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EDITORIAL

Welcome to *Lithics* 36.

Since its initial publication in 1980, *Lithics* has evolved from a photocopied newsletter to a peer-reviewed publication with an international readership. I am pleased to say that *Lithics* 36 represents a new iteration of the journal as we continue to strengthen our online presence.

This issue of *Lithics* is the first on the new online platform where articles will from now on be published. In addition to creating a better interface for easily accessing articles, the new system streamlines the way in which submissions, peer reviews and eventually formatting are handled.

This is also the first issue of *Lithics* in which articles will be given Digital Object Identifiers (DOIs) that allow the location and metadata to be permanently fixed to the document. Referring to an online document by its DOI provides a more stable way of locating electronic articles for future reference. Additionally, all articles published in previous issues of *Lithics* will be assigned DOIs so that they may continue to inform future research.

The world of publishing is changing and our new online indexing system is only the first step in keeping up with the times. New publications tangent to our mission sprout up every year stimulating our intellect and urging us to remain current. To do our part, a future plan includes creating online-first publications in which scholars can rapidly communicate their peer-reviewed research to colleagues without waiting for the next printing of *Lithics*.

We also hope to take full advantage of our new online publication medium by enabling and encouraging authors to submit supplementary information as well as digital materials such as interactive maps and 3D models. Eventually this change to digital content will provide a

richer, more interactive environment than traditional print versions, an environment that will continue to evolve. Whatever the future holds, we resolve to stay up to date in order to keep *Lithics* relevant.

Please take the time to visit our new website and let us know what you think.

Of course delivery is nothing without content and one thing that we cannot automate is the hard work of our authors, reviewers and editorial staff. This issue's articles, which stretch from the Palaeolithic to the Neolithic and from the New World to the Old, are credits to the breadth of knowledge and hard work of the many different individuals involved. I am certain that you will find the results of their efforts both interesting and stimulating. On behalf of all of us, I extend them a warm thank you.

I would also like to take this opportunity to say thank you to our outgoing assistant editor Lynden Cooper who has been with us for the past year. At the same time, I would like to welcome our new assistant editor (but old friend to *Lithics*) Peter Hoare. Thank you both for your past and future endeavours.

As always, we are looking for quality content to maintain *Lithics* as the pre-eminent journal dedicated to the study of stone technology. If you have an article in mind, I encourage you to submit an abstract to us so that you might take advantage of the big changes and hard work that are going on at *Lithics* right now.

I know you will enjoy *Lithics* 36. Happy reading!

Wei Chu

Cover. A Bársony House handaxe from the Herman Ottó Museum, Miskolc, Hungary, Inventory No.: 53.45.1. (Photograph © Péter Szolyák)

ANCIENT MAYA WARFARE: EXPLORING THE SIGNIFICANCE OF LITHIC VARIATION IN MAYA WEAPONRY

K. Aoyama¹ & E. Graham²

ABSTRACT

Variation in the kinds of weapons used in Maya warfare—and, one could argue in warfare in general—or the ways in which weapons were manufactured has been given scant attention as a function of diverse cultures and traditions. The results of the study described here suggest that lances (thrusting weapons with long wooden shafts and chipped stone heads) were the weapon of choice among both the Preclassic and the Classic Maya. In the Classic period, from which we have pictorial as well as other archaeological evidence, Maya elites used lances in hand-to-hand combat. Atlatl darts are also present in the Classic-period record but are not as common as lance heads. Points used as arrowheads do not appear in the Maya lowlands until the Terminal Classic, and then only in certain places. These changes do not follow a pattern that can be attributed to technological advances in resource acquisition, e.g. hunting. We discuss the increase in the production and use of atlatl darts as well as bows and arrows during the Terminal Classic period, which we argue reflects cultural change in the practices of warfare. We go further to hypothesise that changing warfare practices were one symptom of the cultural destabilisation that led to the demise of Classic Maya political authority.

Our paper derives from Maya research, but we think it has implications for the study of lithics more generally. Use of stone tools in the Old World, for example, is not normally associated with urbanism. The Maya example, in which neither the cultural nor technological context of urbanism involved the use of metals, can perhaps add a new social dimension to stone tool studies. With specific regard to the research described below, there is also the implication that the primary stimulus behind adoption of an artefact can be its role in competition or conflict—that is, in the socially sanctioned killing or harming of human beings—rather than its use in resource acquisition. Such a stimulus is as likely to have existed in the Palaeolithic as in the Bronze or Iron Age.

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Keywords: Maya civilisation, weapons, warfare, lances, atlatl darts, bows and arrows

INTRODUCTION

The culture of warfare—the weapons used, the fighting techniques honed, the men and women involved, the rituals employed and especially the rules of engagement and how ‘winning’ is measured—is a major key to the nature of the society waging a war. War, which we define here as a form of socially sanctioned competition that entails conflict and violence, is not now nor has it ever been peripheral to culture; it is central. The public face of war—that is, the rationale openly presented by leaders or other heads of state in war offensives—is rarely the explanation for the conflict (see e.g. Strachan 2001, 1115) but is instead the ‘excuse’ provided *after* the decision to wage war has already been made based on economic and political factors.

There are two reasons why we emphasise economic motives for warfare in the discussion that follows, although economics and politics are clearly intertwined as stimuli (Kettunen 2014, 95). The first is that economic motives provide the strongest explanation available for the taking of captives; the second is that the drive to win—achieving a tangible increase in economic and hence political power—becomes a potential explanatory factor in material culture change. We consider the changes in stone tool weaponry against this background.

WHAT WAS MAYA WARFARE ABOUT?

Wars are often understood as conflicts fought by people who agree on the rules of engagement. This is because there are social norms and codes of conduct that govern the practice of warfare and the justification for

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killing. As described with great insight by Halsall (2003), '[w]arfare ... is a form of communication, and in some instances a type of diplomacy. When warfare is aimed at making a particular statement to an enemy, or at achieving a specific goal, then it is important that the enemy understands that statement'. Both sides need to be aware of what actions mean (Halsall 2003, 8–9). Rules change, however, and the usual codes and norms can be ignored. At the Battle of Agincourt, Henry V ordered his men to kill the French prisoners who had been captured in battle, but his men refused. Henry had to turn to his archers, who stood outside the chivalric system, to do the dirty work (Keegan 1976, 85–86, 110–111). Thus Agincourt, an epic struggle in English history, can also be described as '... a story of slaughter-yard behaviour and of outright atrocity' (Keegan 1976, 79).

