zvelebil, eds. *LBK Dialogues Studies in the Formation of the Linear Pottery Culture*. Oxford: Archaeopress, pp. 71–82.

Pearsall, D.M. 2008. Plant Domestication and the Shift to Agriculture in the Andes. In: H. Silverman and W. H. Isbell, eds. *The Handbook of South American Archaeology*. New York: Springer, pp. 105–120.

Pechtl, J. 2015. Linearbandkeramik Pottery and Society. In: C. Fowler, J. Harding and D. Hofmann, eds. *The Oxford Handbook of Neolithic Europe*. Oxford: Oxford University Press, pp. 555–572.

Pechtl, J. & Hofmann, D. 2016. Die Keramik der Grabung 2008 in der ältestlinienbandkeramischen Siedlung von Niederhummel, Lkr. Freising. In: J. Pechtl, T. Link and L. Husty, eds. *Neue Materialien Des Bayerischen Neolithikums. Tagung Im Kloster Windberg Vom 21. Bis 23. November 2014*. Würzburg: Würzburg University Press, pp. 11–36.

Pécsi, M. & Sárfalvi, B. 1964. *The Geography of Hungary*. Budapest: Corvina Press.

Petrasch, J. 1986. Typologie und Funktion neolithischer Öfen in Mittel- und Südosteuropa. *Acta Praehistorica et Archaeologica*, 18, pp. 33–83.

Petrasch, J. 1999. Mord und Krieg in der Bandkeramik. *Archäologisches Korrespondenzblatt*, 29, pp. 505–516.

Pickersgill, B. 2016. Domestication of Plants in Mesoamerica: An Archaeological Review with Some Ethnobotanical Interpretations. In: R. Lira, A. Casas and J. Blancas, eds. *Ethnobotany of Mexico: Interactions of People and Plants in Mesoamerica*. New York, NY: Springer, pp. 207–231.

Piezonka, H., Kosinskaya, L., Dubovtseva, E., Chemyakin, Y., Enshin, D., Hartz, S., Kovaleva, V., Panina, S., Savchenko, S., Skochina, S., Terberger, T., Zakh, V., Zhilin, M., & Zykov, A. 2020. The emergence of hunter-gatherer pottery in the Urals and West Siberia: New dating and stable isotope evidence. *Journal of Archaeological Science*, 116, pp. 105100.

Pink, S., Fors, V. & Glöss, M. 2018. The contingent futures of the mobile present: automation as possibility. *Mobilities*, 13, pp. 615–631.

Pluciennik, M. 1998. Deconstructing the 'Neolithic' in the Mesolithic-Neolithic Transition. In: M. Edmonds and C. Richards, eds. *Understanding the Neolithic of North-Western Europe*. Glasgow: Cruithne Press, pp. 61–83.

Pluciennik, M. 1999. Archaeological Narratives and Other Ways of Telling. *Current Anthropology*, 40, pp. 653–678.

Pluciennik, M. 2001. Archaeology, anthropology and subsistence. *Journal of the Royal Anthropological Institute*, 7, pp. 741–758.

Pollard, J. 2008. Deposition and material agency in the early Neolithic of southern Britain. In: B. J. Mills and W. H. Walker, eds. *Memory work: Archaeologies of material practices*. Santé Fe: School of Advanced Research, pp. 41–59.

Portillo, M., Belarte, M.C., Ramon, J., Kallala, N., Sanmartí, J., & Albert, R.M. 2017. An ethnoarchaeological study of livestock dung fuels from cooking installations in northern Tunisia. *Quaternary International*, 431, pp. 131–144.

Potushniak, M. 1996. Неолит Закарпатья. In: С. В. Ошибкина, ed. *Неолит Северной Евразии*. Moscow: Наука.

Potushniak, M. 2004. Data to the question of the Starčevo/Körös Culture dwellings in the Upper Tisza Region. *Jósa András Múzeum Évkönyve*, XLVI, pp. 53–69.

Powell, D.M. 1998. Patterns and processes of sediment sorting in gravel-bed rivers. *Progress in Physical Geography*, 22, pp. 1–32.

Powers, M.C. 1953. A New Roundness Scale for Sedimentary Particles. *Journal of Sedimentary Research*, 23, pp. 117-119.

Price, T.D. 1991. The Mesolithic of Northern Europe. *Annual Review of Anthropology*, 20, pp. 211–233.

Price, T.D. 2000. Europe's first farmers: an introduction. In: T. D. Price, ed. *Europe's First Farmers*. Cambridge: Cambridge University Press, pp. 1–18.

Puchinger, L., Sauter, F. & Schrattenecker, J.D. 2019. Chemical Identification of Pitch Found in the Sites of the Early Neolithic Settlement at Brunn am Gebirge, Wolfholz. Studies in Organic Archaeometry IX. In: P. Stadler and N. Kotova, eds. *Early Neolithic Settlement Brunn Am Gebirge, Wolfholz, in Lower Austria Volume 1 / Part b. Early Neolithic Settlement Brunn Am Gebirge, Wolfholz, Site 2 in Lower Austria and the Origin of the Western Linear Pottery Culture (LPC).* Langenweißbach: Beier and Beran, pp. 577–582.

Qi, F., Meng, S., Song, F., Guo, H., Xu, X., Shao, Y., & Chen, Y. 2019. Fractal characterization of ceramic crack patterns after thermal shocks. *Journal of the American Ceramic Society*, 102, pp. 3641–3652.

Quinn, G.D. 2007. *Fractography of Ceramics and Glasses. NIST Recommended Practice Guide*. Washington DC: National Institute of Standards and Technology.

Quinn, P.S. 2013. *Ceramic Petrography: The Interpretation of Archaeological Pottery and Related Artefacts in Thin Section*. Oxford: Archaeopress.

Quitta, H. 1960. Zur Frage der ältesten Bandkeramik in Mitteleuropa. *Praehistorische Zeitschrift*, 38, pp. 1–38.

Quitta, H. 1964. Zur Herkunft des frühen Neolithikums in Mitteleuropa. In: P. Grimm, ed. *Varia Archaeological. Wilhelm Unverzagt Zum 70. Geburtstag Dargebracht.* Berlin: Akademie Verlag, pp. 14–24.

Raczky, P. 1983. A korai neolitikumból a középső neolitikumba való átmenet kérdései a Közép- és Felső-Tiszavidéken. *Archaeológiai Értesitő*, 110, pp. 161–194.

Raczky, P. 1988. *A Tiszavidék Kulturális És Kronológiai Kapcsolatai a Balkánnal És Az Égeikummal a Neolitikum Rézkor Időszakában. Újabb Kutatási Eredmények És Problémák*. Szolnok: Szolnok Megyei Múzeumok Igazgatósága.

Raczky, P. 2015. Settlements in South-East Europe. In: C. Fowler, J. Harding and D. Hofmann, eds. *The Oxford Handbook of Neolithic Europe*. Oxford: Oxford University Press, pp. 235–254.

Raczky, P., Sümegi, P., Bartosiewicz, L., Gál, E., Kaczanowska, M., Kozlowski, J.K., & Anders, A. 2010. Ecological barrier versus mental marginal zone? Problems of the northernmost Koros Culture settlements in the Great Hungarian Plain. In: D. Gronenborn and J. Petrasch, eds. *Die Neolithisierung Mitteleuropas: Internationale Tagung, Mainz 24. Bis 26. Juni 2005*. Budenheim: RGZM, pp. 147–174.

Radig, W. 1930. *Der Wohnbau Im Jungsteinzeitlichen Deutschland*. Leipzig: C. Kabitzsch.

Rageot, M., Théry-Parisot, I., Beyries, S., Lepère, C., Carré, A., Mazuy, A., Filippi, J.-J., Fernandez, X., Binder, D., & Regert, M. 2019. Birch Bark Tar Production: Experimental and Biomolecular Approaches to the Study of a Common and Widely Used Prehistoric Adhesive. *Journal of Archaeological Method and Theory*, 26, pp. 276–312.

Rascovan, N., Sjögren, K.-G., Kristiansen, K., Nielsen, R., Willerslev, E., Desnues, C., Rasmussen, S. 2018. Emergence and Spread of Basal Lineages of Yersinia pestis during the Neolithic Decline. *Cell*, 176, pp. 295-305.

Rathje, W.L. & Murphy, C. 1992. *Rubbish! The Archaeology of Garbage*. New York: Harper Collins Publishers.

Rausand, M. & Øien, K. 1996. The basic concepts of failure analysis. *Reliability Engineering & System Safety*, 53, pp. 73–83.

Raymond, J.S. 2008. The Process of Sedentism in Northwestern South America. In: H. Silverman and W. H. Isbell, eds. *Handbook of South American Archaeology*. New York: Springer, pp. 79–90.

Reckwitz, A. 2002. Toward a Theory of Social Practices A Development in Culturalist Theorizing. *European Journal of Social Theory*, 5, pp. 243–263.

Reddy, J. 2005. *An Introduction to the Finite Element Method*. Third Edition. New York: McGraw-Hill.

Reed, E.S. & Bril, B. 1996. The Primacy of Action in Development. In: M.L. Latash and M.T. Turvey, eds. *Dexterity and Its Development*. Mahwah: Lawrence Erlbaum Associates, pp. 431-451.

Regert, M. 2004. Investigating the history of prehistoric glues by gas chromatography–mass spectrometry. *Journal of Separation Science*, 27, pp. 244–254.

Reid, K.C. 1984. Fire and Ice: New Evidence for the Production and Preservation of Late Archaic Fiber-Tempered Pottery in the Middle-Latitude Lowlands. *American Antiquity*, 49, pp. 55–76.

Reid, K.C. 1989. A materials science perspective on hunter-gatherer pottery. In: G. Bronitsky, ed. *Pottery Technology: Ideas and Approaches*. Boulder: Westview, pp. 167–180.

Reinach, S. 1893. *Le Mirage Oriental*. Paris: G. Masson.

Reineck, H.-E. & Singh, I.B. 1980. *Depositional Sedimentary Environments: With Reference to Terrigeneous Clastics*. Second Edition. Berlin and Heidelberg: Springer.

Reinecke, V. 2006. *Untersuchungen Zur Jungpleistozänen Reliefentwicklung Und Morphodynamik Im Nördlichen Harzvorland*. Aachen: Geographisches Institut der RWTH Aachen.

Renfrew, C. 1972. *The Emergence of Civilisation. The Cyclades and the Aegean in the Third Millenium B.C.* London: Methuen.

Renfrew, C. 1982. Explanation revisited. In: C. Renfrew, M. J. Rowlands and B. A. Segraves, eds. *Theory and Explanation in Archaeology*. New York: Academic Press, pp. 5–23.

Renfrew, C. 1987. *Archaeology and Language. The Puzzle of Indo-European Origins*. London: Penguin Books.

Renfrew, C. 2009. Demography and Archaeology. *Human Biology*, 81, pp. 381–384.

Reno, J. 2011. Beyond risk: Emplacement and the production of environmental evidence. *American Ethnologist*, 38, pp. 516–530.

Reno, J.O. 2014. Toward a New Theory of Waste: From 'Matter out of Place' to Signs of Life. *Theory, Culture & Society*, 31, pp. 3–27.

Reno, J. 2015. Waste and Waste Management. *Annual Review of Anthropology*, 44, pp. 557–572.

Resentini, A., Andò, S. & Garzanti, E. 2018. Quantifying roundness of detrital minerals by image analysis: Sediment transport, shape effects, and provenance implications. *Journal of Sedimentary Research*, 88, pp. 276–289.

Reynolds, P.J. 1982. The ploughzone. *Festschrift zum*, 100, pp. 315–341.

Reynolds, P.J. 1988. Sherd movement in the ploughzone—physical data base into computer simulation. In: S. P. Q. Rahtz, ed. *Computer and Quantitative Methods in Archaeology*. Oxford: British Archaeological Series, pp. 201–219.

Rice, P.M. 1987. *Pottery Analysis: A Sourcebook*. Chicago: University of Chicago Press.

Richard, N. 2012. Archaeology, Biology, Anthropology: Human Evolution According to Gabriel de Mortillet and John Lubbock (France, England c. 1860-1870). *History and Philosophy of the Life Sciences*, 34, pp. 9–31.

Richards, C. & Thomas, J. 1984. Ritual activity and structured deposition in Later Neolithic Wessex. In: R. Bradley and J. Gardiner, eds. *Neolithic Studies: A Review of Some Current Research*. Oxford: Archaeopress, British Archaeological Reports, pp. 189–218.

Richards, Martin 2003. The Neolithic Invasion of Europe. *Annual Review of Anthropology*, 32, pp. 135–162.

Richards, Michael 2003. The Neolithic transition in Europe: archaeological models and genetic evidence. *Documenta Praehistorica*, 30, pp. 159–167.

Rick, J.W. 1976. Downslope movement and archaeological intrasite spatial analysis. *American Antiquity*, 41, pp. 133–144.

Ricoeur, P. 1970. *Freud and Philosophy. An Essay on Interpretation*. Yale: Yale University Press.

Řídký, J., Končelová, M., Šumberová, R., Limburský, P., & Květina, P. 2014. How Were Neolithic Ditches Filled In? Deposition Study of Two Enclosures from Bohemia. *European Journal of Archaeology*, 17, pp. 579–601.

Riederer, J. 1985. Keramologische Untersuchungen an der Keramik von Eitzum. In: G. Schwarz-Mackensen, ed. *Die Frühbandkeramische Siedlung Bei Eitzum Landkreis Wolfenbüttel*. Braunschweig: Veröffentlichungen des Braunschweiger Landesmuseums, pp. 30–38.

Ritter-Burkert, J. 2020. Suspiciously rich pits in the Wetterau. In: D. Hofmann, ed. *Magical, Mundane or Marginal? Deposition Practices in the Early Neolithic Linearbandkeramik Culture*. Leiden: Sidestone Press, pp. 169–180.

Robb, J. 2010. Beyond agency. *World Archaeology*, 42, pp. 493-520.

Robb, J. 2013. Material Culture, Landscapes of Action, and Emergent Causation: A New Model for the Origins of the European Neolithic. *Current Anthropology*, 54, pp. 657–683.

Robb, J. 2014. The Future Neolithic: a New Research Agenda. In: A. Whittle and P. Bickle, eds. *Early Farmers: The View from Archaeology and Science*. Oxford: Oxford University Press, pp. 21–28.

Robb, J. 2015. What Do Things Want? Object Design as a Middle Range Theory of Material Culture. *Archeological Papers of the American Anthropological Association*, 26, pp. 166–180.

Robb, J. 2020. Material Time. In: I. Gaskell and S.A. Carter, eds. *The Oxford Handbook of History and Material Culture*. Oxford: Oxford University Press, pp. 123-139.

Rodriguez, J., Edeskär, T. & Knutsson, S. 2013. Particle shape quantities and measurement techniques: a review. *The Electronic Journal of Geotechnical Engineering*, 18/A, pp. 169–198.

Rodriguez, J.M., Johansson, J.M.A. & Edeskar, T. 2012. Particle Shape Determination by Two-Dimensional Image Analysis in Geotechnical Engineering. In: *Proceedings of Nordic Conference on Soil Mechanics and Geotechniques*. Copenhagen: Danish Geotechnical Society, pp. 207–218.

Roesler, J., Harders, H. & Baeker, M. 2007. *Mechanical Behaviour of Engineering Materials*. Berlin: Springer.

Roffet-Salque, M., Regert, M., Evershed, R.P., Outram, A.K., Cramp, L.J.E., Decavallas, O., Dunne, J., Gerbault, P., Mileto, S., Mirabaud, S., Pääkkönen, M., Smyth, J., Šoberl, L., Whelton, H.L., Alday-Ruiz, A., Asplund, H., Bartkowiak, M., Bayer-Niemeier, E., Belhouchet, L., Bernardini, F., Budja, M., Cooney, G., Cubas, M., Danaher, E.M., Diniz, M., Domboróczki, L., Fabbri, C., González-Urquijo, J.E., Guilaine, J., Hachi, S., Hartwell, B.N., Hofmann, D., Hohle, I., Ibáñez, J.J., Karul, N., Kherbouche, F., Kiely, J., Kotsakis, K., Lueth, F., Mallory, J.P., Manen, C., Marciniak, A., Maurice-Chabard, B., Mc Gonigle, M.A., Mulazzani, S., Özdoğan, M., Perić, O.S., Perić, S.R., Petrasch, J., Pétrequin, A.-M., Pétrequin, P., Poensgen, U., Joshua Pollard, C., Poplin, F., Radi, G., Stadler, P., Stäuble, H., Tasić, N., Urem-Kotsou, D., Vuković, J.B., Walsh, F., Whittle, A., Wolfram, S., Zapata-Peña, L., & Zoughlami, J. 2015. Widespread exploitation of the honeybee by early Neolithic farmers. *Nature*, 527, pp. 226–230.

Ros, J., Evin, A., Bouby, L., & Ruas, M.-P. 2014. Geometric morphometric analysis of grain shape and the identification of two-rowed barley (Hordeum vulgare subsp. distichum L.) in southern France. *Journal of Archaeological Science*, 41, pp. 568–575.

Rost, A. 1992. *Siedlungsarchäologische Untersuchungen Zwischen Leine Und Weser. Zur Besiedlungsgeschichte Einer Mittelgebirgslandschaft*. Neumünster: Wachholtz Verlag.

Rowley-Conwy, P. 2007. *From Genesis to Prehistory. The Archaeological Three Age System and Its Contested Reception in Denmark, Britain and Ireland*. Oxford: Oxford University Press.

Rück, O. 2007. *Neue Aspekte Und Modelle in Der Siedlungsforschung Zur Bandkeramik. Die Siedlung Weisweiler 111 Auf Der Aldenhovener Platte, Kr. Düren.* Rahden/Westfalen: Marie Leidorf GmbH.

Rück, O. 2013. From yard to house row: the Bandkeramik village - layouts in rows and feature-free areas provide a new view on settlement structure. In: C. Hamon, P. Allard and M. Ilett, eds. *The Domestic Space in LBK Settlements*. Rahden/Westfalen: Verlag Marie Leidorf, pp. 201–230.

Rudebeck, E. 2000. *Tilling Nature, Harvesting Culture: Exploring Images of the Human Being in the Transition to Agriculture*. Leiden: Sidestone Press.

Russell, B. 1945. *The History of Western Philosophy and Its Connection with Political and Social Circumstances from the Earliest Times to the Present Day*. New York: Simon and Schuster.

Russell, B. 2014. *The Problems of Philosophy*. New York: Start Publishing.

Rye, O.S. 1977. Pottery Manufacturing Techniques: X-Ray Studies. *Archaeometry*, 19, pp. 205–211.

Rye, O.S. 1981. *Pottery Technology: Principles and Reconstruction*. Washington DC: Taraxacum.

Sahlins, M.D. 1972. *Stone Age Economics*. Chicago: Aldine Atherton Inc.

Sahlins, M.D. 1976. *Culture and Practical Reason*. Chicago: University of Chicago Press.

Saile, T. 2010. Aspects of neolithisation in the Weser-Harz region. In: D. Gronenborn and J. Petrasch, eds. *Die Neolithisierung Mitteleuropas: Internationale Tagung, Mainz 24. Bis 26. Juni 2005*. Budenheim: RGZM, pp. 439–448.

Salque, M., Radi, G., Tagliacozzo, A., Uria, B.P., Wolfram, S., Hohle, I., Stäuble, H., Hofmann, D., Whittle, A., Pechtl, J., Schade-Lindig, S., Eisenhauer, U., & Evershed, R.P. 2012. New insights into the Early Neolithic economy and management of animals in Southern and Central Europe revealed using lipid residue analyses of pottery vessels. *Anthropozoologica*, 47, pp. 45–62.

Sanhueza Riquelme, L. 1988. Antecedentes y proposición metodológica para el estudio de huellas de alteración en cerámica. *Conserva*, 2, pp. 69–79.

Saridaki, N., Kotsakis, K., Urem-Kotsou, D., Papadakou, T., & Papaioannou, A. 2019. Pottery Production at Neolithic Pieria, Macedonia, Greece. In: S. Amicone, P. S. Quinn, M. Marić, N. Mirković-Marić and M. Radivojević, eds. *Tracing Pottery-Making Recipes in the Prehistoric Balkans 6th–4th Millennia BC*. Oxford: Archaeopress, pp. 129–143.

Sava, V., Tudorie, A. & Savu, M. 2015. *Ghiroc 'Balastiera Vest'. A Neolithic Settlement in the Lower Mureş Basin*. Cluj-Napoca: Mega.

Schiffer, M.B. 1972. Archaeological Context and Systemic Context. *American Antiquity*, 37, pp. 156–165.

Schiffer, M.B. 1987. *Formation Processes of the Archaeological Record*. Albuquerque, NM: University of New Mexico Press.

Schiffer, M.B. 2014. *Behavioral Archaeology: Principles and Practice*. New York: Routledge.

Schiffer, M.B. & Miller, A.R. 1999. *The Material Life of Human Beings. Artifacts, Behavior, and Communication.* London: Routledge.

Schiffer, M.B. & Skibo, J.M. 1989. A Provisional Theory of Ceramic Abrasion. *American Anthropologist*, 91, pp. 101–115.

Schmid, M. 2009. Smallest Enclosing Circle. *ImageJ Macros*,.

Schwarz-Mackensen, G. 1983. Zu den Grabungen der frühbandkeramischen Siedlung bei Eitzum, Kreis Wolfenbüttel, in den Jahren 1956 bis 1958. *Nachrichten aus Niedersachsens Urgeschichte*, 52, pp. 209–227.

Schwarz-Mackensen, G. 1985. *Die Frühbandkeramische Siedlung Eitzum, Landkreis Wolfellbüttel*. Braunschweig: Veröffentlichungen des Braunschweiger Landesmuseums.

Scott, J.C. 2017. *Against the Grain. A Deep History of the Earliest States*. New Haven: Yale University Press.

Seidler, J. & Amicone, S. 2017. *Report: Petrography Analysis of Pottery from Tăşnad Sere*. Tubingen: Competence Center Archaeometry Baden-Wuerttemberg (CCA-BW).

Selley, R.C. 2000. *Applied Sedimentology*. Second Edition. London: Academic Press.

Sennett, R. 2008. *The Craftsman*. New Haven: Yale University Press.

Shamanaev, A.V. 2001. Reused Pottery Fragments as a Focus of Functional Analysis. Life after Death–An Example from Uppåkra. *Acta Archaeologica Lundensia*, 36, pp. 143–148.

Shanks, M., Platt, D. & Rathje, W.L. 2004. The Perfume of Garbage: Modernity and the Archaeological. *Modernism/modernity*, 11, pp. 61–83.

Shanks, M. & Tilley, C.Y. 1987. *Social Theory and Archaeology*. Cambridge: Polity in association with Blackwell.

Shanks, M. & Tilley, C.Y. 1992. *Re-Constructing Archaeology: Theory and Practice*. London and New York: Routledge.

Shaw, I. & Jameson, R. (eds.) 2002. *A Dictionary of Archaeology*. Oxford: John Wiley & Sons.

Shepard, A. 1956. *Ceramics for the Archaeologist*. Washington D.C.: Carnegie Institution of Washington.

Sherratt, A. 1982. The development of Neolithic and Copper Age settlement in the Great Hungarian Plain. Part I: the regional setting. *Oxford Journal of Archaeology*, 1, pp. 287–316.

Sherratt, A. 1995. Reviving the grand narrative: archaeology and long-term change. The Second David L. Clarke Memorial Lecture. *Journal of European Archaeology*, 3, pp. 1–32.

Shott, M.J. 1996. Mortal Pots: On Use Life and Vessel Size in the Formation of Ceramic Assemblages. *American Antiquity*, 61, pp. 463–482.

Shott, M.J. & Sillitoe, P. 2001. The Mortality of Things: Correlates of Use Life in Wola Material Culture Using Age-at-Census Data. *Journal of Archaeological Method and Theory*, 8, pp. 269–302.

Shott, M.J. & Sillitoe, P. 2004. Modeling Use-Life Distributions in Archaeology Using New Guinea Wola Ethnographic Data. *American Antiquity*, 69, pp. 339–355.

Shott, M.J. & Williams, E. 2006. Purepecha Pottery Ethnoarchaeology. *Archaeological Papers of the American Anthropological Association*, 16, pp. 47–56.

Siegmund, F. & Hainski, S. 1992. Älteste Bandkeramik im Ilmetal bei Einbeck. *Neue Ausgrabungen und Forschungen in Niedersachsen*, 20, pp. 1–26.

Sillar, B. 2000a. Dung by Preference: The Choice of Fuel as an Example of How Andean Pottery Production Is Embedded Within Wider Technical, Social, and Economic Practices*. *Archaeometry*, 42, pp. 43–60.

Sillar, B. 2000b. *Shaping Culture: Making Pots and Constructing Households. An Ethnoarchaeological Study of Pottery Production, Trade and Use in the Andes*. Oxford: J. and E. Hedges.

Silva, F. & Vander Linden, M. 2017. Amplitude of travelling front as inferred from 14 C predicts levels of genetic admixture among European early farmers. *Scientific Reports*, 7, pp. 1–9.

Skibo, J.M. 1987. Fluvial Sherd Abrasion and the Interpretation of Surface Remains on Southwestern Bajadas. *North American Archaeologist*, 8, pp. 125–141.

Skibo, J.M. 1992. *Pottery Function : A Use-Alteration Perspective*. New York: Plenum Press.

Skibo, J.M. 2013. Understanding Pottery Function. In: *Understanding Pottery Function*. Springer New York, pp. 1–25.

Skibo, J.M. & Schiffer, M.B. 1987. The effects of water on processes of ceramic abrasion. *Journal of Archaeological Science*, 14, pp. 83–96.

Skibo, J.M., Schiffer, M.B. & Reid, K.C. 1989. Organic-Tempered Pottery: An Experimental Study. *American Antiquity*, 54, pp. 122–146.

Slager, S., Van der Plas, L. & Van Doesburg, J.D.J. 1978. Examination of LBK potsherds from Hienheim. *Analecta Praehistorica Leidensia*, 11, pp. 193–201.

Smith, A. 1978. *Lectures on Jurisprudence / Adam Smith / Edited by R. L. Meek, D. D. Raphael, P. G. Stein*. Oxford: Clarendon Press.

Sommer, U. 1990. Dirt theory, or archaeological sites seen as rubbish heaps. *Journal of Theoretical Archaeology*, 1, pp. 47–60.

Sommer, U. 1991. *Zur Entstehung archäologischer Fundvergesellschaftungen: Versuch einder archäologischen Taphonomie*. Bonn: Habelt.

Sommer, U. 2001. ‘Hear the instruction of thy father, and forsake not the law of thy mother’: Change and persistence in the European early Neolithic. *Journal of Social Archaeology*, 1, pp. 244–270.

Sommer, U. 2006. The Linearbandkeramik settlement of Hanau-Klein Auheim (Hesse): a specialised mining settlement? In: G. Körlin and G. Weisgerber, eds. *Stone Age-Mining Age*. Bochum: Deutches Bergbau-Museum, pp. 187–194.

Sommer, U., Amicone, S. & Chernysheva, E. 2019. Micro- and Macroarchaeology – How Can the Two Be Combined? In: N. Palincaş and C. C. Ponta, eds. *Bridging Science and Heritage in the Balkans: Studies in Archaeometry, Cultural Heritage Restoration and Conservation*. Oxford: Archaeopress, pp. 1–15.

Sommer, U. & Astaloş, C. 2015. The village and the house in the early Neolithic. Research into activity areas and rubbish disposal at the late Criş settlement of Tăşnad (Satu Mare County, Romania). In: C. Virag, ed. *Neolithic Cultural Phenomena in the Upper Tisa Basin*. Satu Mare: Muzeul Județean Satu Mare, pp. 75–97.

Sommer, U. & Gramsch, A. 2011. German Archaeology in Context. An Introduction to History and Present of Central European Archaeology. In: A. Gramsch and U. Sommer, eds. *A History of Central European Archaeology. Theory, Methods, and Politics*. Budapest: Archaeolingua, pp. 7–40.

Šošić Klindžić, R. & Hršak, T. 2014. The Starcevo Culture. In: B. Bunčić, ed. *Gifts of the Earth. The Neolihtic between the Sava, Drava and Danube*. Zagreb: Arheološki muzej u Zagrebu, Muzej Slavonije Osijek, Sveučilište u Zagrebu Filozofski fakultet, pp. 14–28.

Soudský, B. 1966. *Bylany Osada Nejstarších Zemědělců z Mladší Doby Kamenné*. Praha: Academia.

Soudský, B. & Pavlů, I. 1972. The Linear Pottery Culture settlements patterns of Central Europe. In: P. J. Ucko, R. Tringham and G. W. Dimbleby, eds. *Man, Settlement and Urbanism*. London: Duckworth, pp. 317–328.

Souvatzi, S. 2008. Household dynamics and variability in the Neolithic of Greece: the case for a bottom-up approach. In: D. W. Bailey, A. W. R. Whittle and D. Hofmann, eds. *Living Well Together? Settlement and Materiality in the Neolithic of South-East and Central Europe*. Oxford: Oxbow Books, pp. 17–27.

Souvatzi, S. 2013. Diversity, Uniformity and the Transformative Properties of the House in Neolithic Greece. In: D. Hofmann and J. Smyth, eds. *Tracking the Neolithic House in Europe: Sedentism, Architecture and Practice*. New York: Springer, pp. 45–64.

Spataro, M. 2005. Early Neolithic pottery production in the Balkans: minero-petrographic analyses of the ceramics from the Starčevo-Criş site of Foeni-Sălaş (Banat, Romania). *Atti della Società per la Preistoria Protostoria Regione Friuli-Venezia Giulia*, 14, pp. 25–43.

Spataro, M. 2006. Pottery typology versus technological choices: an early Neolithic case study from Banat (Romania). *Analele Banatului*, XIV, pp. 63–77.

Spataro, M. 2007. Everday Ceramics and Cult Objects: A Millennium of Cultural Transmission. In: M. Spataro and P. Biagi, eds. *A Short Walk through the Balkans: The First Farmers of the Carpathian Basin and Adjacent Regions*. Trieste: Società per la preistoria e protostoria della regione Friuli-Venezia Giulia, pp. 149–160.

Spataro, M. 2008. Early Neolithic pottery production in Romania: Gura Baciului and Şeuşa La-Cărarea Morii (Transylvania). In: D. Bailey, A. Whittle and D. Hofmann, eds. *Living Well Together? Settlement and Materiality in the Neolithic of South-East and Central Europe*. Oxford: Oxbow Books, pp. 91–100.

Spataro, M. 2010. The Neolithisation of the Central Balkans: leapfrogging diffusion and cultural transmission. In: D. Gronenborn and J. Petrasch, eds. *Die Neolithisierung Mitteleuropas: Internationale Tagung, Mainz 24. Bis 26. Juni 2005*. Budenheim: RGZM, pp. 95–105.

Spataro, M. 2011. A comparison of chemical and petrographic analyses of Neolithic pottery from South-eastern Europe. *Journal of Archaeological Science*, 38, pp. 255–269.

Spataro, M. 2014. Continuity and change in pottery manufacture between the early and middle Neolithic of Romania. *Archaeological and Anthropological Sciences*, 6, pp. 175–197.

Spear, F.S. 1981. An Experimental Study of Hornblende Stability and Compositional Variability in Amphibolite. *American Journal of Science*, 281, pp. 697–734.

Spengler, O. 1918. *The Decline of the West: Form and Actuality*. London: Allen and Unwin.

Stadler, P. 2010. Auswertung der 14C-Daten von Mold mittels Kombinationskalibrationen und Sequencing der durch Seriation ermittelten Hausabfolge. In: E. Lenneis, ed. *Die Bandkeramische Siedlung von Mold Bei Horn in Niederosterreich*. Rahden/Westfalen: Marie Leidorf GmbH, pp. 23–32.

Stadler, P. & Kotova, N. 2010. Early Neolithic settlement from Brunn Wolfholz in Lower Austria and the problem of the origin of (Western) LBK. In: J. K. Kozlowski and P. Raczky, eds. *Neolithization of the Carpathian Basin: Northernmost Distribution of the Starčevo/Körös Culture*. Kraków: Polska Akademia Umiejętności, pp. 325–348.

Stanciu, I. & Virag, C. 2013. Neue frühslawische Siedlungsfunde aus dem oberen Theissbecken (Tăşnad-Sere, Nordwestrumänien). *Acta Archaeologica Carpathica*, XLVIII, pp. 171–194.

Stanislawski, M.B. 1978. If Pots were Mortal. In: R. A. Gould, ed. *Explorations in Ethnoarchaeology*. Albuquerque: University of New Mexico Press, pp. 201–227.

Starnini, E. 1993. Typological and Technological Analyses of the Körös Culture Chipped, Polished and Ground Stone Assemblages of Méhtelek-Nádas (North-Eastern Hungary). *Atti della Società per la Preistoria Protostoria Regione Friuli-Venezia Giulia*, VIII, pp. 29–96.

Starnini, E. 2001. The Mesolithic/Neolithic transition in Hungary: the lithic perspective. In: R. Kertész and J. Makkay, eds. *From the Mesolithic to the Neolithic. Proceedings of the International Archaeological Conference Held in the Damjanich Museum of Szolnok, September 22-27, 1996*. Budapest: Archaeolingua, pp. 395–404.

Starnini, E. 2008. Material culture traditions and identity. In: D. Bailey, A. Whittle and D. Hofmann, eds. *Living Well Together? Settlement and Materiality in the Neolithic of South-East and Central Europe*. Oxford: Oxbow Books, pp. 101–108.

Starnini, E. & Szakmány, G.Y. 1998. The lithic industry of the Neolithic sites of Szarvas and Endrőd (south-easrern Hungary): techno-typological and archaeometrical aspects. *Acta Archaeologica Academiae Scientiarum Hungaricae*, 50, pp. 279–342.

Staššíková-Štukovská, D. 2002. The stone and Middle Age ovens in Loess sites of Slovakia. Influences on their quality for food preparation. In: M. Mesnil and K. Fechner, eds. *Pain, Fours et Foyers Des Temps Passes: Archéologie et Traditions Boulangères Des Peuples Agriculteurs d'Europe et Du Proche Orient / Bread, Ovens and Hearths of the Past: Archaeology and Baking Traditions of Agriculture Civilisations in Europe and the Near East*. Brussels: Université Libre, pp. 259–269.

Statham, I. 1976. A Scree Slope Rockfall Model. *Earth Surface Processes*, 1, pp. 43–62.

Stäuble, H. 1990. Die ältestbandkeramische Grabenanlage in Eitzum, Ldkr. Wolfenbüttel: Überlegungen zu Verfüllung und Interpretation von Befunden. *Jahresschrift für mitteldeutsche Vorgeschichte*, 73, pp. 331–344.

Stäuble, H. 1995. Radiocarbon Dates of the Earliest Neolithic in Central Europe. *Radiocarbon*, 37, pp. 227–237.

Stäuble, H. 1997. Häuser, Gruben und Fundverteilung. In: J. Lüning, ed. *Ein Siedlungsplatz Der Ältesten Bandkeramik in Bruchenbrücken, Stadt Friedberg/Hessen*. Bonn: Habelt, pp. 17–150.

Stäuble, H. 2005. *Häuser Und Absolute Datierung Der Ältesten Bandkeramik*. Bonn: Universitätsforschungen zur Prähistorischen Archäologie.

Stäuble, H. 2013. What You See Is What It Was? In: P. Allard and M. Ilett, eds. *The Domestic Space in LBK Settlements*. Rahden/Westfalen: Marie Leidorf GmbH, pp. 231–245.

Stäuble, H. & Lüning, J. 1999. Phosphatanalysen in bandkeramischen Häusern. *Archäologisches Korrespondenzblatt*, 2, pp. 169–187.

Stäuble, H. & Wolfram, S. 2012. Taphonomie heute: Reanimation erwünscht. Studien zur Bandkeramik. In: T. Link and D. Schimmelpfennig, eds. *Taphonomische Forschungen (Nicht Nur) Zum Neolithikum. Beiträge Zur*

Sitzung Der AG Neolithikum Im Rahmen Der 80. Verbandstagung Des West- Und Süddeutschen Verbands Für Altertumsforschung e. V. in Nürnberg Am 26. Und 27. Mai 2010. Kerpen: Welt und Erde, pp. 33–55.

Stehli, P. 1994. Chronologie der Bandkeramik im Merzbachtal. In: J. Lüning, ed. *Die Bandkeramik Im Merzbachtal Auf Der Aldenhovener Platte*. Köln: Rheinland-Verlag, pp. 79–191.

Stein, J.K. 1987. Deposits for Archaeologists. *Advances in Archaeological Method and Theory*, 11, pp. 337–395.

Steponaitis, V. 1983. *Ceramics, Chronology and Community Patterns: An Archaeological Study at Moundville*. New York: Academic Press.

Steponaitis, V. 1984. Technological Studies of Prehistoric Pottery from Alabama: Physical Properties and Vessel Function. In: S. E. Van der Leeuw and A. C. Pritchard, eds. *The Many Dimensions of Pottery: Ceramics in Archaeology and Anthropology*. Amsterdam: University of Amsterdam Press, pp. 79–123.

Steward, J. 1977. *Evolution and Ecology: Essays on Social Transformation*. J. C. Steward and R. F. Murphy, eds. Urbana: University of Illinois Press.

Stocking, G.W. 1968. *Race, Culture, and Evolution. Essays in the History of Anthropology*. Chicago: The University of Chicago Press.

Stocking, G.W. 1987. *Victorian Anthropology*. New York: The Free Press.

Strathern, M. 1988. *The Gender of the Gift: Problems with Women and Problems with Society in Melanesia*. Berkeley: University of California Press.

Strien, H.C. 2012. Chronological and Social Interpretation of the Artefactual Assemblage. In: A. Bogaard, ed. *Plant Use and Crop Husbandry in an Early Neolithic Village: Vaihingen an Der Enz, Baden-Württemberg*. Bonn: Habelt, pp. 19–23.

Stuiver, M., Reimer, P.J., Bard, E., Beck, J.W., Burr, G.S., Hughen, K.A., Kromer, B., McCormac, G., Plicht, J.V.D., Spurk, M. 1998. INTCAL98 Radiocarbon Age Calibration, 24,000–0 cal BP. *Radiocarbon*, 40, pp. 1041–1083.