Killing in warfare is socially sanctioned by many societies, but rules about who should be killed, and how, have changed over time. Sometimes the change is dramatic, as in the case of the Spanish conquest of the Americas (Graham *et al.* 2013). Sometimes we know that changes occurred but lack of information makes them difficult to pin down, as in the post-Roman West (Halsall 2003, 9). The question to be asked is: when, in the aim to win, do individuals who are recognised by both sides as warriors change the rules of engagement?

The changes may be viewed at first as cultural violations (non-traditional practice), as in Henry's deployment of archers at Agincourt, but if they enhance the chances of 'winning', the rule-changers all too often get away with it. In fact, one could see this kind of rule-changing as the driving force behind the evolution of complex society. We do not have to look too far to find examples. From present to past we have: drones; the dropping of the atomic bomb on Hiroshima; 18th-century English colonists in what would become the United States fully condoning the use of snipers in the War of Independence; the British introduction of the long bow in the Battle of Crécy, in northern France, in 1346 (de Wailly 1987); the introduction of firearms; the introduction of metal; and the introduction of the bow and arrow. The key question is, what are the circumstances in which people change the

rules? Indeed, what are the rules of engagement in the first place?

These are questions which remain to be answered in Maya warfare. Rules of engagement are critical to the understanding of conflict and its outcome because such rules are rooted in social, cultural, political and religious practices and beliefs. This is not the place to discuss these factors with regard to the Maya, but we make the point because Maya weapons are not simply flaked stone with interesting shapes that can tell us about production techniques or chronology or technology. Maya weapons are personal extensions of the men (and women?) who used them in combat or competition to achieve a goal. The weapons are the materialisations of deep-seated cultural, social, political, religious and cosmological beliefs. Any change in the form of a weapon or its hafting or its material is not simply a technological change—it is a sea change.

Before we discuss the Maya weaponry in question, and in the spirit of a paper on warfare, we stress that our approach is tactical. We are employing a particular standpoint—that the people we archaeologists traditionally group together as 'Maya' had primarily economic motives for engaging in wars—because this standpoint enables us to generate new ideas on Maya competition and conflict to be explored and tested on the basis of future data (Graham 2009, 28). We are not the first to emphasise the importance of economic motives (see Kettunen 2012, 2014) and we are cognisant that the motives for warfare are in fact highly complex (Freidel *et al.* 1993; Reilly & Garber 2003; Martin 2006; García Capistrán 2014; Gutiérrez 2014). It has recently been stated that we must look beyond material gain to understand why people go to war (Scherer & Verano 2014, 4), but we focus here on material gain. Our working hypothesis is that among the Maya, socially sanctioned armed competition (warfare) was aimed at appropriating (or maintaining) wealth. War was waged to expand access to tribute and resources. The extent to which the actual taking of land was an aim is unclear, although the absence of evidence of combat in most Maya cities suggests that wealth was gained—and masses of people (elites and commoners alike) in order to occupy their land. We adopt the wars

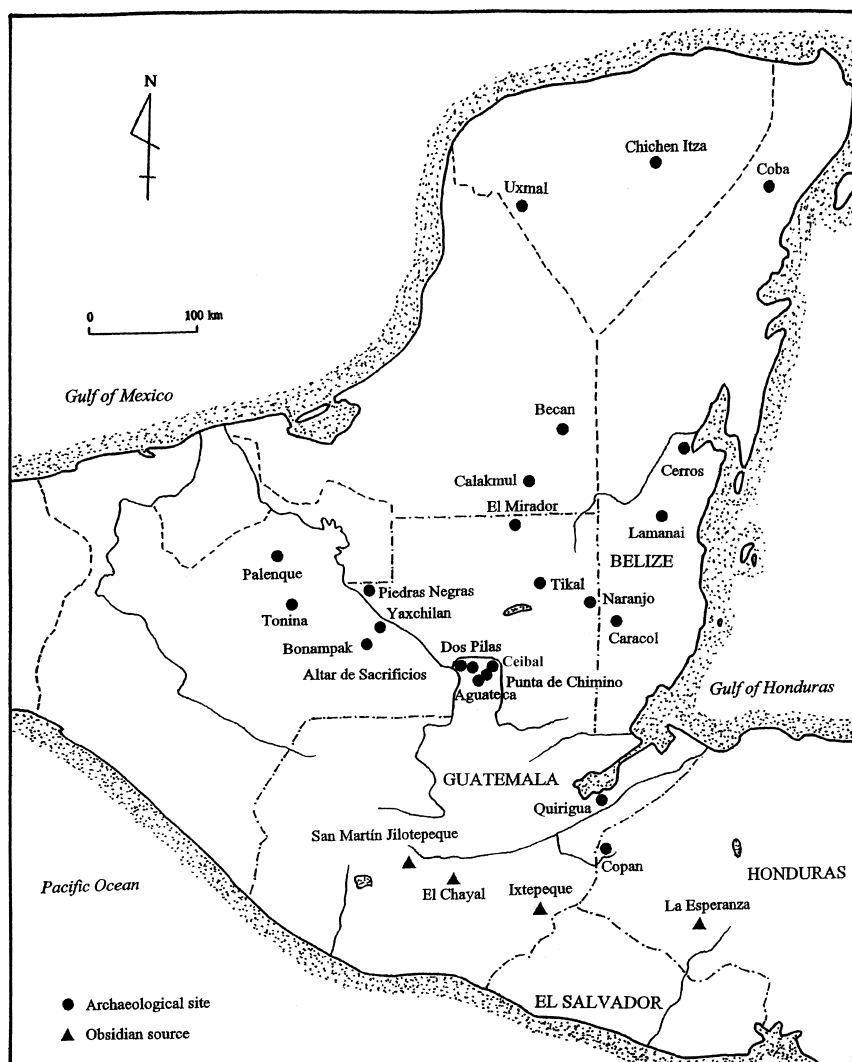


Figure 1. The Maya area, showing the location of major sites and obsidian sources.

‘won’—in ways other than by killing working hypothesis that the aim was to *capture* one’s opponent in close combat and, by doing so, the captor had the rights to the captive’s wealth through the tribute and taxes once paid to the captive (Graham 2011, 38–43; Graham *et al.* 2013). Becoming a captive almost certainly involved a loss of honour and prestige and, in some cases, one’s life was forfeit. Where and when captives were killed—and this is a key point—the social sanctioning fell under the rubric of the rules of engagement of warfare (*not* ‘human sacrifice’).