Sullivan, A.P.I. 1988. Prehistoric Southwestern Ceramic Manufacture: The Limitations of Current Evidence. *American Antiquity*, 53, pp. 23–35.

Sullivan, A.P.I., Skibo, J.M. & Buren, M. van 1992. Sherds as Tools: The Roles of Vessel Fragments in Prehistoric Succulent Plant Processing. *North American Archaeologist*, 12, pp. 243–255.

Sümegi, P. 1999. Reconstruction of flora, soil and landscape evolution, and human impact on the Bereg Plain from late-glacial up to the present, based on palaeoecological analysis. In: J. Hamar and A. Sárkány-Kiss, eds. *The Upper Tisza Valley*. Szeged: Tisza Klub, pp. 171–203.

Sümegi, P., Gulyás, S., Kertész, R., & Timár, G. 2013. Mesolithic-Neolithic transition in the Carpathian Basin: was there an ecological trap during the Neolithic? In: M. O. Baldia, T. K. Perttula and D. S. Frink, eds. *Comparative Archaeology and Paleoclimatology. Socio-Cultural Responses to a Changing World*. Oxford: Archaeopress, pp. 119–126.

Sun, Q., Zheng, J., Coop, M.R., & Altuhafi, F. 2019. Minimum image quality for reliable optical characterizations of soil particle shapes. *Computers and Geotechnics*, 114, pp. 1–6.

Sutton, D. 2006. Cooking Skill, the Senses, and Memory: The Fate of Practical Knowledge. In: E. Edwards, C. Gosden and R. B. Phillips, eds. *Sensible Objects: Colonialism, Museums and Material Culture*. London: Bloomsbury Academic, pp. 87–118.

Swabey, W.C. 1923. The Laws of Thought. *The Philosophical Review*, 32, pp. 211–221.

Swift, E. 2012. Object Biography, Re-use and Recycling in the Late to Post-Roman Transition Period and Beyond: Rings made from Romano-British Bracelets. *Britannia*, 43, pp. 167-215.

Szabó, J., Vass, R. & Tóth, C. 2012. Examination of Fluvial Development on Study Areas of Upper-Tisza Region. *Carpathian Journal of Earth and Environmental Sciences*, 7, pp. 241–253.

Szakmány, G.Y. & Starnini, E. 2007. Archaeometric Research on the First Pottery Production in the Carpathian Basin: Manufacturing Traditions of the Early Neolithic, Körös Culture Ceramics. *Archeometriai Műhely*, 2, pp. 5–19.

Szécsényi-Nagy, A., Brandt, G., Haak, W., Keerl, V., Jakucs, J., Möller-Rieker, S., Köhler, K., Mende, B.G., Oross, K., Marton, T., Osztás, A., Kiss, V., Fecher, M., Pálfi, G., Molnár, E., Sebők, K., Czene, A., Paluch, T., Šlaus, M., Novak, M., Pećina-Šlaus, N., Ősz, B., Voicsek, V., Somogyi, K., Tóth, G., Kromer, B., Bánffy, E., & Alt, K.W. 2015. Tracing the genetic origin of Europe's first farmers reveals insights into their social organization. *Proceedings of the Royal Society B: Biological Sciences*, 282, pp. 20150339.

Szekszárdi, A. 2005. A vizsgálati lehetőségek áttekintése a Tokaji-hegységi limnokvarciton és limnoopaliton, a pattintott kőeszközök eredetének azonositása céljából/Limnic quartzite reconsidered on limnic silicites of theTokaj Mts. for the purpose of lithic provenance analysis. *Archeometriai Műhely*, 2, pp. 56–61.

Szepesi, J., Lukács, R., Biró, K.T., Markó, A., & Pécskay, Z. 2018. Geology of the Tokaj Mountains Obsidians. *Archeometriai Műhely*, XV, pp. 167–180.

Szilágyi, V. & Szakmány, G.Y. 2007. Petrographic and Geochemical Study of Cermics of Neolithic Settlements on the Northern Boundary of the Great Hungarian Plain – Tiszaszőlős-Domaháza (Körös Culture) and Füzesabony-Gubakú (ALP Culture, Szatmár Group). *Archeometriai Műhely*, 3, pp. 31–46.

Tabor, D. 1977. Wear–A Critical Synoptic View. *Journal of Lubrication Technology*, 99, pp. 387–395.

Takashimizu, Y. & Iiyoshi, M. 2016. New parameter of roundness R: circularity corrected by aspect ratio. *Progress in Earth and Planetary Science*, 3, pp. 1–16.

Tammemagi, H. 1999. *The Waste Crisis. Landfills, Incinerators, and the Search for a Sustainable Future*. Oxford: Oxford University Press.

Tani, M. 1994. Why Should More Pots Break in Larger Households? Mechanisms Underlying Population Estimates from Ceramics. In: W. Longacre and J. M. Skibo, eds. *Kalinga Ethnoarchaeology. Expanding Archaeological Method and Theory*. Washington D.C.: Smithsonian Institution Press, pp. 51–70.

Taubald, H. & Biró, K.T. 2007. Archaeometrical Analysis of Neolithic Pottery and Comparison to Potential Sources of Raw Materials in the Immediate Environment of the Settlements - A First Summary of the Möb-DAAD Exchange Program. In: K. T. Biró, V. Szilágyi and A. Kreiter, eds. *Vessels: Inside and Outside. Proceedings of the 9th European Meeting on Ancient Ceramics. October 24–27, 2007*. Budapest: Hungarian National Museum, pp. 71–75.

Tegel, W., Elburg, R., Hakelberg, D., Stäuble, H., & Büntgen, U. 2012. Early Neolithic Water Wells Reveal the World's Oldest Wood Architecture. *PLoS ONE*, 7, pp. e51374.

Theocharis, D. 1973. *Neolithic Greece*. Athens: National Bank of Greece.

Thér, R., Kallistová, A., Svoboda, Z., Květina, P., Lisá, L., Burgert, P., & Bajer, A. 2019. How Was Neolithic Pottery Fired? An Exploration of the Effects of Firing Dynamics on Ceramic Products. *Journal of Archaeological Method and Theory*, 26, pp. 1143–1175.

Thissen, L. 2005. The role of pottery in agropastoralist communities in early Neolithic southern Romania. In: D. W. Bailey, A. W. R. Whittle and V. Cummings, eds. *(Un)Settling the Neolithic*. Oxford: Oxbow, pp. 71–78.

Thissen, L. 2009. First ceramic assemblages in the Danube catchment, SE Europe - a synthesis of the radiocarbon evidence. *Buletinul Muzeului Judeţean Teleorman*, pp. 9–30.

Thissen, L. 2012. Starčevo-Criş Pottery from Teleor 003, S Romania. *Buletinul Muzeului Judeţean Teleorman*, 4, pp. 5–45.

Thissen, L. 2015. Ceramics from an Early Neolithic (Criş I) site in S Romania: 'Buduiasca–Boldul lui Moş Ivănuş. *Buletinul Muzeului Judeţean Teleorman*, 7, pp. 5–44.

Thomas, J. 1993. Discourse, Totalization and 'The Neolithic'. In: C. Y. Tilley, ed. *Interpretative Archaeology*. Oxford: Berg, pp. 357–394.

Thomas, J. 1999. *Understanding the Neolithic.* Rev. 2nd ed. London: Routledge.

Thomas, J. 2004. *Archaeology and Modernity*. London: Routledge.

Thomas, J. 2012. Some deposits are more structured than others. *Archaeological Dialogues*, 19, pp. 124–127.

Thomas, J. 2015a. Commentary: What Do We Mean by 'Neolithic Societies'? In: C. Fowler, J. Harding and D. Hofmann, eds. *The Oxford Handbook of Neolithic Europe*. Oxford: Oxford University Press, pp. 1073–1092.

Thomas, J. 2015b. House societies and founding ancestors in Early Neolithic Britain. In: C. Renfrew, M. Boyd and I. Morely, eds. *Death Rituals, Social Order and Archaeology of Immortality in the Ancient World*. Cambridge: Cambridge University Press, pp. 138–152.

Thomas, J. 2015c. Why 'The Death of Archaeological Theory'? In: C. Hillerdal and J. Siapkas, eds. *Debating Archaeological Empiricism. The Ambiguity of Material Evidence*. London: Routledge, pp. 11–31.

Tichý, R. 1960. Zur Ältesten Volutenkeramik in Mähren. *Pamáftky Archeologické*, 51, pp. 415–441.

Tichý, R. 1962. Volutové nálezy z Mohelnice u Zábřeha. *Sborník Československé společnosti archeologické*, 2, pp. 201–204.

Tilley, C. 2007. Materiality in materials. *Archaeological Dialogues*, 14, pp. 16–20.

Tischendorf, T. & Girardelli, D. 2016. Die Befunde. In: H. Stäuble and U. Veit, eds. *Der Bandkeramische Siedlungsplatz Eythra in Sachsen. Studien Zur Chronologie Und Siedlungsentwicklung*. Leipzig: Professur für Ur- und Frühgeschichte, pp. 27–42.

Tite, M.S., Kilikoglou, V. & Vekinis, G. 2001. Strength, Toughness and Thermal Shock Resistance of Ancient Ceramics, and Their Influence On Technological Choice. *Archaeometry*, 43, pp. 301–324.

Todorova, M. 2009. *Imagining the Balkans*. Updated edition. Oxford: Oxford University Press.

Torchy, L. & Gassin, B. 2010. Le travail de la poterie en contexte chasséen: des outils en silex pour la production céramique? *Bulletin de la Société préhistorique française*, 107, pp. 725–735.

Torcică, I. 2010. Observaţii asupra unor vase Gumelniţene cu perforaţii din Tell-ul de la Vităneşti-Măgurice, Jud. Teleorman. *Buletinul Muzeului Judeţean Teleorman*, 2, pp. 99–105.

Török, Z. 2002. The Romanian wetland inventory. *Scientific Annals of the Danube Delta Institute and Development*, 9, pp. 161–173.

Tóth, Z. 2012. Bone, antler, and tusk tools of the Early Neolithic Körös Culture. In: *The First Neolithic Sites in Central/South-East European Transect. Volume III: The Körös Culture in Eastern Hungary*. Oxford: Archaeopress, pp. 171–178.

Tresset, A. & Vigne, J.D. 2007. Substitution of species, techniques and symbols at the Mesolithic/Neolithic transition in Western Europe. In: A. Whittle and V. Cummings, eds. *Going over: The Mesolithic/Neolithic Transition in NW Europe*. London: The British Academy, pp. 189–210.

Trigger, B. 2006. *A History of Archaeological Thought*. Cambridge: Cambridge University Press.

Tringham, R. 1971. *Hunters, Fischers, and Farmers of Eastern Europe, 6000-3000 BC*. London: Hutchinson University Library.

Trogmayer, O. 1966. Ein neolitisches Hausmodellfragment von Röszke. *Acta Antiqua et Archaeologica*, 10, pp. 11–26.

Tsetlin, Y.B. 2003. Organic tempers in ancient ceramics. In: S. Di Pierro, V. Serneels and M. Maggetti, eds. *Ceramics in Society. Proceedings of the 6th European Meeting on Ancient Ceramics, Fribourg, Switzerland, 3 - 6 October 2001*. Fribourg: Department of Geosciences, Mineralogy and Petrography, University of Fribourg, pp. 289–310.

Tsetlin, Y.B. 2010. Ceramic investigations in Russia. Scientific approaches, pottery production structure, modern possibilities and some research results. *Journal of Nordic Archaeological Science*, 17, pp. 65–81.

Tsing, A.L. 2005. *Friction. An Ethnography of Global Connection*. Princeton: Princeton University Press.

Van Buren, M., Skibo, J.M. & Sullivan, A.P. 1992. The archaeology of an agave roasting location. In: S. K. Fish and P. R. Fish, eds. *The Marana Community in the Hohokam World*. Tucson: University of Arizona Press, pp. 88–96.

Vaquer, J.M. 2013. Las aporías de la Arqueología Hermenéutica. En busca de un nuevo criterio de validez. *Arqueología*, 19, pp. 151–172.

Vargiolu, R., Morero, E., Boleti, A., Procopiou, H., Pailler-Mattei, C., & Zahouani, H. 2007. Effects of abrasion during stone vase drilling in Bronze Age Crete. *Wear*, 263, pp. 48–56.

Varien, M.D. & Mills, B.J. 1997. Accumulations research: Problems and prospects for estimating site occupation span. *Journal of Archaeological Method and Theory*, 4, pp. 141–191.

Vatsvåg Nielsen, S. 2019. The thing-in-itself. A reaction to current use of the term in archaeology. *Archaeological Dialogues*, 26, pp. 123–126.

Vaz Pinto, I., Schiffer, M.B., Smith, S., & Skibo, J.M. 1987. Effects of temper on ceramic abrasion resistance. *Archeomaterials*, 1, pp. 119–134.

van de Velde, P. 2008. On Bandkeramik features. In: P. Van de Velde, ed. *Excavations at Geleen-Janskamperveld 1990/1991*. Leiden: Leiden University Press, pp. 71–90.

Vergara, S.E. & Tchobanoglous, G. 2012. Municipal Solid Waste and the Environment: A Global Perspective. *Annual Review of Environment and Resources*, 37, pp. 277–309.

Verhoeven, M. 2011. The Birth of a Concept and the Origins of the Neolithic: A History of Prehistoric Farmers in the Near East. *Paléorient*, 37, pp. 75–87.

Vernant, J.-P. 1996. *Myth and Society*. New York: Zone Books.

Vernant, J.-P. 2006. *Myth and Thought Among the Greeks*. New York: Zone Books.

Vieugué, J. 2010. Les estèques en céramique des potiers néolithiques de l'habitat de Kovačevo (6200-5500 av. J.-C.), Bulgarie. *Bulletin de la Société préhistorique française*, 107, pp. 709–723.

Vieugué, J. 2012. Spécialisation fonctionnelle des premières productions céramiques dans les Balkans (6100-5500 av. J.-C.). *Bulletin de la Société préhistorique française*, 109, pp. 251–265.

Vieugué, J. 2014. *Fonction Des Contenants et Des Outils En Céramique. Les Premières Productions de Bulgarie (VIe Millénaire Av. J.-C.)*. Paris: CNRS Éditions.

Vieugué, J. 2015. What were the recycled potsherds used for? Use-wear analysis of Early Neolithic ceramic tools from Bulgaria (6100–5600 cal. BC). *Journal of Archaeological Science*, 58, pp. 89–102.

Vieugué, J., Gomart, L. & Salanova, L. 2010. Les estèques en céramique des potiers néolithiques de l'habitat de Kovačevo (6200-5500 av. J.-C.), Bulgarie. *Bulletin de la Société préhistorique française*, 107, pp. 709–723.

Vieugué, J., Mirabaud, S. & Regert, M. 2008. Contribution méthodologique à l'analyse fonctionnelle des céramiques d'un habitat néolithique : l'exemple de Kovačevo (6 200-5 500 av. J.-C., Bulgarie). *ArchéoSciences*, 32, pp. 99–113.

Vieugué, J., Mirabaud, S., Wright, V., Chadefaux, C., & Regert, M. 2009. Bone Powder and Animal Fats Contained in the Ceramic Vessels from the Earliest Neolithic Site of Bulgaria, Kovačevo (6200-5500 B.C.). In: L. Astruc, A. Gaulon and L. Salanova, eds. *Méthodes d'approche Des Premières Productions Céramiques: Étude de Cas Dans Les Balkans et Au Levant Table-Ronde de La Maison de l'Archéologie et de l'Ethnologie (Nanterre, France) 28 Février 2006, 29–38*. Rahden: Verlag Marie Leidorf, pp. 29–38.

Vindrola-Padrós, B. 2015. *The Narratives of Broken Pots: Understanding Pottery Breakage through an Experimental Approach*. Unpublished MA Thesis, University College London.

Vindrola-Padrós, B., Moulding, D., Astaloş, C., Virag, C., & Sommer, U. 2019. Working with broken agents: Exploring computational 2D morphometrics for studying the (post)depositional history of potsherds. *Journal of Archaeological Science*, 104, pp. 19–33.

Virag, C. 2008a. Materiale ceramice neolitice de la Călineşti-Oaş-Dâmbul Sfintei Mării. *Studii şi Comunicări Satu Mare*, XXV, pp. 35–44.

Virag, C. 2008b. *The Neolithic in Nord-West of Romania and Neighbouring Area.* Unpublished PhD thesis, Lucian Blaga University.

Virag, C. 2015a. *Cercetări Arheologice În Judeţul Satu Mare, II. Situri Arheologice Din Epoca Neolitică*. Satu Mare: Muzeul Județean Satu Mare.

Virag, C. 2015b. Some aspects about the Neolithic settlement from Tăşnad (Satu Mare County, Romania). In: C. Virag, ed. *Neolithic Cultural Phenomena in the Upper Tisa Basin*. Satu Mare: Muzeul Județean Satu Mare, pp. 97–126.

Virag, C. 2016. Câteva considerații privind un pandantiv de lut de la Tășnad-Sere. *Acta Mvsei Porolissensis*, 38, pp. 65–72.

Virag, C., Astaloş, C., Gindele, R., Kádas, Z., Hágó, A., Daroczi, T., Dobos, Z., Kiss, L., Nagy, T., Pinkováy, B., & Sava, V. 2006. *Cronica Cercetărilor Arheologice Din România. Campania 2005*. Bucureşti: CIMEC-Institutul de Memorie Culturală.

Vokaer, A. 2010. Cooking in a Perfect Pot. Shapes, Fabrics and Function of Cooking Ware in Late Antique Syria. In: S. Menchelli, S. Santoro, M. Pasquinucci and Guiducci, eds. *Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean. Archaeology and Archaeometry Comparison between Western and Eastern Mediterranean*. Oxford: Archaeopress, British Archaeological Reports, pp. 115–129.

Vuković, J. 2011. Early Neolithic Pottery from Blagotin, Central Serbia: A Use-Alteration Analysis. In: R. Krauß, ed. *Beginnings – New Research in the Appearance of the Neolithic between Northwest Anatolia and the Carpathian Basin*. Rahden/Westf: Verlag Marie Leidorf, pp. 205–212.

Vuković, J. 2013. Pottery shreds as tools in late Neolithic Vinča. *Starinar*, 63, pp. 191–207.

Vuković, J. 2015. Secondary Use, Reuse and Recycling of Ceramic Vessels: Evidence from Late Neolithic Vinča. *Archaica*, 3, pp. 111–126.

Vuković, J. 2019. Technology and Function: Performance Characteristics and Usage Aspects of the Neolithic Pottery of the Central Balkans. In: S. Amicone, P. S. Quinn, M. Marić, N. Mirković-Marić and M. Radivojević, eds. *Tracing Pottery-Making Recipes in the Prehistoric Balkans 6th–4th Millennia BC*. Oxford: Archaeopress, pp. 172–181.

Wadell, H. 1933. Sphericity and Roundness of Rock Particles. *The Journal of Geology*, 41, pp. 310–331.

Wadell, H. 1935. Volume, Shape, and Roundness of Quartz Particles. *The Journal of Geology*, 43, pp. 250–280.

Warfe, A. 2015. A study on the strength and thermal shock resistance of Egyptian shale-tempered pottery. *Journal of Archaeological Science*, 55, pp. 26–33.

Waterbolk, H.T. & Modderman, P.J.R. 1959. Die Grossbauten der Bandkeramik. *Palaeohistoria*, 6/7, pp. 163–171.

Waters, M.R. 1992. *Principles of Geoarchaeology: A North American Perspective*. Tucson: The University of Arizona Press.

Webmoor, T. 2007. What about 'one more turn after the social' in archaeological reasoning? Taking things seriously. *World Archaeology*, 39, pp. 563–578.

Webmoor, T. & Witmore, C.L. 2008. Things Are Us! A Commentary on Human/Things Relations under the Banner of a 'Social' Archaeology. *Norwegian Archaeological Review*, 41, pp. 53–70.

Weiner, A.B. 1992. *Inalienable Possessions: The Paradox of Keeping-While-Giving*. University of California Press.

Wentworth, C.K. 1919. A Laboratory and Field Study of Cobble Abrasion. *Journal of Geology*, 27, pp. 507–521.

West, S.M. 1992. *Temper, Thermal Shock and Cooking Pots: A Study of Tempering Materials and Their Physical Significance in Prehistoric and Traditional Cooking Pottery*. Unpublished MSc Thesis, The University of Arizona.

Whitbread, I.K. 1986. The Characterisation of Argillaceous Inclusions in Ceramic Thin Sections. *Archaeometry*, 28, pp. 79–88.

Whitbread, I.K. 1995. *Greek Transport Amphorae: A Petrological and Archaeological Study*. Athens: British School at Athens.

White, C., Odegaard, N. & Shackle, A.L. 2009. Prehistoric and ethnographic repair techniques and materials on southwestern Native American pottery. In: J. Ambers, C. Higgitt, L. Harrison and D. Saunders, eds. *Holding*

It All Together: Ancient and Modern Approaches to Joining, Repair and Consolidation. London: Archetype Publications Ltd, pp. 18–24.

White, L.A. 1959. *The Evolution of Culture. The Development of Civilization to the Fall of Rome*. New York: McGraw-Hill.

Whittle, A.W.R. 1990. Radiocarbon dating of the Linear Pottery culture: the contribution of cereal and bone samples. *Antiquity*, 64, pp. 297–302.

Whittle, A.W.R. 1996. *Europe in the Neolithic. The Creation of New Worlds*. Cambridge: Cambridge University Press.

Whittle, A.W.R. 1998. Fish, faces and fingers: presences and symbolic identities in the Mesolithic-Neolithic transition in the Carpathian basin. *Documenta Praehistorica*, 25, pp. 133–150.

Whittle, A.W.R. 2004. Connections in the Körös Culture World: Exchange as an organising principle. *Anateus*, 26, pp. 17–26.

Whittle, A., Bartosiewicz, L., Borič, D., Petitt, P., & Richards, M. 2002. In the beginning: New radiocarbon dates for the early Neolithic in northern Serbia and south-east Hungary. *Anateus*, 25, pp. 63–117.

van Wijk, I.M. 2016. *Settlement Dynamics on the Cannerberg (Maastricht, the Netherlands). Archaeological Research of Bandkeramik and Iron Age Settlements*. Leiden: Archol.

Wilkie, L.A. 1996. Glass-Knapping at a Louisiana Plantation: African-American Tools? *Historical Archaeology*, 30, pp. 37–49.

Witmore, C.L. 2014. Archaeology and the New Materialisms. *Journal of Contemporary Archaeology*, 1, pp. 1–44.

Wobker, H.G. 2015. Surface topography and surface integrity. In: I. D. Marinescu, T. K. Doi and E. Uhlmann, eds. *Handbook of Ceramics Grinding and Polishing*. Oxford: Elsevier, pp. 101–132.

Wolfe, N.D., Dunavan, C.P. & Diamond, J. 2007. Origins of major human infectious diseases. *Nature*, 447, pp. 279.

Wolfendale, P. 2014. The Noumenon's New Clothes (Part 1). *Speculations*, III, pp. 290–366.

Wolfram, S. 2013. Two sides of the coin: ceramic taphonomy and domestic space in the Linear Pottery settlements Hanau-Klein-Auheim and Eythra (Germany). In: C. Hamon, P. Allard and M. Ilett, eds. *The Domestic Space in LBK Settlements*. Rahden/Westfalen: Marie Leidorf GmbH, pp. 79–90.

Xu, X., Tian, C., Sheng, S., Lin, Z., & Song, F. 2014. Characterization of thermal-shock cracks in ceramic bars. *Science China Physics, Mechanics & Astronomy*, 57, pp. 2205–2208.

Zápotocká, M. 1989. Zur Funktion archäologischer Befunde aus der neolithischen Siedlung in Bylany. In: J. Rulf, ed. *Bylany Seminar 1987: Collected Papers*. Prague: Archaeological Institute of the Czechoslovak Academy of Sciences, pp. 187–193.

Zheng, J. & Hryciw, R.D. 2015. Traditional soil particle sphericity, roundness and surface roughness by computational geometry. *Géotechnique*, 65, pp. 494–506.

Zhilin, M. 2000. Chronology of the transition from the Mesolithic to the Neolithic in the forest zone of eastern Europe. *Lietuvos Archeologija*, 19, pp. 287–297.

Zimmermann, A. 1988. Steine. In: U. Boelicke, D. von Brandt, J. Lüning and P. Stehli, eds. *Die Bandkeramische Siedlungsplatz Langweiler 8, Gemeinde Aldenhoven, Kreis Düren*. Köln: Rheinland-Verlag, pp. 569–785.

Zvelebil, M. 1995. Neolithization in Eastern Europe: A view from the frontier. *Documenta Praehistorica*, XXII, pp. 107–151.

Zvelebil, M. 1996. The agricultural frontier and the transition to farming in the circum-Baltic region. In: D. Harris, ed. *The Origins and Spread of Agriculture and Pastoralism in Eurasia*. London: University College London Press, pp. 323–45.

Zvelebil, M. 2004. The Many Origins of the LBK. In: A. Lukes and M. Zvelebil, eds. *LBK Dialogues: Studies in the Formation of the Linear Pottery Culture*. Oxford: Archaeopress, British Archaeological Reports, pp. 183–205.

Zvelebil, M., Lukes, A. & Petitt, P. 2010. The emergence of the LBK culture: search for the ancestors. In: D. Gronenborn and J. Petrasch, eds. *The Spread of the Neolithic to Central Europe*. Mainz: Römisch-Germanischen Zentralmuseum, pp. 301–325.

Zvelebil, M. & Zvelebil, K.V. 1988. Agricultural transition and Indo-European dispersals. *Antiquity*, 62, pp. 574–583.

Appendices

Appendix 1. Some brief examples on modern expression of the social knowledge of breakage

In the following appendix, I present a few brief examples of how the social knowledge of breakage occurs in our contemporary world. First of all, I have listed a few observations I have made when visiting a contemporary potter in the town of [redacted] (Satu Mare province, northwest Romania). These observations do not stem from a systematic study, but simply serve to highlight an example of how modern-day potters create and possibly reproduce their knowledge of pottery breakage. During my several visits to Géza [redacted] workshop, he kindly provided information on his family history (as a third-generation potter), how he manufactures his pots and the potential problems that occur when manufacturing these vessels. In the table below, I list a few proverbs and phrases I have gathered when carrying out my fieldwork in south-eastern and central Europe (Table A1.1).

1. During fabrication: according to Geza, if errors occur when forming vessels on the wheel, needing to entirely restart the forming process, clays can be reused on the spot. However, he also mentions that the reusing of clays cannot be done more than twice, as this produces bubbles that can then burst when throwing.
2. Repair: Geza adds copper oxide as a sort of adherent glaze in the cracks or fractures to repair some vessels (Figure A1.1). He mentioned that this can be done when pots crack during the drying or firing process. The example provided in Figure A1.1 shows a pot broken after the firing process took place and was repaired using this technique.

Figure A1.1: Example of a dish repaired with copper oxide.

3. Keeping cracked pots: Geza maintains a great number of cracked pots around his house, workshop and gardens. Several of these pots were originally made by his grandfather (which are over a century old!) and his father. These pots are usually around the house or displayed in his small family museum and are mostly cracked along the body or chipped in the rims. The vessels hold great importance to him, as they retain the association with his relatives, from whom he learnt the craft.
   Geza also has several cracked pots of his own making. Some hang in the walls of his home, his workshop and his garden, while others are used as flowerpots. Interesting is the fact that

Geza remembers exactly the way in which they were cracked and the potential factors contributing to the breakage process. For example, a ceramic colander hanged in his garden to which he pointed at a crack in-between the perforations (Figure A1.2). The exterior crack had formed during drying process, yet he still proceeded to fire and glaze it without adding any copper oxide to mend the cracks. In contrast, Figure A1.3 shows a pot with a typical S-shaped crack on its exterior base formed during drying stages and which worsened when fired. In this case, the crack appears to have been too severe to mend, and the unglazed pot was simply reused as a flowerpot after it was fired.

Figure A1.2: Example of a cracked colander pot, which hanged from a wall in Géza's garden.

Figure A1.3: Example of a cracked pot reused as a flowerpot.

Country or Place of Origin	Proverb or Phrase	Translation	Colloquial Meaning(s)	Source
Albania	*Kotrova rrokulliset kodër-kodër por vetom injehëre thyhet*	The pot goes from one bump to another, but it only breaks once	**»** Makes reference to risky situations. You may do risky things, and nothing happens, but if it does (the breakpoint) it will be fatal	Local Informant
Bulgaria	*Здраве да е [Zdrave da e]*	Let it be for health	**»** Phrase is said when an object is broken accidentally. The person whom the vessel belonged to usually says this phrase to the person who broke the vessel. The phrase releases the person who broke it from the guilt of breaking the object.	Local Informant
Croatia	*Bit će muško!*	It's going to be a male!	**»** Expression comes from old belief that if the bride breaks a glass at a wedding, the first child in the marriage will be a boy. **»** More recently, the expression is used sarcastically and humorously in scenarios where an object broken accidentally is loud but does not produce much damage.	Local Informant and online forum*
Denmark	*Du skal ikke græde over spildt mælk*	Do not cry when you spill milk	**»** Phrase is said when an object is broken accidentally	Local Informant
France	*Les pots fêlés sout ceux qui dureut le plus*	The flawed pot lasts longest	**»** It is a phrase that expresses a contradiction: the longevity of people who are chronically ill. It also forwards a certain admiration of the resilience of these people.	Stone 2006, Bohn 1857
Germany		The jar or pitcher keeps going to the well until it breaks	**»** A critique of someone who has repeatedly done the same thing too many times	Local Informant

	Der Krug geht so lange zum, Brunnen bis er bricht		» Can also be cautionary tale, *i.e.* if one continues to behave in a certain way there will eventually be consequences	
Germany	*Schan dir diesen Scherebenhaufen an. [Variation: Jetzthaben wir den Scherbenhaufen]*	Look at this 'sherd heap'. [Variation: Now we have a 'sherd heap']	» Refers to a situation or location that is messy, so can be related to the English expression 'this is a mess!'	Local Informant
Germany	*Glück und Glas, wie leicht bricht das*	Both glass and luck break easily		Local Informant
Germany	*In Einem Hafen zwey, Suppen sieden; und, man kann an den Scherben sehen, was am Hafen gewesen ist, sind im Oberd*	Simmer two soups in one pot, and one can tell from the shards what was in the pot	» One does not always need to directly experience an event to know that it happened	(Adelung 1811, 239; Krünitz 1780, 1)
Germany	*Je größer der Scherbenhaufen, desto größer das Glück*	The larger the stack of sherds, the more luck	» Originates from potters, where sherds were stock, so a well filled storage area/container was indicative of luck » Possibly also related to the German tradition of breaking porcelain on the evening before a wedding and having the to-be-weds sweep the sherds up together (alternatively only the bride). The more sherds mean the more friends they have that care about them. » Another suggestion is that the sound that it makes scares away demons/evil spirits.	Local Informant
Italy	*Pignatta rotta non cade mai da uncino*	A cracked pot never fell off the hook		Bohn 1857
Italy	*Dura più una pentola fessa che una nuova*	An old pot lives longer than a new one		Strauss 1998

Italy	*Ogni pignattaro loda la sua pignatta, e piu. quella che tiene rotta*	Every potter praises his pot, especially if cracked		Bohn 1857
Romania	*Cioburile aduc noroc*	Sherds bring good luck	**»** Phrase is said when an object is broken accidentally	Local Informant
Romania (Oltenia)	*A crăpat un drac*	A demon has died (cracked)	**»** Demon makes reference to either an illness or 'bad luck'. Whenever a vessel breaks accidently, it is believed that a demon must have been lurking around, but through the breakage of the vessel, has left. It is as though the vessel absorbed the evil. **»** It is also considered bad fortune to store or use broken pots in the house, even if they are slightly cracked or chipped. **»** Phrase is said when an object is broken accidentally.	Local Informant
Russia	*посуда бьётся на счастье [posuda byotsya na schaste]*	Dishes break for happiness	**»** Phrase is said when an object is broken accidentally. **»** It is also commonly pronounced in weddings just after newlyweds break bottles	Local Informant
Russia	*(они) горшки побили [(oni) gorshki pobili]*	They broke jars	**»** The phrase is used when two people, usually friends, have had a quarrel with each other. **»** Also, it is said that if a vessel is broken during a fight it will generate more despair and misunderstandings. **»** Another informant mentioned that any vessel that is cracked (even slightly) cannot be stored, and has to be chucked away, because it might bring a fight. You cannot drink from a broken pot, you cannot eat from a broken plate.	Local Informant
Serbia	*Na njegovu glavu!*	Upon its head!	**»** Phrase is said when an object is broken accidentally **»** The meaning of the phrase could derive from the idea that some form of evil has struck the object instead of the person's head, which provides some comfort to the misfortunate person who has destroyed it.	Local informant

Slovakia	*Tak dlho sa chodí s krčahom po vodu kým sa krčah nerozbije*	One will go gather water with a vessel until it breaks	**»** It represents a warning against dishonest or irresponsible behaviour that somebody will continue to reproduce until it backfires.	Local Informant
Spain	*Cada ollero su olla alaba, y más si la trae quebrada*	Every potter praises his pot, especially if cracked	» Everyone has some pride in what they do. This sometimes leads people to believe that what they have is always the best, despite clear signs of it being problematic (‘broken’). » The phrase also invites caution: one should be careful as people tend to be biased towards that which they praise.	Stone 2006; Bohn 1857; Local Informant
Spain	*La vajilla rota no se vuelve a romper*	The broken vessel never breaks again		Strauss 1998
Ukraine	*посуд б'ється на щастя [posud b'yet`sya na shhastya]*	Dishes break for luck	**»** Phrase is said when an object is broken accidentally	Local Informant

Table A1.1: Some European proverbs and phrases I have gathered from numerous sources (mostly face-to-face with locals) in my attempt to illustrate the linguistic expression of this form of knowledge in modern times.

Appendix 2. Evidence of coiling of äLBK pots from Eitzum

The following radiographs show evidence that some pots from the oldest *Linearbandkeramik* at Eitzum were manufactured by coiled bases. These coils appear to be arranged in a spiral. The images show different areas where bases were pressed, and where usually cracks developed along the junction of the coils. The settings of the X-ray machine varied according to pottery base, so these specifications are given in the captions of figures. The number of bases from Eitzum for this technique was 37 out of 173 fragments measured for EVEs. In this appendix, I present the four bases that showed the clearest signs of being coiled.

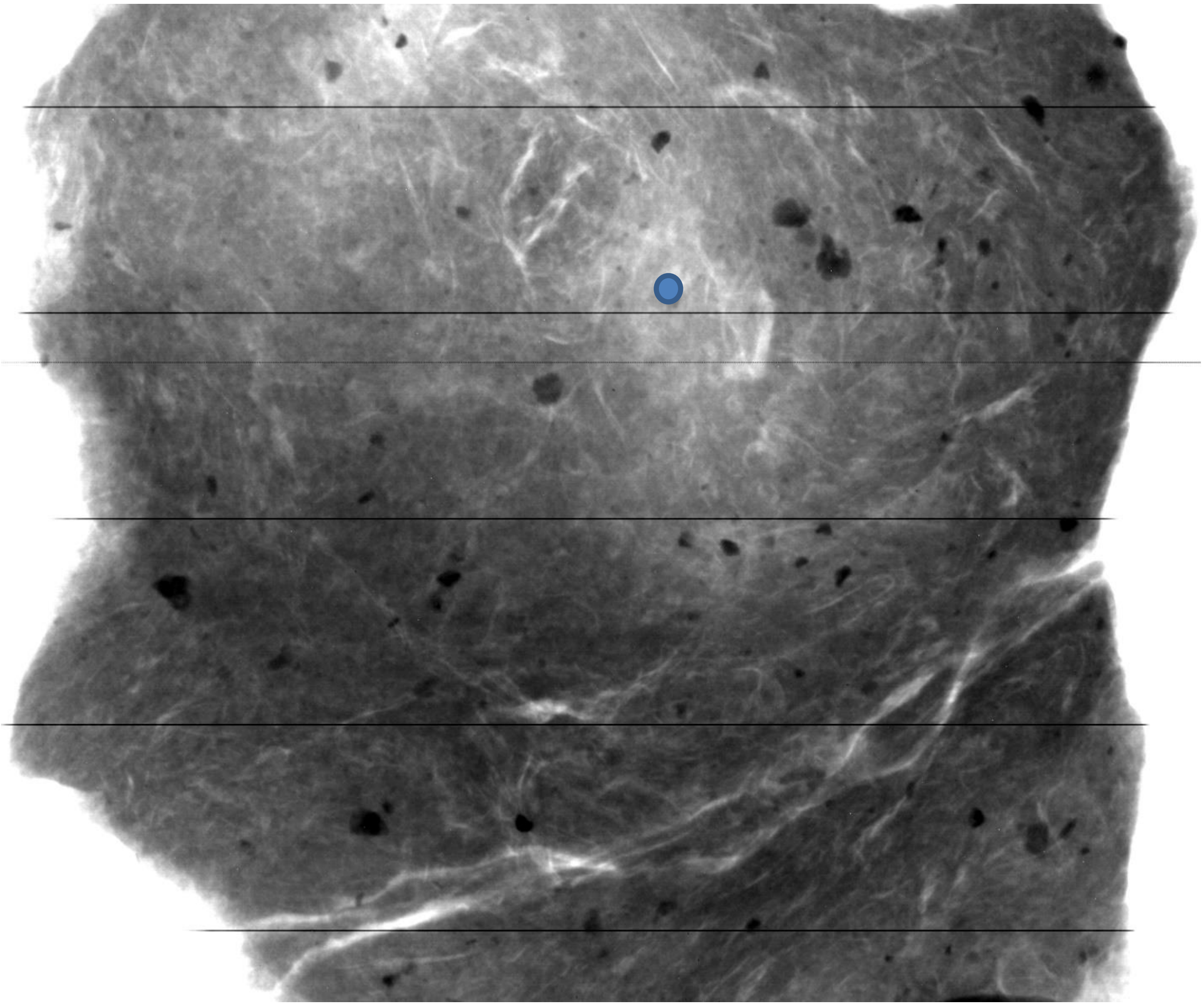

Figure A2.4: Base fragment 7185 found at WLH1, zone A (radiograph settings: 50kV and 100A). Blue dot is approximately at the centre of the base.

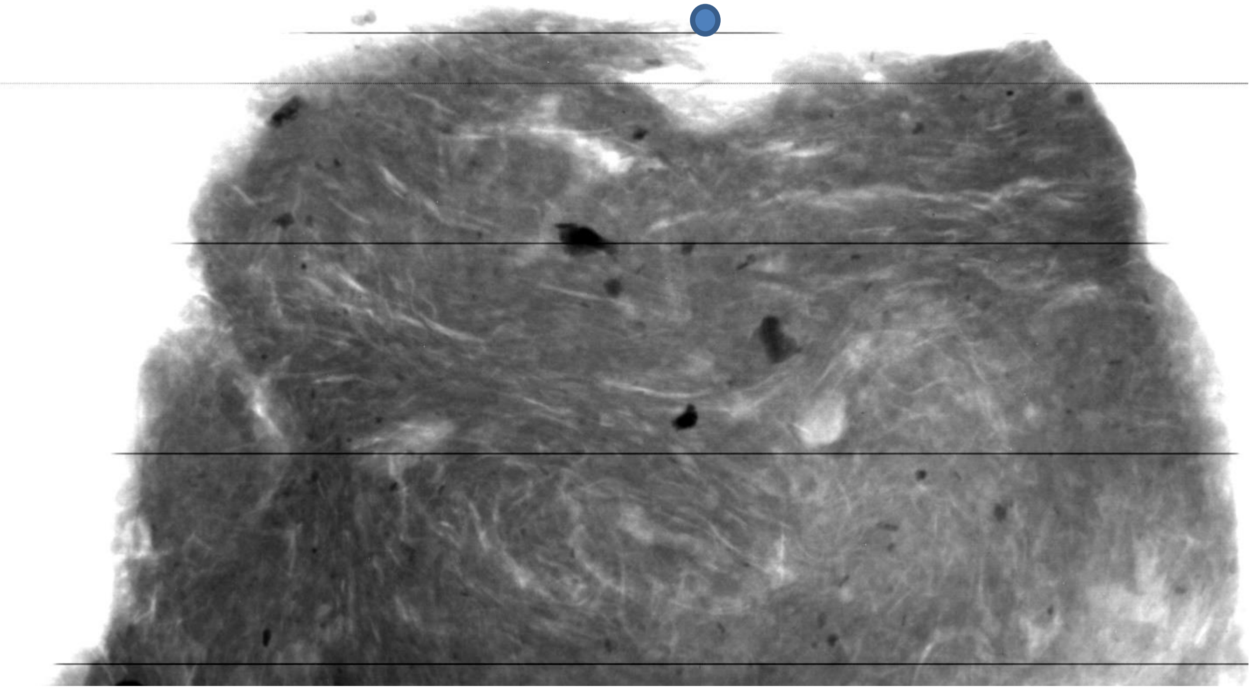

Figure A5.2: Base fragment 7920 found at WLH1, zone A (radiograph setting: 50kV and 100A). Notice how pores and cracks (bright areas) are horizontally oriented following coils. Blue dot is approximately at the centre of the base.

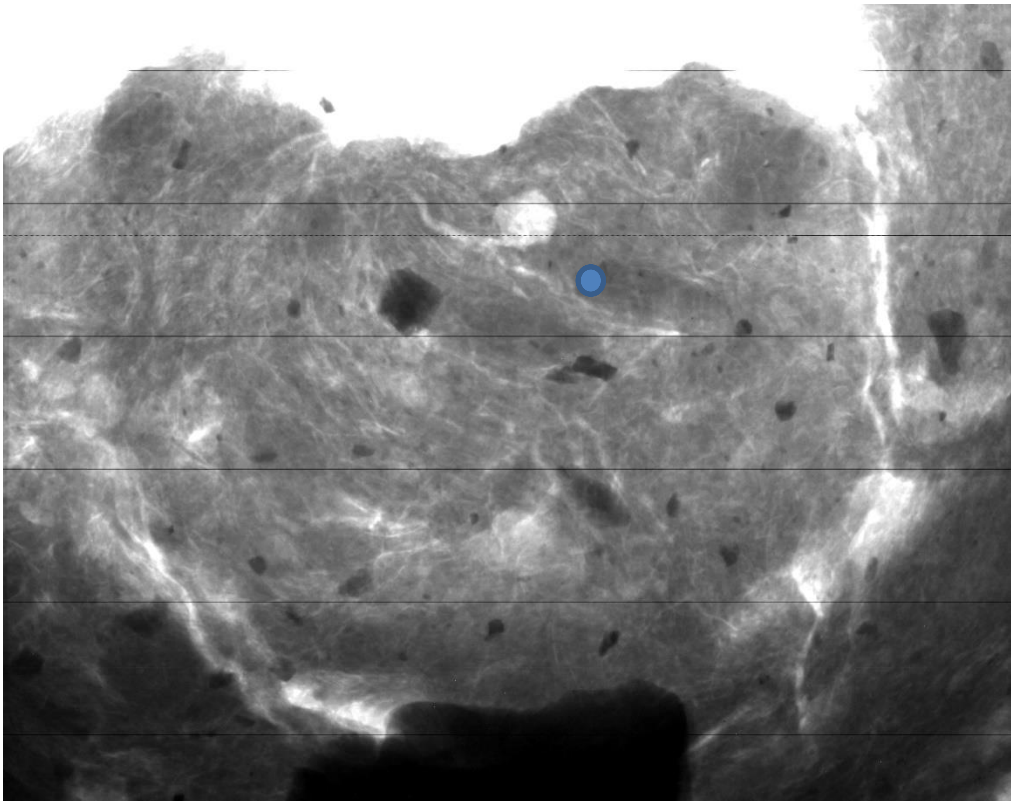

Figure A2.6: Base fragment 9294 found at WLH1, zone A (radiograph settings: 55kV and 100A). Blue dot is approximately at the centre of the base.

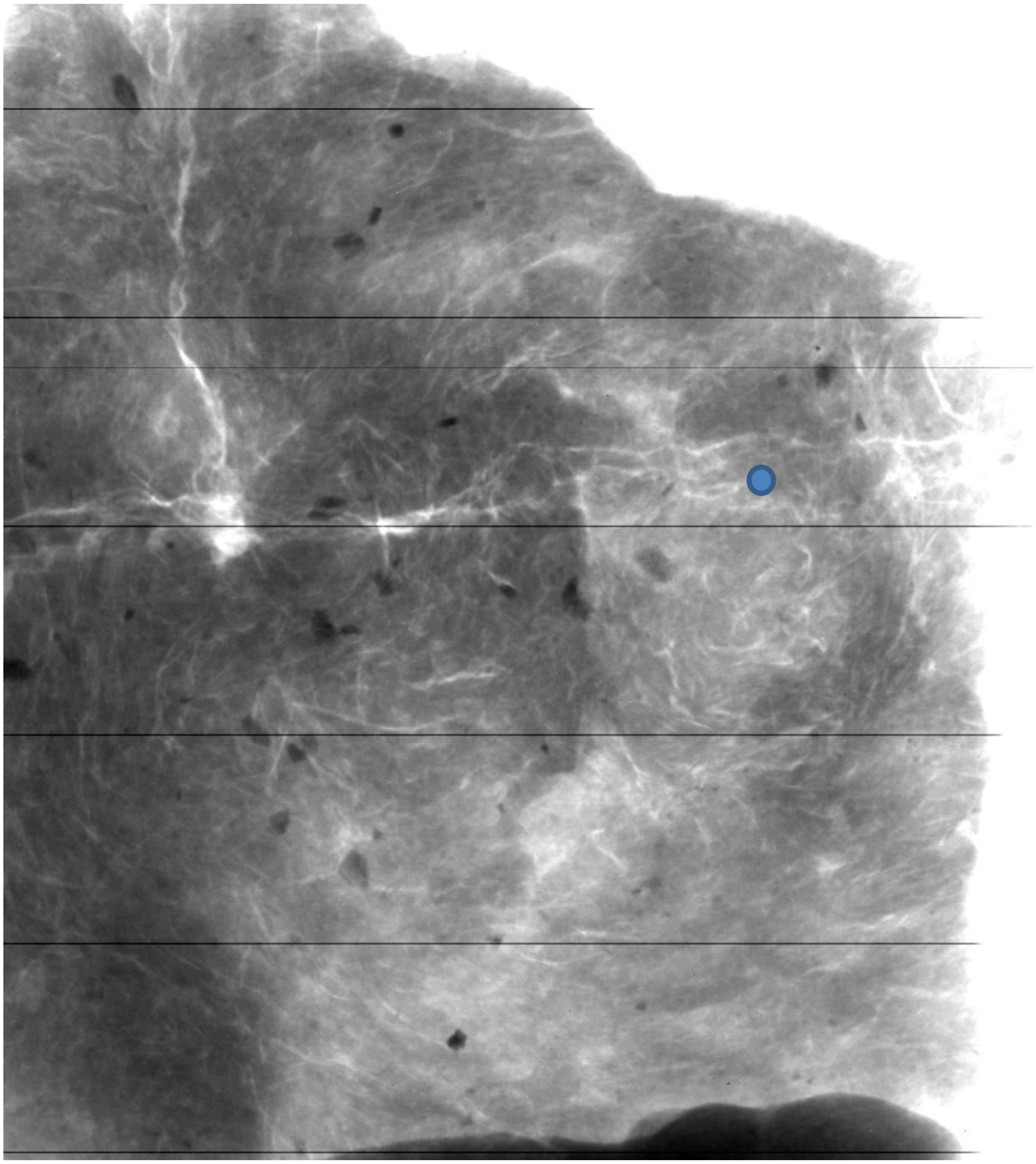

Figure A2.7: Base fragment 6183 found at feature 10, zone D (radiograph settings: 55kV and 100A). Blue dot is approximately at the centre of the base.

Appendix 3. History of excavations and finds processing at sampled sites

A3.1 Tăşnad Sere

Following its discovery when the Cehal channel was built, Tăşnad Sere has been excavated in different campaigns for the last 30 years. Neța Iercoşan (Satu Mare Museum) began excavations began in 1989 (1994; 1996; 1997; 1999), and they were continued during the second half of the 1990s. During 2001 and 2002, a hotel development in the area encouraged new excavations (Németi, Astaloș and Gál 2002; Németi *et al.* 2003), which continued from 2004-2009 (Astaloș 2005; Virag 2005; 2015b; Virag *et al.* 2007). Excavations were performed according to feature, such as: pits, ovens, post-holed houses, and graves. These units were labelled as contexts/complexes and numbered sequentially according to their excavation year. However, stratigraphic information of finds was often not recorded or the labels containing this information was lost, which created problems in the understanding of deposit formation (as stressed by Sommer and Astaloș 2015, 82).

Excavations in the 1990s and between years 2004-2006 focused on the first bank of the now channelled Cehal and uncovered mainly Neolithic finds, which included trenches Su. II/2005, Su. III/2005 and Su. IV/2005. In 2009, one trench (Su. X/2009) was opened on this first terrace, and another three (Su. XI/2009, Su. XII/2009 and Su. XIII/2009) on the second terrace further to the west (Virag 2015b). While several semi-subterranean houses have been excavated throughout these years, most noticeable are the three houses with postholes found in Su. X/2009 on the western bank of the Cehal, *i.e*. features 100/2009, 101/2009 and 110/2009 (Figure 5.2). The latter was interpreted as a weaving hut, as suggested by the large amount of loom weights retrieved (Astaloș *et al.* 2013, 48). In trenches Su. XI/2009, Su. XII/2009 and Su. XIII/2009 mostly post-SKC finds were retrieved. Thus, a pattern emerged from these excavations. Neolithic SKC settlements mostly occupied the eastern portions of the site, right off the western margin of the modern Cehal channel, while Middle Neolithic and post-Neolithic materials were confined to the western end of the site.

From 2012, due to further threats from the erosion of the Cehal river and trampling of cows grazing in the area, a collaborative project began between the Satu Mare Museum and University College London (UCL), and excavations took a different turn in terms of techniques and methods of material recovery (Astaloș *et al.* 2013; Sommer and Astaloș 2015; Sommer *et al.* 2019). Due to the well-preserved occupation layer at the site, the major aims of this project were to identify Early Neolithic activity areas and understand (post)depositional processes at the site. Following the observed pattern of occupations at the site (particularly in reference to the 2009 excavations) and after a series of six testpits, a 10x10m trench labelled UCL Trench 1 (UCLT1 from now on) was set out on the eastern bank of the Cehal River opposite from trench Su. X/2009 (Figure 5.2). UCLT1 was subdivided in 1x1m squares and excavated in 5cm spits. For each spit, detailed 3D recording of features and finds larger than one centimetre was carried out by coupling photogrammetry, planning and total station information. In addition, the orientation and inclination of finds was registered to understand post-depositional processes. Soil samples were taken from every square and spit for geochemical and magnetic analysis, as well as for botanical and microbiological studies. In addition, micromorphology blocks are also sampled from key features. Bulk soil samples and micromorphology blocks were mostly extracted to unveil the depositional processes at the site. Ten litre botanical samples were retrieved for taxonomic identification of seeds for every spit and square (Sommer and Astaloș 2015, 85), and processed by systematic bucket floatation (heavy fraction = 1mm mesh). Bucket floatation also allows to retrieve microrefuse. Lastly, microbiological studies of enzyme activity in soils were performed with the purpose of understanding the organic refuse at the site and identifying potential activity areas by Elena Chernysheva (Sommer *et al.* 2019, 5).

Finds from the 1990s and early 2000s excavations were often washed with plastic cleaning brushes, sorted into vessel units, refitted, and a selection of these vessels recorded according to their shapes, decoration and fabric composition. Some of the SKC material from context 216 (Trench Su. XIII/2009) has been published (Virag 2015b), but most of the material excavated during these times remains unprocessed. The washing and refitting performed on sherds from the first excavations of the site hindered but did not impede use-wear analysis, as many of the traces left by brushes could be identified and not all material had been washed at the time of my analysis. Due to the limited stratigraphic and spatial information of finds, distributional analyses were not possible.

In contrast, in the 2012-2017 excavations finds were washed carefully by hand and only minimally using sponges, no refitting of sherds was performed, and every find was bagged with its own label, containing their 3D spatial reference number. In this sense, the assemblage is ideal to understand the role of potsherds in Neolithic populations, and particularly how fragments become deposited in different contexts. In a few occasions, labels have become destroyed and some finds have repeated numbers, but in most of these situations the square and spit numbers are available to provide some spatial reference.

A3.2 Călinești-Oaș-Dâmbul Sfintei Mării

After a series of preliminary surveys in which pottery sherds were recovered, excavations at Călinești-Oaș-D.S.M. were conducted between 1999 and 2001 (Németi and Astaloș 2001). Several trenches were opened (Figure 5.7), and once archaeological features were encountered, they were subdivided into smaller grid units, which varied in size. Features were then excavated in artificial 20-30cm deep spits, leaving baulks for section drawings. The stratigraphy consisted of: (i) a layer of ploughed topsoil down to a depth of around 0.30m directly over (ii) the archaeologically rich dark clay substrate from the pit features, and lastly (iii) a yellowish silty sterile layer found below these features. The topsoil of the site has been affected by ploughing, which can be clearly observed from the surface material recovered from the site.

A first trench, S3, was opened in 1999, which uncovered part of a pit complex (labelled here as CC2) containing a large number of potsherds. Trench Sp.1/2000 was opened the following year to excavate the rest of this pit. The Sp.1/2000 8x8m trench was divided into 4x4m squares, leaving two baulks from W-E and N-S (Figure 5.7 and 5.9). In the same year, a 40m long and 1.5m wide trench (S1/2000) cut pit CC1 from west to east, and researchers subdivided the trench into smaller 1x1.5m units. In 2001, a last campaign was organized in the southern portion of the site, and four trenches were opened: S1/2001, S2/2001, S3/2001, and Sp.1/2001. Trenches S1/2001, S2/2001, and Sp.1/2001 uncovered two archaeological pits: CC3 and CC4.

Processing of ceramic finds was only carried out for pit CC2, and this included: washing with brushes, refitting and reconstructing vessels for morphological analysis. The processing methods hampered use-wear analysis, but due to the relatively small number of vessels reconstructed this did not affect morphometric/archaeometric analysis of potsherds. Lastly, while most spatial information of potsherds from feature CC2 was well recorded, some of the ceramic material was mixed during transportation to the Satu Mare Museum; thus, some of the spatial information of these finds was lost.

A3.3 Méhtelek-Nádas

In 1970, the Szamos/Someș River overflowed the embankment near the Hungarian-Romanian border, and flooded the Szatmárnémeti and Szamosköz regions in Hungary (Kalicz 2011, 14; Makkay 2007, 199). As the waters finally drained, in 1971 an embankment was designed about 200-300m south of the village of Méhtelek. The site of Méhtelek-Nádas was discovered during building operations (Makkay 2007, 199). First surface surveys were conducted in 1972 by János Makkay and Nándor Kalicz (Jósa András Museum), and the following year excavations started at the site in two field seasons.

Methods utilised during fieldwork in 1973 were the same as those described for Călinești-Oaș-D.S.M. and the older excavations of Tășnad Sere. Ten trenches (I-III, and 1-7) were dug, six were excavated a few metres south of the embankment – this includes trenches II and 1-5– and four in the actual embankment –*i.e.* trenches I, III and 6 (Figure 5.11). A total of six pit features were found and excavated. Since there was no subdivision of the features, apart from some anecdotal comment, spatial information about finds is restricted to their feature. Only a few features have section drawings or records. This description is detailed in the next section.

Unfortunately, finds processing methods at this site have limited some parts of my analysis. Pottery sherds were severely brushed, which left little scope for the study of use-wear traces. Nonetheless, some use-wear information was retrieved from the exceptionally rich assemblage of perforated fragments through microphotogrammetric techniques. Since several vessels were reconstructed from sherds, the archaeometric and morhpometric analysis of finds was impaired. Furthermore, stratigraphic information of finds appeared to have been misplaced or the labels mixed, as only a few inventoried finds still have this information. Despite these caveats, all the fragments from pit III were inventoried and allowed at least an archaeometric/morphometric assessment of this feature as a whole. Furthermore, the rich assemblage of perforated fragments in pits 1-3α and pit III, provided a unique record from which to study the repair of pottery vessels during Early Neolithic times (see description below; Chapter 8).

A3.4 Eitzum

The first excavations at Eitzum occurred in three annual field seasons from 1956 to 1958, the last of these being the largest and most prolific in terms of the amount of material retrieved. Three zones were excavated: A, B and C[1] (Figure 5.14). Excavations were performed in long trenches between 10-15m long. Features were excavated leaving baulks at intervals for section drawings. The finds between the baulks were kept separate. Two houses with longpits (labelled here as H1/1956-58 and H2/1957-58) and several rows of postholes were originally interpreted by Franz Niquet in zones A and B. Unfortunately, some of these longpits and postholes were dissected by drainage work (Figure 5.15, 5.16, and 5.17; Table 5.3), which was also observed in later excavations.

In 1987, a four-week excavation was performed by Jens Lüning (University Frankfurt) as part of the DFG funded project "*Ausgrabungen zum Beginn des Neolithikums in Mitteleuropa I*" in the area just 15m north of Niquet's zone B, which is designated here as zone D (Figure 5.15 and 5.19). While field methods were mostly similar to Niquet's, there were some crucial differences, which allowed here a more detailed study on the deposition and distribution of ceramic finds. Firstly, rather than using just profiles, some longpits in Lüning's excavations were segmented with a numerical grid system (Table 5.2), and profiles were drawn in each of the squares. Nonetheless, because of time constraints and in order to ensure a representative sample, only half of these segmented longpits were excavated (Stäuble 1990, 331; 2005, 29). This was accomplished through systematic sampling, *i.e*. selecting every other square in the grid like a chequerboard (Figure 5.19). Secondly, these longpits were excavated in 10cm spits, providing crucial stratigraphical positioning of finds. Thirdly, a systematic sampling for analysing phosphorus content in soil was undertaken to

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[1] It is important to note that zone C was not sampled for my analysis, as only a handful of fragments were retrieved from this entire area, and pits were not clearly delineated.

identify depositional episodes (Stäuble 1990, 336–337). Two houses with longitudinal pits and a series of adjacent pits were uncovered in the 1987 trench: H4/1987 and H5/1987.

With respects to the processing and analysis of ceramic finds from Eitzum, material from the 1950s excavation was washed with brushes, labelled and grouped into vessel units. Only some vessels were glued together. The labelling system developed by Schwarz-Mackensen (1985) for the morphological-stylistical analysis of the vessels diverged from the original labels given by Niquet. While this method provided a reliable record of the morphology and stylistic attributes of LBK vessels, it did cause some problems which I will describe below. Ceramic fragments from the 1987 excavations were also grouped and if possible refitted to form vessels. However, in this case refitting was fuelled by taphonomic interests, namely, to determine how pottery sherds were deposited into pits. Also, contrary to previous finds processing methods, the labelling system did not diverge from the one used in the excavation, which meant that spatial information was not lost.

In my analysis of the potsherds from Eitzum, some problems were encountered partly because of finds processing methods. Even just 30 years after of Niquet's excavations, Schwarz-Mackensen (1985, 39) alerts us of the loss of spatial information on ceramic finds. In my case this was no different. On occasions boxes with finds were found with several labels or with contradicting information between Niquet's labels and Schwarz-Mackensen's codes, which complicated the interpretation of the finds' contexts. In terms of the stratigraphic positioning of finds, information was often confined to two different layers: an upper layer, composed of the topsoil and the B-Horizon, and a lower layer, consisting of the pit features themselves. However, in some features, such as WLH1, this information was completely lost. Other limitations encountered included: the effects of washing fragments with brushes, which complicated the interpretation of use-wear, and the consequences of refitting/gluing fragments into vessels, which reduced the sample size for morphometric analysis and on occasions even damaged the edges of some of the fragments.

A3.5 Klein Denkte

The site was originally mapped by J. Volker in 1972 through LBK surface finds (Stäuble 2005, 26; *Fundmeldung* 11.07.1972). As part of the DFG funded project on oldest LBK settlements mentioned above, it was until 1987 that the site was systematically excavated. Excavation methods at Klein Denkte followed the same procedure as the 1987 excavations in Eitzum, with two notable exceptions. First of all, while longpits were segmented in squares, as in the Eitzum excavations, at Klein Denkte all the squares in the grid were excavated and all of the archaeological material retrieved. Secondly, loose finds (LF) were recorded. Five zones were selected at Klein Denkte, but only zone 4 revealed longitudinal pits and potsherds clearly attributable to an äLBK house (Figure 5.20). Finds have also been processed in similar ways to the Eitzum material from the 1987 excavations, with some of the ceramics being refitted and most of the spatial information held intact (see above).

Appendix 4. Preliminary bulk soil sample analysis

This appendix synthesises bulk soil sample information from SKC sites Tășnad Sere and Călinești-Oaș. In the former site two instances of data collection have occurred: (i) in field pH measurements by the excavation team during the 2015-2016 campaigns and (ii) loss on ignition (LOI), pH, and magnetic susceptibility analysis as part of a MSc project by Marina Paraskova (2018), performed at the Institute of Archaeology (IoA) laboratories, Unviersity College London (UCL). All bulk soil samples from Tășnad Sere come from UCLT1. Samples measured in the field were performed using a Hanna HI-98127 portable pH meter, while pH measurements conducted in the laboratory using a HANNA Microcomputer pH Meter HI 99024 (Paraskova 2018, 32). After stirring soil samples in deionised water in a 1:2.5 ratio, sample readings were obtained soaking the pH electrode in this substance for two minutes (*Ibid.*). Magnetic susceptibility values were calculated through five readings of soil in a 10cc container using a MS2 Bartington Magnetic Susceptibility Meter set at 0.1 high sensitivity (Paraskova 2018, 30), these included: two empty sensor readings (A and D), and two readings with sample inside (B and C). Volume magnetic susceptibility (κ) was then calculated by subtracting the average values of the empty sensor readings from those of the samples. Mass magnetic susceptibility (χ) is then provided by dividing volume magnetic susceptibility over sample weight (*Ibid.*). However, I have recalculated these values, due to some mistakes observed in the data from Paraskova. Lastly, for obtaining values on loss on ignition, the fine fraction (<2mm) of soils samples were dried at 105°C and weighed to obtain total sample weight. Afterwards, samples were weighed after firing at 550°C for two hours and 1000°C for one hour to obtain carbon and carbonate content respectively (*Idem.*, 31).

The small number of samples analysed from feature CC1 at Călinești-Oaș are from excavations conducted in the year 2000 and were performed by me at the IoA (UCL). The reader must bear in mind that this analysis is part of an ongoing study of the site and the data provided are purely preliminary. Low frequency mass-specific magnetic susceptibility readings have been obtained so far using the same equipment and procedures as Paraskova (2018).

ID	Square	Spit	Feature	χlf x10^{-8} m^{3}kg^{-1}*	pH (field)	pH (lab)	LOI C%	LOI CaO%	LOI CaO3%
nn1	A1	7	-	-	7.2	-	-	-	-
nn2	A1	9	-	-	7.4	-	-	-	-
nn3	A1	10	-	-	7.3	-	-	-	-
nn4	A1	13	-	-	7.2	-	-	-	-
nn5	A3	12	-	-	6.3	-	-	-	-
nn6	A3	13	-	-	5.7	-	-	-	-
nn7	A3	14	-	-	7.1	-	-	-	-
MS3 I	A3	-	4	25.6569	-	6.3	4.4714	1.6774	2.9919
MS3 II	A3	-	4	18.6695	-	6.3	3.6874	1.7353	3.0953
MS4 I	A3	-	4	19.5558	-	6.3	3.6241	2.3627	4.2144
MS4 II	A3	-	4	16.8592	-	6.3	3.5169	0.0533	0.0952
MS3 III	A3		Natural beneath posthole (Feat. 4)	17.2179	-	6.4	Error	Error	Error
MS4 III	A3		Natural beneath posthole (Feat. 4)	16.5474	-	5.8	3.1766	1.7576	3.1350

nn8	A4	9	-	-	7.2	-	-	-	-
nn9	A4	11	-	-	7.1	-	-	-	-
A4	A4	-	12	17.1583	-	6.2	3.7825	1.6705	2.9797
nn10	A5	9	-	-	7.3	-	-	-	-
nn11	A5	10	-	-	7.2	-	-	-	-
nn12	A8	7	-	-	6.9	-	-	-	-
B0/8	B0	8	7	19.0896	-	6.3	3.7130	1.6306	2.9084
nn13	B1	10	-	-	7.2	-	-	-	-
nn14	B1	13	-	-	7.2	-	-	-	-
nn15	B1	14	-	-	7.3	-	-	-	-
nn16	B1	15	-	-	7.2	-	-	-	-
nn17	B1	16	-	-	7.3	-	-	-	-
nn18	B1	17	-	-	7.2	-	-	-	-
MS1 I	B1	-	5	18.5346	-	6.5	3.2949	1.7382	3.1005
MS1 IIA	B1	-	5	18.8297	-	6.6	3.0538	1.5991	2.8524
MS1 IIB	B1	-	5	18.6296	-	6.4	3.0943	1.7317	3.0888
MS1 III	B1	-	Natural beneath posthole (Feat. 5)	18.7422	-	6.5	3.3480	1.7865	3.1865
MS2 I	B1	-	5	14.6475	-	6.5	3.5211	1.8763	3.3468
MS2 II	B1	-	Natural beneath posthole (Feat. 5)	19.2861	-	6.5	3.6079	1.7274	3.0811
nn19	B2	12	-	-	6.8	-	-	-	-
nn20	B3	9	-	-	7.2	-	-	-	-
nn21	B4	7	-	-	7.3	-	-	-	-
nn22	B4	8	-	-	7.1	-	-	-	-
B4/12-13	B4	12-13	-	20.7860	-	6.2	3.8784	1.9501	3.4784
nn23	B5	8	-	-	7.2	-	-	-	-
B5/10	B5	10	-	21.4552	-	6.1	3.9421	1.5497	2.7642
nn24	B6	7	-	-	7.3	-	-	-	-
nn25	B6	8	-	-	7.3	-	-	-	-
B6/10	B6	10	-	19.2780	-	5.5	3.8131	1.8154	3.2381
nn26	B7	7	-	-	7.5	-	-	-	-
nn27	B7	9	-	-	7.2	-	-	-	-
B7/10	B7	10	-	20.2189	-	6.1	4.1170	1.7043	3.0400
B8/9	B8	9	-	18.1005	-	6.1	3.7959	1.7467	3.1155
C1/15	C1	15	10	19.4851	-	6.2	3.5359	1.6333	2.9133
MS8	C1	-	10	19.5366	-	5.9	Error	Error	Error
MS11	C2	-	11	22.4366	-	5.8	3.7871	1.5818	2.8214
D4/ 13	D4	13	17	17.6675	-	6.6	3.7254	1.6002	2.8542
D4	D4	-	16	19.4017	-	5.9	3.8671	1.7846	3.1832
nn28	ZZ0	5	-	-	7.3	-	-	-	-
nn29	ZZ1	2	-	-	7.6	-	-	-	-

nn30	ZZ1	3	-	-	7.2	-	-	-	-
nn31	ZZ2	3	-	-	6	-	-	-	-
ZZ2/6	ZZ2	6	-	20.6567	-	6.0	3.9228	1.7108	3.0515
ZZ2/7	ZZ2	7	-	19.6531	-	6.8	3.8598	1.7812	3.1772
ZZ2/8	ZZ2	8	-	18.3405	-	6.0	3.8518	1.6805	2.9975
ZZ2/9	ZZ2	9	-	18.1768	-	6.2	3.9517	1.8287	3.2618
ZZ2/10	ZZ2	10	-	18.9279	-	6.1	4.1667	1.7609	3.1409

*Table A4.2: Bulk soil sample data collected in UCLT1 at Tășnad Sere. Feat. = feature, χlf = low-frequency mass-specific magnetic susceptibility. *Recalculated values by Bruno Vindrola-Padrós (data from Paraskova 2018; with permission by Marina Paraskova and Ulrike Sommer).*

ID	Context	Unit	Layer	χlf x10^{-8} m^3kg^{-1}*
1	CC1	m3	Lower Layer	21.96707
2	CC1	m5	Upper Layer	43.12775
3	CC1	m7 (G1)	Sterile	12.3506
4	CC1	near m2	Sterile	15.52718

Table A4.2: Bulk soil sample data currently available from CC1 at Călinești-Oaș. χlf = low-frequency mass-specific magnetic susceptibility.

Appendix 5. Table of equivalence for Eitzum contexts

The following appendix provides detail of the labelled contexts from Eitzum zones A and B. As noted in Chapter 5, in her re-analysis of Niquet's original excavations, Schwarz-Mackensen (1985) relabelled several pit contexts, which are presented in Table A5.1. Also mentioned in Chapter 5, is that after more than 30 years from Schwarz-Mackensen's work, some labels and materials were mixed, which forced me to have to relabel once more some of the features from Eizum zones A and B. These are also presented in Table A3.1. Lastly, profile sections of feature 14 from Eitzum zone B (Table A3.2) were also relabelled by Schwarz-Mackensen (*Idem.*). However, due to my interest in the spatial distribution of potsherds, I have had to compile the information from both authors to retrieve the spatial information of finds from this pit feature. This involved some relabelling on my part as well, and this information is presented in Table A5.2.

Zone	Niquet Features	Schwarz-Mackensen Features	Vindrola-Padrós Features
A	2	2	WLH1
	3	3	
	IIb 22	4	
	IIb 20/ IIb 21	5	5
	IIb 21	6	6
	IIa27A	7	ELH1
	IIa27B	8	
	IIa25	9	9
B	4	13	13
	5	14	14
	6	15	15
	2/Pf.2		2/Pf.2
	2/Pf.5		2/Pf.5
	9	16	16
	15	17	17

Table A5.3: Table of equivalence for features in Eitzum zones A and B according to Niquet (1963), Schwarz-Mackensen (1985), and the present author.

Niquet Profiles	Schwarz-Mackensen Profiles	Vindrola-Padrós		
		Profiles	Segments	Segment No.
A-B	E-F	E-F	E-F to E2-F2	1
C-D		E_2-F_2	E_2-F_2 to J-K	2
O-P	G-H	G-H		
E-F	J-K	J-K	J-K to N-O	3
R-S	L-M	L-M		
G-H	N-O	N-O	N-O to N_2-O_2	4
L-M	P-Q	P-Q		
I-K		N_2-O_2	N_2-O_2 to south End	5

Table A5.4: Table of equivalence of section profiles from feature 14, zone B (Eitzum), according to Niquet (1963), Schwarz-Mackensen (1985), and the present author.

Appendix 6. Lithic perforators used for drilling experiments

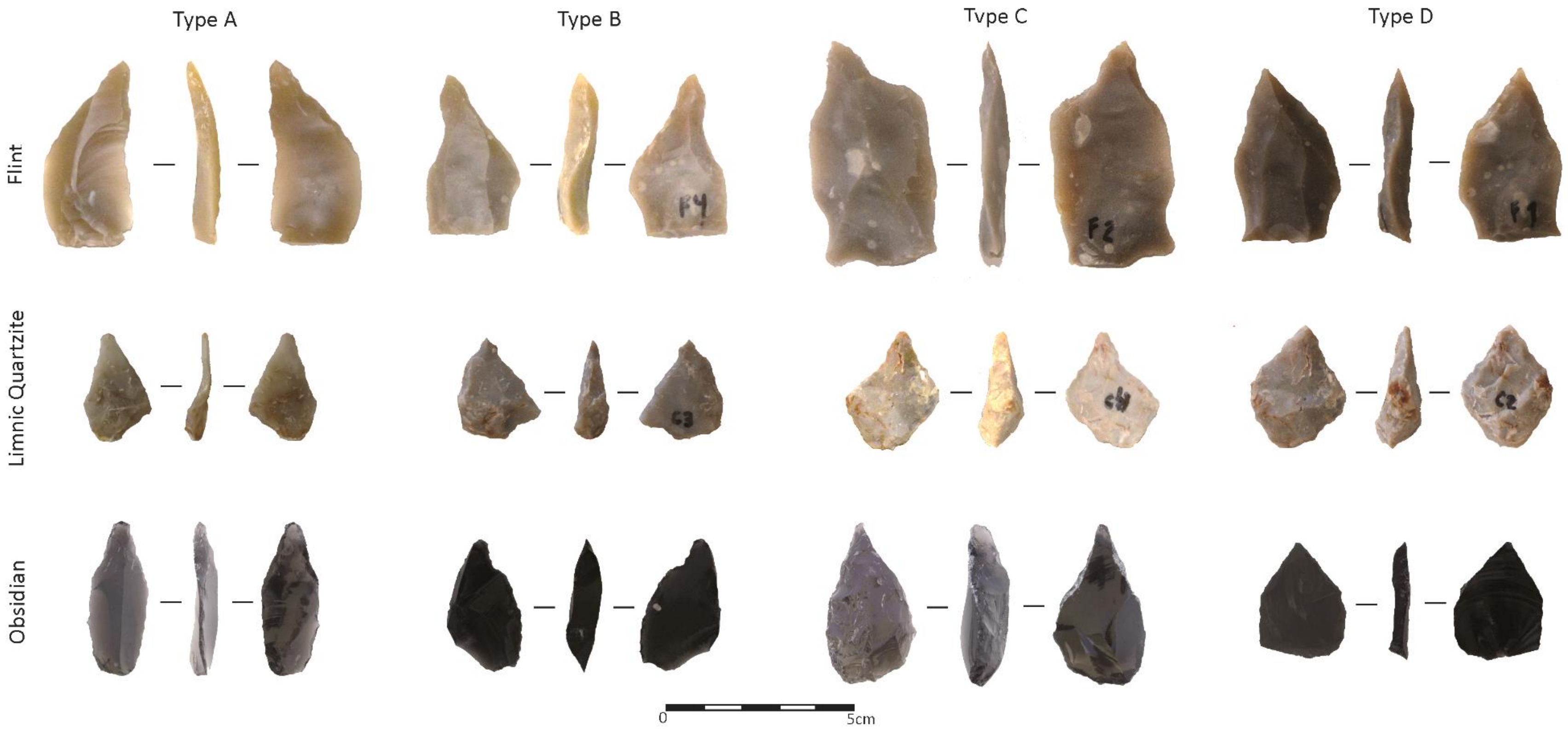


Figure A6.8: Some of the lithic perforators used for drilling experiments.