ARCHAEOLOGICAL EVIDENCE FOR WARFARE

Despite our knowledge from Maya hieroglyphic inscriptions of the ubiquity of conflict among the ancient Maya (Martin & Grube 2008), war is difficult to demonstrate

archaeologically (Aoyama 2005), although earthworks or stone walls are often cited as evidence of a defensive system (e.g. Webster 1976; Golden *et al.* 2008). Among the Maya cities that were abandoned in the Terminal Classic, such as Tikal, Palenque, Bonampak, or Dos Pilas (Figure 1), most were abandoned gradually with inhabitants usually carrying away a large portion of their weapons and other belongings to their next residences. Identifiable ancient Maya weaponry is seldom recovered from datable contexts or contexts in which the use of the weapon is clear. Although all the lithics from a site are generally analysed technologically as a group, there are good reasons to conduct diachronic studies of possible lithic weapons in particular, from both primary and secondary contexts. Specific research questions include: what was the

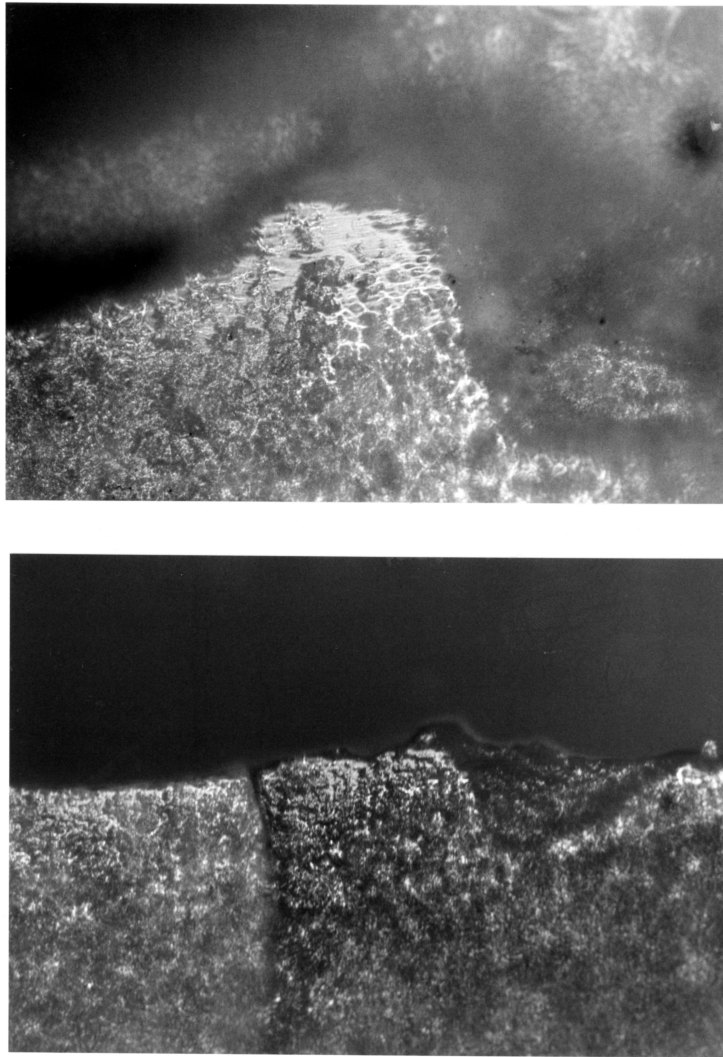


Figure 2. Examples of use-wear on chert bifacial points from Aguateca, Late Classic period (200x): (top) D2C type polish and parallel striations on a lateral edge used to cut shell or bone; (bottom) E1 type polish and parallel striations on a lateral edge used to cut meat or hide.

temporal and spatial variation in potential lithic weaponry? What was the nature of warfare, and what was its role in the rise and decline of Maya civilisation?

Since 1986, Aoyama has studied 195,947 lithic artefacts from Copan, Honduras, as well as Aguateca and Ceibal, Guatemala, including obsidian and chert points. Using high-powered microscopy techniques, he has conducted microwear analysis on 7719 stone artefacts from several Maya sites (Aoyama 1995, 1999, 2007 & 2009). In 1987, he conducted an experimental study of use-wear on obsidian and chert in Honduras in order to establish a framework for the interpretation of Maya stone-tool use (Aoyama 1989 & 1999). The results of

267 replication experiments conducted on a range of worked materials permitted identification of use-wear patterns. The instrument used in the study was a metallurgical microscope (Olympus BX60M) with 50–500x magnification and an incident-light attachment. Use-wear patterns were documented with an Olympus photomicrographic system PD-20 attached to a digital camera.

Judging by the presence of microwear in association with projectile-impact damage as well as the sizes (mean width = 36 mm, S.D. = 8.0 mm, $n = 28$), many obsidian and chert bifacial points were used as thrusting spears (lances) or as darts (Figure 2). Moreover, results of microwear analysis indicate that both

obsidian prismatic blade points and chert small unifacial points (mean width = 11.8 mm, S.D. = 3.6 mm, $n = 13$) were mainly used as arrowheads (Aoyama 2005, 294).

CASE STUDIES: MAYA WARFARE AND CHIPPED STONE WEAPONS

Copan, Honduras

A series of large-scale international archaeological projects conducted at Copan, Honduras, since 1975 have made it one of the more intensively studied regions in the Maya lowlands (Fash 2001). Of 74,614 chipped stone artefacts recovered from Copan, possible weapons include obsidian bifacial points ($n = 354$), obsidian prismatic blade points ($n = 80$) and chert bifacial points ($n = 119$). Imported obsidian was more frequently used than local chert for the production of these tools (Aoyama 1999). The straight-line distance from Copan to the closest obsidian source at Ixtepeque (80 km) is shorter than for most Maya lowland areas. Because they have sharper cutting edges, obsidian bifacial points should have been more effective weapons than those made from chert. In the words of one modern Lacandon Maya, '[o]bsidian makes a wound that causes heavy bleeding. A chert point will usually kill, but an obsidian point always kills' (Nations 1989, 454).

The pre-Columbian occupation of Copan began during the Early Preclassic period (1400–1000 BC) and lasted until the Early Postclassic period (AD 900–1100) (Longyear 1952; Webster 1989, 1999; Houston & Fowler 1992; Fash 2001; Bell *et al.* 2004). During the Preclassic period (1400 BC–AD 50) obsidian was mainly imported as small nodules to Copan for the production of percussion flakes. There is no evidence of local blade production or bifacial technology. During the Protoclassic and Classic periods (AD 50–900), truly significant changes in society took place at Copan, and local blade production began as the result of sociopolitical development (Aoyama 2001).

K'inich Yax K'uk' Mo' founded a royal dynasty in 426 (see Bell *et al.* 2004). Although nearly all obsidian continued to be procured from Ixtepeque, as in the previous period, this foreign ruler may have started to obtain small numbers of finished artefacts—primarily

prismatic blades, but also small quantities of bifacial atlatl (spearthrower) dart points and prismatic blade points—from central Mexico, including green obsidian from the Pachuca source (Aoyama 2001, 352). We can distinguish between dart points and spear points by combining microwear analysis and attribute measurements, such as point width, thickness and weight (see Aoyama 2009, 125–126). At the beginning of the Early Classic period, the Copan Valley hilltop site of Cerro de las Mesas was founded 2 km northwest of the Principal Group (Fash 2001, 89). Fash & Barbara Fash (2000, 447–448) speculate that K'inich Yax K'uk' Mo' and his followers established themselves at this fortress-like site and unified the diverse, competing noble lines. Then the Principal Group was established in the centre of the Copan Valley. There was a marked increase in the production of obsidian bifacial points during the Early Classic period (AD 250–600); most points were used in lances but some were atlatl darts. In particular, the percentage of bifacial points among all Early Classic obsidian artefacts at the hilltop fortified center of Cerro de las Mesas in the Copan Valley (4.4%) is considerably higher than the mean percentage of obsidian bifacial points in the Copan valley (0.4%, S.D. = 0.9). This high percentage might be taken as evidence for warfare with the implication that warfare played an important role in the rise of the Copan dynasty (Aoyama 2005, 300).

It is important to note that the percentage of Pachuca green obsidian tools among all obsidian chipped stone artefacts at Cerro de las Mesas (6.7%) is the second highest in the Early Classic Copan Valley (indicating its possible ties with central Mexico), only after that for the Yax Structure (9.8%) in the central part of Copan, which K'inich Yax K'uk' Mo' commissioned (Aoyama 1999, 105). The prevalence of artefacts made from central Mexican obsidian is possibly attributable to the presence of foreigners with access to Pachuca obsidian; it could also have been an outcome of marriage alliances that entailed tribute from central Mexico; and/or it could mean that trade connections in general had opened up.

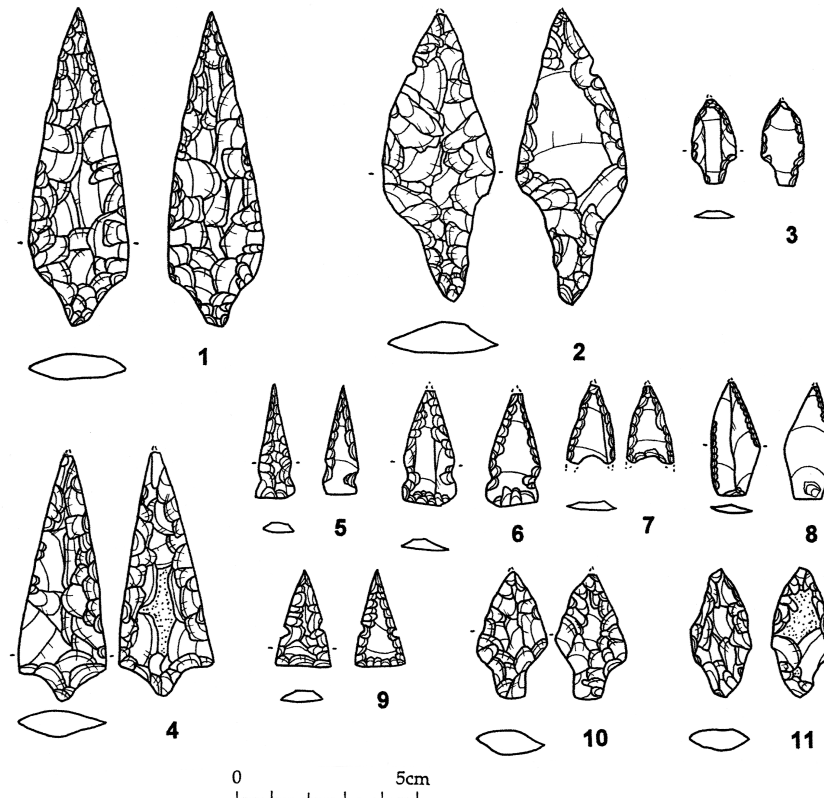


Figure 3. Obsidian and chert points from the Copan region, Honduras: (1, 4) were manufactured from chert, (3) was from Pachuca green obsidian, (11) was from La Esperanza obsidian while the others were manufactured from Ixtepeque obsidian. (1) Protoclassic period, (2–3) Early Classic period, (4–11) Late and Terminal Classic periods, (1, 2, 4, 10, 11) bifacial points, (3, 5–9) prismatic blade points. Note projectile impact damage on (2–4), (6–8) and (10). Drawings are in Japanese technical style. Each illustration shows the sequence of flake detachment. Flake scars, fissures and ripple marks demonstrate the relationships of adjacent flake scars.

In the Late Classic period in the Copan Valley, we find that small quantities of both side-notched and un-notched prismatic blade points were being manufactured from Ixtepeque obsidian. The results of microwear analysis indicate that most of them were used as arrow points. The distal tips of the prismatic blade points were exclusively used for piercing unidentified material. There is no indication of an increase in obsidian or chert lance or dart points at this time. There is, however, an increase in the production and use of atlatl darts as well as bows and arrows during the Terminal Classic period (AD 800–900), which again points to warfare. The presence of arrow points in greater numbers may also indicate a change in the practices of warfare (Figure 3). The chipped stone data are consistent with the evidence of the violent destruction of several buildings of central Copan (Andrews & Fash 1992; Fash *et al.* 1992, 427). Large

concentrations of obsidian bifacial lance and dart points as well as arrow points in the final phase occupation layers in the central part of Copan in the early 9th century, along with other lines of evidence for warfare, such as stone sculptures of warriors and central Copan building destruction, indicate that warfare—and possibly warfare of a new kind—gained acceptance and was among the several causes that brought about the demise of centralised dynastic rule.

Aguateca, Guatemala

Aguateca was a walled Classic Maya city located in the Petexbatun region of Guatemala (Inomata 1997). It occupied a highly defensible location on the top of a steep 90 m escarpment. Archaeological, epigraphic and iconographic studies show that the Dos Pilas/Aguateca dynasty expanded its power through warfare in

the eighth century (Martin & Grube 2008). More than 4 km of defensive walls and barricades were constructed in a hasty manner in Aguateca at the beginning of the 9th century. Its epicentre was burned down during an attack by an enemy or rival group around AD 810. Elite residents of the central part of the city fled rapidly or were captured, leaving most of their belongings behind (Inomata 1997). In fact the way in which Aguateca is said to have met its demise stands in contrast to Maya warfare as we know it throughout most of the Classic period. For a city to be abandoned, the rules of engagement must have changed because, in the past, winners would often bring those over whom they triumphed back to the city. Losing (captured) rulers or their lords were almost assuredly made vassals so that they would pay tribute to the new captor/conqueror. An abandoned Aguateca was not going to be paying tax or tribute, which implies serious cultural disruption in the region far beyond the effect of being the losing side in a battle.