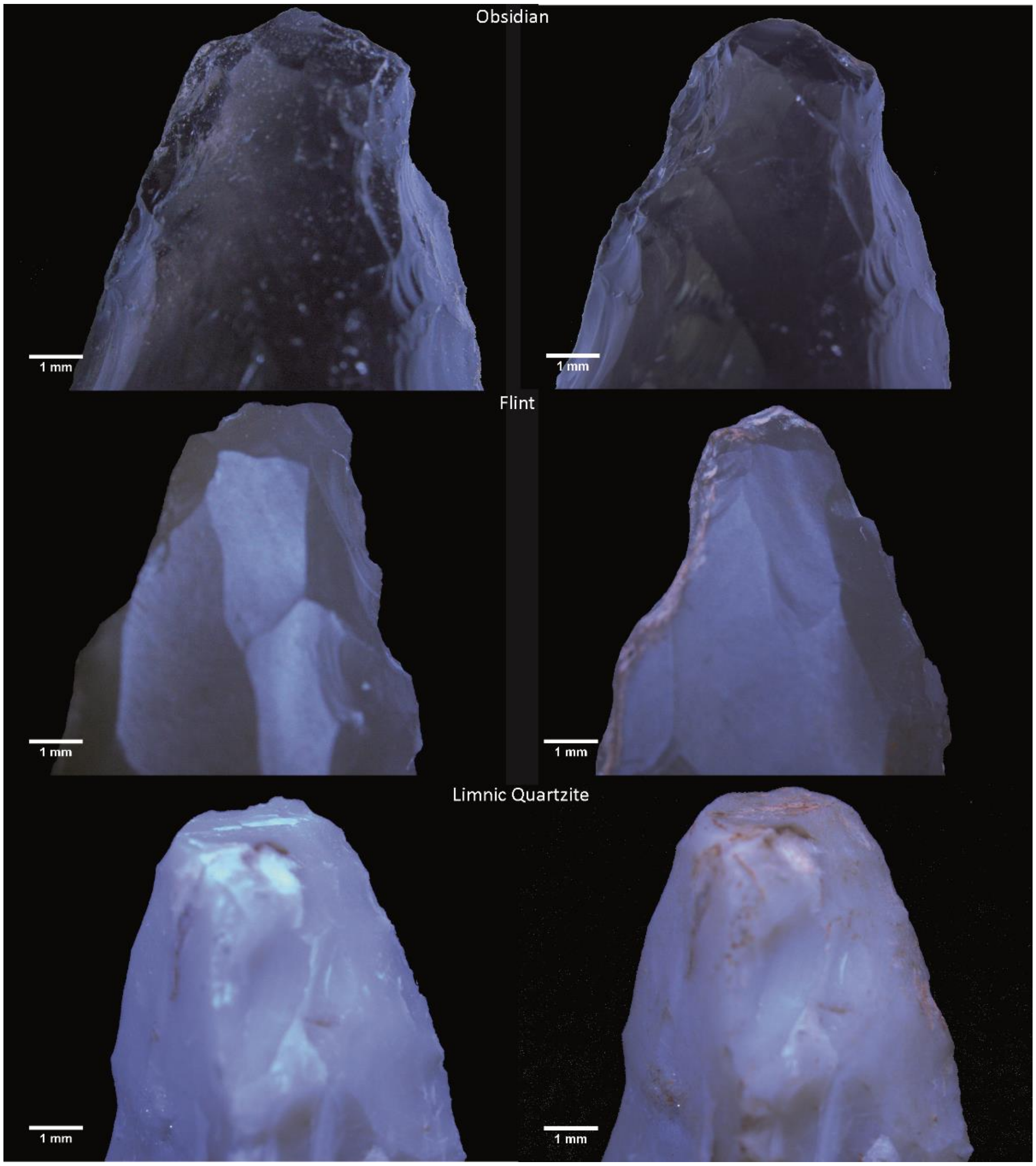


Figure A6.9: Dorsal side of type A lithic perforators' tips before (left) and after (right) use.

Appendix 7. Ceramic disc specimen manufacturing protocol

In this appendix, further detail is given on the clay selection and disc specimen manufacture for thermal shock, three-point-bend and drilling experiments. Please note that for the latter experiments, only untempered pinched specimens were used. Furthermore, detail is also given on how disc shape, size and particle orientation was closely monitored after specimen manufacture through several quantitative parameters detailed below.

1. *Clay extraction and selection*: clays were collected from several outcrops surrounding the Tăşnad Sere town (Satu Mare Province, Romania), and their position recorded with a GPS. Following observations from compositional/provenance studies from *Starčevo-Körös-Criş* ceramics (Kreiter 2010; Kreiter and Szakmány 2011; Kreiter *et al.* 2013; Spataro 2005; 2008; 2014; Szakmány and Starnini 2007; Szilágyi and Szakmány 2007; Taubald and Biró 2007) that suggest the use of local resources for the manufacture of pottery, the purpose was to select a local type of clay suitable for manufacturing experimental samples.

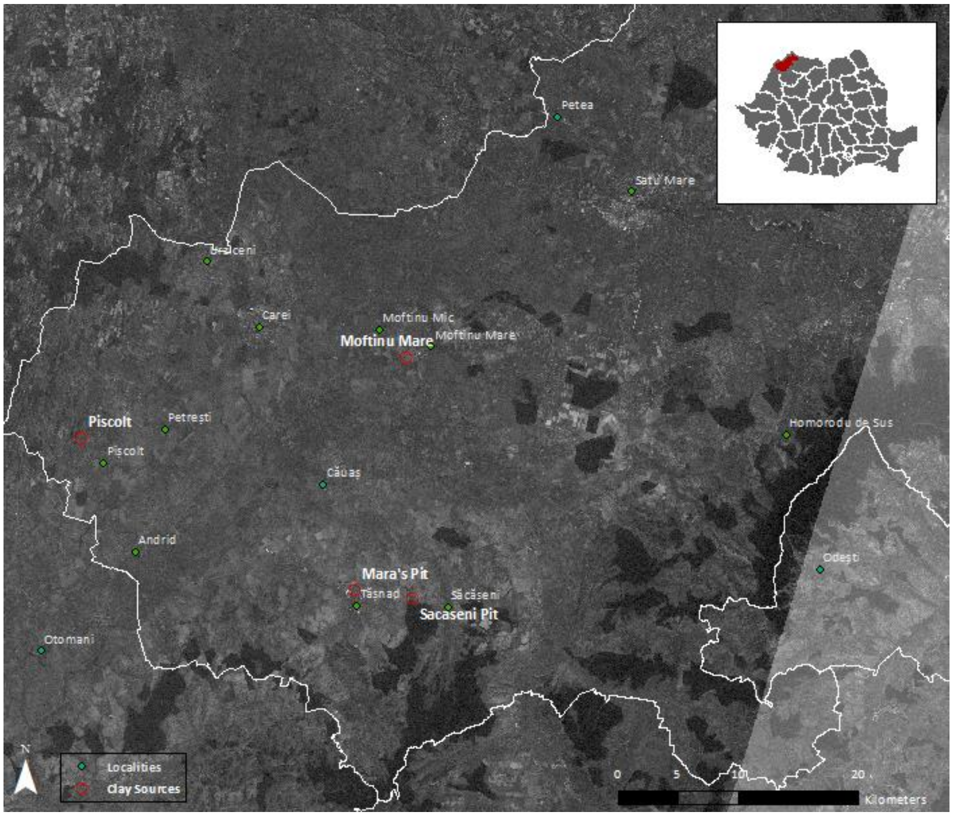


Figure A7.10: Location of clays obtained from Satu Mare province (Romania).

Clays were extracted from: Sacăşeni, Tăşnad Sere town centre (also known here as Mara's Pit), Pişcolt, and Moftinu Mare (see Figure A7.1). The first of these clays was obtained from an outcrop found midway between the town of Tăşnad Sere and Sacăşeni. Mara's Pit was selected as a location based on information by a local inhabitant who stated that these clays had been utilised by her grandmother to manufacture pottery. Mudbricks have been historically made from various tertiary clay sources in this area (Marinescu *et al.* 1967; Sommer *et al.* 2019). The last sources correspond to clays nearby two Neolithic sites (Hágó and Németi 2013; Marta *et al.* 2017).

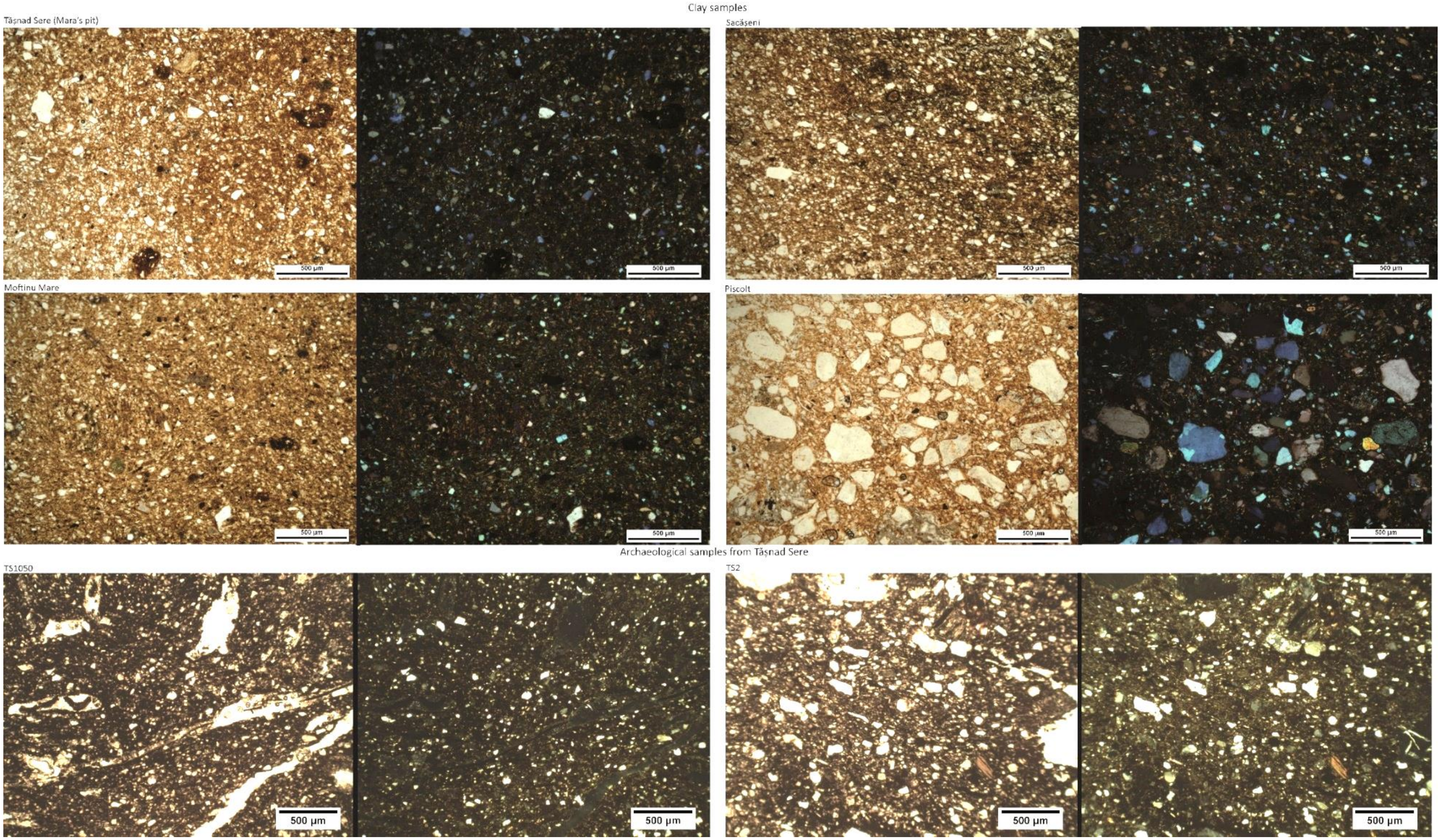


Figure A7.11: Photomicrographs in plain polarised (PPL; left) and cross-polarised light (XP; right) of clay samples from Tăşnad Sere (Mara's Pit), Sacăşeni, Moftinu Mare, and Pişcolt (top), and of Early Neolithic pottery samples (bottom) from Tăşnad Sere (with permission by Ulrike Sommer and Silvia Amicone).

Clay Source	Colour Value	Colour Name
Sacăşeni	7.5 YR 3/4	Strong Brown
Mara’s Pit	7.5 YR 4/6	Dark Brown
Pişcolt	10 YR 4/4	Dark Yellowish Brown
Moftinu Mare	7.5 YR 3/3	Dark Brown

Table A7.5: Colour description of clays sampled. Colour of the clays in wet state was determined according to Munsell Chart values.

Several briquettes were manufactured using these clays to measure the shrinkage rate of the material for pottery production. Because there was a need for fabricating untempered specimens, which would function as a control group, it was also essential to determine the survival rates of these clays without temper. For this reason, the untempered briquettes were then fired at temperatures just reaching over 800⁰C for an hour. The results from this test are shown in Table A7.2. Out of these results, the clays from Mara’s Pit and Pişcolt had the best survival rate and shrank less.

Briquette No.	Clay	Shrinkage (mm)	Breakage/Survival during firing
1	Sacăşeni	8	Broke
2	Sacăşeni	8	Broke
3	Sacăşeni	8	Survived
4	Sacăşeni	9	Survived
5	Sacăşeni	10	Survived
6	Mara’s Pit	7	Survived
7	Mara’s Pit	8	Survived
8	Mara’s Pit	8	Survived
9	Mara’s Pit	11	Survived
10	Mara’s Pit	7	Survived
11	Pişcolt	6	Survived
12	Pişcolt	6	Survived
13	Pişcolt	6	Survived
14	Pişcolt	6	Survived
15	Pişcolt	7	Survived
16	Moftinu Mare	10	Survived
17	Moftinu Mare	11	Survived
18	Moftinu Mare	10	Survived
19	Moftinu Mare	9	Survived
20	Moftinu Mare	10	Survived

Table A7.6: Results from the test on clays.

After firing clay briquettes in the bonfire, petrographic thin sections were manufactured to ensure similar mineralogical composition could be observed with archaeological ceramic samples. Photomicrographs in Figure A7.2 show Sacăşeni, Mara’s Pit and Moftinu Mare are non-calcareous micaceous clays. These clays seem to correspond well with archaeological samples from Tăşnad Sere and other SKC sites from adjacent regions (Figure A7.2). Despite the similarity of inclusion types, *i.e*. quartz, polycrystalline quartz, amphibole, and muscovite, in Pișcolt clays inclusions are mostly silt-sized, which differs from the archaeological samples analysed. Considering the fact that clay pellets are found almost in all SKC pottery samples, which suggest fine cleaning of clays was not performed during Early Neolithic times in this region, this would tentatively rule out Pișcolt clays as a viable option for specimen manufacture. Furthermore, the clays were hard to work with when attempting to manufacture pots.

Based on this brief characterisation of the clays and similarity to SKC pottery samples from Tăşnad Sere, their workability during pottery manufacture and shrinkage and survival rates, as well as the closeness of the clay source to the site, the clays sourced from Mara's Pit located in Tăşnad Sere town centre were selected for disc specimen manufacture.

2. *Clay preparation*: Clays were firstly left to dry at 40^{o}C for 24 hours, ground with pestle and mortar, and then sieved through a mesh (#35) of 500µm (Figure A7.3). The purpose of homogenising the clay size was to avoid any substantial differences in grain sizes, which could potentially become a contributing factor in crack formation and propagation in specimens. Afterwards, clays were weighed in a dry state, and then soaked over night with water.

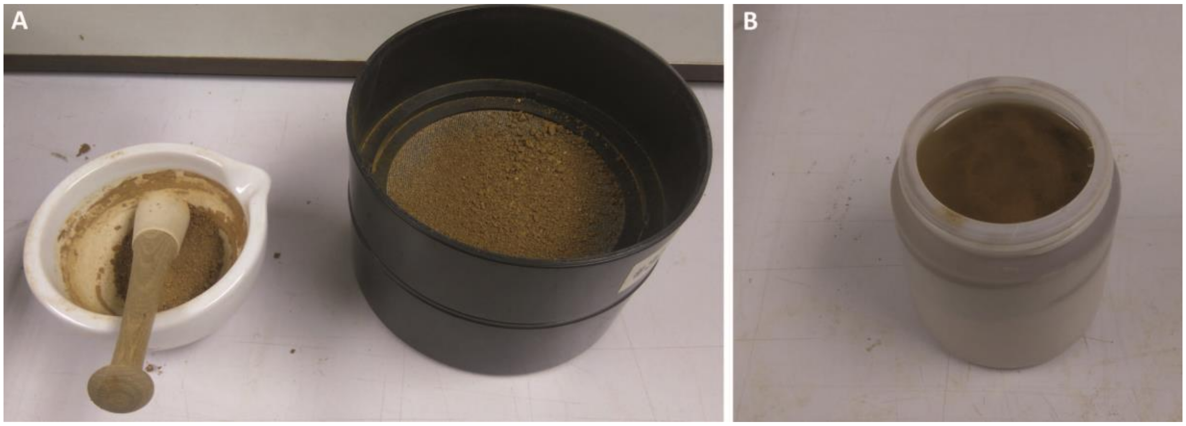


Figure A7.12: Preparation of clays for manufacture of ceramic discs: grinding and sieving of clay (a), and application of moisture to clay (b).

3. *Organic temper selection and preparation*: as already stated, two types of organic temper were added to the tested specimens, *i.e.* chaff and cow dung. The chaff was collected from harvested wheat fields in the Satu Mare province (Romania) during summer of the year 2016. Upon storage, this organic material was firstly ground with pestle and mortar and then sieved through a 2mm mesh. These measurements followed observations from Neolithic potsherds recorded throughout my research project (where the most represented fibre size was between one to two millimetres) and petrographical examinations by Johannes Seidler and Silvia Amicone at the Mineralogy Department, Tübingen University (Seidler and Amicone 2017).

   Dung was obtained from a cow named Shirley located in Kentish Town City Farm during winter. It was specified by the employees of the farm that during this season Shirley was only fed with hay at the time the sampling process took place (Figure A7.4). The cow dung was then dried at 40°C for 48hrs and disaggregated manually before the kneading process.

Figure A7.13: Shirley eating from a sack of hay at Kentish Town City Farm.

4. *Kneading and Manufacture*: as specified in the main text, the proportions for the composition of the specimens were 5g of dry organic temper per 100g of dry clay. Moulds were created in order to standardise the fabrication of the ceramic discs. Following suggestions by Hein *et al.* (2008, 37), the moulds were created by cutting a 60mm wide PVC tube into 10mm thick slices (Figure A7.5b).

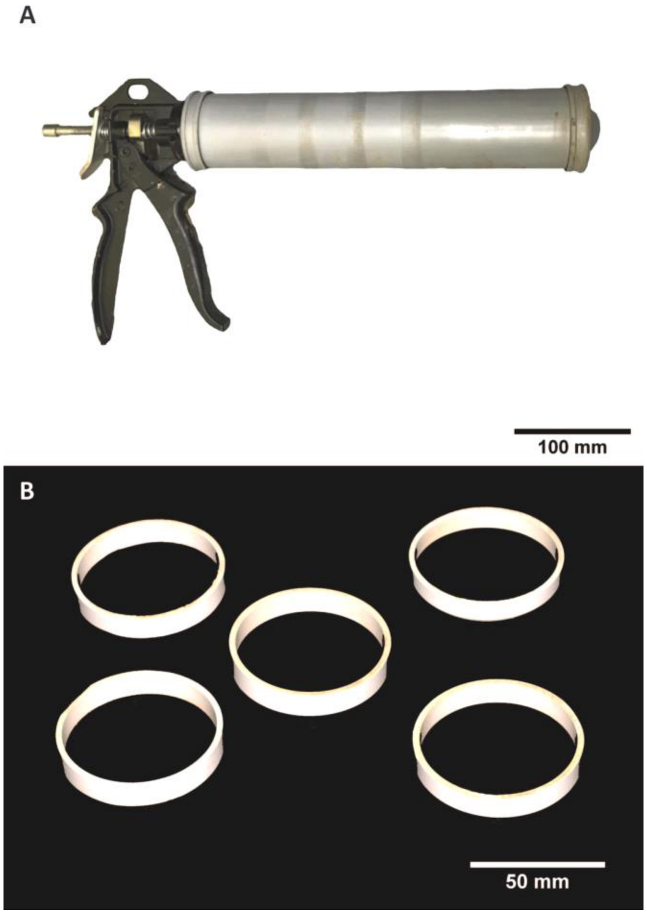


Figure A7.14: Some instruments used during the manufacturing process: (a) the clay extruder and (b) the PVC moulds.

Two manufacturing techniques were used: pressing/pinching and spiralled coiling. For the former, specimens were manufactured by pressing the kneaded clay into the disc moulds (Figure A7.6a). For the latter, coils were firstly produced with a clay extruder possessing a barrel with a 12mm wide opening (Figure A7.5a). The purpose of using the clay extruder was to ensure a standard coil size of 12mm per specimen, and maintain the pressure exerted on the manufacturing of coils consistent. Coils were then positioned from the centre of the mould outwards in a counterclockwise direction (Figure A7.6b), and finally rolled over with a rolling pin to remove any excess clay. While this last procedure left the surface of the discs smooth, X-rays showed that the coiled structure of the specimens was maintained (Figure A7.7, A7.8 and A7.9).

Figure A7.15: Manufacturing of ceramic discs: (a) pressed/pinched specimens, (b) coiled specimens, (c) drying in oven, and (d) firing of specimens in pottery kiln.

5. *Drying and firing*: Specimens were left to dry for the first 24 hours in an oven at 30°C, and then at 110°C for another 24hrs (Figure A7.6c). Afterwards, they were put into a potting kiln at 800°C for one hour and left to slowly cool down for 36hrs (Figure A7.6d).

6. *Monitoring specimen size, shape, and particle orientation*: the size and shape of specimens were monitored in order to ensure samples were standardised (*ergo* not a contributing factor in results of experiments), and that there were clear observable differences between pinched and coiled discs. After preparation, all specimens were photographed to monitor

their variation in size and shape. Through ImageJ/Fiji software, size was measured by ferret diameter of specimens, while shape was monitored with sphericity and circularity parameters as detailed in Chapter 6.

Results of size and shape variation are presented in Table A7.3, which essentially show very low levels of variation (<0.05) among all specimens. These results then ensure that size and shape variation between specimens would not be a contributing factor in results obtained through these experiments.

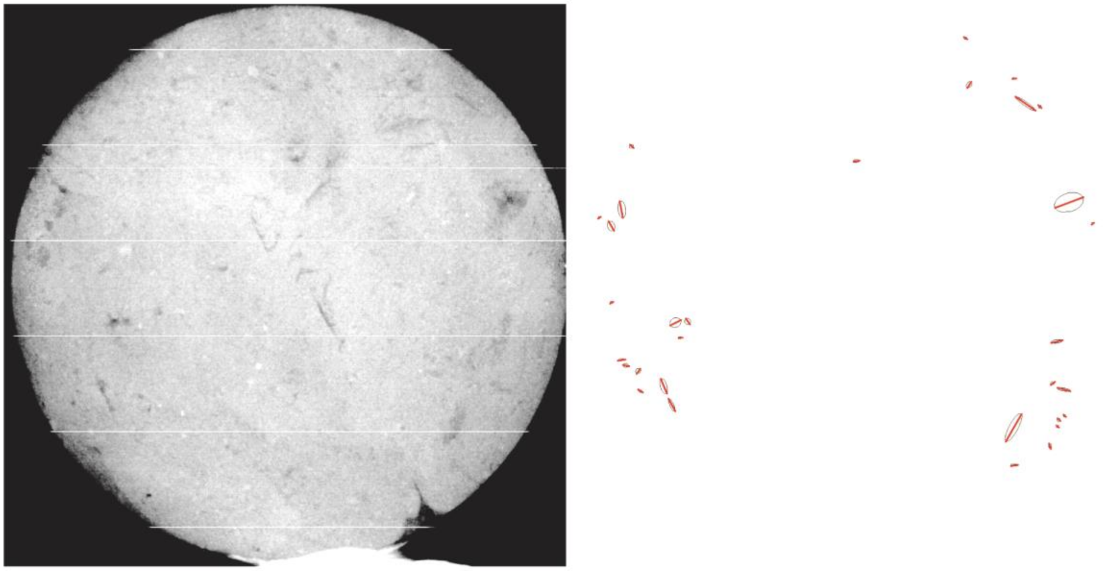
Parameters	Mean	Standard Deviation	Coefficient of Variation
Thickness	9.80	0.46	0.05
Diameter	54.32	0.85	0.02
Circularity	0.81	0.04	0.05
Sphericity	0.97	0.01	0.01

Table A7.7: Measurements of variation according to size and shape of specimens.

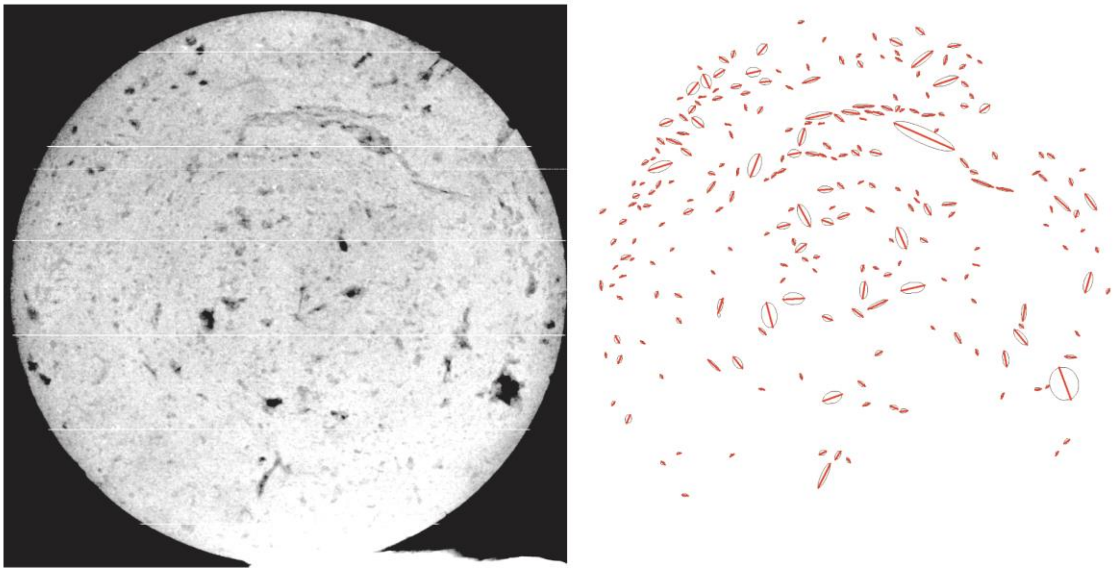
Lastly, the orientation and distribution of pores were also examined before thermal shock experiments to guarantee there were clear observable differences between pinched/pressed and coiled discs, and to monitor crack formation during the process of drying and firing, which could affect the future characterisation of thermally-induced cracks. For these reasons, X-ray radiographs were produced on these specimens before their submission to thermal shock according to specifications given in Chapter 6.

Radiographs were processed in ImageJ/Fiji software in order to segment the region of interest: the voids. The brightness/contrast levels were adjusted to highlight these features, which correspond to less dense areas (represented as darker areas in the radiograph). To assist the segmentation process, image profiles were plotted to obtain the range of HU values representing voids, which varied in accordance to the different composition of the specimens. After the range of values was determined, voids were segmented and turned to binary format using the Threshold tool. Other image processing tools, such as open, close-, and fill holes, were also utilised to clarify and sharpen the boundaries of the pores. Lastly, the best fitting ellipse was calculated for each void with the "Analyze Particles…" function of the software and their long-axis drawn.

Figures A7.6-A7.8 display the different orientations of elongated voids according to manufacturing techniques. In these figures, the images on the left are the original radiographs, while the images on the right are the processed radiographs showing the orientation of voids. As expected, radiographs show the orientation of voids in pinched specimens is random, while voids in coiled specimens follow a clear spiral pattern.

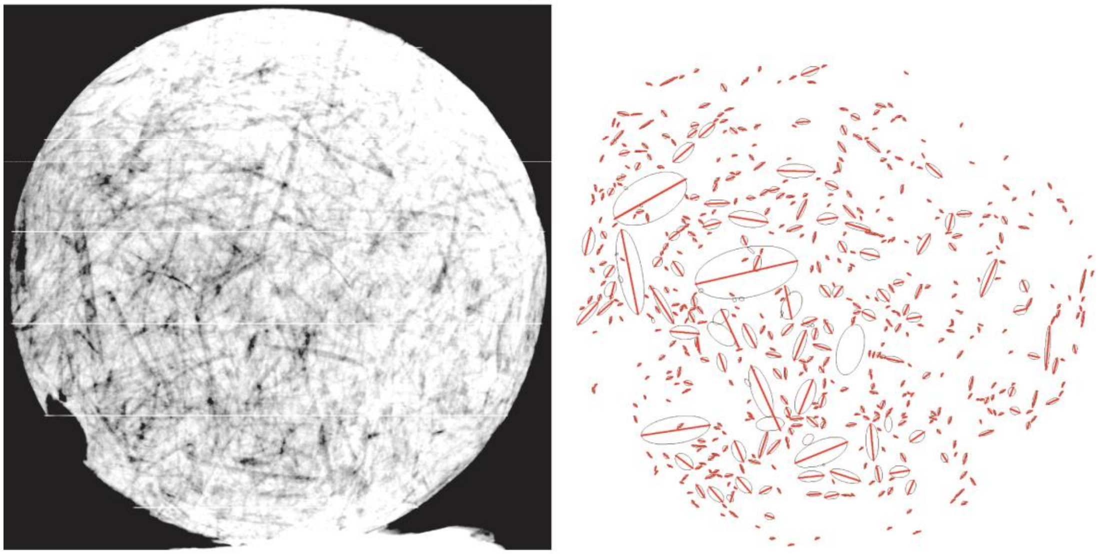


Untermpered Pinched

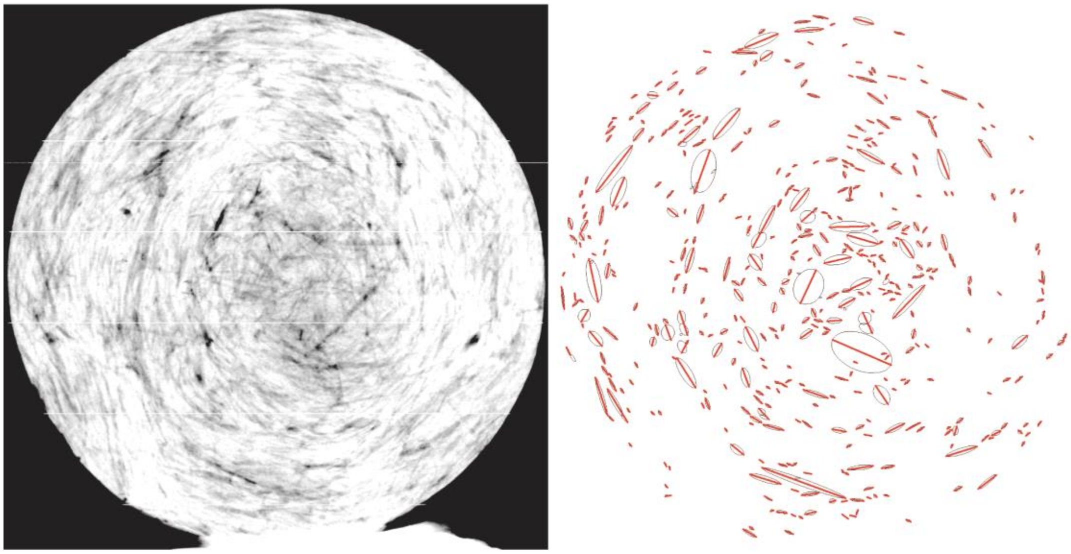


Untempered Coiled

Figure A7.16: X-ray radiographs of untempered experimental discs (left) and processed images showing orientation of fibres (right). Red lines indicate the longest axis of particles and pores.



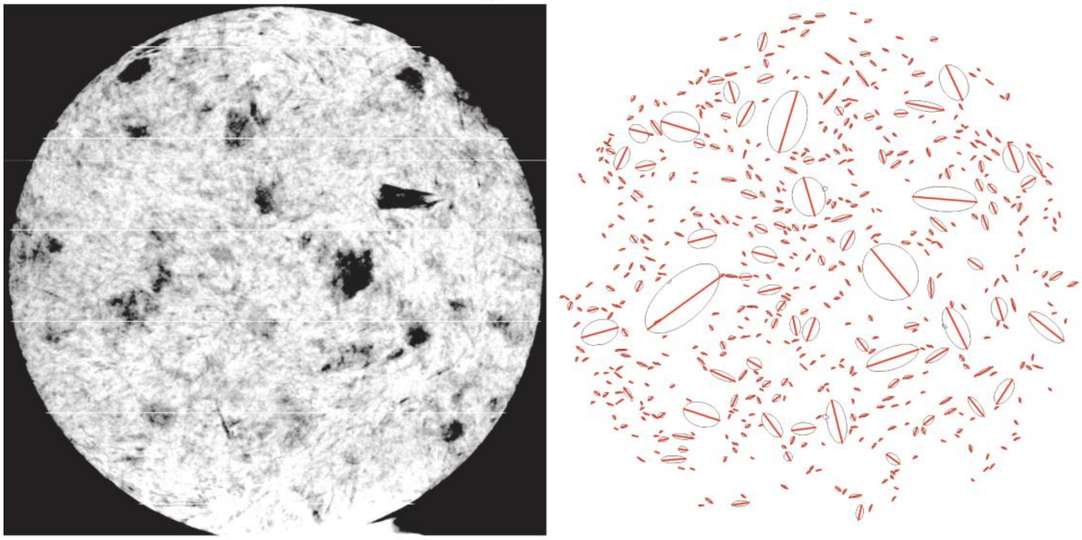
Chaff-tempered Pinched



Chaff-tempered Coiled

Figure A7.17: X-ray radiographs of chaff-tempered experimental discs (left) and processed images showing orientation of fibres (right). Red lines indicate the longest axis of particles and pores.

Dung-tempered Pinched



Dung-tempered Coiled

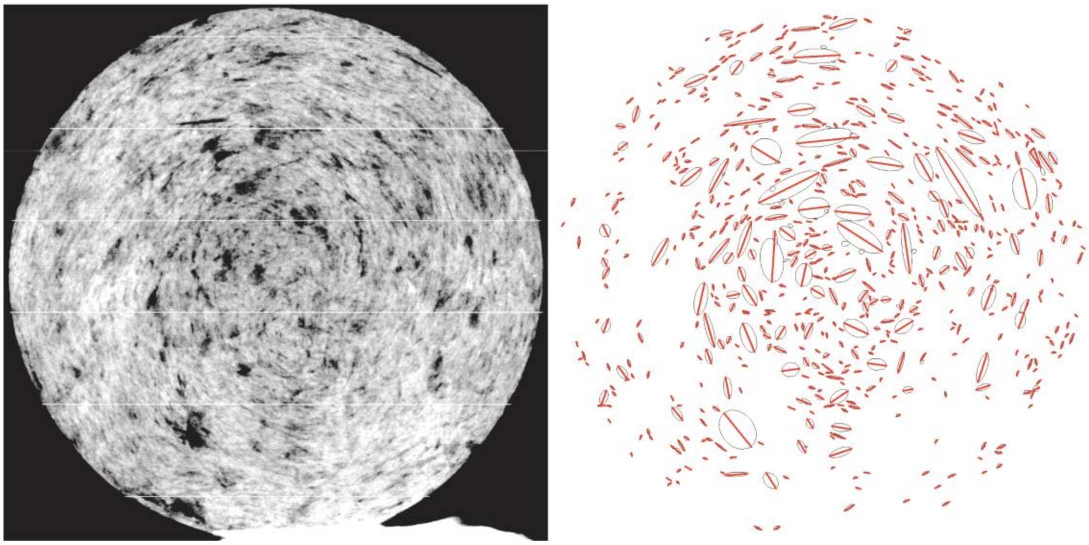


Figure A7.18: X-ray radiographs of dung-tempered experimental discs (left) and processed images showing orientation of fibres (right). Red lines indicate the longest axis of particles and pores.

Sample ID	Test	Forming Technique	Temper Type	Firing Temp. (°C)	Amount (g)	
					Dry Clay	Dry Temper
1	Thermal shock	Pinched	Untempered	800	-	-
22	Thermal shock	Coiled	Untempered	800	-	-
47	Thermal shock	Pinched	Wheat chaff	800	100	5
61	Thermal shock	Coiled	Wheat chaff	800	100	5
70	Thermal shock	Pinched	Cow dung	800	100	5
73	Thermal shock	Coiled	Cow dung	800	100	5
9	Three-point-bend	Pinched	Untempered	800	-	-
11	Three-point-bend	Pinched	Untempered	800	-	-
12	Three-point-bend	Pinched	Untempered	800	-	-
13	Three-point-bend	Coiled	Untempered	800	-	-
16	Three-point-bend	Coiled	Untempered	800	-	-
18	Three-point-bend	Coiled	Untempered	800	-	-
43	Three-point-bend	Pinched	Wheat chaff	800	100	5
51	Three-point-bend	Pinched	Wheat chaff	800	100	5
52	Three-point-bend	Pinched	Wheat chaff	800	100	5
55	Three-point-bend	Coiled	Wheat chaff	800	100	5
58	Three-point-bend	Coiled	Wheat chaff	800	100	5
62	Three-point-bend	Coiled	Wheat chaff	800	100	5
63	Three-point-bend	Pinched	Cow dung	800	100	5
64	Three-point-bend	Pinched	Cow dung	800	100	5
65	Three-point-bend	Pinched	Cow dung	800	100	5
77	Three-point-bend	Coiled	Cow dung	800	100	5
78	Three-point-bend	Coiled	Cow dung	800	100	5
80	Three-point-bend	Coiled	Cow dung	800	100	5

Table A7.8: List of specimens used in thermal shock tests and three-point-bend tests

Appendix 8. Other sherd-size distribution and morphometric information from Early Neolithic sites

This appendix details some extra information on the results presented in Chapter 7, this includes: the relation of sherd composition and sherd-size distributions and morphometrics from context C2/2005 at Tășnad-Sere, the spatial and stratigraphic distribution of potsherds from UCLT1 at Tășnad-Sere, the inconclusive results from sherd-size distribution and morphometric analysis of sherd from pit 1-3α at Méhtelek-Nádas, and lastly the sherd-size distribution and morphometric results of fragments found above pit features from zones A and B at Eitzum.

A8.1 Tasnad Sere

Figures A8.1 and A8.2 synthesise information on the sherd size distribution and morphometric results of fragments sorted by their composition from feature C2/2005 at Tășnad-Sere. Results show there is no perceptible difference of values according to fragment composition, which is why these figures were included in the Appendix section.

To complement information provided in Chapter 7, a next set of values from Tășnad Sere was the distribution of ceramic finds from UCLT1. Figures A8.3 and A8.4 include the sherd-size distributions and morphometric values of fragments from rows 1-8 and columns ZZ-G. The pattern observed was a clear outlining of material accumulation indoors/outdoors, and clarify the depth of the occupation layer, which effectively does not exceed 15cm.