In total, 437 chert bifacial points were collected in the Aguateca region (of which 308 came from Aguateca), while other possible chipped stone weapons from Aguateca include two obsidian bifacial lances, 27 obsidian prismatic blades and four chert small unifacial points (Figure 4). The royal palace and the residences of the elite scribes/artists of Aguateca each contained some 30 to 40 chert bifacial lance and dart points. Because many weapons were used in the last battle, each household must have originally possessed many more pointed tools. Some complete and nearly complete points appear to have been stored in the royal palace, elite residences, and other structures, but most chert bifacial lance and dart points were snapped or otherwise broken.

The broken lance and dart points were scattered more or less evenly across the burned structures in the final occupation layers, as one would expect if they had been used in the fighting; they were not concentrated as would be the case in a midden or cache context. The residents of Aguateca, including elite scribes/artists, seem to have used most of their inventory of chert bifacial points during the final defense of the city. Without exception, the structures excavated in the epicentre of Aguateca burned to the ground at the time of abandonment. Together these data strongly suggest that many

broken lances and atlatl darts were deposited in battle (Aoyama 2005, 297).

The percentage of bifacial points in the total sample of chert artefacts at the epicenter of Aguateca (5.5%) is greatly higher than those outside of Aguateca (1.3%, S.D. = 0.07). The areas outside the epicentre were abandoned shortly after the destruction of the epicentre itself, as if commoners—or at least those based outside the epicentre—were forced to leave (Inomata 1997). The large number of broken lance points and atlatl darts found in the epicenters suggests strongly that elites (rulers, nobles, scribes, retainers) controlled the fighting. This along with other lines of evidence, such as the violent destruction of residential structures and the pattern of point deposition, further indicates that fighting involved hand-to-hand combat and personal contact. Scant skeletal evidence was found to indicate that bodies had been left, although this is a risky statement in the tropics where preservation is so poor. The aim of the enemy seems to have been to terminate Aguateca as a political and economic power.

Variation in production

The results of lithic and other studies suggest that a significant portion of Maya elites, both men and women, engaged in craft production at Aguateca (Aoyama 2007 & 2009; Emery & Aoyama 2007) and produced prismatic blades and points. Concentrations of obsidian blade manufacturing debris and chert small bifacial thinning flakes were found in some elite residences in the epicenter of Aguateca. Some elite household members appear to have manufactured obsidian prismatic blades or bifacial points in or near their residences. The male scribe/artist of Structure M8-4 specialised in the production of shell and bone objects of high symbolic value and other royal regalia in a courtly setting (Aoyama 2007, 20–21). A female household member seems to have mainly used the north room of Structure M8-4 and engaged in bone or shell and wood carving there, in addition to food preparation and textile production. In addition, the largest concentration of chert small bifacial thinning flakes in this structure was recovered from the north room, which suggests that it was the female household member who was engaged in

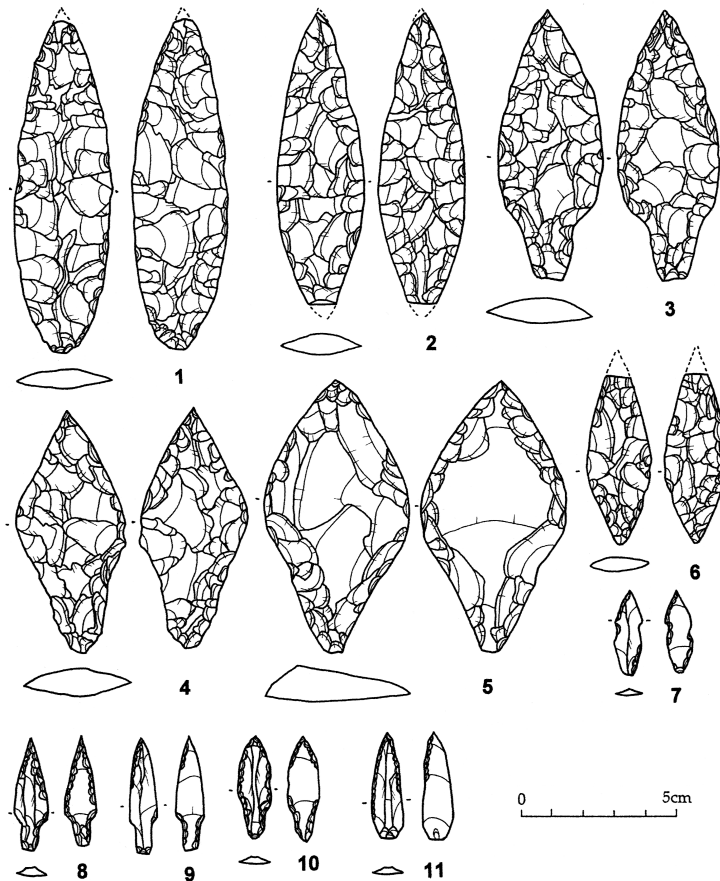


Figure 4. Chert and obsidian points from Aguateca, Guatemala. (1–7) were manufactured from chert while the others were manufactured from El Chayal obsidian; (1–6) bifacial points, (7) small point, (8–11) prismatic blade points. Note projectile impact damage, such as longitudinal macrofracture on (1), lateral macrofracture on (2) and distal break on (6). Drawings are in Japanese technical style. Each illustration shows the sequence of flake detachment. Flake scars, fissures and ripple marks demonstrate the relationships of adjacent flake scars.

bifacial point manufacture. Furthermore, it is interesting to note that 11 of the 36 chert bifacial points recovered from this structure were found in this room (Aoyama 2009, 128). Microwear analysis indicates that at least some bifacial points were used as lances and darts. The male scribe/artist may have used all of them. Alternatively, the larger number of bifacial points found in the north room suggests that the female household member may have used some bifacial points in defence of the city or other purposes. Although portraits of Maya warrior queens are rare in Classic Maya art, two stelae of Naranjo show Lady Six Sky (AD 682–741) trampling captives in the manner of a warrior-king. A similar depiction is also known from Calakmul (Martin & Grube 2008, 74) and Naachtun. At least some elite women at Aguateca may have acted defensively in the final battle.

Ceibal, Guatemala

Ceibal (also spelled ‘Seibal’) was the largest city in the Pasión region and was occupied from 1000 BC to AD 900. Since 2005, the members of the Ceibal-Petexbatun Archaeological Project have uncovered evidence of substantial construction activities in the early stages of settlement at Ceibal, especially during the Middle Preclassic period (1000–400 BC). The site’s first ceremonial platform and public plaza were constructed around 1000 BC (Inomata *et al.* 2013).