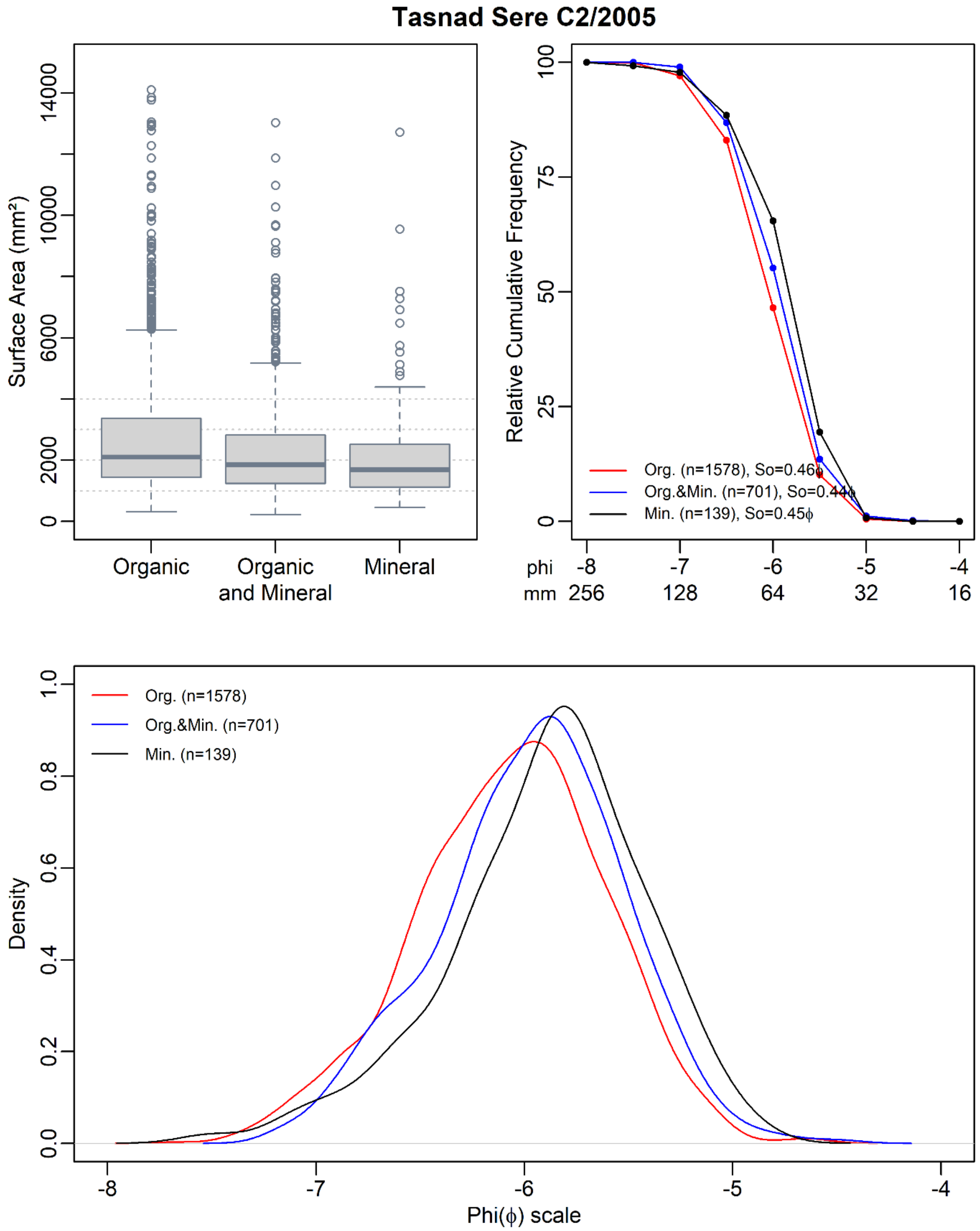


Figure A8.19: Sherd-size distribution of fragments from features at Tășnad Sere according to composition.

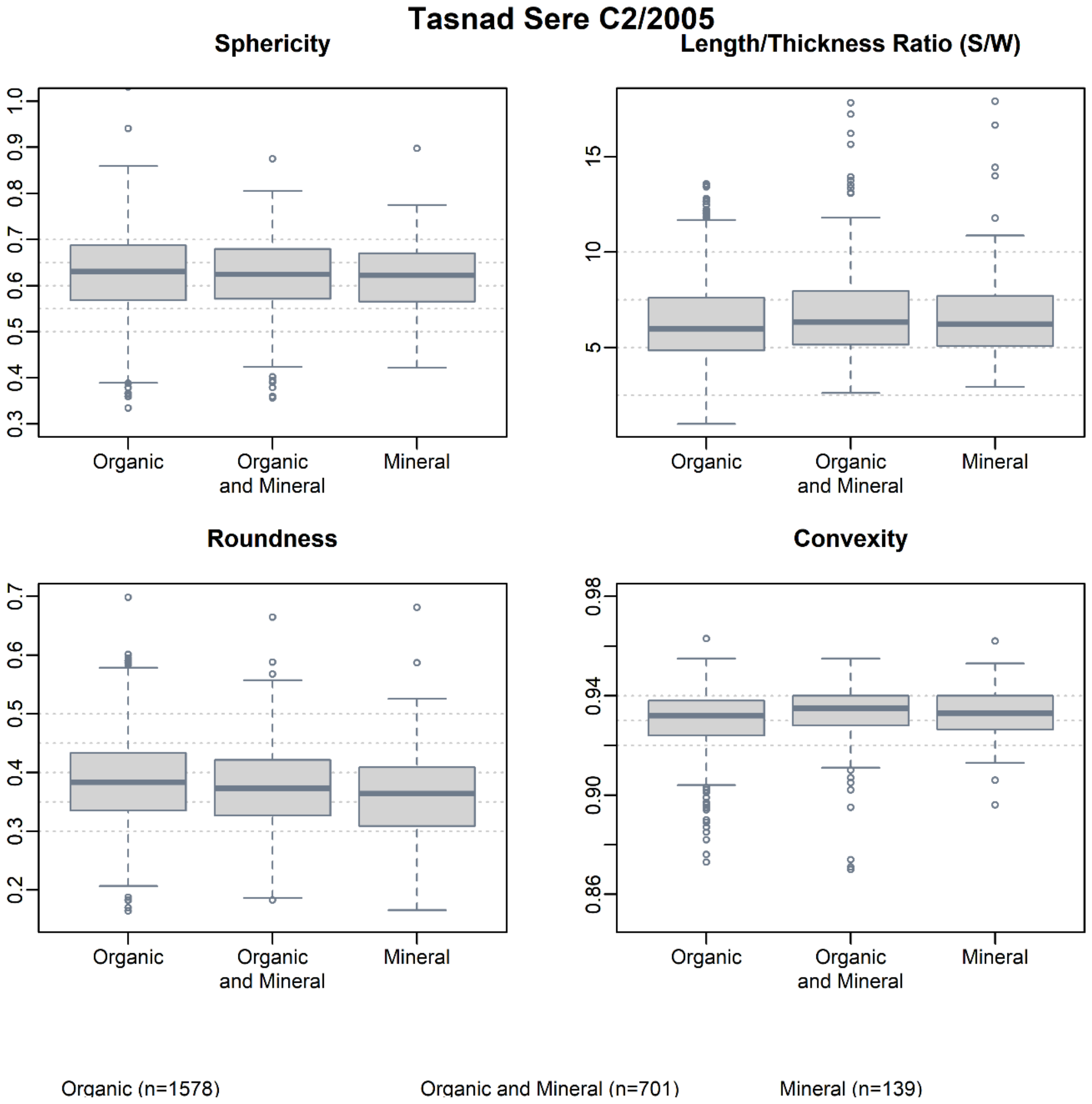


Figure A8.20: Morphometric distribution of fragments from features at Tășnad Sere according to composition.

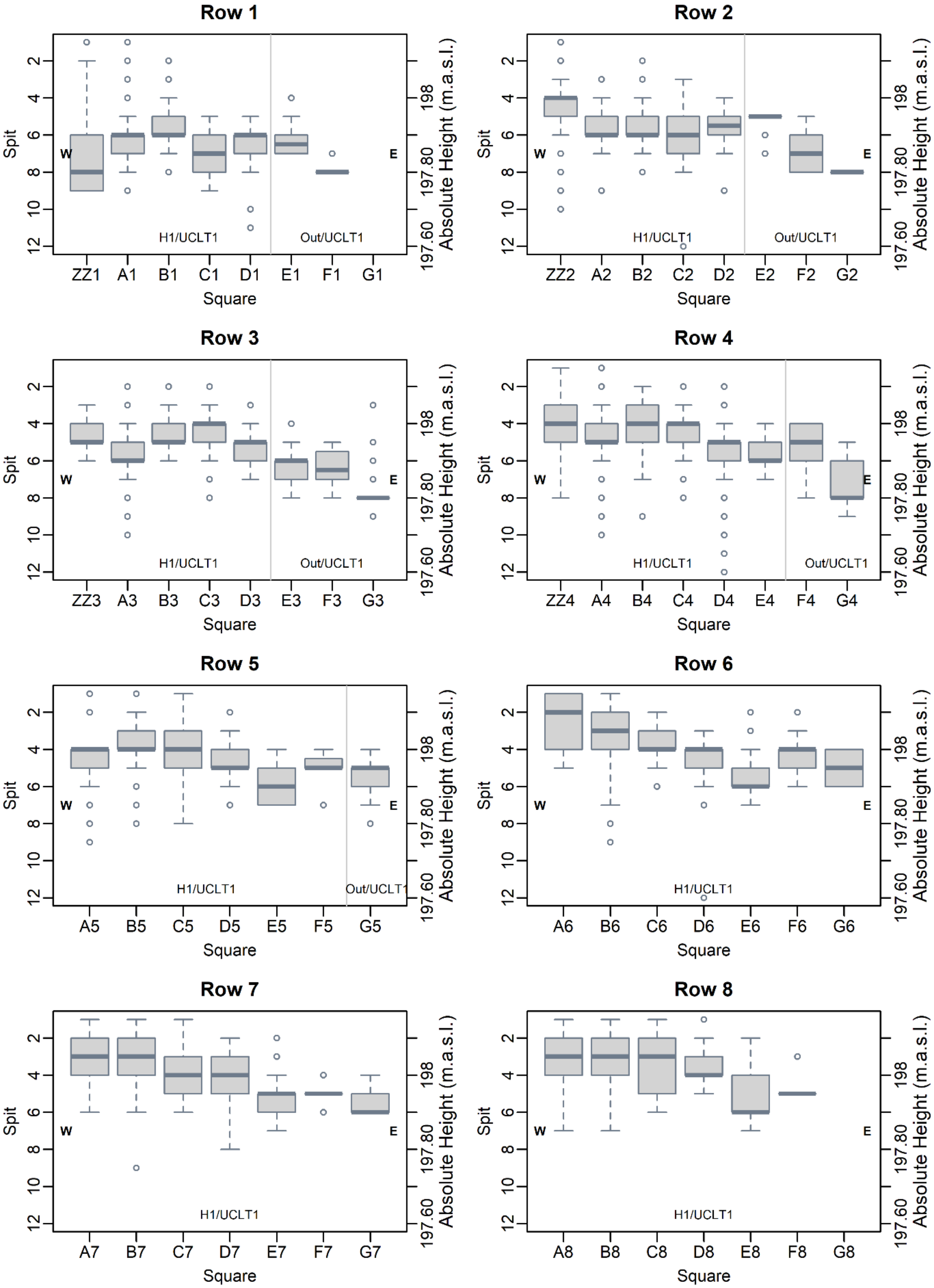


Figure A8.21: Spatial and stratigraphic distribution of fragments from UCLT1 at Tășnad Sere according to rows 1-8.

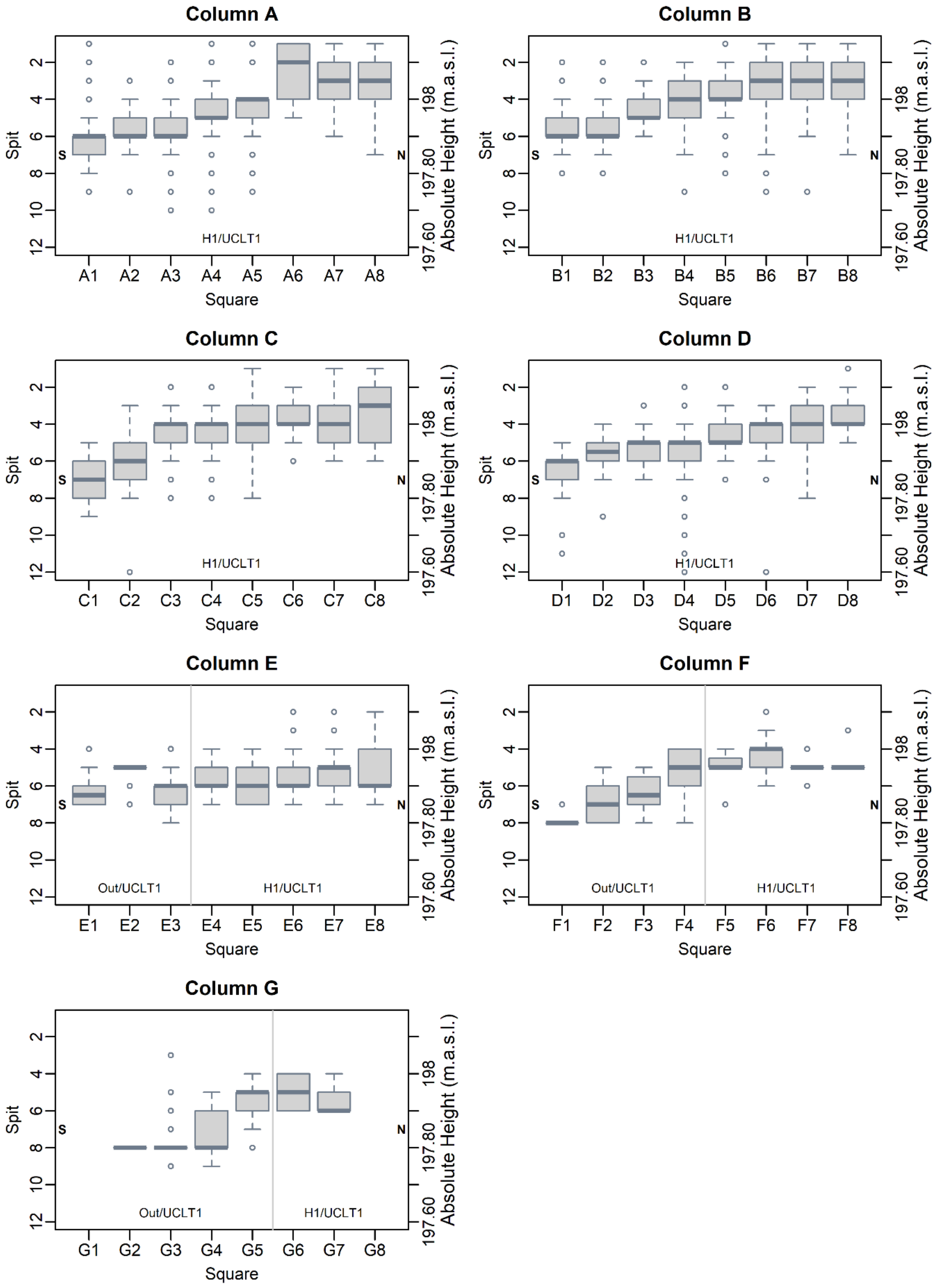


Figure A8.22: Spatial and stratigraphic distribution of fragments from UCLT1 at Tășnad Sere according to columns ZZ-G.

A8.2 Méhtelek-Nádas

A8.2.1 Basic recording of material

Table A8.1 synthesizes the sample size information for the pit features analysed in Méhtelek-Nádas. These total values were estimated from published records (Kalicz 2011). While fragments measured for sherd-size distribution analysis are numerous, the sample size for morphometric analysis is small and warrants caution in the interpretation of the results. Thus, only coarse-grained information can be obtained from the morphometric study of potsherds from these pits.

Feature	Sherd-size Distribution Sample (n1)			Morphometrics Sample (n2)			Total Number**
	Weight	Fragment No.	Percent*	Weight	Fragment No.	Percent*	
Pit III	16971	489	84.3	3011	110	18.96	580
Pit 1-3	54360	1223	60.54	8239	235	11.63	2020

*Table A8.9: Sample size information from Méhtelek-Nádas. *Percentages are calculated according to number of fragments. **Numbers obtained from Kalicz (2011).*

A large number of small pots were deposited in pit 1-3α (Table A8.2). Around 10 base sherds from pit 1-3α could not be measured, as rim chart could not be adapted to the particular shape of these bases. Furthermore, these numbers also do not take into account the vessels that have been reconstructed from the site in previous studies, which add up to 17 in pit 1-3α (Kalicz 2011, 15). Considering these limitations, values obtained from brokenness ratio most likely suggest that very little fragmentation occurred.

Feature	Vessel Size	Base diameter	Base sherd(s)	EVEs	Total EVEs	Brokenness Ratio (s/v)*
Pit III	Very Small	1-5cm	5	3.075	15.325	31.86
	Small	6-10cm	35	9.7		
	Medium	11-15cm	15	2.075		
	Large	16-20cm	3	0.475		
Pit 1-3α	Very Small	1-5cm	12	4.9	28.375	43.10
	Small	6-10cm	64	16.525		
	Medium	11-15cm	40	6.3		
	Large	16-20cm	5	0.65		

*Table A8.10: Calculation of Vessel EVEs from Méhtelek-Nádas according to feature. *Sherd numbers are equivalent to sampled fragments (n1).*

A8.2.2 Pit 1-3α

The sherd-size distribution from pit 1-3α is negatively skewed and well-sorted assemblage with a predominance of medium-sized fragments (Figure 7.41). Morphometric data presented in Figure 7.42, illustrate that fragments from this pit are moderately compact/oblong, slightly elongated, slightly angular, and with a highly rough surface. This suggests fragments had little exposure to abrasion or fragmentation before being deposited. However, the data presented from EVEs, the low number of body sherds, and of the sample size of sherds from pit 1-3α, indicate the potential sorting of fragments by archaeologists. In sum, sherd-size distribution and morphometric data from pits 1-3α should be taken to be inconclusive.

A8.3 Eitzum

Sherd-size distribution and morphometric information of fragments found in layers above pit features is provided (Figures A8.5 and A8.6). It is important to note the comparatively higher amount of fragmentation and abrasion in these layers as signalled by sphericity and roundness values. There is no considerable difference according to sherd-size distribution or morphometric parameters, only one observation can be made. The material found above feature 14 displays slightly higher roundness values than sherds from the pit fill below. This could indicate that the upper layer has been slightly more affected by post-depositional action, such as the drainage work that occurred at the site well before the 1950s excavations.

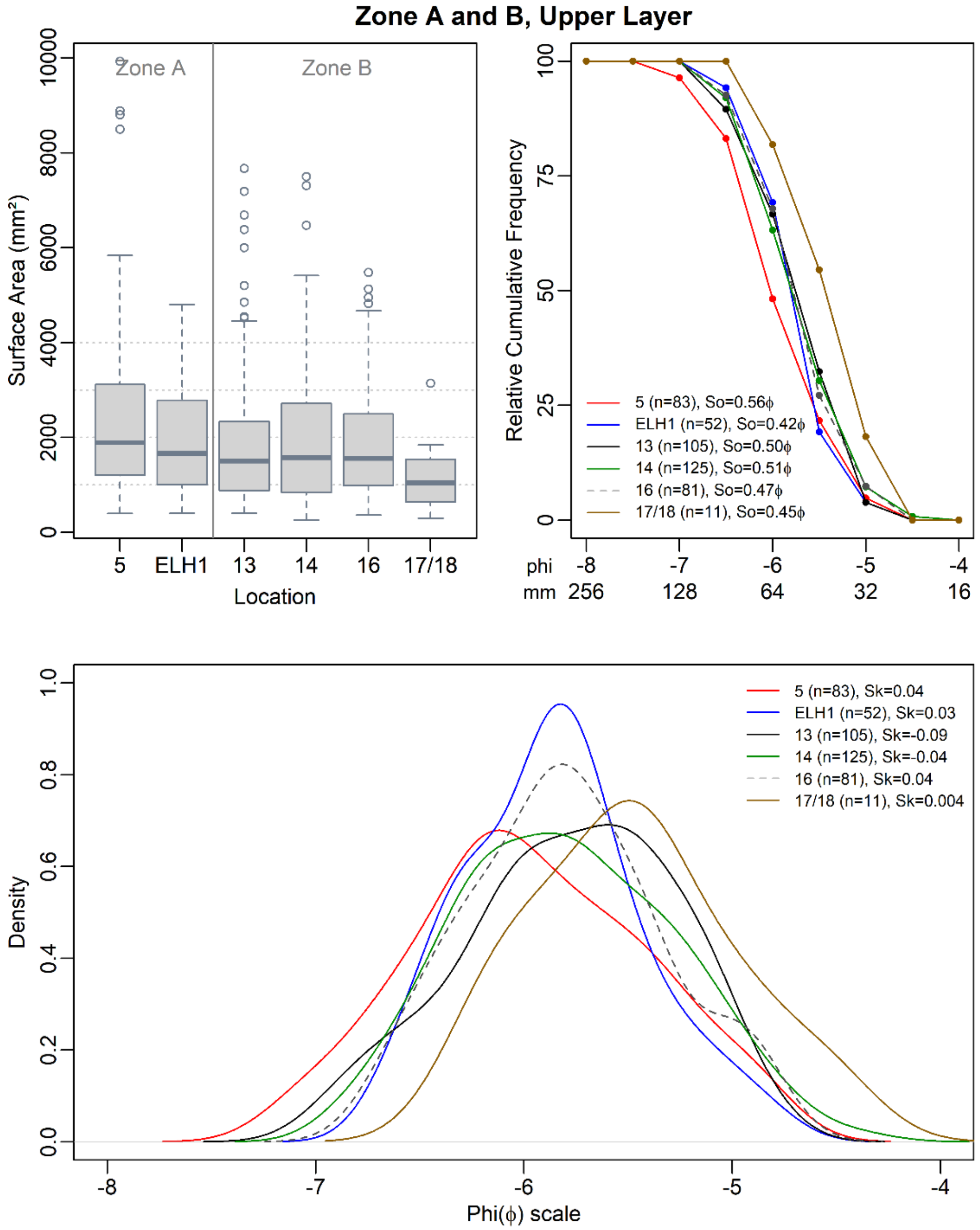


Figure A8.23: Sherd-size distribution of sherds from the layers above pit features from zones A and B at Eitzum.

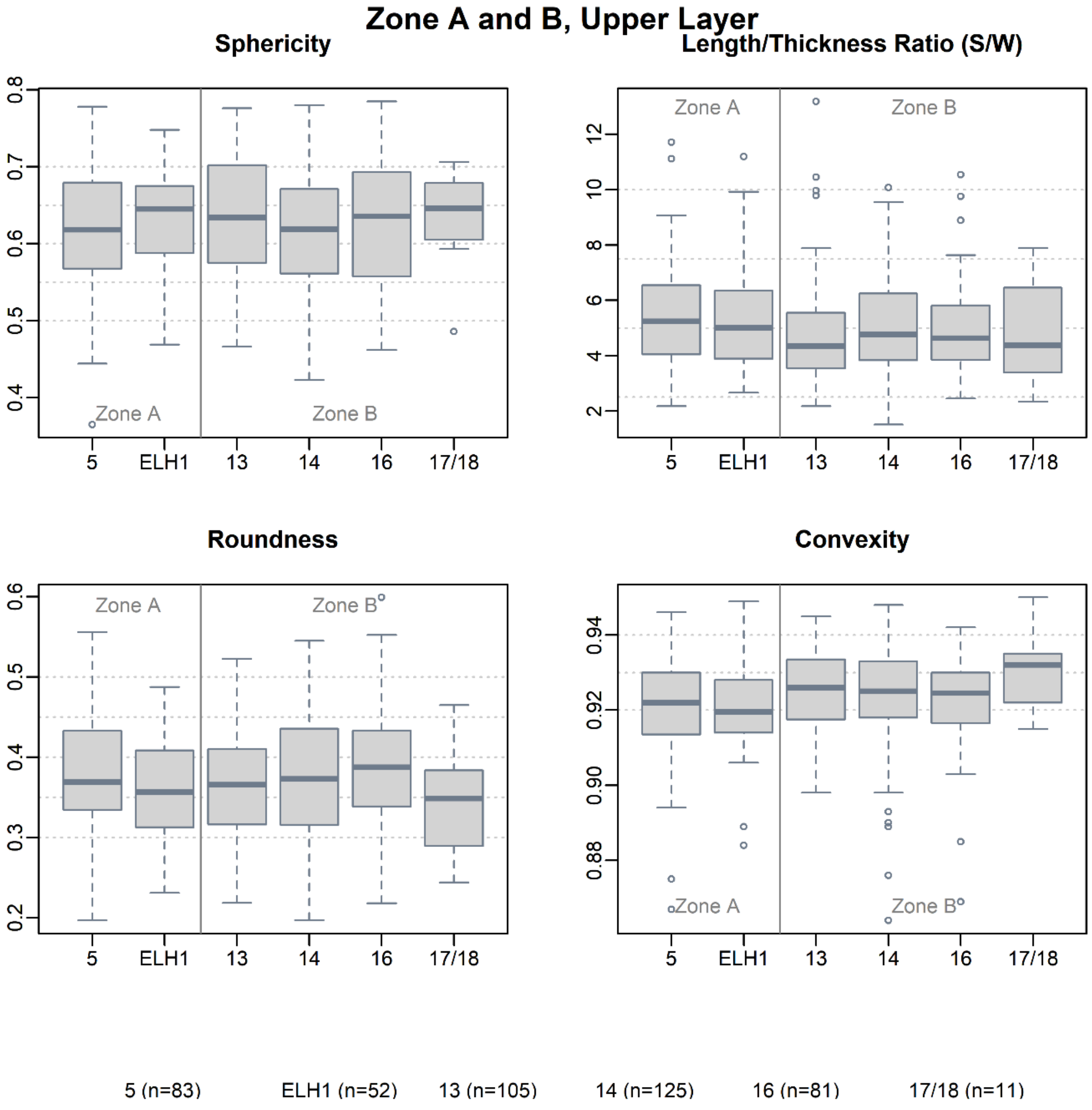


Figure A8.24: Morphometric results from the layers above pit features from zones A and B at Eitzum.

Appendix 9. Detail on database of Early Neolithic potsherd accumulation in central and south-eastern Europe

As mentioned in Chapter 7, a database was created with information on the number of fragments per pit feature and the maximum dimensions of these features from Early Neolithic sites in central and south-eastern Europe. The aim was to gain a better understanding of material accumulation patterns observed in NHF and UTB regions by examining a broader region. The data was retrieved from published reports, articles and books. It included all types of pit features (*i.e.* longpits, pits, and pit complexes), but excluded occupation layers. The reason for only including pit features was mostly to make comparison between SKC and LBK sites fair, as occupation surfaces in LBK sites are not commonly preserved (as mentioned in Chapter 4 and 5). Furthermore, focus was made only on features that could be dated directly, through relative or absolute dating techniques, or indirectly (by association to dated areas) to first phases of that site occupation. I also used information from radiocarbon dates and ceramic seriation according to the particular region where the Neolithic is said to have started. For example, dates from Rhineland are closer to 5200 calBC , while dates in Lower Saxony can be set around the 54th century BC.

Another clarification from the data collected, is the overall difference in sample number, as SKC sites have less numbers of features represented per site sampled. While large-scale excavations occur in southeast Europe, pottery remains are often not quantified, partly because the sheer volume of material retrieved makes this task unpractical. For example, roughly around 23 tons of Neolithic pottery have been retrieved from the site of Kovačevo in Bulgaria (Vieugué, personal communication). Secondly, when quantification does occur in SKC sites, it depends on the pottery analyst’s interests. Thus, there is a possibility that the features with medium or high number of pottery finds are the ones selected for study and, thus, quantified. Despite these caveats, there are a handful of SKC sites where a systematic quantification pottery was performed, which should provide some reassurance to the reader on the results obtained.

Using this database, the volume of pits was calculated using the following equation developed by Kazdová (1984, 166)

$$\text{Pit Volume} = \frac{(\text{LxWxD})}{2}$$

where L, W and D correspond to the maximum length, width and depth of pits respectively. While the accuracy of this volume representation can be put into question, it is a quick and practical way of assessing material accumulation at a large scale, particularly considering this basic information is easily available in published material where quantification of ceramic sherds was undertaken. With this volume calculation, the number of fragments was divided by the volume of features to calculate the density of finds per pit feature. Jonathan Last (1995, 206; 1998) uses this calculation as a measure of discard intensity, but it is used here rather as a representation of the degree of material accumulation, as not everything that ends in pits is the product of human discard (regardless of how it is defined).

Another clarification is that I collected data of pit dimensions from author descriptions in texts. Only when this information was not stated I obtained measurement information from published plans and profiles. Furthermore, if pit features were not completely excavated, I only calculated pit dimensions of portions excavated, *i.e.* if half of a pit was excavated then I used the dimensions of that half. Other small decisions had to be made for each site individually, and the justification for each decision is provided below (ordered alphabetically).

- *Bruchenbrücken*: For this site, data was available from previous calculations from Last (1995). However, in this study the author does not include sieved finds in this number. As my interest was in the degree of accumulation, I added all sieved finds to the numbers provided by Last (1995).
- *Bylany*: This site has been subject to many excavations and investigations, and to my knowledge Area F of the site remains the oldest area of the site, which is why it was the only area of the site included in my analysis. Sometimes pit features were found divided into a, b and c, which I decided to unify. In this case, I simply added all the potsherds from these subdivided areas and took the largest dimension of length, width and depth to calculate the volume of the feature. I also excluded features for the following reasons: they did not possess any finds, some pit measurements were missing (usually depth), pits with radiocarbon dates younger than 5300calBC and/or if features had finds dated by seriation after early LnK phases (*i.e.* after 1c). Eliminated features that were natural, *e.g*. product of windthrow. There was only one feature whose dimensions were taken from a plan provided by Pavlů (2000): pit 2259a and 2259b.
- *Cannerberg*: The data from this site was obtained from (van Wijk 2016). Many features were excluded from the database, as dimensions from these features were found missing, particularly their depth. The other dimensions, *i.e*. length and width, could be obtained from the site plans.
- *Eitzum*: Data from zone D were taken from finds registry held at the Braunschweig Landesmuseum. The pit dimensions were extracted from site plans and descriptions from the only publication available (Stäuble 2005). The potsherd data from zones A and B were obtained from Schwarz-Mackensen's (1985a) publication, and feature dimensions were obtained from Niquet's (1963) original publication.
- *Gerlingen*: In Grube 2/19 point 16, Grube2/27 point 3, Grube 3/15 point 11, Grube 4/70 point 34, Grube 4/134 point 3, and Grube 3/55 point 6 Neth (1999) states several small undecorated fragments were retrieved, but does not specify a number. For these features, I have written the minimum of 3 fragments.
- *Gura Baciului*: The data from Gura Baciului were obtained from Lazarovici and Maxim's (1995) volume. The maximum depth of feature G33 was determined by the section drawing in Figure 9. The maximum depth of feature B20 was not explicitly specified and had to be inferred. The text description in page 84 states a starting point at -30cm, and the table in page 85 specifies a maximum depth of -130. Similarly, for pit B23/B28 the maximum depth was calculated according to the information specified in tables for ceramic materials (*Idem.*, 89). It is also important to note that there were several features that were excluded due to the lack of information on feature dimensions.
- *Klein Denkte*: Due to the lack of information in excavation sheets, in many occasions the dimensions of pit features from Klein Denkte had to be partly obtained from Stauble's (2005) descriptions and plans.
- *Langweiler 8*: The data for this site were obtained from the extensive volume Ulrich Boelicke and R.W. Aniol (1988). In this site, I was forced to remove features that had one of the pit dimensions missing.
- *Lánycsók - Bácsfa puszta, Égett malom dűlő*: While most information of pit feature 1 was provided by Kalicz (1990, 34), the maximum pit depth information was missing in the text and plans. Thus, I had to make an estimate of the depth of the feature based on Kalicz's description. In the text he states that only the lower half of the pit feature was preserved. Considering the depth of the adjacent feature 2/9 around two metres, I estimated the maximum depth for feature 1 to be one metre.
- *Méhtelek-Nádas*: For this site, I used sherd numbers provided by Kalicz (2011), which involves for pits 1-3α and 4-5α only inventoried finds.

- *Miercurea Sibiului-Petris*: Feature dimensions were obtained from the published plans (Luca *et al.* 2008). The maximum depth of pits was obtained from the description given in the same publication. Features B20-21 and B1 were estimated around 0.6m, but this corresponded to the minimum depth recorded in the plans.
- *Mold*: Information from this sites was obtained from two volumes (Lenneis 2010; Lenneis and Schwarzäugl 2014). Features from House 11, *i.e.* 70, 350, 470, 520, 521, 522, 531, 555, and 771, were removed from the database due to the early dates associated with this house (Stadler 2010, Table 2). Furthermore, due to their spatial proximity to House 11, features from House 16 were also removed from the database. These correspond to features 475, 478, 479, 503, 907, 908, 909, 910, and 913. In addition, there were no metric data provided for features 50, 53, 477, 502, 694, 767, 787, 941 and 942 in the second volume published for the site (Lenneis 2014), and thus these features had to be removed from the database.
- *Niederhummel*: With the exception of the maximum depth, the information on pit dimensions, as well as the sherd number, were obtained from Joachim Pechtl and Daniela Hofmann’s (2016) publication. The maximum depths for the features were kindly provided by the latter author via email (Hofmann, personal communication).
- *Schwanfeld*: The number of sherds recovered from several houses in this site were obtained from Figure 1 in Fröhlich’s (2012) article, and the dimensions of the features were obtained from plans and profiles available in Stäuble’s (2005) publication. While most of the find numbers in Fröhlich’s paper were presented according to house unit, I used the largest longpit of the houses as pit dimension for calculating density.
- *Strögen*: I obtained the information on the depth of Feature 41 from Stauble’s (2005) topographical map, as this information was unavailable in the volume on Strögen (Lenneis and Lüning 2001).
- *Szentpéterszeg-Körtvélyes*: Sherd numbers from this site are based on an estimate given by the author. Kalicz (2012, 77) mentions several thousands of sherds were retrieved from the completely excavated pit 4. Consequently, I inputted the minimum number attributable to his observations.
- *Tiszaszőlős–Domaháza-puszta*: I had to estimate the number of finds from pit 6 through the density plot provided by Domboróczki (2010); thus, the number of sherds represents an estimate of the absolute minimum number retrieved.
- *Weisweiler 111*: For this site, I only utilised features dated to the older and middle LBK in the database. Also, while features 675 and 676 were not dated through ceramic seriation, they were included because they were ascribed to earlier house phases according to *Hofplatz* model. Furthermore, with the exception of pit 42, the information on the maximum depth of features had to be calculated from the mean values provided in the statistical summary of pit feature types (Rück 2007, Table 5).

The final table with the information used for Figure 7.76 is presented in the following pages.

Feature	Site	Type	Dates (CalBC)	Group	Phase	Length	Width	Depth	Volume	Fragments	Density	References
XIII/b	Becsehely	pit		SKC	Körös	3	2	0.75	2.25	525	233.3333	Kalicz 1990
XV/a	Becsehely	pit		SKC	Körös	1.6	1.4	0.6	0.672	320	476.1905	
58	Boldul lui Moș Ivănuș	pit complex	6000-5900	SKC	Criș I	3.25	1.25	0.9	1.828125	3700	2023.932	Thissen 2015
7	Březno			LBK	I					65	0.2	
157	Březno			LBK	I					96	18.9	
161	Březno			LBK	I					62	97.3	
184	Březno			LBK	I					22	7.3	
185	Březno			LBK	I					170	72.2	
217	Březno			LBK	II					17	12.9	
225	Březno			LBK	II					29	52.5	
230	Březno			LBK	II					18	51.1	
240	Březno			LBK	II					9	0.4	
241	Březno			LBK	I					44	146.7	
247	Březno			LBK	II					7	5.6	
249	Březno			LBK						13	53.1	
253	Březno			LBK	II					32	3.9	
254	Březno			LBK	II					10	10.4	
302	Březno			LBK	II					102	12	
320	Březno			LBK	I					29	7.2	
325	Březno			LBK	I					15	27.8	
326	Březno			LBK	I					50	212.8	
327	Březno			LBK	I					13	206.3	
340	Březno			LBK	II					10	17.1	
393	Březno			LBK						7	16.8	
399	Březno			LBK	I					47	21.6	
404	Březno			LBK	I					75	40.3	
449	Březno			LBK	II					54	270	Last 1995

450	Březno			LBK	II					9	21.9	
608	Březno			LBK	I					31	23.6	
616	Březno			LBK	I					8	41.6	
618	Březno			LBK	I					39	77	
619	Březno			LBK	I					23	2.9	
712	Březno			LBK	II					11	6.2	
717	Březno			LBK	II					6	3.5	
718	Březno			LBK	II					26	5.1	
2	Bruchenbrücken			LBK	älteste LBK					231	35.1	Last 1995; Stäuble 2005
5	Bruchenbrücken	pit	5344–5254	LBK	älteste LBK					714	115.8	
24	Bruchenbrücken			LBK	älteste LBK					85	61	
27	Bruchenbrücken			LBK	älteste LBK					155	86.1	
28	Bruchenbrücken			LBK	älteste LBK					106	15.3	
38	Bruchenbrücken			LBK	älteste LBK					81	101	
45	Bruchenbrücken	pit		LBK	älteste LBK					163	41.7	
18/23	Bruchenbrücken	long pit	5344–5254	LBK	älteste LBK					1536	232.5	
74/76	Bruchenbrücken	long pit		LBK	älteste LBK					722	106.3	
79	Bruchenbrücken			LBK	älteste LBK					561	105.2	
150	Bruchenbrücken	long pit		LBK	älteste LBK					1048	350	
212	Bruchenbrücken			LBK	älteste LBK					69	86	
248	Bruchenbrücken	pit		LBK	älteste LBK					116	73	
257	Bruchenbrücken	pit		LBK	älteste LBK					48	44	
501	Bylany	pit complex	5360	LBK	1c		6.9	3.8	1.18	15.4698	191	12.34664	Květina and Pavlů 2007
511	Bylany	pit complex	5360	LBK	1c	2.7	2	0.4	1.08	29	26.85185	
665	Bylany	pit	5360	LBK	1c	2.1	1.2	0.75	0.945	284	300.5291	
945	Bylany	pit	5360	LBK	1c	3.2	2.9	0.5	2.32	325	140.0862	

2101	Bylany	pit complex		LBK		13.3	7.8	1.32	68.4684	425	6.207243
2102	Bylany	pit	5440	LBK	1c	4.2	3.4	1	7.14	27	3.781513
2103	Bylany	pit	5400	LBK	1c	3.85	2.2	0.85	3.59975	29	8.056115
2104	Bylany	pit		LBK		4.1	3.4	0.88	6.1336	11	1.7934
2105	Bylany	pit complex	5480	LBK	1c	8.85	1.6	0.6	4.248	122	28.7194
2106	Bylany	pit		LBK		1.05	0.85	0.15	0.066938	1	14.93931
2108	Bylany	pit	5480	LBK	1c	2	1.4	0.4	0.56	3	5.357143
2115	Bylany	pit	5480	LBK	1c	3.4	1.5	0.36	0.918	64	69.71678
2116	Bylany	pit	5480	LBK	1c	4.25	2.8	0.67	3.9865	61	15.30164
2117	Bylany	pit	5480	LBK	1c	3.6	1.9	0.9	3.078	19	6.17284
2118	Bylany	pit		LBK		3.25	2.1	0.42	1.43325	4	2.79086
2119	Bylany	pit		LBK		1.4	1	0.19	0.133	1	7.518797
2120	Bylany	pit	5380	LBK	1c	5	3.1	0.95	7.3625	78	10.59423
2121	Bylany	pit	5480	LBK	1c	3.3	2.4	0.65	2.574	121	47.00855
2122	Bylany	pit		LBK		5.3	3.45	0.73	6.674025	17	2.547189
2123	Bylany	pit	5500	LBK	1c	5.5	3.2	0.7	6.16	135	21.91558
2124	Bylany	pit?		LBK		2.8	1.25	0.75	1.3125	30	22.85714
2125	Bylany	pit complex		LBK		6.8	4.8	0.65	10.608	70	6.598793
2126	Bylany	pit	5500	LBK	1c	3.4	2	0.7	2.38	32	13.44538
2127	Bylany	pit complex	5400	LBK	1c	9.4	2.3	0.78	8.4318	46	5.455537
2129	Bylany	pit		LBK	1c	2.3	2.2	0.5	1.265	10	7.905138
2130	Bylany	pit		LBK	1c	2.5	2.55	0.2	0.6375	9	14.11765
2131	Bylany	layer		LBK		9.5	5.7	0.15	4.06125	4	0.984918
2132	Bylany	pit		LBK		3.4	1.7	0.85	2.4565	1	0.407083
2133	Bylany	pit		LBK		4.6	2.9	0.67	4.4689	12	2.685225
2134	Bylany	pit		LBK		3.1	2.9	0.6	2.697	7	2.595476
2136	Bylany	pit		LBK		3.2	3.2	1.15	5.888	7	1.188859

2137	Bylany	pit complex		LBK		4.2	1.6	0.4	1.344	3	2.232143
2138	Bylany	pit		LBK		3.1	1.3	0.5	1.0075	4	3.970223
2139	Bylany	pit		LBK		2	1.6	0.38	0.608	1	1.644737
2140	Bylany	pit		LBK		2.3	1.6	0.65	1.196	8	6.688963
2141	Bylany	pit complex		LBK		5.2	2.1	0.55	3.003	11	3.663004
2147	Bylany	pit complex		LBK		5.5	2.8	0.55	4.235	54	12.75089
2148	Bylany	pit		LBK		1.9	1.6	0.45	0.684	8	11.69591
2150	Bylany	pit?		LBK		2	0.7	0.68	0.476	1	2.10084
2151	Bylany	pit complex	5360	LBK	1c	9.5	3.6	1.3	22.23	90	4.048583
2152	Bylany	pit		LBK		2.6	1.85	0.75	1.80375	15	8.316008
2153	Bylany	pit complex		LBK		3.15	1.55	0.6	1.46475	21	14.33692
2155	Bylany	pit		LBK		4.4	3.8	0.82	6.8552	29	4.230365
2156	Bylany	pit		LBK		2.4	1.3	0.53	0.8268	3	3.628447
2157	Bylany	pit complex		LBK	1c	9.8	1.7	1.2	9.996	137	13.70548
2158	Bylany	pit		LBK		5.9	4.2	0.9	11.151	34	3.049054
2159	Bylany	pit complex		LBK	1c	7.8	3.2	0.84	10.4832	17	1.621642
2160	Bylany	pit	5380	LBK	1c	1.65	1.3	0.6	0.6435	11	17.09402
2161	Bylany	pit	5380	LBK	1c	3.1	1.2	0.6	1.116	22	19.71326
2162	Bylany	pit	5380	LBK	1c	3.6	1.9	0.2	0.684	8	11.69591
2163	Bylany	pit	5440	LBK	1c	5.8	2	0.4	2.32	20	8.62069
2164	Bylany	pit	5480	LBK	1c	3.3	1.2	0.2	0.396	23	58.08081
2165	Bylany	pit	5480	LBK	1c	4.8	2	0.65	3.12	16	5.128205
2167	Bylany	pit	5440	LBK	1c	2.7	1.5	0.58	1.1745	1	0.851426
2168	Bylany	pit complex	5440	LBK	1c	12.6	4.2	1.12	29.6352	130	4.386675

2169	Bylany	pit complex	5440	LBK	1c	6.9	3.8	1.18	15.4698	33	2.133189
2170	Bylany	pit	5440	LBK	1c	8.3	4.4	0.9	16.434	106	6.450043
2171	Bylany	pit	5460	LBK	1c	1.6	1.6	0.3	0.384	7	18.22917
2172	Bylany	pit	5440	LBK	1c	3.5	1.8	0.45	1.4175	2	1.410935
2173	Bylany	layer	5420-5440	LBK	1c	39	7	0.2	27.3	448	16.41026
2174	Bylany	pit	5460	LBK	1c	1.9	1.6	0.45	0.684	14	20.46784
2175	Bylany	pit complex	5480	LBK	1c	8.4	2.9	0.7	8.526	30	3.518649
2176	Bylany	ditch		LBK		2.8	0.7	0.5	0.49	3	6.122449
2177	Bylany	pit		LBK		7	4	0.9	12.6	33	2.619048
2178	Bylany	pit		LBK		2.5	2.2	0.45	1.2375	14	11.31313
2179	Bylany	pit		LBK		2.5	2.2	0.45	1.2375	3	2.424242
2180	Bylany	pit		LBK		2.9	2.7	0.8	3.132	19	6.066411
2183	Bylany	pit		LBK		2.2	1.55	0.35	0.59675	4	6.702974
2185	Bylany	pit		LBK		2.6	1.2	0.26	0.4056	2	4.930966
2186	Bylany	pit	5420	LBK	1c	4	1.7	0.22	0.748	1	1.336898
2189	Bylany	pit	5480	LBK	1c	3.3	2	1.4	4.62	44	9.52381
2193	Bylany	pit	5380	LBK	1c	4.8	2.6	0.75	4.68	36	7.692308
2194	Bylany	pit complex	5420-5440	LBK	1c	10.4	4.1	1.08	23.0256	232	10.07574
2204	Bylany	pit complex	5420-5460	LBK	1c	9.9	3.3	0.6	9.801	167	17.03908
2206	Bylany	pit complex	5360	LBK	1c	9.8	3.6	1.4	24.696	77	3.117914
2207	Bylany	pit complex		LBK		7.35	3.4	1.5	18.7425	35	1.867414
2208	Bylany	pit		LBK		1.3	1.1	0.3	0.2145	3	13.98601
2211	Bylany	pit	5480	LBK	1c	2.1	1.4	0.25	0.3675	2	5.442177
2212	Bylany	pit	5440	LBK	1c	3.8	1.8	0.5	1.71	20	11.69591
2213	Bylany	pit	5480	LBK	1c	3.8	1.4	0.3	0.798	16	20.05013

2214	Bylany	pit	5480	LBK	1c	2.7	1.6	0.35	0.756	5	6.613757
2215	Bylany	pit	5480	LBK	1c	3.7	1.7	0.85	2.67325	23	8.603759
2216	Bylany	pit	5480	LBK	1c	2.2	1.5	0.4	0.66	60	90.90909
2218	Bylany	pit	5480	LBK	1c	3.9	3.3	0.7	4.5045	29	6.438006
2219	Bylany	pit	5460	LBK	1c	2.2	1.7	0.3	0.561	9	16.04278
2220	Bylany	pit		LBK		2	1.7	0.65	1.105	6	5.429864
2221	Bylany	pit		LBK		3.3	2	0.8	2.64	14	5.30303
2222	Bylany	pit	5440	LBK	1c	1.9	1.8	0.35	0.5985	2	3.341688
2228	Bylany	pit	5420	LBK	1c	1.95	1.3	0.32	0.4056	1	2.465483
2229	Bylany	pit	5460	LBK	1c	4.9	2	0.76	3.724	18	4.833512
2230	Bylany	pit	5460	LBK	1c	1.9	1.2	0.28	0.3192	1	3.132832
2231	Bylany	pit	5500	LBK	1c	2.1	1.4	0.36	0.5292	2	3.779289
2232	Bylany	pit	5500	LBK	1c	3.1	1.8	0.34	0.9486	27	28.463
2233	Bylany	pit		LBK		5.6	4.3	0.73	8.7892	36	4.095936
2236	Bylany	pit	5400	LBK	1c	2.5	1.6	0.36	0.72	21	29.16667
2237	Bylany	pit		LBK		2.4	1.7	0.4	0.816	4	4.901961
2239	Bylany	pit		LBK		1.06	1	0.32	0.1696	3	17.68868
2240	Bylany	pit	5400	LBK	1c	3.2	1.8	0.48	1.3824	9	6.510417
2241	Bylany	pit		LBK		4.3	1.45	0.32	0.9976	9	9.021652
2242	Bylany	ditch	5440	LBK	1c	23.4	0.7	0.5	4.095	44	10.74481
2243	Bylany	pit	5440	LBK	1c	3.6	1.9	0.8	2.736	12	4.385965
2245	Bylany	pit	5420	LBK	1c	1.9	1.6	0.42	0.6384	13	20.36341
2247	Bylany	pit		LBK		4.6	3	0.76	5.244	3	0.572082
2248	Bylany	pit	5420	LBK	1c	3.3	1.6	0.22	0.5808	8	13.7741
2249	Bylany	pit	5420	LBK	1c	4	1.45	0.36	1.044	12	11.49425
2250	Bylany	pit	5420	LBK	1c	2.4	1.8	0.74	1.5984	91	56.93193
2251	Bylany	pit		LBK		1.35	0.96	0.36	0.23328	3	12.86008
2252	Bylany	pit		LBK		2.35	1.15	0.36	0.48645	5	10.27855
2254	Bylany	pit		LBK		3.85	1.65	0.46	1.461075	10	6.844276

2255	Bylany	pit complex	5400	LBK	1c	5.1	2.6	0.7	4.641	18	3.878474
2257	Bylany	pit	5400	LBK	1c	3.6	1.6	1.1	3.168	43	13.57323
2258	Bylany	pit	5400	LBK	1c	1.7	1.05	3.4	3.0345	11	3.624979
2260	Bylany	pit	5400	LBK	1c	4.7	2.2	5.5	28.435	27	0.949534
2262	Bylany	pit complex	5400	LBK	1c	6.9	1.7	0.7	4.1055	41	9.986603
2264	Bylany	pit		LBK		3.75	1.55	1.08	3.13875	5	1.592991
2265	Bylany	pit	5400	LBK	1c	3.6	1.4	0.5	1.26	3	2.380952
2266	Bylany	pit		LBK		2.65	2	0.26	0.689	2	2.902758
2267	Bylany	pit	5440	LBK	1c	2	1.25	0.24	0.3	7	23.33333
2268	Bylany	pit	5440	LBK	1c	3.5	2.6	0.28	1.274	9	7.064364
2271	Bylany	pit		LBK		2.25	2.05	0.98	2.260125	2	0.884907
2272	Bylany	pit complex		LBK		7.2	0.9	0.74	2.3976	9	3.753754
2276	Bylany	ditch	5400	LBK	1c	3.1	0.54	0.34	0.28458	1	3.51395
2279	Bylany	pit	5440	LBK	1c	2.35	1.35	0.5	0.793125	10	12.60835
2280	Bylany	pit	5440	LBK	1c	3.4	1.65	0.6	1.683	39	23.17291
2281	Bylany	pit	5440	LBK	1c	2.75	1.7	0.54	1.26225	4	3.168944
2282	Bylany	pit	5440	LBK	1c	2.95	1.4	0.94	1.9411	25	12.8793
2284	Bylany	pit	5460	LBK	1c	2.05	1.5	0.54	0.83025	13	15.65793
2285	Bylany	pit complex		LBK		4.55	2.25	0.92	4.70925	11	2.335828
2286	Bylany	pit complex		LBK		6.6	1.5	0.7	3.465	34	9.81241
2289	Bylany	pit		LBK		1.5	0.76	0.35	0.1995	2	10.02506
2300	Bylany	pit		LBK		2.6	1.6	0.62	1.2896	20	15.50868
2303	Bylany	pit	5440	LBK	1c	3.6	1.8	0.68	2.2032	22	9.985476
2304	Bylany	pit		LBK		3	1.4	0.53	1.113	4	3.59389
2306	Bylany	pit		LBK		2.1	1.2	0.75	0.945	4	4.232804
2307	Bylany	pit		LBK		2.2	1.5	0.68	1.122	2	1.782531

2308	Bylany	pit	LBK		3.2	3	0.75	3.6	9	2.5	
2309	Bylany	ditch	LBK		2.7	1.6	0.4	0.864	8	9.259259	
CC1	Călinești-Oaș-D.S.M.	pit	SKC	Criș IIIB/IVA	7	1.5	1.1	5.775	271	46.92641	Vindrola-Padrós *et al.* 2019
CC2	Călinești-Oaș-D.S.M.	pit complex	SKC	Criș IIIB/IVA	10	5	0.9	22.5	652	28.97778	
CC3	Călinești-Oaș-D.S.M.	pit complex	SKC	Criș IIIB/IVA	7.2	7	0.8	20.16	138	6.845238	
2093/43-12	Cannerberg	long pit	LBK	13	2.75	1.5	0.55	1.134375	27	23.80165	
2194	Cannerberg	long pit	LBK	9-11	3.2	1.3	0.6	1.248	3	2.403846	
2195	Cannerberg	long pit	LBK	9-11	2.9	1	0.24	0.348	7	20.11494	
2213 or 2113	Cannerberg	pit	LBK	9-11	2.8	2	1.34	3.752	15	3.997868	
500	Cannerberg		LBK	16	3.7	1.5	0.7	1.9425	196	100.9009	
700	Cannerberg		LBK	13	5.9	5.9	1	17.405	957	54.9842	
598	Cannerberg		LBK	18	2.8	1	0.5	0.7	19	27.14286	
753/2054	Cannerberg	long pit	LBK	11-13	2	1.3	1	1.3	25	19.23077	
774	Cannerberg	long pit	LBK	11-13	2.2	1	0.4	0.44	20	45.45455	
656	Cannerberg	pit	LBK		2.3	1.6	0.34	0.6256	12	19.18159	van Wijk 2016
674	Cannerberg	pit	LBK		2.3	1.4	0.34	0.5474	11	20.09499	
675	Cannerberg	pit	LBK		2.1	1	0.34	0.357	9	25.21008	
983	Cannerberg	long pit	LBK	18	2.6	1.1	1	1.43	188	131.4685	
1363	Cannerberg	long pit	LBK	20	1.7	1.5	0.96	1.224	9	7.352941	
2304	Cannerberg	long pit	LBK	20	2.8	2.3	0.96	3.0912	30	9.704969	
2494	Cannerberg	long pit	LBK	20	1.8	1.5	0.96	1.296	9	6.944444	
2039	Cannerberg	long pit	LBK	12	5	1.9	0.93	4.4175	94	21.279	
2043	Cannerberg	long pit	LBK	12	3.3	1.5	0.52	1.287	20	15.54002	
2046	Cannerberg	long pit	LBK	12	2.8	1.2	0.29	0.4872	6	12.31527	
640	Cannerberg	long pit	LBK	16	2.5	1.4	0.78	1.365	108	79.12088	

2061	Cannerberg	long pit	LBK		2.3	0.8	0.6	0.552	45	81.52174	
596	Cannerberg	pit	LBK		1	1	0.58	0.29	1	3.448276	
2	Einbeck	pit	LBK	älteste LBK	4	2	0.53	2.12	125	58.96226	Siegmund and Hainski 1992
3	Einbeck	pit	LBK	älteste LBK	5	3	0.43	3.225	39	12.09302	
4	Einbeck	pit	LBK	älteste LBK	4.6	2.6	0.31	1.8538	155	83.61204	
11/22 (Zone D)	Eitzum	long pit	LBK	älteste LBK	24	5	0.5	30	448	14.93333	Stäuble 2005; BLM
23 (Zone D)	Eitzum	pit	LBK	älteste LBK	16	2	0.6	9.6	160	16.66667	
24 (Zone D)	Eitzum	pit	LBK	älteste LBK	4.6	2.8	0.3	1.932	38	19.66874	
26 (Zone D)	Eitzum	long pit	LBK	älteste LBK	23	5	0.6	34.5	491	14.23188	
13 (Zone B)	Eitzum	pit	LBK	älteste LBK	7.5	4.5	0.6	10.125	233	23.01235	Schwarz-Mackensen 1985
14 (Zone B)	Eitzum	long pit	LBK	älteste LBK	11.5	3	0.55	9.4875	286	30.14493	
15 (Zone B)	Eitzum	long pit	LBK	älteste LBK	11	3	0.6	9.9	228	23.0303	
16 (Zone B)	Eitzum	pit	LBK	älteste LBK	3	2	0.2	0.6	167	278.3333	
WLH1 (Zone A)	Eitzum	long pit	LBK	älteste LBK	6	3	0.5	4.5	1150	255.5556	
ELH1 (Zone A)	Eitzum	long pit	LBK	älteste LBK	8	4	0.5	8	150	18.75	
G2/4	Gerlingen	pit	LBK	älteste/ältere LBK	3.6	2.2	0.3	1.188	97	81.64983	Neth 1999
G2/14	Gerlingen	pit complex	LBK	älteste/ältere LBK	12.6	4.8	0.9	27.216	250	9.185773	
G2/19	Gerlingen	pit	LBK	älteste/ältere LBK	3.3	1.45	0.75	1.794375	126	70.21944	
G2/27	Gerlingen	pit complex	LBK	älteste/ältere LBK	3.2	1.9	0.5	1.52	11	7.236842	

G2/40	Gerlingen	pit complex	LBK	älteste/ältere LBK	4.8	4.1	0.7	6.888	348	50.52265
G4/109	Gerlingen	long pit	LBK	älteste/ältere LBK	4.2	1.8	0.7	2.646	34	12.84958
G4/117	Gerlingen	pit	LBK	älteste/ältere LBK	1.9	0.95	0.38	0.34295	8	23.32702
G3/14	Gerlingen	long pit	LBK	älteste/ältere LBK	2.9	1.05	0.35	0.532875	46	86.32418
G3/15	Gerlingen	pit	LBK	älteste/ältere LBK	1.7	1.7	0.36	0.5202	29	55.74779
G4/70	Gerlingen	long pit	LBK	älteste/ältere LBK	19.4	3.6	0.93	32.4756	460	14.16448
G4/122	Gerlingen	pit complex	LBK	älteste/ältere LBK	7.8	6.6	0.5	12.87	126	9.79021
G4/134	Gerlingen	long pit	LBK	älteste/ältere LBK	10	3.2	0.6	9.6	91	9.479167
G4/140	Gerlingen	long pit	LBK	älteste/ältere LBK	4.4	1.65	0.4	1.452	17	11.70799
G4/144	Gerlingen	pit	LBK	älteste/ältere LBK	2.2	0.25	0.55	0.15125	14	92.56198
G4/147	Gerlingen	long pit	LBK	älteste/ältere LBK	3.6	1.8	0.42	1.3608	72	52.91005
G4/148	Gerlingen	pit	LBK	älteste/ältere LBK	2.5	1.4	0.65	1.1375	27	23.73626
G4/149	Gerlingen	pit	LBK	älteste/ältere LBK	2.2	1.5	0.28	0.462	9	19.48052
G3/28	Gerlingen	long pit	LBK	älteste/ältere LBK	3.9	1	0.75	1.4625	16	10.94017
G3/55	Gerlingen	pit	LBK	älteste/ältere LBK	2.7	1.25	0.6	1.0125	29	28.64198
G3/68	Gerlingen	pit complex	LBK	älteste/ältere LBK	3.3	1.75	0.47	1.357125	36	26.52666
G3/118	Gerlingen	long pit	LBK	älteste/ältere LBK	5.6	1.7	0.75	3.57	38	10.64426

G3/127	Gerlingen	pit	LBK	älteste/ältere LBK	2.9	2.05	0.88	2.6158	28	10.70418	
G3/146	Gerlingen	pit	LBK	älteste/ältere LBK	2.2	1.3	0.3	0.429	8	18.64802	
3	Ghioroc Balastiera Vest	pit	SKC		3.4	2.1	0.5	1.785	163	91.31653	Sava *et al.* 2015
7	Ghioroc Balastiera Vest	pit	SKC		0.9	0.9	0.65	0.26325	30	113.9601	
10	Ghioroc Balastiera Vest	pit	SKC		5.6	2.6	0.28	2.0384	27	13.24568	
12	Ghioroc Balastiera Vest	pit	SKC		1.6	1.6	0.2	0.256	38	148.4375	
14	Ghioroc Balastiera Vest	pit	SKC		2	1.75	0.3	0.525	40	76.19048	
24	Ghioroc Balastiera Vest	pit	SKC		4.4	4.14	0.34	3.09672	152	49.08419	
25	Ghioroc Balastiera Vest	pit	SKC		3	2.2	0.58	1.914	48	25.07837	
27	Ghioroc Balastiera Vest	pit house	SKC		2.82	2.65	0.4	1.4946	68	45.49712	
B5V	Gura Baciului	pit house	SKC	Criș IIB	4	3	0.9	5.4	24	4.444444	Lazarovici and Maxim 1995
B2A	Gura Baciului	pit house	SKC	Criș IA-IB	3.1	3	1.2	5.58	42	7.526882	
B20	Gura Baciului	pit house	SKC	Criș IIA	3	2.5	1	3.75	725	193.3333	
B10	Gura Baciului	pit house	SKC	Criș IC-IIA	2.2	2.2	0.4	0.968	161	166.3223	
B23	Gura Baciului	pit house	SKC	Criș IIA-IIB	2.5	2.4	0.3	0.9	306	340	
B1	Gura Baciului	pit house	SKC	Criș IB-IC	2.5	2	0.5	1.25	288	230.4	
B27	Gura Baciului	pit house	SKC		4	3.2	0.8	5.12	63	12.30469	

B8	Gura Baciului	pit house	SKC	Criș IC-IIA	2.8	2.3	0.4	1.288	38	29.50311	
B30	Gura Baciului	pit house	SKC	Criș IVB	2.7	2.3	0.9	2.7945	108	38.64734	
B28	Gura Baciului	pit house	SKC	Criș IVA-IVB	3	2.8	0.7	2.94	55	18.70748	
B28a	Gura Baciului	pit house	SKC	Criș IVB	3.6	2.8	0.4	2.016	7	3.472222	
B9	Gura Baciului	pit house	SKC	Criș IIIB-IVA	2.5	2.1	0.5	1.3125	43	32.7619	
G14	Gura Baciului	pit	SKC	Criș IIIB	1.1	0.9	0.4	0.198	14	70.70707	
G33	Gura Baciului	pit	SKC	Criș IC-IIA	1.3	0.65	0.3	0.12675	1	7.889546	
nl	Ibrány-Nagyerdő	pit	SKC	Körös	4	2	1	4	2259	564.75	Domboróczki 2012
59	Klein Denkte	long pit	LBK	älteste LBK	12	4.5	0.6	16.2	57	3.518519	Stäuble 2005; BLM
71	Klein Denkte	long pit	LBK	älteste LBK	4	1.5	0.75	2.25	134	59.55556	
74	Klein Denkte	long pit	LBK	älteste LBK	5	2	0.45	2.25	60	26.66667	
67	Klein Denkte	long pit	LBK	älteste LBK	10	6	0.2	6	42	7	
101	Klein Denkte	long pit	LBK	älteste LBK	8	6	0.5	12	61	5.083333	
47-0	Langweiler 8	long pit	LBK	5-I-V	6.8	1.2	0.6	2.448	16	6.535948	Boelicke and Aniol 1988
52-0	Langweiler 8	F-Grube	LBK	1-3-I-V	4	2.8	0.56	3.136	36	11.47959	
114-0	Langweiler 8	pit	LBK	3-IV	2	2	0.45	0.9	326	362.2222	
152-0	Langweiler 8	pit	LBK	I-VI	2.4	1.6	0.5	0.96	33	34.375	
155-0	Langweiler 8	pit	LBK	III	2	2	0.66	1.32	17	12.87879	
156-0	Langweiler 8	long pit	LBK	5-III	1.6	1.2	0.4	0.384	107	278.6458	
157-0	Langweiler 8	long pit	LBK	5-III	4	2	0.65	2.6	6	2.307692	
161-0	Langweiler 8	long pit	LBK	III	4.8	2	0.56	2.688	93	34.59821	
243-0	Langweiler 8	pit	LBK	3-IV	12	4	0.58	13.92	480	34.48276	
263-0	Langweiler 8	pit	LBK	3-IV	3.7	2.7	0.61	3.04695	70	22.97379	
291-0	Langweiler 8	long pit	LBK	I-VI	4	2	0.52	2.08	4	1.923077	
358-0	Langweiler 8	long pit	LBK	I-VI	2	1.2	0.3	0.36	2	5.555556	

448-0	Langweiler 8	long pit	LBK	I-VI	10.4	2.8	0.54	7.8624	560	71.22507
449-0	Langweiler 8	long pit	LBK	I-VI	4.4	2	0.3	1.32	3	2.272727
602-0	Langweiler 8	long pit	LBK	I-VI	2.4	1.2	0.2	0.288	31	107.6389
638-0	Langweiler 8	pit	LBK	5-III	3.6	2.8	0.84	4.2336	1	0.236206
774-0	Langweiler 8	F-Grube	LBK	1-3-VI	2	1.2	0.46	0.552	18	32.6087
828-1	Langweiler 8	pit	LBK	1-VI	2	0.8	0.41	0.328	31	94.5122
1033-0	Langweiler 8	long pit	LBK	3-VI	3	2.4	1.05	3.78	98	25.92593
1034-0	Langweiler 8	long pit	LBK	3-VI	2.8	2	1.05	2.94	69	23.46939
1145-0	Langweiler 8	pit	LBK	II-XII	5.2	5.2	1.07	14.4664	90	6.221313
1174-0	Langweiler 8	pit	LBK	II-XIII	2.4	2	0.56	1.344	62	46.13095
1232-0	Langweiler 8	pit	LBK	3-VI	3.2	2.5	0.77	3.08	13	4.220779
1248-0	Langweiler 8	pit	LBK	3-VI	5.2	3.6	0.73	6.8328	88	12.87905
1284-0	Langweiler 8	long pit	LBK	5-II	4	1.6	0.28	0.896	37	41.29464
1391-0	Langweiler 8	long pit	LBK	II-XIII	2.8	0.8	0.46	0.5152	7	13.58696
1392-0	Langweiler 8	long pit	LBK	II-XIII	3.2	1.2	0.26	0.4992	11	22.03526
1399-0	Langweiler 8	pit	LBK	II-XIII	3.6	2.2	0.61	2.4156	13	5.381686
1958-0	Langweiler 8	long pit	LBK	2-VI	2	0.8	0.38	0.304	18	59.21053
2122-0	Langweiler 8	long pit	LBK	I-I	2.2	0.9	0.18	0.1782	9	50.50505
2135-0	Langweiler 8	long pit	LBK	3-VI	4	2	0.36	1.44	37	25.69444
2227-0	Langweiler 8	pit	LBK	2-III	3.2	1.2	0.83	1.5936	65	40.78815
2229-0	Langweiler 8	pit	LBK	2-III	1.2	1.2	0.33	0.2376	51	214.6465
2321-0	Langweiler 8	pit	LBK	II-XIII	2.6	2.4	0.27	0.8424	16	18.99335
2403-0	Langweiler 8	long pit	LBK	5-IV	4	1.6	0.48	1.536	5	3.255208
2415-0	Langweiler 8	pit	LBK	5-IV	1.8	1.6	0.55	0.792	2	2.525253
2480-0	Langweiler 8	pit	LBK	II-XIII	1.2	1.2	0.23	0.1656	59	356.2802
2511-0	Langweiler 8	F-Grube	LBK	II-XIV	0.9	0.8	0.52	0.1872	20	106.8376
2516-0	Langweiler 8	F-Grube	LBK	II-XIV	7.4	6.4	1.27	30.0736	80	2.66014
2523-0	Langweiler 8	F-Grube	LBK	II-XIV	1.6	0.6	0.5	0.24	78	325
2526-0	Langweiler 8	F-Grube	LBK	II-XIII	1.2	1.2	0.17	0.1224	31	253.268
2706-0	Langweiler 8	long pit	LBK	II-XIII	2.5	2	0.6	1.5	54	36

2711-0	Langweiler 8	F-Grube	LBK	5-VI	2	1.2	0.19	0.228	5	21.92982
2858-0	Langweiler 8	long pit	LBK	5-V	1.2	0.6	0.22	0.0792	2	25.25253
2947-0	Langweiler 8	pit	LBK	V	2	1.5	0.39	0.585	20	34.18803
2983-0	Langweiler 8	long pit	LBK	I-V	3.2	1.6	0.46	1.1776	7	5.944293
3239-0	Langweiler 8	pit	LBK	5-V	3.2	1.4	0.38	0.8512	12	14.09774
3447-0	Langweiler 8	pit	LBK	3-III	5.2	2.8	1	7.28	25	3.434066
3704-0	Langweiler 8	long pit	LBK	I-VI	13.6	5.2	1.05	37.128	77	2.073906
3708-0	Langweiler 8	F-Grube	LBK	1-3-I-V	1.8	1.8	0.22	0.3564	12	33.67003
3868-0	Langweiler 8	pit	LBK	II-XIII	1.2	0.9	0.5	0.27	152	562.963
3885-0	Langweiler 8	pit	LBK	II-XIII	1.6	1.6	0.64	0.8192	153	186.7676
3972-0	Langweiler 8	pit	LBK	II-XIII	3.6	1.2	0.95	2.052	74	36.06238
4236-0	Langweiler 8	long pit	LBK	5-III	6.4	2.4	0.6	4.608	39	8.463542
4268-0	Langweiler 8	long pit	LBK	2-II	2.4	0.6	0.3	0.216	3	13.88889
4286-0	Langweiler 8	long pit	LBK	2-II	4.4	2	0.8	3.52	25	7.102273
4300-0	Langweiler 8	F-Grube	LBK	1-3-I-V	4.4	3.2	0.8	5.632	20	3.551136
4483-0	Langweiler 8	pit	LBK	II-XIII	2.4	1.8	0.19	0.4104	26	63.35283
5008-0	Langweiler 8	long pit	LBK	I-VII	4	1.6	0.4	1.28	168	131.25
5025-0	Langweiler 8	long pit	LBK	2-V	4.5	1.8	1.5	6.075	185	30.45267
5033-1	Langweiler 8	long pit	LBK	3-IV	1.5	0.5	0.5	0.1875	165	880
5078-0	Langweiler 8	long pit	LBK	I-VII	4	3.6	1.3	9.36	296	31.62393
5080-0	Langweiler 8	long pit	LBK	I-VII	5.6	3.4	0.5	4.76	63	13.23529
5143-0	Langweiler 8	pit	LBK	2-V	9.4	7.4	1.5	52.17	395	7.571401
5148-0	Langweiler 8	long pit	LBK	4-VI	7	3.2	0.8	8.96	387	43.19196
5176-0	Langweiler 8	long pit	LBK	4-VI	14	2.8	0.7	13.72	476	34.69388
5224-1	Langweiler 8	long pit	LBK	II	1.8	1.2	0.85	0.918	124	135.0763
5224-2	Langweiler 8	long pit	LBK	5-II	3.2	1.8	1.1	3.168	52	16.41414
5224-3	Langweiler 8	long pit	LBK	5-II	1.4	1.4	0.6	0.588	14	23.80952
5225-0	Langweiler 8	long pit	LBK	5-II	2.8	1.2	0.4	0.672	9	13.39286
5248-0	Langweiler 8	pit	LBK	5-II	2	1.6	0.56	0.896	17	18.97321
5251-0	Langweiler 8	pit	LBK	I-VII	6	4	0.75	9	271	30.11111

5255-0	Langweiler 8	pit		LBK	2-V	1.7	1.6	0.63	0.8568	80	93.37068	
414-1	Langweiler 8	pit		LBK	4-II	7.5	4	0.45	6.75	5	0.740741	
1	Lánycsók	pit complex		SKC	Körös	4	2.5	1	5	175	35	Kalicz 1990
2/9	Lánycsók	pit complex		SKC	Körös	12	6.5	2	78	1658	21.25641	
1-3α	Méhtelek-Nádas	pit complex	5850-5620	SKC	Körös	11	5	1.2	33	2020	61.21212	Kalicz 2011
III	Méhtelek-Nádas	pit		SKC	Körös	4.5	3	1.62	10.935	580	53.0407	
7/α	Méhtelek-Nádas	pit		SKC	Körös	6	5.5	1.25	20.625	458	22.20606	
4-5α	Méhtelek-Nádas	pit complex	5630-5520	SKC	Körös	11	9.5	1.35	70.5375	2564	36.34946	
B10/2003	Miercurea Sibiului-Petriș	pit house	>5120	SKC	Criș IB-IC	5.5	5.3	0.4	5.83	382	65.52316	Luca *et al.* 2008
B19-G26	Miercurea Sibiului-Petriș	pit complex	>5050	SKC	Criș IB	7	4.5	1	15.75	1223	77.65079	
B17	Miercurea Sibiului-Petriș	pit house	>5080	SKC		5	3.5	0.6	5.25	649	123.619	
B20-21	Miercurea Sibiului-Petriș	pit house		SKC	Criș IC-IIA	7	5	0.6	10.5	315	30	
B1	Miercurea Sibiului-Petriș	pit house	>4990	SKC	Criș IC-IIA	5.5	4.5	0.4	4.95	141	28.48485	
B9	Miercurea Sibiului-Petriș	pit house	>4180	SKC	Criș IIB	3	2	0.6	1.8	585	325	
18	Miskovice			LBK	Early LBK					37	26.5	Last 1995
19a	Miskovice			LBK	Early LBK					15	10.7	
19b	Miskovice			LBK	Early LBK					52	18.6	
22	Miskovice			LBK	Early LBK					159	21.8	
29	Miskovice			LBK	Early LBK					83	13.6	
34	Miskovice			LBK	Early LBK					24	8.3	
35a	Miskovice			LBK	Early LBK					101	22	
35b	Miskovice			LBK	Early LBK					17	4	
37	Miskovice			LBK	Early LBK					173	36.8	

9	Miskovice			LBK	Early LBK					103	68.7	
41	Miskovice			LBK	Early LBK					579	144.8	
43	Miskovice			LBK	Early LBK					211	117.2	
45a	Miskovice			LBK	Early LBK					28	9	
45b	Miskovice			LBK	Early LBK					58	20.7	
45c	Miskovice			LBK	Early LBK					23	38.3	
61	Miskovice			LBK	Early LBK					33	13.2	
66a	Miskovice			LBK	Early LBK					22	13.8	
66b	Miskovice			LBK	Early LBK					8	10	
76	Miskovice			LBK	Early LBK					12	4.8	
51	Mold	long pit		LBK	älteste LBK	4.3	1.6	0.18	0.6192	46	74.28941	Lenneis 2010; Lenneis and Schwarzäugl 2014
52	Mold	long pit	5310-5140	LBK	älteste LBK	2.2	1.65	0.45	0.81675	22	26.93603	
54	Mold	long pit		LBK	älteste LBK	3.2	1.8	0.3	0.864	60	69.44444	
55	Mold	long pit		LBK	älteste LBK	1.9	0.95	0.4	0.361	20	55.40166	
56	Mold	pit	5370-5210	LBK	älteste LBK	2.95	1.95	0.56	1.6107	81	50.28869	
58	Mold	long pit		LBK	älteste LBK	2.05	1.7	0.16	0.2788	12	43.04161	
59	Mold	long pit		LBK	älteste LBK	1.9	1.75	0.35	0.581875	3	5.155747	
60	Mold	pit		LBK	älteste LBK	2.3	2.3	0.22	0.5819	3	5.155525	
64	Mold	long pit	5310-5140	LBK	älteste LBK	3.7	2.7	0.47	2.34765	99	42.16983	
88	Mold	long pit		LBK	älteste LBK	1.95	0.9	0.25	0.219375	1	4.558405	
91	Mold	long pit	5310-5140	LBK	älteste LBK	1.4	1.35	0.25	0.23625	60	253.9683	
124	Mold	long pit		LBK	älteste LBK	1.5	1	0.13	0.0975	2	20.51282	
125	Mold	long pit	5260-5115	LBK	älteste LBK	4	2.85	0.6	3.42	318	92.98246	
126	Mold	pit		LBK	älteste LBK	2.3	1.07	0.37	0.455285	15	32.9464	
127	Mold	pit		LBK	älteste LBK	1.95	1.85	0.45	0.811688	14	17.24802	