During the Middle Preclassic period, obsidian was imported from the Guatemalan highlands primarily in the form of blade cores used in the manufacture of percussion and pressure blades. There was also local production of chert bifacial artefacts, including bifacial spear or lance points. A chert spear/lance point and a shell

ornament representing a decapitated human head (Inomata *et al.* 2010, 34), both recovered from the Central Plaza of Ceibal and dated to the early Middle Preclassic period (1000–700 BC), are the earliest evidence of warfare at Ceibal. Stemmed unifacial points made from obsidian were recovered from late Middle Preclassic contexts (700–400 BC). These are the earliest obsidian pointed weapons at Ceibal recovered to date.

A medial fragment of a bifacial atlatl dart point made of Pachuca green obsidian from central Mexico was found in an Early Classic deposit in the central part of Ceibal. Its material, form and workmanship, especially the overlapping fine transverse parallel pressure flaking along the edges and faces (Carballo 2007, 178), leave no doubt that it was manufactured at Teotihuacan, in central Mexico. During the Early Classic period (AD 250–600), the elites of the nearby fortified centre of Punta de Chimino in the Petexbatun region obtained small numbers of prismatic blades made of Pachuca and other central Mexican obsidian, as well as a bifacial point made of green obsidian from the Pachuca source (Aoyama 2011, 47). Again, the appearance of Mexican obsidian artefacts in the archaeological record may reflect the presence of foreigners, and/or developing long-distance exchange networks and/or marriage alliances that entailed some tribute coming from central Mexico. It might also reflect the presence of warriors culturally rooted in warfare practices common to central Mexico.

The Ceibal-Petexbatun Archaeological Project has recovered a total of 116 chert points and 11 obsidian points from primary and secondary contexts, while the Ceibal Project of Harvard University uncovered 77 chert bifacial points and 11 obsidian points from all periods (Willey 1978, 102). Stela 2 of Aguateca portrays Ruler 3 of the Dos Pilas-Aguateca dynasty as a warrior, standing over the captured ruler of neighbouring Ceibal in AD 735 (Figure 5 [I. Graham 1967, figure 5]). In contrast to the absence of bifacial and unifacial points at the nearby minor centre of Caobal (Aoyama & Munson 2012), it should be noted that more than one-half of chert bifacial points ($n = 63$) in the present Ceibal sample as well as a small unifacial point made of chert were recovered from Late Classic contexts, which suggests the

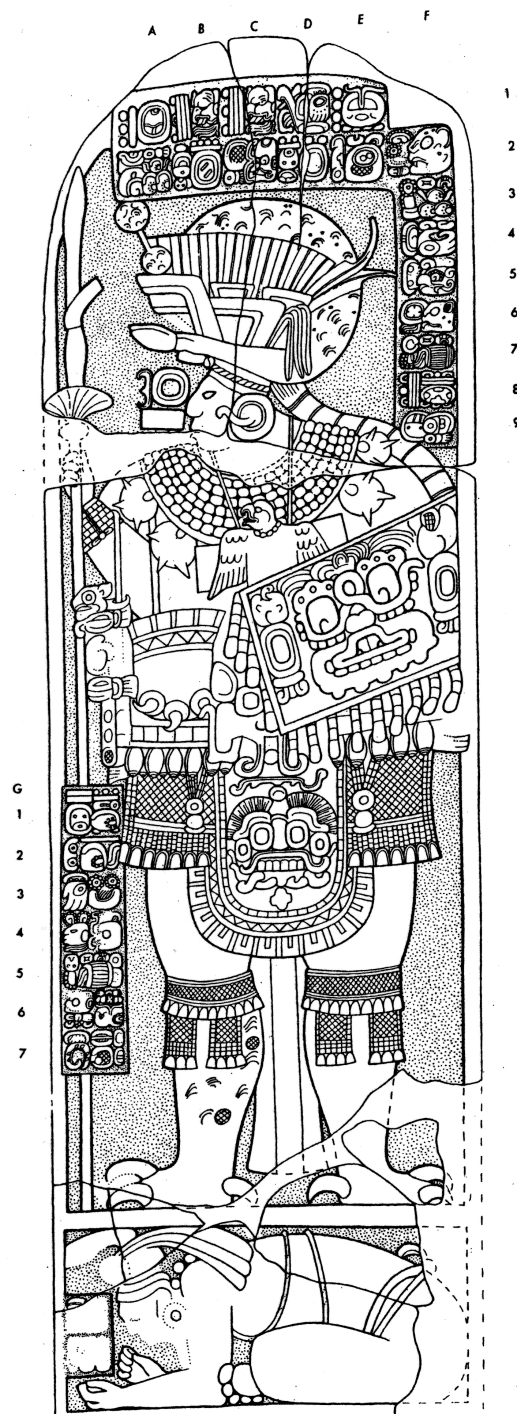


Figure 5. Stela 2 of Aguateca portrays Ruler 3 as a warrior (I. Graham 1967, Fig. 5).

intensification of warfare at Ceibal during this period.

Possible chert pointed weapons, in addition to four bifacial points from primary contexts, include 37 bifacial points and a small unifacial point recovered from secondary contexts of the Terminal Classic period in the central part of Ceibal. Apart from a small unifacial point made

of chert, obsidian prismatic blade points, including a side-notched stemmed point used as an arrow point, appear for the first time from contexts of the Terminal Classic period. Although lance or dart points were more important than the bow and arrow in Classic Maya warfare, as was apparently true at Copan, the bow and arrow were present at Ceibal during the Terminal Classic period.

There is increasing evidence of the production and use of chert and obsidian bifacial points as well as both side-notched and un-notched arrow points in the central part of Ceibal during the Terminal Classic period, as there is compelling epigraphic and archaeological evidence for warfare in the Petexbatun and Pasion regions (Martin & Grube 2008, 61; Inomata & Triadan 2010). The artefact changes almost certainly are tied to changes in the practice (and ethics?) of warfare in these regions. The fall of the Ceibal dynasty was marked by the destruction of its temple pyramid and royal palace (Houston & Inomata 2009, 309). Stucco sculptures of human figures that decorated the royal palace were intentionally beheaded. Lithic and other data do point towards Ceibal's direct involvement in such events, suggesting that warfare may have been one of the factors that led to the demise of centralised dynastic authority at Ceibal during the 10th century.