128	Mold	pit	5310-5140	LBK	älteste LBK	3.3	1.9	0.32	1.0032	82	81.73844
129	Mold	pit	5260-5115	LBK	älteste LBK	1.65	1.3	0.17	0.182325	3	16.45413
132	Mold	long pit		LBK	älteste LBK	4.7	2.45	0.25	1.439375	1	0.694746
133	Mold	long pit	5310-5140	LBK	älteste LBK	3.5	1.65	0.5	1.44375	38	26.32035
177	Mold	pit	5310-5140	LBK	älteste LBK	1.35	0.65	0.23	0.100913	13	128.8245
214	Mold	long pit		LBK	älteste LBK	5.1	1.4	0.21	0.7497	99	132.0528
215	Mold	long pit	5370-5210	LBK	älteste LBK	1.85	1.55	0.25	0.358438	30	83.6966
216	Mold	pit		LBK	älteste LBK	7.15	1.55	0.45	2.493563	59	23.66093
241	Mold	long pit		LBK	älteste LBK	1.7	1.6	0.25	0.34	23	67.64706
264	Mold	long pit		LBK	älteste LBK	3.5	1.35	0.23	0.543375	3	5.521049
347	Mold	long pit		LBK	älteste LBK	5.9	3.6	0.2	2.124	13	6.120527
348	Mold	long pit		LBK	älteste LBK	5.45	2.95	0.21	1.688138	2	1.184738
349	Mold	pit		LBK	älteste LBK	1.9	1.35	0.3	0.38475	87	226.1209
460	Mold	long pit		LBK	älteste LBK	3.6	2.58	0.46	2.13624	26	12.17092
461	Mold	pit		LBK	älteste LBK	2.25	1.2	0.15	0.2025	4	19.75309
473	Mold	pit	5215-5070	LBK	älteste LBK	2.2	1.85	0.3	0.6105	103	168.7142
480	Mold	pit		LBK	älteste LBK	4.05	2.5	0.45	2.278125	96	42.13992
481	Mold	pit		LBK	älteste LBK	2.02	1.75	0.35	0.618625	159	257.0216
482	Mold	pit	5215-5070	LBK	älteste LBK	1.95	1.5	0.37	0.541125	197	364.0564
483	Mold	long pit		LBK	älteste LBK	1.52	1.2	0.26	0.23712	25	105.4318
504	Mold	long pit		LBK	älteste LBK	2	1.65	0.45	0.7425	59	79.46128
556	Mold	pit		LBK	älteste LBK	2.15	1.25	0.27	0.362813	153	421.7054
557	Mold	long pit		LBK	älteste LBK	4.7	1.65	0.62	2.40405	224	93.1761
558	Mold	pit		LBK	älteste LBK	5.95	2.05	0.45	2.744438	271	98.74519

559	Mold	pit	5310-5140	LBK	älteste LBK	6.65	3.3	0.35	3.840375	799	208.0526
560	Mold	long pit		LBK	älteste LBK	4.7	1.8	0.42	1.7766	200	112.5746
591	Mold	pit		LBK	älteste LBK	4.1	1.25	0.28	0.7175	3	4.181185
634	Mold	long pit	5215-5070	LBK	älteste LBK	1.7	1.3	0.6	0.663	9	13.57466
640	Mold	long pit	5210-5040	LBK	älteste LBK	7.25	2.85	0.35	3.615938	68	18.80563
645	Mold	pit		LBK	älteste LBK	1.92	1.5	0.75	1.08	92	85.18519
647	Mold	pit		LBK	älteste LBK	1	0.88	0.55	0.242	4	16.52893
648	Mold	long pit		LBK	älteste LBK	1.6	1.37	0.32	0.35072	10	28.51277
681	Mold	long pit	5210-5040	LBK	älteste LBK	14.7	3.5	0.45	11.57625	156	13.47587
692	Mold	pit		LBK	älteste LBK	3.95	2.55	0.42	2.115225	288	136.1557
693	Mold	long pit	5200-5010	LBK	älteste LBK	3.8	1.6	0.22	0.6688	3	4.485646
695	Mold	long pit		LBK	älteste LBK	5	4	0.4	4	187	46.75
696	Mold	pit	5200-5010	LBK	älteste LBK	5.5	4	0.4	4.4	907	206.1364
697	Mold	long pit	5200-5010	LBK	älteste LBK	4.15	3	0.45	2.80125	303	108.166
753	Mold	pit		LBK	älteste LBK	1.1	0.45	0.23	0.056925	6	105.4018
754	Mold	pit	5200-5010	LBK	älteste LBK	3.95	1.45	0.25	0.715938	7	9.77739
768	Mold	pit		LBK	älteste LBK	1.95	1.65	0.18	0.289575	2	6.906674
784	Mold	long pit	5200-5010	LBK	älteste LBK	8.8	3.55	0.43	6.7166	568	84.5666
785	Mold	pit		LBK	älteste LBK	4.65	2.25	0.4	2.0925	26	12.42533
786	Mold	long pit	5200-5010	LBK	älteste LBK	9.55	7	0.48	16.044	1161	72.3635
788	Mold	long pit		LBK	älteste LBK	3.85	3.8	0.45	3.29175	127	38.5813
789	Mold	pit		LBK	älteste LBK	1.75	1.25	0.14	0.153125	1	6.530612
845	Mold	pit		LBK	älteste LBK	2	1.65	0.12	0.198	1	5.050505

846	Mold	pit	5200-5010	LBK	älteste LBK	9.2	3.3	0.45	6.831	405	59.28854	
847	Mold	pit		LBK	älteste LBK	6.15	4.4	0.38	5.1414	336	65.35185	
911	Mold	pit		LBK	älteste LBK	4.25	3.3	0.3	2.10375	1544	733.9275	
912	Mold	long pit		LBK	älteste LBK	8	4.8	0.54	10.368	285	27.48843	
940	Mold	pit		LBK	älteste LBK	7.3	3.3	0.45	5.42025	425	78.40967	
1	Neckenmarkt			LBK	älteste LBK	14	6.5	0.6	27.3	2788	102.1245	Guzman 2004; Lenneis and Lüning 2001
17	Neckenmarkt			LBK	älteste LBK	2.9	2.3	0.6	2.001	175	87.45627	
43	Neckenmarkt			LBK	älteste LBK	3.55	1.8	0.4	1.278	17	13.30203	
45	Neckenmarkt			LBK	älteste LBK	1.5	0.95	0.22	0.15675	4	25.51834	
99	Neckenmarkt			LBK	älteste LBK	3.6	2.55	0.28	1.2852	88	68.47183	
100	Neckenmarkt			LBK	älteste LBK	4	1.9	0.3	1.14	399	350	
101	Neckenmarkt			LBK	älteste LBK	7.65	3	0.3	3.4425	195	56.64488	
112	Neckenmarkt			LBK	älteste LBK	1.35	1.25	0.2	0.16875	23	136.2963	
119	Neckenmarkt			LBK	älteste LBK	1.65	1.5	0.23	0.284625	11	38.64734	
167	Neckenmarkt			LBK	älteste LBK	1	0.5	0.18	0.045	5	111.1111	
208	Neckenmarkt			LBK	älteste LBK	2.75	1.3	0.18	0.32175	6	18.64802	
231	Neckenmarkt			LBK	älteste LBK	8.25	1.5	0.2	1.2375	1	0.808081	
6	Neckenmarkt			LBK	älteste LBK	4.08	1.9	0.3	1.1628	32	27.51978	
13	Neckenmarkt			LBK	älteste LBK	3	1.7	0.4	1.02	29	28.43137	
37	Neckenmarkt			LBK	älteste LBK	13	4	0.4	10.4	624	60	
102	Neckenmarkt			LBK	älteste LBK	3.9	3.1	0.4	2.418	943	389.9917	
107	Neckenmarkt			LBK	älteste LBK	4.7	3.6	0.58	4.9068	31	6.317763	
108	Neckenmarkt			LBK	älteste LBK	1.3	1.2	0.16	0.1248	69	552.8846	
14	Neckenmarkt			LBK	älteste LBK	10.8	2.4	0.4	5.184	600	115.7407	
39	Neckenmarkt			LBK	älteste LBK	5.55	2.9	0.35	2.816625	199	70.65193	
16	Neckenmarkt			LBK	älteste LBK	9.6	6.3	0.7	21.168	1253	59.19312	
113	Neckenmarkt			LBK	älteste LBK	3.5	2.9	0.5	2.5375	256	100.8867	
C	Niederhummel	pit complex		LBK	mittel LBK	6.5	2.5	0.55	4.46875	144	32.22378	Pechtl and Hofmann 2016;

E	Niederhummel	pit complex		LBK	älteste LBK	5.3	4.8	0.61	7.7592		181	23.32715	Hofmann, personal communication
F	Niederhummel	long pit		LBK	älteste LBK	6.6	2.1	0.4	2.772		150	54.11255	
G	Niederhummel	long pit		LBK	älteste LBK	7.5	2.2	0.3	2.475		280	113.1313	
127	Schwanfeld	pit		LBK	älteste LBK	4.13	2.52	0.9	4.68342		32	6.832614	Fröhlich 2012; Stäuble 2005
353	Schwanfeld	pit		LBK	älteste LBK	7.41	3.24	0.72	8.643024		63	7.289115	
624	Schwanfeld	pit		LBK	älteste LBK	6.74	3.44	0.83	9.622024		78	8.106403	
665	Schwanfeld	pit		LBK	älteste LBK	3.7	2.72	0.96	4.83072		114	23.59897	
857	Schwanfeld	pit		LBK	älteste LBK	3.7	1.86	0.63	2.16783		23	10.60969	
H6	Schwanfeld	long pit		LBK	älteste LBK	15.58	4.83	0.55	20.69414		105	5.073901	
H8	Schwanfeld	long pit		LBK	älteste LBK	5.3	1.92	0.61	3.10368		598	192.6745	
H9	Schwanfeld	long pit		LBK	älteste LBK	7.37	3.27	0.8	9.63996		265	27.48974	
H11	Schwanfeld	long pit		LBK	älteste LBK	29.79	2.8	0.58	24.18948		697	28.81418	
H12	Schwanfeld	long pit		LBK	älteste LBK	13.47	3.6	0.49	11.88054		390	32.82679	
H14	Schwanfeld	long pit		LBK	älteste LBK	7.21	1.43	0.5	2.577575		93	36.08042	
H15	Schwanfeld	long pit		LBK	älteste LBK	20.28	2.68	0.52	14.1311		707	50.03148	
H16	Schwanfeld	long pit		LBK	älteste LBK	17.59	4.69	1	41.24855		498	12.07315	
H18	Schwanfeld	long pit		LBK	älteste LBK	10	1.95	0.65	6.3375		279	44.02367	
H19	Schwanfeld	long pit		LBK	älteste LBK	8.13	2.1	0.67	5.719455		238	41.61236	
5	Strögen	long pit	5570-4970	LBK	älteste LBK	2.8	1.7	0.45	1.071		631	589.169	Lenneis and Lüning 2001
6	Strögen	long pit		LBK	älteste LBK	10.7	3.5	0.7	13.1075		378	28.83845	
10	Strögen	long pit		LBK	älteste LBK	4	2	0.25	1		90	90	
34	Strögen	long pit		LBK	älteste LBK	3	2.7	0.15	0.6075		53	87.2428	
41	Strögen	long pit		LBK	älteste LBK	8.4	3.2	0.63	8.4672		7	0.82672	
TI2	Szentgyörgyvölgy–Pityerdomb	pit		TLBK	Transdanubian Linear Pottery	2.4	1.5	0.72	1.296		795	613.4259	Bánffy 2004
TI3	Szentgyörgyvölgy–Pityerdomb	pit		TLBK	Transdanubian Linear Pottery	4.6	3.5	0.84	6.762		744	110.0266	
TI4	Szentgyörgyvölgy–Pityerdomb	pit		TLBK	Transdanubian Linear Pottery	2.3	1.5	0.92	1.587		63	39.69754	

TI5	Szentgyörgyvölgy–Pityerdomb	pit		TLBK	Transdanubian Linear Pottery	1.6	1.6	0.63	0.8064	277	343.502
TI7	Szentgyörgyvölgy–Pityerdomb	pit		TLBK	Transdanubian Linear Pottery	1.5	1.2	0.48	0.432	176	407.4074
TI8	Szentgyörgyvölgy–Pityerdomb	long pit		TLBK	Transdanubian Linear Pottery	2.3	1.1	0.92	1.1638	321	275.8206
TI9	Szentgyörgyvölgy–Pityerdomb	long pit	5490-5320	TLBK	Transdanubian Linear Pottery	3.5	1.1	0.8	1.54	552	358.4416
TI11	Szentgyörgyvölgy–Pityerdomb	pit		TLBK	Transdanubian Linear Pottery	4	1.6	0.7	2.24	890	397.3214
TI12	Szentgyörgyvölgy–Pityerdomb	long pit		TLBK	Transdanubian Linear Pottery	2.8	0.7	1.18	1.1564	883	763.5766
TI14	Szentgyörgyvölgy–Pityerdomb	pit		TLBK	Transdanubian Linear Pottery	2.2	1.8	0.72	1.4256	396	277.7778
TI15	Szentgyörgyvölgy–Pityerdomb	pit		TLBK	Transdanubian Linear Pottery	2.4	1.7	0.7	1.428	383	268.2073
TI16	Szentgyörgyvölgy–Pityerdomb	long pit		TLBK	Transdanubian Linear Pottery	3.2	1.4	0.73	1.6352	238	145.5479
TII13	Szentgyörgyvölgy–Pityerdomb	long pit		TLBK	Transdanubian Linear Pottery	3.6	1.3	1.03	2.4102	968	401.6264
TII17	Szentgyörgyvölgy–Pityerdomb	pit	5480-5320	TLBK	Transdanubian Linear Pottery	1.7	1.6	0.53	0.7208	594	824.0844
TII18	Szentgyörgyvölgy–Pityerdomb	pit	5620-5470	TLBK	Transdanubian Linear Pottery	1.6	1.4	0.53	0.5936	217	365.566
TII19	Szentgyörgyvölgy–Pityerdomb	pit	5480-5300	TLBK	Transdanubian Linear Pottery	3.7	3.3	1.09	6.65445	120	18.03305
TII20	Szentgyörgyvölgy–Pityerdomb	pit	5480-5320	TLBK	Transdanubian Linear Pottery	0.85	0.85	0.7	0.252875	738	2918.438
TII21	Szentgyörgyvölgy–Pityerdomb	long pit	5480-5320	TLBK	Transdanubian Linear Pottery	3.7	1.5	0.67	1.85925	323	173.726
TII24	Szentgyörgyvölgy–Pityerdomb	pit		TLBK	Transdanubian Linear Pottery	1.6	1	0.74	0.592	522	881.7568
TII25	Szentgyörgyvölgy–Pityerdomb	pit		TLBK	Transdanubian Linear Pottery	2.3	1.4	0.82	1.3202	241	182.5481

TII26	Szentgyörgyvölgy–Pityerdomb	pit		TLBK	Transdanubian Linear Pottery	2.2	1.4	0.53	0.8162	156	191.1296	
TII27	Szentgyörgyvölgy–Pityerdomb	long pit		TLBK	Transdanubian Linear Pottery	7	1.65	1.27	7.33425	1003	136.7556	
TII29	Szentgyörgyvölgy–Pityerdomb	long pit		TLBK	Transdanubian Linear Pottery	3.3	1	0.97	1.6005	411	256.7948	
TII30	Szentgyörgyvölgy–Pityerdomb	pit		TLBK	Transdanubian Linear Pottery	2.6	2.5	0.86	2.795	2083	745.2594	
TII31	Szentgyörgyvölgy–Pityerdomb	pit		TLBK	Transdanubian Linear Pottery	1.6	1.3	0.8	0.832	864	1038.462	
4	Szentpéterszeg-Körtvélyes	pit complex		SKC	Körös	9	4	1.55	27.9	2000	71.68459	Kalicz 2012
C2/2005	Tășnad Sere	pit		SKC	Criș IIIB/IVA	7	5.1	1.3	23.205	2424	104.4602	
7/UCLT1	Tășnad Sere	pit		SKC	Criș IIIB/IVA	2.48	1.81	0.45	1.00998	809	801.006	
10	Teleor003-Măgura Buduiasca			SKC	Criș IIIB	0.5	0.6	0.7	0.105	29	276.1905	
12	Teleor003-Măgura Buduiasca			SKC	Criș IIIB	1.1	0.65	0.2	0.0715	59	825.1748	
13	Teleor003-Măgura Buduiasca		5791-5707	SKC	Criș IIIB	3.8	2.7	1	5.13	1366	266.2768	Andreescu *et al.* 2003; Thissen 2009; 2012; Van As 2010; Van As *et al.* 2004
18	Teleor003-Măgura Buduiasca			SKC	Criș IIIA	2.8	2.5	0.6	2.1	382	181.9048	
19	Teleor003-Măgura Buduiasca			SKC	Criș IIIB	1	0.8	0.3	0.12	137	1141.667	
35	Teleor003-Măgura Buduiasca			SKC		2.7	1.7	0.5	1.1475	794	691.939	
B5	Teleor003-Măgura Buduiasca	oval pit		SKC		2.3	2.3	1.1	2.9095	450	154.6658	
6	Tiszaszőlős-Domaháza-puszta	pit	5850-5730	SKC	Körös/Szatmár	9	7.5	2	67.5	3438	50.93333	Domboróczki 2010
164	Turdaș-Luncă	pit		SKC	Criș IC	2.6	1.8	0.3	0.702	404	575.4986	Luca *et al.* 2012
32	Weisweiler 111	pit		LBK	mittel LBK	7.15	3.28	0.44	5.15944	2	0.387639	Rück 2007
16	Weisweiler 111	long pit		LBK	mittel LBK	4	1.33	0.44	1.1704	12	10.2529	

42	Weisweiler 111	pit	LBK	mittel LBK	22.3	0.66	0.68	5.00412		9	1.798518
53	Weisweiler 111	long pit	LBK	mittel/jünger LBK	5.69	2.9	0.44	3.63022		8	2.203723
219	Weisweiler 111	pit	LBK	mittel LBK	1.42	1.25	0.44	0.3905		9	23.04738
237	Weisweiler 111	long pit	LBK	mittel/jünger LBK	6	1.68	0.44	2.2176		5	2.25469
254	Weisweiler 111	long pit	LBK	ältere LBK	12	2.75	0.44	7.26		39	5.371901
240	Weisweiler 111	long pit	LBK	ältere LBK	3.16	1.96	0.44	1.362592		13	9.54064
356	Weisweiler 111	pit	LBK	mittel LBK	2.75	1.69	0.44	1.02245		1	0.978043
357	Weisweiler 111	pit	LBK	mittel LBK	3.27	1.72	0.44	1.237368		2	1.616334
385	Weisweiler 111	pit	LBK	mittel LBK	4.89	4.66	0.44	5.013228		41	8.178363
461	Weisweiler 111	pit	LBK	mittel LBK	2.7	2.81	0.44	1.66914		3	1.797333
462	Weisweiler 111	long pit	LBK	mittel LBK	3.6	2.73	0.44	2.16216		1	0.4625
464	Weisweiler 111	pit	LBK	mittel LBK	3.83	4.06	0.44	3.420956		2	0.584632
744	Weisweiler 111	long pit	LBK	ältere LBK	5.76	1.48	0.44	1.875456		4	2.132815
876	Weisweiler 111	pit	LBK	ältere LBK	1.89	1.89	0.44	0.785862		2	2.544976
997	Weisweiler 111	pit	LBK	mittel LBK	3.24	3.15	0.44	2.24532		4	1.781483
1032	Weisweiler 111	pit	LBK	mittel LBK	2.56	1.96	0.44	1.103872		52	47.10691
1056	Weisweiler 111	pit	LBK	mittel LBK	4.97	5.91	0.44	6.461994		14	2.166514
1099	Weisweiler 111	pit	LBK	mittel LBK	1.94	1.81	0.44	0.772508		12	15.53382

Table A9.11: Data on the accumulation of finds per pit feature used for Figure 7.81. Data from sites in Last (1995) only contained information on the number of sherds and density of sherds per pit feature, this includes: Bruchenbrücken, Březno and Miskovice. LBK = Linierbandkeramik, SKC = Starčevo-Körös-Criş, TLBK/TLP = Transdanubian Linear Pottery, nn = not labelled.

Appendix 9. Wear Analysis with full description

A9.1 Tășnad Sere

Table 8.1 displays the information recorded for all fragments displaying traces of wear at Tășnad Sere, which add up to 20 sherds. Categories A, E, K, L, H, and U are represented in the assemblage from C2/2005, with a clear predominance of the first of these categories. In comparison, only category A fragments were identified in contexts from UCLT1.

A9.1.1 Pit C2/2005

The macroscopic examination of the 2418 fragments composing the sampled C2/2005 assemblage, identified only 12 fragments with unequivocal evidence for use. Four types of wear mechanisms were identified: percussion, smoothing/scraping/sliding, drilling and refiring.

A9.1.1.1 Percussion: category K

Percussion have been inferred from pedestal fragment 774, which appears to have been purposely rounded. Its rough edges were formed by chipping or retouching of a pedestal base, as indicated by the negative scars around the edges of the potsherd (Figure 8.9a). The position of the negative scars suggests the sherd was struck from different directions. Unfortunately, no traces of use-related wear were found, and so its role in social practices is hard to determine.

A9.1.1.2 Smoothing, scraping or sliding: categories A, H and L

Fragments were also found abraded to form rounded shapes (Figure 8.9b and c; category L). Base fragments 773 and 1762 show abrasion on parts of their fracture surfaces (Figure 8.9b and c). While the methods of manufacturing of these potsherds is clear, their uses are difficult to determine, as no use-related wear was observed. Potential uses include a support for potting or use as an anvil or hammer during pottery manufacture (*e.g.* Gosselain 2010, 679–680); if paddle-and-anvil techniques were used at the site as seen in some *Starčevo* sites in west Hungary (Gomart 2016).

Five fragments in context C2/2005 exhibit use-wear traces on their exterior or fracture surfaces, which correspond to categories A and H. None of these sherds present traces of manufacturing or reformatting, meaning fragments were not pre-prepared before use and their concave edges should be attributed to either use or their breakage pattern.

The fragment from category H (*i.e*. fragment 743) has a localised patch of abrasion on its exterior surface, with some clear striations showing the direction of its use perpendicular to the vessel's mouth (Figure 8.10a). The pedestalled inclusions present on the active surface suggest the abrader was finer than the distance between the mineral inclusions (Skibo 1992, 109), such as clays or fine-grained rocks. Some of the pedestalled inclusions showed striations running in the same direction (Figure 8.10a2). The highly worn active surface and the striations suggest a fine-grained hardened material was worked with this surface. Thus, it is highly likely the fragment was used as a 'smoother' during the surface finishing of vessels (Vieugué 2015, 95) in leather hard or even fired state. The small amount of quartz inclusions on the pots being formed would have left their marks on the inclusions of the smoother. Furthermore, the original surface of fragment 743 appears to have been exceptionally smooth and maybe burnished, which would have made it a suitable surface for evening out other vessels' surfaces during manufacture.

All fragments from category 'A' have traces of abrasion and smooth textures on portions of their fracture surfaces (fragments 380, 633, 645, 725, 772, 1681). Another common trace were grain pullouts in their fracture surfaces. Since grinding often causes microcracking as well, sliding is the more likely process. The pulling out of grains could be also related to adhesive wear, suggesting that a sticky substrate was worked. Striations, while very difficult to identify due to modern washing, were mostly detected at the interstice between exterior and fracture surfaces. The main differences between the five fragments ascribed to category 'A' lie in their section and shape. While fragments 380 and 645 possessed a straight section (see example in Figure 8.10b), fragments 633, 725, and 772 (Figure 8.10c) had a convex-shaped worked edge (resembling a scraper) and a rounded edge section. These section shapes can be informative on the gestures involved in the use of these fragments. While straight section implies positioning the fragment at a 90° angle to the worked surface (Vieugué 2010, 718), a rounded section implies the fragment was used at different inclinations to the worked material, like for example following the curvature of a pot when removing excess clay (Figure 8.23). Lastly, fragment 1681 shared most of the features of fragments 633, 725 and 772, but the worked area of the fracture surface was restricted to the interstice between interior and fracture surface, and thus did not possess an entirely rounded section. Hence, the fragment must have been solely used at a sharp angle to the worked surface.

Of the six fragments from category 'A', fragments 633, 725, 772, and 1681 are likely to have been scrapers or ribs for modelling pots when clays are still wet, as suggested by grain pullouts, diffuse boundaries, and the overall plan and section shapes of the sherds. The remaining fragments 380 and 645 are difficult to classify, but straight sections can suggest smoothing or levelling out protuberances could have been performed on pots in leather hard state (*e.g*. Crandell *et al.* 2015), which is also supported by the 'clear' outline of wear observed for fragments 380 and 645.

A9.1.1.3 Drilling: category E

Fragment 1 had both blind- and through-holes (category E). The blind-hole was found at the centre of the fragment (Figure 8.11a). One important trace was the presence of striations on the outer rim of the hole where part of the slip on the interior surface of the vessel was removed. These striations suggest rotational movement was involved. On the lower part of this outer rim two cracks were also visible, suggesting an origin from the drilling process. At the bottom of the blind-hole, four lateral cracks are found emanating radially from a centre, which suggests a point of crack origin (Figure 8.11a2). These types of cracks are characteristic of an indentation with a sharp object, and are commonly observed in most standardized indentation tests like Vikers or Knoop (McColm 1990, 146, 148).

Striations viewed in the normals plot are regularly spaced and make up a complete ring-shaped pattern across the perforation wall (Figure 8.12). The latter is also visible in the graph displaying the variation of depth (Figure 8.13). The presence of rotational striations already indicates the use of a glass or lithic perforator, and the way they are spaced suggests some support could have been used to manufacture the specimen, such as a rod or a bow-drill. Lastly, plots of the centre and the aspect ratio of the perforation according to depth display very flat curves (Figure 8.14), which supports the contention that the perforation must have been done using a support.

The second perforation (Figure 8.11b) completely pierces the fragment and has a biconical section, showing a mismatch between perforations. However, the through-hole was fractured in half. This is not unexpected, as it is well known that flaws, voids or, to an extent, holes act as stress concentrators where fractures can form (Rice 1987, 362). Some striations are visible on the perforation wall, suggesting a lithic or glass perforator was utilised for drilling. While the 3D model could not be rendered for reasons mentioned above, the mismatch between perforations is suggestive of hand-drilling.

In sum, the perforations in fragment 1 shows two different processes during drilling of both perforations. Traces of the through-hole on the edges of the fragment suggested it was created during vessel repair. However, the blind-hole in the centre of the internal surface of the fragment seems to be the product of a later operation once the repaired pot had broken. This is suggested by the overall stability showed in the drilling of this perforation, which would require the use of a rod-drill and would, therefore, be difficult if the pot were still in one piece. Therefore, the fragment shows how a vessel was repaired, and upon breakage fragment 1 was salvaged for the manufacture of another tool, maybe a spindle whorl. This is suggested by the central location the perforation occupies in the fragment, and the flatness of the sherd.

A9.1.1.4 Refired fragments: category U

Around 145 fragments (around 6% of the sampled assemblage from C2/2005) show heavy traces of refiring, such as: clear change in colouration, bloating and deformation (Figures 8.17 and 8.18). The colour of fragments was the main indicator of refiring (Figure 8.17), of which five fragments were completely grey. Some grey fragments from Tășnad Sere reflect temperatures above 1000°C (Sommer *et al.* 2019, Figure 5). Other high temperature signatures include sherds with pumiceous texture, signs of bloating, and a single case of thermal-elastic deformation (Figure 8.18b). A complete pedestal (fragment 878), was completely refired, as indicated by its reddish colour, and several radial cracks on its bottom (blue arrows in Figure 8.18). The extent of the colour indicates the whole fragment was submitted to firing after the vessel had broken. The cracks can also result from thermal stresses when bases are unevenly heated (Chapter 9). When the base is unevenly heated at its centre, a temperature gradient is created to periphery, between an expanding central area being heated and a cooler periphery. Radial cracks are formed relieving these stresses (section 9.2). The geometry of the specimen might also be another contributing factor, as the differences in thickness can make this temperature gradient much worse. The radial cracks would suggest that the pedestal formed part of a vessel that was unevenly heated as part of some intended activity like cooking, and the extent of its colouration change suggests that at some point after the vessel had broken it was entirely positioned over a fire.

In contexts with an oven and pieces of hearth, it is possibly that many of the fragments provided some containment of heat during firing or cooking activities. Powdered X-ray diffraction and thin-section analysis of four pieces of hearth from pit C2/2005 and UCLT1 indicate temperatures around 700°C were reached (Figure 9.3), which is just around the temperatures at which some colouration changes in fragments can occur. For example, one of the dung-tempered specimens in thermal shock tests discussed in Chapter 9 (Figure 9.8f), which was fired at a peak temperature of 800°C, showed colouration changes when repeatedly heated close to that temperature. It is also not uncommon that parts of vessels are found *in situ* inside ovens, for example at Alsónyék-Bátaszék (Bánffy *et al.* 2010, 42) or at Lepenski Vir (Borić and Dimitrijević 2007, 61). Some of the 146 refired fragments could have been part of the base of an oven, as seen at the LBK site of Mohelnice (Thér *et al.* 2019) or in some Vinča sites (Duričić 2014), but unfortunately no contextual information is available to support this claim.

A9.1.2 House H1/UCLT1 and pit fill 7/UCLT1

Seven used fragments were found in UCLT1, five belonging to house H1/UCLT1 and only two from pit fill 7/UCLT1. No reused fragments were found in the outside areas of the house (*i.e.* Out/UCLT1). Only two wear mechanisms could be inferred: smoothing, scraping or sliding, and refiring.

A9.1.2.1 Smoothing, scraping or sliding: category A

Five sherds showed wear traces of smoothing, scraping and/or sliding mechanisms (fragments 3807, 4319, 4811, 5642, 11840). All sherds had smooth surfaces in plan view and fine striations running parallel to vessel wall. Except fragment 4811, all fragments possess diffuse boundaries between worn and unworn areas. Wear striations in fragments 3807, 4319, 5642, and

11840 were found exclusively between exterior and fracture surface and with a rounded section. Fragment 4319, because of the extended use of the fragments edge, the margin between exterior and fracture surfaces became faceted. The combination of diffuse boundaries, faceting, striations and rounded sections all point to the use of fragments as scrapers for working soft materials like wet clay.

Fragment 4811 had wear of the interstice of interior and fracture surfaces, a clear boundary between worn and unworn areas, and a straight section. Fragment 4811 has a shape resembling a potter's rib. The characteristics of this fragment, such as its straight sections and clear boundaries, highlight the fact that relatively hard materials must have been worked, such as pots in leather-hard state.

Only fragments 15825 and 16914 were found with wear traces in pit filling 7/UCLT1, both belonging to category A. The former has a straight section, clear boundaries between worn and unworn areas of the fracture surface, and some faded striations running parallel to vessel wall. Fragment 16914 was rounded in section, had diffused boundaries, and some striations on the fracture surface running against vessel wall. Fragment 15825 was possibly used as a smoother for finishing the surfaces of pots, and fragment 16914 was likely a scraper used at different angles during forming stages of pottery manufacture.

A9.1.2.2 Refiring: category U

79 fragments were found with signs of having been refired, of which 67 were found in the occupation layer and only 12 inside pit fill 7/UCLT1. In house H1/UCLT1, 77 out of the 79 refired sherds have been identified by their colour. 17 were completely grey and two had a pumiceous texture, which suggests a small number of fragments were submitted to very high temperatures. Considering that thin-section and pXRD analysis of hearth fragments showed temperatures reached 700°C, this could explain the colouration changes of refired sherds found at UCLT1. Unfortunately, there were not any other distinguishable traces or patterns displaying the use of fragments for any firing or cooking activities; hence, the intentional reuse of fragments in H1/UCLT1 for cooking activities remains hypothetical at the moment.

A9.2 Méhtelek-Nádas

The only wear traces detected in samples from Méhtelek-Nádas were perforations, *i.e.* through- and blind-holes (category D), from twelve fragments: two of them from pit III and ten from pit 1-3 α. While some of the perforated sherds analysed were already published (Kalicz 2011, 69, 85; Makkay 2007, 206), others were discovered during my analysis of non-diagnostic materials (Figure 8.26).

A9.2.1 Drilling: category D

Rim fragment 11188 was rather crudely drilled from both sides, as there is a substantial mismatch between the perforations made. Both perforations are partial, as the fragment broke through the perforations. Rotational striations are visible throughout the specimen’s through hole (Figure 8.27), indicating the perforation was made with flint, limnic quarzite or obsidian. There are at least three pitted areas showing multiple attempts to drill from the exterior surface (red arrows in Figure 8.27). It seems likely that the sherd was drilled by holding the perforator by hand, suggesting the vessel was still in one piece when the perforations were made.

Pit 1-3α contained a substantial number of drilled sherds, (fragments 10331, 10516, 10791, 10849, 10850, 10851, 10852, 10853, 16616 and 10847; Figure 8.26). The first category D fragment recorded in Pit 1-3α, *i.e*. fragment 10331, is perforated in an unusual location, on the exterior surface of a curved fragment with a lug (Figure 8.26). The absence of the biconical section suggests it was unfinished. Normals obtained through the rendered 3D model of the perforation shows striations across the perforation wall (Figure 8.28), suggesting the use of a lithic or obsidian tool for drilling. The variation of depth plot also displays a marked inflexion point, as signaled by the yellow curve, which confirms this. The yellow curves are unevenly spaced and form incomplete ring patterns (Figure 8.29), suggestive of hand-drilling. Centre and aspect ratio of perforation according to depth displayed in Figure 8.30 also show there was little stability in the drilling of this perforation, as curves are not flat. Thus, it seems the fragment was perforated from its exterior surface by hand, using flint, limnic quartzite or obsidian material to drill.

The through-holes in rim fragments 10516 and 10791 are partially fractured (Figure 8.26), and their biconical section prove that they were drilled from both sides. Three-dimensional reconstructions of these holes were not possible. Fragment 10516 shows signs of rotational striations, with the perforation made from the interior surface of the sherd much longer and wider than its counterpart (Figure 8.31). Fragment 10791 shows some mismatch between perforations but did not show any other significant traces. The lack of traces could be due to its poor preservation.

Fragment 10849 is a rim sherd with a completely preserved through-hole. Its biconical section shows it was drilled from two directions and with mismatch, the perforation created from the interior surface is substantially larger. Normals plots shows several rotational strations on both perforation walls, which indicates lithic or obsidian implements must have been used. 'Variation of depth also signals irregularities of the perforator's edge, but no complete and regularly spaced rings are observed. In the case of the centre/diameter/aspect ratio *vs*. depth plots of the perforation created from the interior surface of the fragment, the steep rise in the start of the curves corresponds simply to a measurement error, as the surface used as the '0' was wrongfully attributed to an area outside the perforation. The aspect ratio of perforation according to depth also highlights a very symmetrical perforation drilled from the interior (Figure 8.34), but deviation from the centre shows a change of direction of the central axis of the perforation. The perforation from the exterior surface of the fragment was definitely created by hand as both curves of centre and aspect ratio according to depth show considerable variation. A residue was also found on the fracture surface being repaired (Figure 8.35), on a topographically high point on the fracture surface. The position of the residue around the rim of the vessel, it is likely to be the result of the addition of some kind of adhesive used during the repair of the vessel, rather than a substance prepared inside the vessel. Thus, it is possible that at least this fragment was detached from the vessel at the time of repair, and then glued on the vessel.

Sherds 10850 and 10851 represent a unique sample to study drilling and repairing of Early Neolithic pottery, as they are conjoining fragments with through-holes (Figure 8.26). In both fragments, the perforations created from the interior surface are wider than their opposing perforation. In fragment 10850, a groove created by wear is observed on the exterior surface between the perforation and the nearest fracture surface. In fragment 10851, a groove is also observed, but on the perforation from the interior surface of the sherd. These grooved areas are visible in the normals plot (arrows in Figure 8.36) and show places where fibres or leather were used to tie both sherds together. A point of tension was created by these fibres between the edge of the perforation on the exterior surface of fragment 10850 and the edge of the perforation on the interior surface of fragment 10851. There are rotational striations showing regularly spaced and fully joined ring patterns in perforations from both fragments (Figure 8.36), but there is some alteration from the wear produced by the material used to bridge the crack. Rotational striations suggest the perforator was made of a lithic or obsidian material with the use of some support like a rod. Variation of depth plots (Figure 8.37) display similar complete and regularly spaced ring patterns, which are more clearly visible on the perforations made from the interior surface of fragments. Finally, the centre and aspect ratio of perforations according to depth (Figure 8.38) show that there is a great amount of stability in all perforations of both fragments, except the one made from the exterior surface of fragment 10850. Reasons for this slight discrepancy in an overall uniform pattern is mostly due to the post-drilling wear created by material used to strap fragments together. Moreover, the almost identical curves in all three plots from Figure 8.38, illustrate the use of the same tool with a support for drilling. In this particular case, drilling from the interior of vessels would be certainly possible, as it has an open V-shaped profile, but judging by the level of uniformity of the drilling sherds must have been detached from the vessel. Unfortunately, the sherds were glued during finds processing, which impaired the identification of residues on the fracture surface that would confirm this claim.

Rim fragment 10852 has a through-hole perforated from exterior and interior surfaces (Figure 8.26), with a biconical section, but there is a big mismatch. The maximum diameter and depth of the perforation from the interior surface is larger than the one from the opposing surface. There is also a groove on the edge of the perforation made from the interior surface of the fragment, which extends to the nearest fracture surface. This is visible on the normal plot, as signaled by the red arrow in Figure 8.39. In this figure, rotational striations are also visible on perforations from both sides, once again suggesting use of stone or glass perforators. The profile of the perforation from the interior surface of the fragment, is slanted and at around 4mm deep it connects with the other perforation. Variation of depth does not show any regularity in the striations formed, which suggests no support was used to make either perforations (Figure 8.40). The inclination of the perforator used in drilling both holes is evident in Figure 8.41. While the aspect ratio of the perforation from the interior surface of the fragment seems to be regular, there is a significant change in perforation's centres according to depth (Figure 8.41), which would rule out any use of support to drill these holes. Furthermore, the similarity in curves in this graph probably indicates that similar techniques and tools were used.

Body fragment 10853 also possesses a complete through-hole close to the edge of the fragment with a biconical section. The interior surface of this fragment has a wider perforation than its opposite and displays a worn area between the perforation made on the exterior surface of the fragment and the closest fracture surface. The normals plot also signals this grooved area (red arrows in Figure 8.42; see also Figure 8.45), and rotational striations are visible, suggesting use of lithic or obsidian perforator. Unfortunately, the perforation seems to have been affected by postdepositional processes and variation of depth could not be calculated through the 3D model. Nonetheless, the centres and aspect ratio of the perforation according to depth certainly rule out the use of a support for drilling (Figure 8.43). Lastly, it is also important to mention the fragment also had some residues on the fracture surface, which could be suggesting the addition of some adhesive to improve mending of the vessel (Figure 8.35).