CONCLUSION

The gradual changes in weaponry at sites such as Ceibal do not suggest a major late invasion of outsiders or even a case of Mayas fighting Mayas according to age-old fighting traditions. Instead, we appear to have a long and gradual 'infiltration' of some important Maya cities—probably carefully chosen—by people whose culture had roots outside the lowlands. Despite the fact that some individuals, on the basis of weapons material and style as well as epigraphic evidence, hail from Teotihuacan in the Early Classic period, the connection to central Mexico may not have been so direct in all cases through time (Stuart 2000). The weapons—as seen through different hafting and manufacturing techniques—vary enough, as do the engagements (as witnessed at Aguateca) to introduce the possibility of variety in place of origin.

Spear/lance points were chipped stone weapons among the Preclassic Maya. The relative scarcity of stone points, however, suggests that more perishable weapons, such as those of hard wood, may have been used more extensively during the Preclassic period than in later periods. We know from Classic Maya art that elites were involved in hand-to-hand combat mainly with what we have called lance points, and, to a lesser degree, atlatl darts (Miller 1999). The adoption of atlatl darts from highland central Mexico in the 4th century AD did not result in replacement of hand-held lances as a predominant weapon in the Maya lowlands but instead seems to have supplemented or complemented their use. An unusually high percentage of bifacial points among all obsidian artefacts at the fortified centre of Cerro de las Mesas in the Copan Valley indicates that warfare was instrumental in the rise of the Copan dynasty during the Early Classic period.

The evidence described here adds support to the idea that Classic Maya warfare was fought mainly by elites. Based on the large number of broken pointed weapons found in the epicenters along with other lines of evidence, such as the violent destruction of residential structures and the pattern of point deposition, the ruler and elite scribes/artists were also warriors. If the goal of Maya warfare was, as suggested, to take captives for the purpose of expanding access to tribute and wealth as well as power and prestige (Graham *et al.* 2013), then the predilection for hand-to-hand combat makes sense. As Keeley (1996, 49–54) points out, if one's objective is to kill or to severely injure, projectile or fire weapons are far outclassed by shock weapons such as axes, maces and bladed weapons. Chert lance points, which were less effective in killing or wounding than obsidian points, were prevalent in most Maya lowland areas except at Copan, whose inhabitants took advantage of its unusual location near one of the primary obsidian sources for the Maya lowlands and used mainly obsidian points.

Throughout most of Maya Classic history, lance points and dart points were more important than the bow and arrow in Maya warfare. Atlatl darts, in fact, seem to represent the first significant change in Maya warfare in the Early Classic. The increase in the production and use of atlatl darts as well as bows and arrows suggests that further significant changes in the

cultural practices of warfare took place in the Terminal Classic. Whereas most conflict probably took place in areas outside of major settlements, the epicentre of Aguateca was attacked and burned, which suggests deeper change in the rules of engagement. These lines of evidence suggest that warfare at some level was always a means to an end in the lowlands. They also suggest that the changes manifested in warfare were closely linked to changes that challenged or at least competed with traditional lowland Maya cultural values.

Variation in the kinds of weapons used by the Maya in combat and the ways in which weapons were manufactured has been given scant attention as a reflection of diverse cultures and traditions. If we are correct in assuming that rules of engagement changed over time, then cultural values are a strong candidate as a stimulus to change, and changes in weapon styles are changes in material culture. Such conflicts of cultural values and not just warfare alone may well have been a major stimulus to the destabilisation that resulted, ultimately, in the demise of centralised dynastic authority that characterised the Maya collapse.

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BEFORE THE FIRE WAS LIT: USING THE EFFECT OF HEAT ON FLINT TO UNDERSTAND DISTURBED PALIMPSESTS AT LYMINGE, KENT, UK

T.S. Lawrence¹ & D.J. Mudd²

ABSTRACT

There has been a tendency to ignore disturbed prehistoric flint scatters in Britain. Consequently, there is a loss of potential information. Even with disturbance, some awareness of the spatial ordering of scatters can be determined, although with a much poorer resolution. It is more challenging, however, to identify phases of occupation at these sites. The intention of this paper is to create methods that assist in identifying phases of occupation by determining the relationship between the degree of burning on flint and its spatial relationship to the heat source. This will be achieved through the analysis of experimental and archaeological evidence. The differential effects of heated flint can be attributed to the material's position under a fire. This can be used as a proxy for now disturbed, stratigraphic relationships. By using the approach set out in this paper, it may be possible to reconstruct past orders of occupation phases and activity dynamics before the fires were lit.

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Keywords: Lithic scatters, palimpsests, experimental flint heating, site occupation

INTRODUCTION

Within Holocene research, surface flint scatters from disturbed prehistoric sites have tended to be ignored with only limited analysis undertaken. English Heritage's advice on managing lithic scatters (English Heritage 2000, 6) notes that just 7% of recorded scatters had been further investigated. More recently, it has been argued that such sites are still undervalued despite their potential contribution to understanding human agency in the prehistoric landscape (Bond 2011).

There are two main problems when dealing with surface scatters: disturbance and palimpsests. Through experimentation, it has been established that artefacts can move up to 3–5 m horizontally after ploughing or trampling (Nielsen 1991; Eren *et al.* 2010). Scatters can thus retain some semblance of low-resolution spatial patterning (Talmage & Chester 1977; Trubowitz 1978; Ammerman 1981; Gifford-Gonzalez *et al.* 1985; Nielsen 1991; Shea & Klenck 1993; Lopinot & Ray 2007; Eren *et al.* 2010). The vertical displacement of ploughed lithics, however, makes it more challenging to identify chronological sequences for surface scatters, other than by identifying typological

differences. Other anthropogenic factors include disturbance through later occupation activity, such as at West Stow (West 1969) or more recently in Bognor Regis (Priestley-Bell 2006). Natural disturbance affecting horizontal displacement of lithics can include cryogenic processes where movement of up to 40 mm a year can be achieved (Bowers *et al.* 1983). Fluvial action can also distort scatters but this completely depends on the power of the watercourse (Hosfield & Chambers 2005). Soil creep and wind action can also play a minor part in horizontal displacement (Collcutt 1992; Huggett 2002). Bioturbation is the foremost factor in natural vertical movement (Collcutt 1992). The magnitude of disturbance, whether anthropogenic or natural, is highly site-specific and, as such, further hinders analysis into disturbed scatters in general.

Palimpsests are another common feature in surface scatters and are difficult phenomena to deconstruct. Owing to their long research history, however, we are now gaining a better understanding of their types and formation processes (Binford 1980 & 1981; Villa 1982, 2004; Malinsky-Buller *et al.* 2011). In essence, a palimpsest is a series of events that overlap spatially to give the illusion of

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contemporaneity. Bailey (2007) describes several types of palimpsests and recognises that there are no clear-cut lines that separate them. This makes analysis of such sites all the more confusing. Hosfield (2005) states that a coarse resolution of palimpsests is not enough if we are to better understand the prehistoric individual in context. Therefore, new methods are needed to tackle this issue. Current methods, though limited, involve understanding local geomorphic (Fanning *et al.* 2009; Davies *et al.* 2015) or anthropogenic site formation processes (Egeland *et al.* 2004; Vaquero 2008). Both of these approaches require a large amount of site-specific information and are therefore not always applicable to other sites.