Two so-called 'rings' were also found (Makkay 2007, 206), fragments 10847 from pit 1-3α and 10848 from pit III. The latter showed traces of heavy abrasion in both the fracture surface and perforation wall of the ring (Figure 8.45, b), which erased most traces of the manufacturing process, such as rotational striations. In contrast, fragment 10847 has a clear biconical section at the perforation, and abrasion is limited to the fracture surface of the fragment. The edges of both fragments are polished, suggesting formation during use (Figure 8.45, a, c-d). It is very difficult to ascertain what role these fragments fulfilled. The polished surface would suggest some rubbing with skin, but the diameter of these fragments is too small to fit an adult's finger. Thus, it could have been part of a necklace, bracelet or maybe earrings.

Rim fragment 16616 is perforated exactly at its centre from both exterior and interior surfaces, with a biconical profile. The normal plots show rotational striations were marked on bot perforations from this fragment and were drilled at a tilted angle (Figure 8.46). Variation of depth shows some of the rotational striations on both perforations are evenly spaced and form complete rings (Figure 8.47), suggesting the use of a support to manufacture them. This is confirmed by the aspect ratio of the perforations according to depth (Figure 8.48). In the same figure, the inclination of the perforations is also visible in the centres of perforation according to depth, where there is a steady increase in the curves of both perforations. The values fall well within the range of rod-drilled tools. The almost identical curves in all the plots from Figure 8.48 is also displaying the same technique and tools were probably used for drilling both holes. Fragment 16616 may be an unfinished spindle whorl, as suggested by the location of the perforation and the drilling technique identified.

A9.3 Eitzum

Among the 3247 sampled, 17 fragments had wear traces and most of them falling into category A (Table 8.2). No pattern was identified in terms of sherd composition or selection of vessel portions.

A9.3.1 Percussion: category K

Fragment 7546 is a rounded body sherd attributed to category K. The potsherd bears several scars from knapping (Figure 8.50). Knapping of the sherd's edges seems to have occurred from several directions in both its interior and exterior surfaces. No use-related wear was identified. Due to the fragment's curvature it could have been intended as a support for rotating pots during potting (*e.g.* Mayor 2010, 651–652).

A9.3.2 Scraping, smoothing or sliding: categories A, L and H

Fragments 7100 and 8734 were rounded by abrasion (category L). Both fragments have a smooth texture and clear outline of wear on fracture surfaces, highlighting that surfaces were abraded against hard materials. 8734 also showed traces of levelled or flattened inclusions in several portions of its fracture surface (Figure 8.51). These traces suggest that both fragments were shaped as the result of manufacture and not the consequence of use. The intended use of the fragments could not be inferred.

Categories A (fragments 8446, 8559, 8560) and the only fragment in this site identified as category H (fragment 8002) were found at WLH1. The latter possessed a very diffuse boundary of wear suggesting soft material was worked, striations on the exterior surface of the fragment running perpendicular to the vessel mouth (blue box in Figure 8.52), and a mineral in this active surface with striations also running in this same direction give some cues on how the fragment was used (red box in Figure 8.52; Plate). The exterior surface of the fragment functioned as a smoother on clay in leather-hard state. Fragments 8446 and 8559 possess similar traces, with smooth surface textures and diffuse outlines of wear (Figure 8.53; Plate), but no striations are visible. Differences between them lie mostly in their edge and profile shape; while number 8446 had a slightly concave edge, the edge of fragment 8559 was slightly convex and highly rounded in section view. Fragment 8446 also shows some faceting, which suggests fragment use was focused on the boundary between interior and fracture surfaces. This indicates use as scrapers on soft materials, most likely for drawing wet clay during pottery manufacture. However, their shape differences show they were moved in different ways: fragment 8559 was moved within a large range of angles, as shown by its rounded section, and fragment 8446 was used exclusively at a sharp angle to the worked surface, as suggested by its faceted section (Figure 8.53). Fragment 8560 differs, as the section shape is considerably straight, and its active surface so worn out that the outline of between worn and unworn areas is unclear (Figure 8.53). It is thus likely that the fragment was used for working harder materials than the other category A fragments, but its actual use is difficult to unravel.

The rest of the fragments identified at Eitzum indicating smoothing, scraping or sliding mechanisms all belong to category A and were all found in zone D, these included: fragments 6133 (feature 10), 6409 (feature 11), 7003 (feature 26) and 6086 from an unknown feature. Fragments 6086 and 6133 possess a very clear boundary between worn and unworn areas in their fracture surface and a straight section, suggesting hard materials must have been worked. Nonetheless, while the former showed striations running perpendicular to vessel wall, in the latter striations ran in opposite direction, *i.e.* parallel to vessel wall (blue box in Figure 8.54). Furthermore, fragment 6086 also had traces of inclusion levelling in the active surface. These fragments were probably used as smoothers on leather-hard or even already dry pots but were used with different gestures.

Fragments 6409 and 7003 had a diffuse boundary between worn and unworn areas on their fracture surfaces. While they were made by working against soft materials, the location of their wear traces suggests different ways of use. Fragment 7003 does not show striations, but the rounded section of its fracture surface suggests the different angles at which the fragment was used (Figure 8.55). In comparison, fragment 6409 shows some very diffuse striations exclusively at the boundary between the interior and fracture surfaces (Figure 8.55). Both potsherds show indication of having performed as scrapers to work wet clays, but their uses differ. While fragment 7003 appears to have been used following the curvature of pots, fragment 6409 was likely used uniquely at a sharp angle, such as when drawing up excess clays in pottery forming stages.

A9.3.3 Drilling: category D

There was only a single perforated fragment present at Eitzum. The wear trace consisted of a through-hole with biconical section suggesting the sherd was drilled from both exterior and interior surfaces. Due to the size of the fragment and the location of the perforation in a marginal area of the sherd, it is likely this fragment was drilled for repair or was broken during manufacture of a tool. Some rotational striations visible on the perforation made from the exterior surface of the fragment, suggest the use of a lithic perforator. No trace of use was visible. Unfortunately, a three-dimensional model of this fragment could not be made, but the mismatch between perforations would suggest the specimen was drilled by hand.

A9.3.4 Grooving or cutting: category J

Cutmarks were found on at least four fragments (Table 8.3). These short parallel cutmarks were found around the edges of the interior surfaces of fragments 7482, 8322, 8695, and 8980 (Figure 8.57), and in certain cases run deep into the sherd. It is possible that more fragments were cut in similar ways at Eitzum and even at Klein Denkte, but these traces were sometimes difficult to distinguish from the eroded elongated pores left by the burnt fibres composing these ceramics. As these grooves are located at the edges of the interior surface and in occasions extending to the fracture surface of fragments, this rules out the possibility of these traces being the result of the manufacture or use of the parent vessels (*i.e*. before primary rupture).

A9.3.5 Refiring: category U

Five fragments bore traces of refiring, all were identified by their colour change. Only one fragment (7570) had extensive colour changes by fire, showing some possibility of use as a heat retainer, support, or cover in firing processes. With the exception of this last fragment, there is little evidence to suggesting the reuse of potsherds as heat retainers or covers in fires. At best, this would seem a rather sporadic role for sherds at the site.

Plates

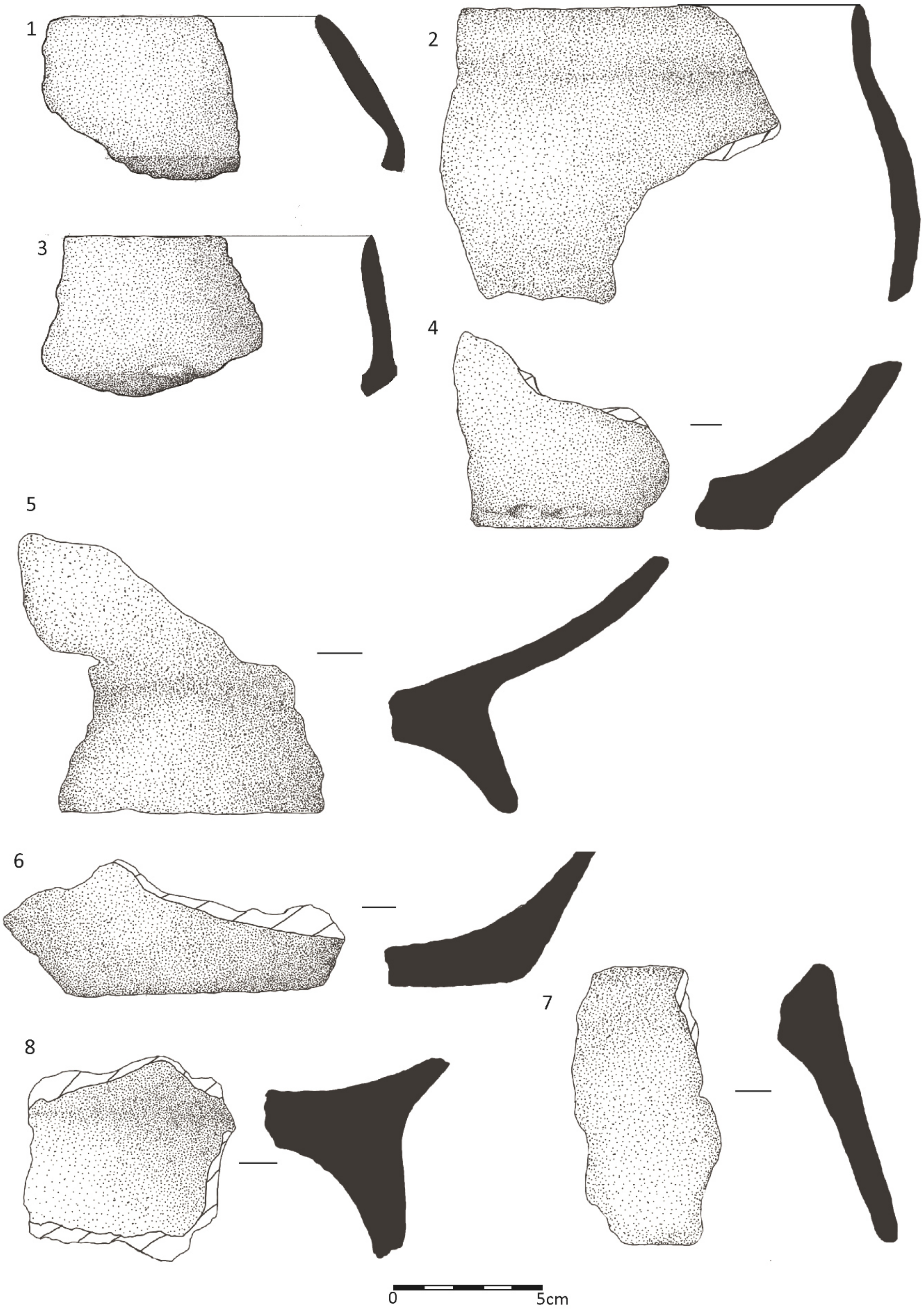


Plate I: Shapes of SKC pots from UCLT1 (Tășnad Sere; Drawings by János Bakai and Bruno Vindrola-Padrós).

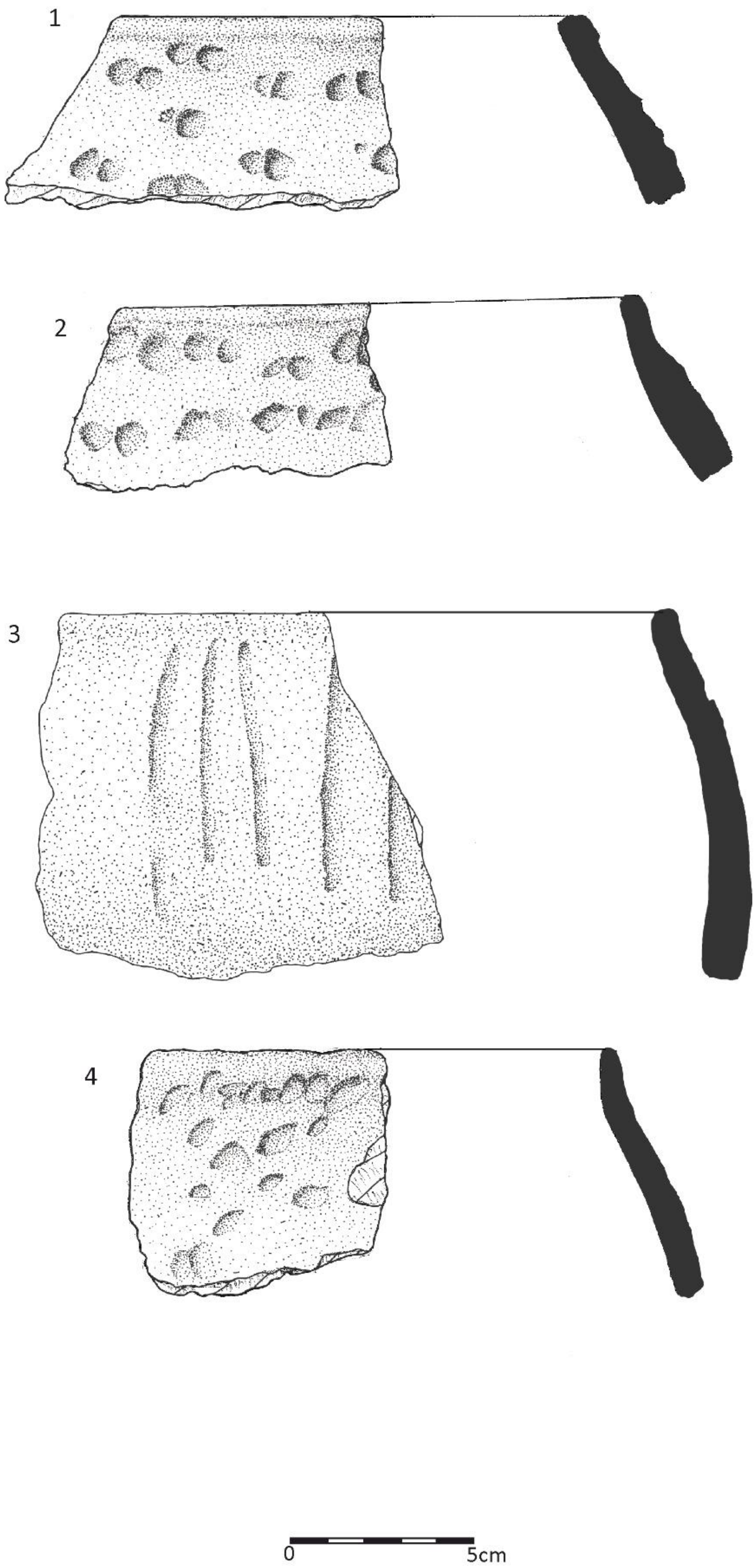


Plate IIXXV: Rim decorations of SKC pots from UCLT1 (Tășnad Sere; Drawings by János Bakai and Bruno Vindrola-Padrós).

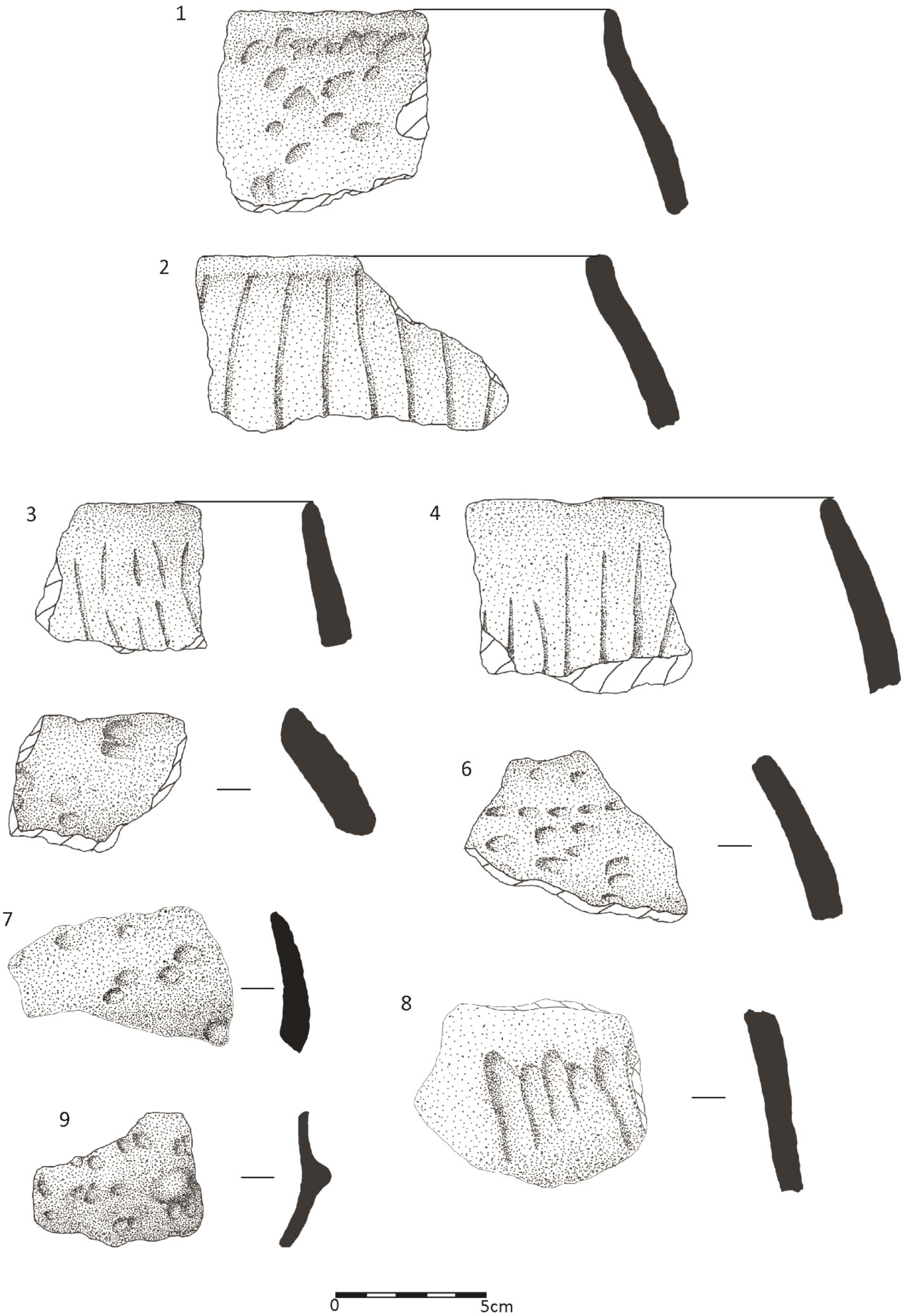


Plate III: More rim decorations of SKC pots from UCLT1 (Tășnad Sere; Drawings by János Bakai and Bruno Vindrola-Padrós).

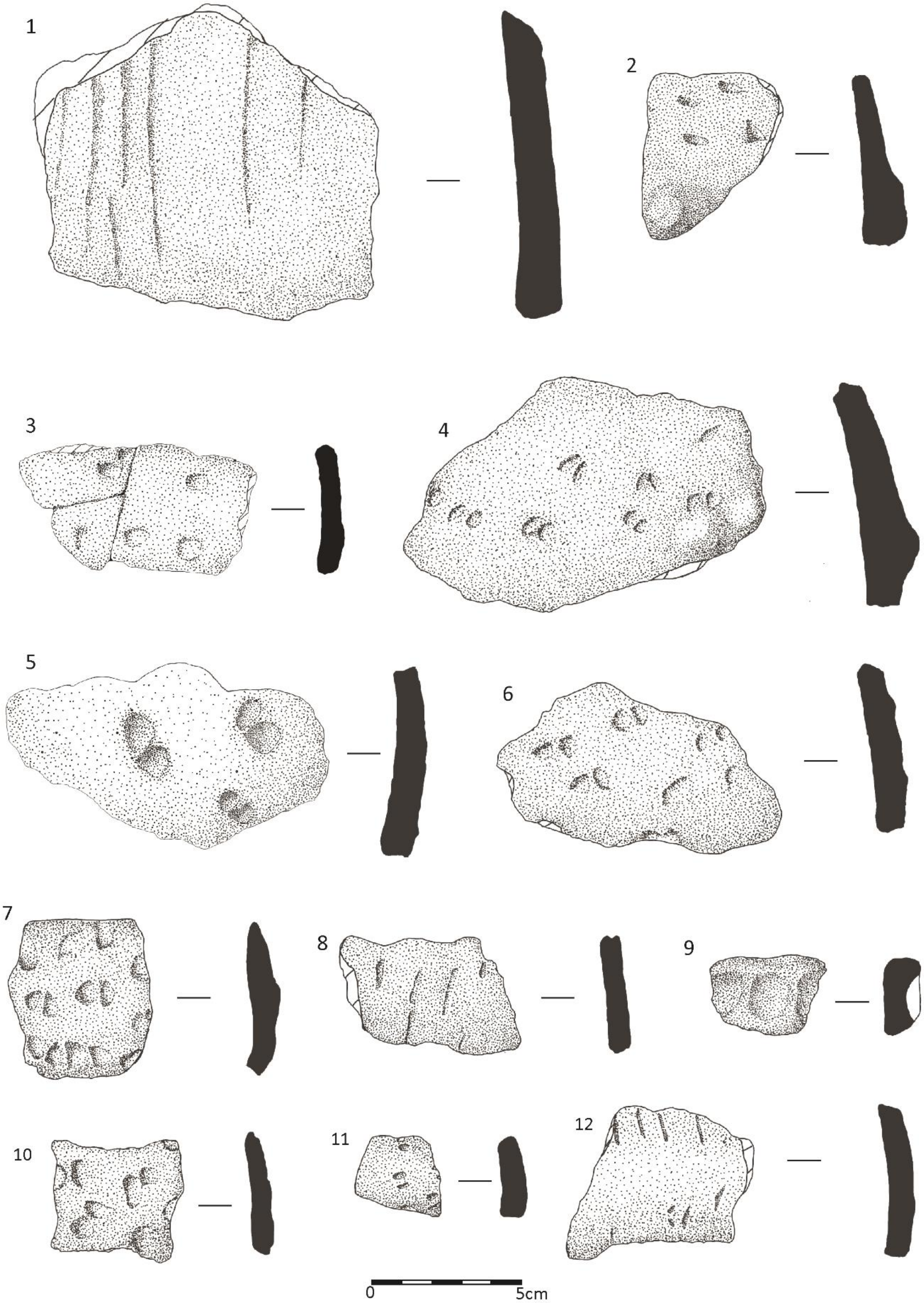


Plate IV: Other decorations of SKC pots from UCLT1 (Tășnad Sere; Drawings by János Bakai and Bruno Vindrola-Padrós).

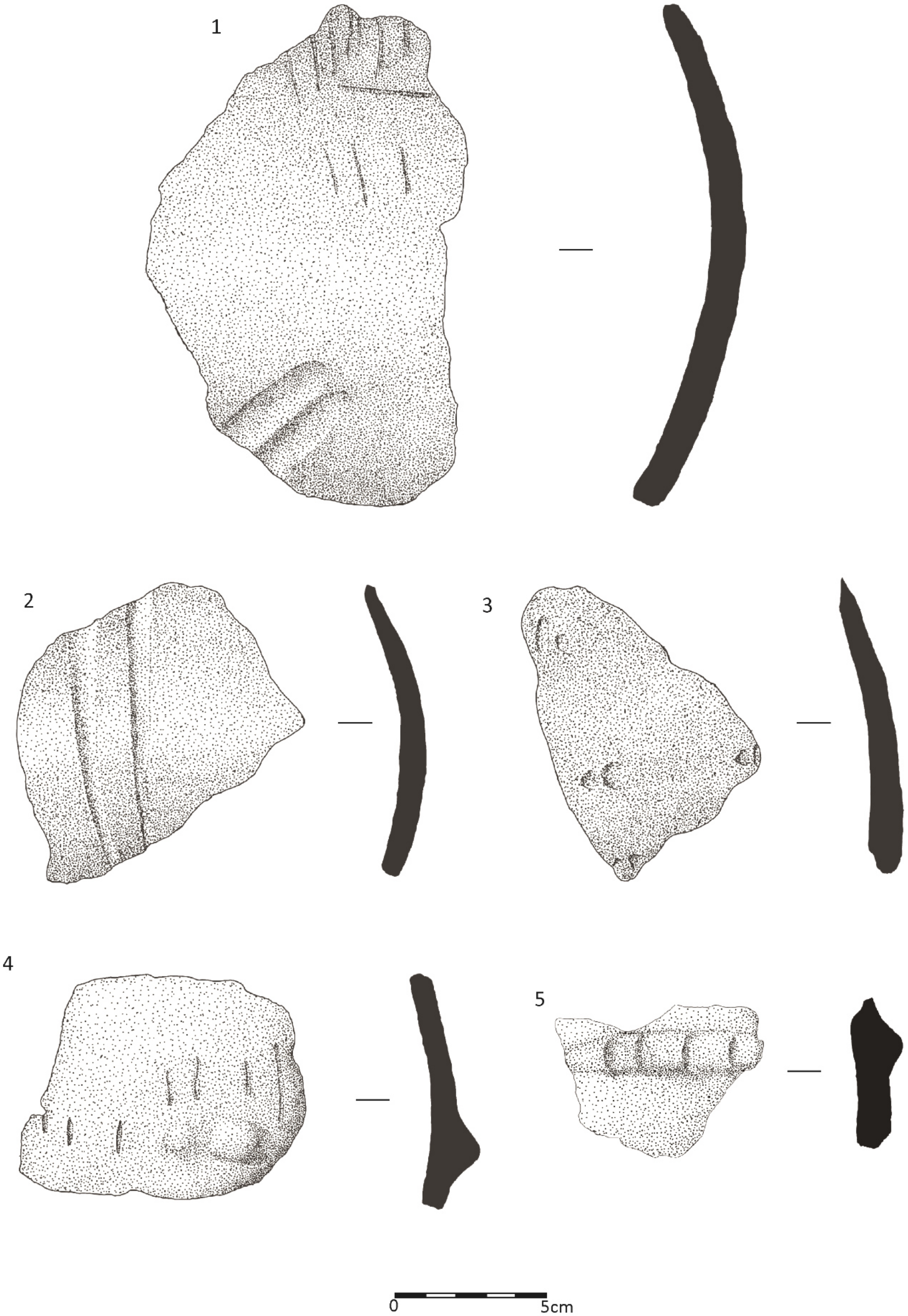


Plate V: Other decorations of SKC pots from UCLT1 (Tășnad Sere; Drawings by János Bakai and Bruno Vindrola-Padrós).

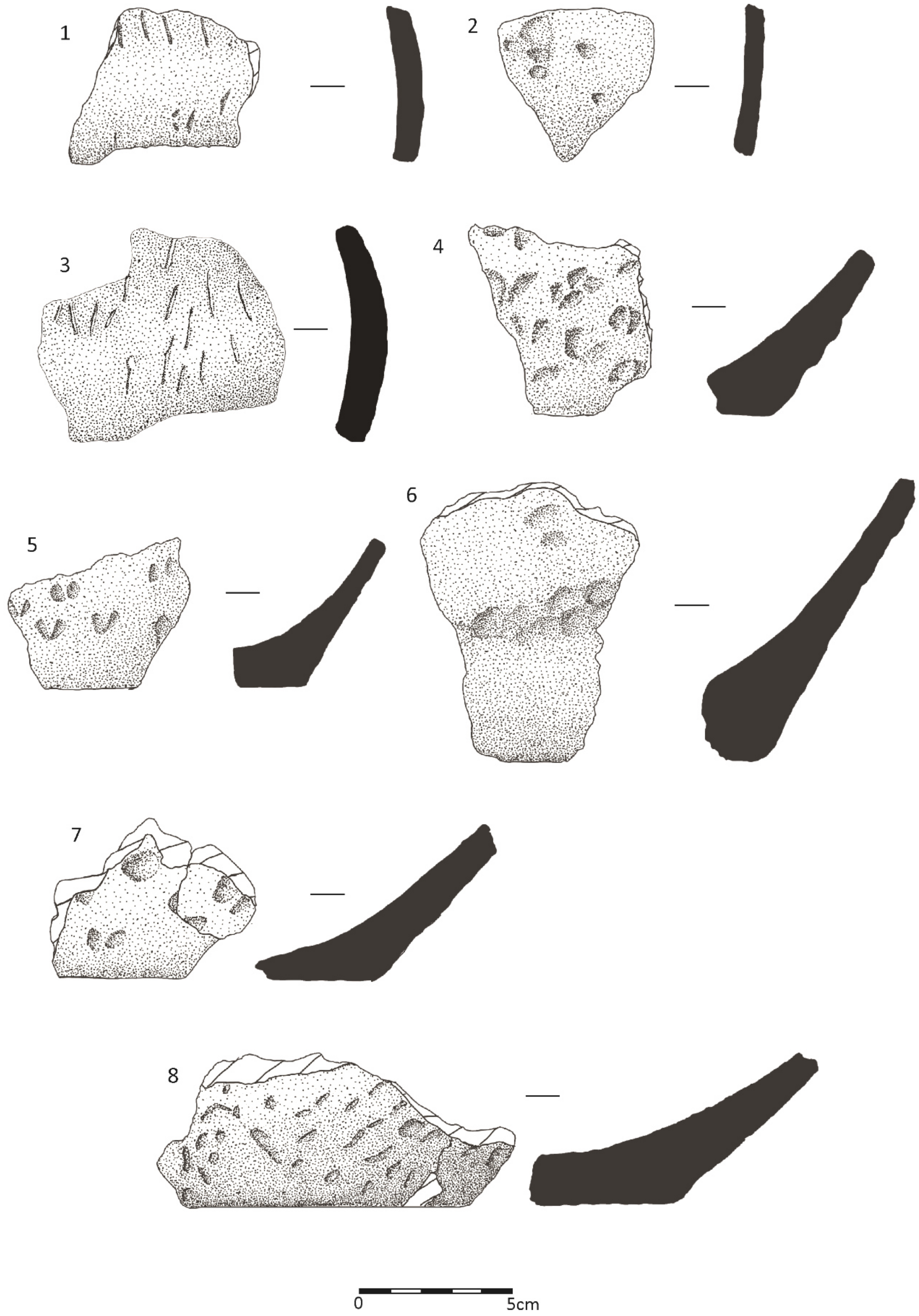


Plate VI: Other decorations of SKC pots from UCLT1 (Tășnad Sere; Drawings by János Bakai and Bruno Vindrola-Padrós).

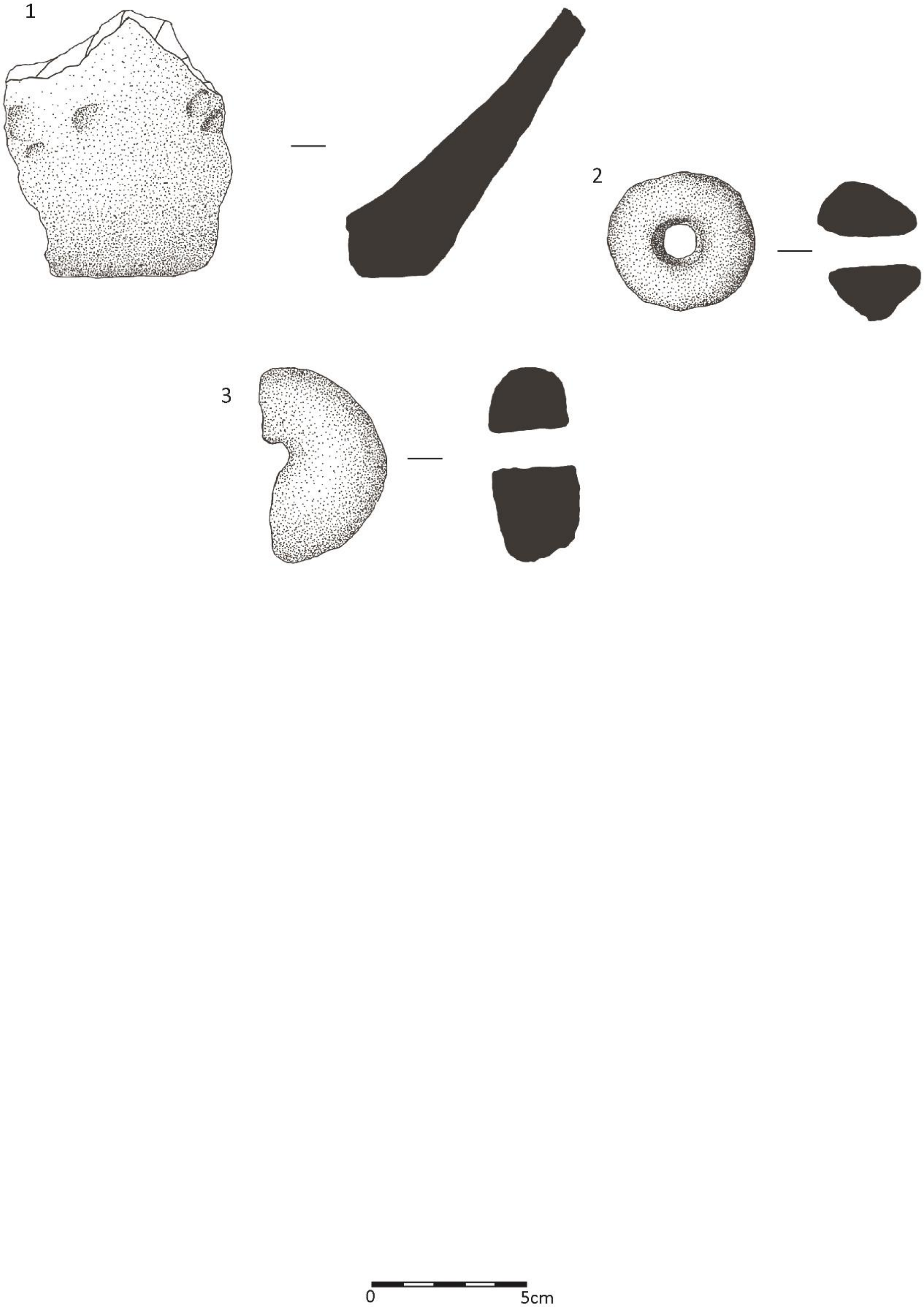


Plate VII: Decorated SKC base sherd and two spindle whorls from UCLT1 (Tășnad Sere; Drawings by János Bakai and Bruno Vindrola-Padrós).

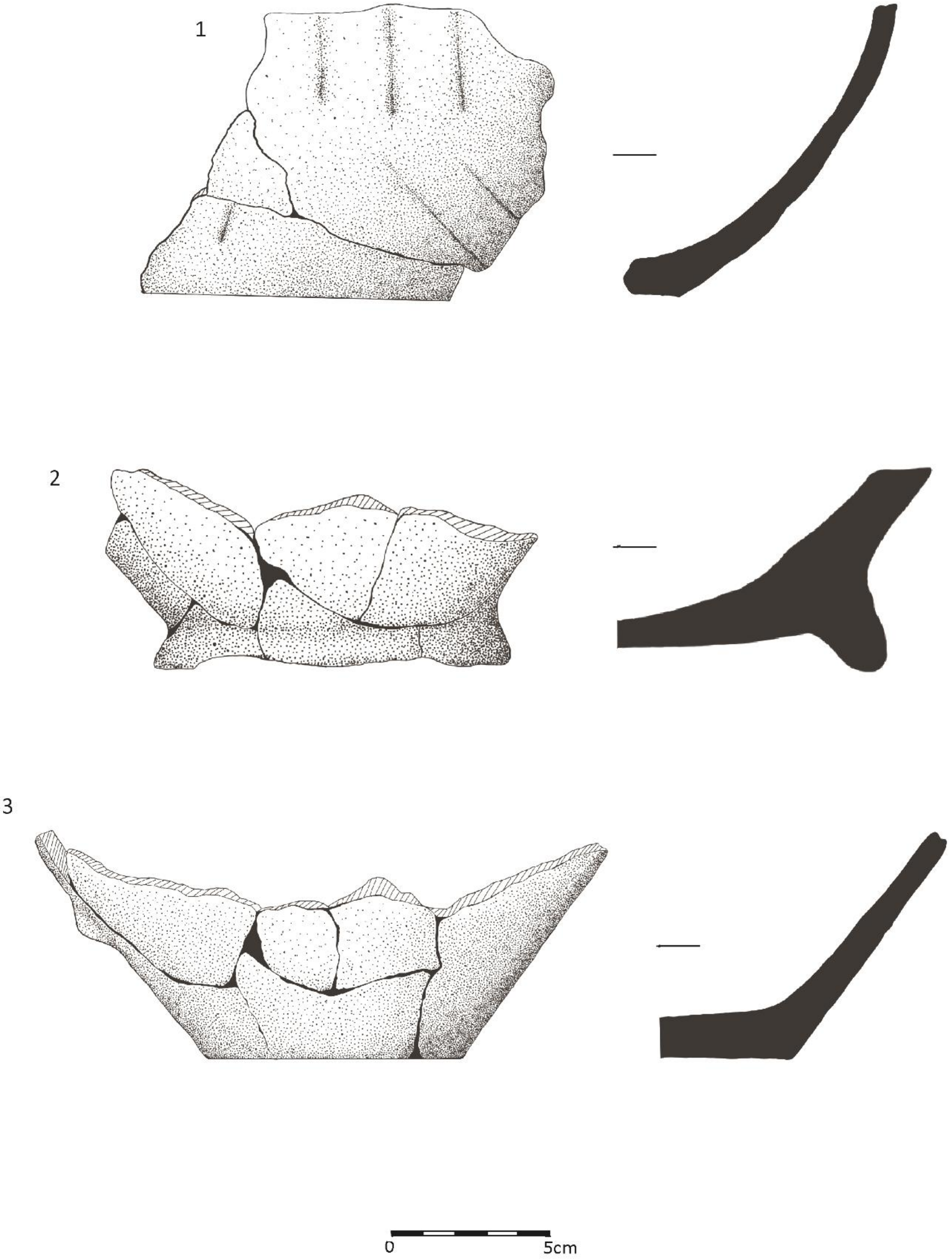


Plate VIII: Vessels found in situ at pit 7/UCLT1 (1 and 2) and at H1/UCLT1 (3; Tășnad Sere).