This paper describes an approach to identifying sequences of occupation phases at disturbed sites that have burnt flint, by detailed analysis of the flint burning and fire use. It is based on the cross-relationship between two factors. The first is the differential physical changes caused by heating flints of varying sizes and surface characteristics (cortical, patinated and unpatinated). The second is the differential effects of heating on flint at varying distances from a fire. These observations were obtained by experimental flint burning, and are compared with the evidence of burning in an archaeological assemblage from a disturbed multi-period prehistoric site at Lyminge (Kent). This evidence comprises different physical characteristics of the burnt flint, and also the differential burning of tool types. We suggest that this approach may have wider applicability for reconstructing relative chronologies at other disturbed sites with burnt flint.

Fire locations aid in the identification of site structure, especially during prehistory (Alpersen-Afil 2012; Mallol *et al.* 2013). Fires are often found to be the focal points of living and manufacturing areas and facilitate the identification of social dynamics within prehistoric groups (Yellen 1977; Binford 1980; Enloe 2006). Experimental research on the structure of fires, the physics of combustion and heat transfer and their effect on sediments and substrate has supported the identification and theoretical modelling of archaeological fire structures (Schiffer *et al.* 1994; Canti & Linford 2000; March 2013; March *et al.* 2014; Brodard *et al.* 2015), particularly in relation to cooking methods (Lucquin & March 2000; Dumarçay *et*

al. 2008). Moreover, through the examination of fire histories (Alpersen-Afil 2008 & 2012; Malinsky-Buller *et al.* 2011; Machado *et al.* 2013), it is possible to recognise phases of occupation and palimpsests at sites. By creating methods that recognise the archaeological significance of flints with different degrees of burning, Sergeant *et al.* (2006) were able to identify hearth locations at the *in situ* palimpsest site of Verrebroek, Belgium (Louwagie & Langohr 2005; Crombé *et al.* 2009 & 2012). Alpersen-Afil (2012) has used fire behaviour and spatial analysis to establish the causes of burnt flints at the Lower Palaeolithic site of Gesher Benot Ya'aqov, Israel. She concludes that, because burnt flints occur in clusters within a wet environmental setting, these flint accumulations must reflect 'phantom' hearths where there is no direct evidence of burning such as charcoal.

What happens, though, when sites have become too disturbed for evidence of *in situ* hearths to survive? How do we interpret the structure of sites, activity dynamics and phases of occupation when flints have been moved taphonomically? This is something that has not yet been addressed. It has become a common misconception amongst archaeologists that flint must have been in direct contact with fire for it to have been modified by heat (Sergeant *et al.* 2006; Alpersen-Afil 2012). Our study attempts to identify the sequence of occupation phases at the multi-period site of Lyminge, by understanding how variations in heat exposure can modify flint morphology. If, for example, flints within an assemblage have different degrees of burning, it follows that they were situated different distances vertically or horizontally from a fire, thus giving a more detailed picture of site structures. Careful experimental recreations of burnt flints will help to identify the intensity of heat at different locations around a hearth. By understanding the dynamics of fires as heat travels through different depths, we aimed to recognise a lithic scatter's spatial relationship to a heat source, and from this, to reconstruct events within occupation phases at the site in the Mesolithic, Late Neolithic/Early Bronze Age (LB/EBA), Anglo-Saxon, Anglo-Norman and modern periods at Lyminge.

The aims of this experiment were twofold:

1. To identify how flint was burnt at Lyminge and what sorts of activities this might represent. The hypothesis is that flint was burnt in different ways for different reasons at the site. Sometimes it may have been done accidentally.
2. To apply the results of experimental burning to the archaeological assemblage, in order to reconstruct a sequence of occupation and burning events.

THE PREHISTORIC AND ANGLO-SAXON PERIODS AT LYMINGE, KENT

Lyminge is a sheltered village situated within a cul-de-sac of hills on the North Downs of southeast England. Springs rise from the chalk at the centre of the village making it an ideal location for settlement. The chalk is a source of good-quality flint. The Lyminge Archaeological Project, an AHRC-funded initiative to reconcile the lack of archaeological data on Anglo-Saxon monastic and royal complexes, carried out a series of open area excavations on Tayne Field, an open area in the centre of the village (Thomas & Knox 2012; Thomas 2013). The opening of two adjacent 30 x 30 m trenches in the 2012 and 2013 seasons uncovered a complex of large Anglo-Saxon timber halls associated with royalty (Figure 1), and a nearby Bronze Age barrow. Excavation began with the removal of topsoil to reveal features cut into the silty clay subsoil and chalk bedrock. The features showed Anglo-Saxon, Saxo-Norman, mediaeval and 20th century (World War 2) activity. Within and around these features lay *ca* 19,000 flints dated typologically mainly to the Late Mesolithic with some LN/EBA components. It is one of the largest Holocene flint assemblages recorded in the Kent Historic Environment Record. Our broader research objectives, of which this study is a part, were to describe and characterise the assemblage, to identify the periods of prehistoric occupation of the site and to understand post-depositional changes to the assemblage, particularly those relating to Anglo-Saxon and Saxo-Norman household discard management (see also Maslin 2015).

Whilst many flints could be assigned to a period by their typology, it was not possible to identify flints from different periods by their location: there had been too much later disturbance.

Some flints lay on the surface bedrock and in the silty clay overlying it, but the majority were found in Anglo-Saxon and Saxo-Norman pits, ditches and postholes cut into the chalk. It was obvious that these flints were not *in situ*, with the possible exception of a small, apparently less disturbed, area in the southeast corner of the site where three 1m² test pits were excavated, yielding 10 microliths (Grid square 6, Figure 2). It is likely that solifluction and bioturbation played a part in disturbing the scatters but the magnitude is unknown (S. Maslin, pers. comm.). Ploughing probably took its toll on the Lyminge flint scatters and explains the poor preservation of the Bronze Age barrow and the lack of preserved floor surfaces within the timber halls (Thomas & Knox 2012). The large number of flints within the sub-soil are indicative of worm sorting, whereas the flints found at different depths through the clayey-sand natural suggest percolation through the strata. The site contains signatures indicative of all five of Bailey's (2007) palimpsests (Table 1).

Finds including flint from features cut into the chalk were assigned to the relevant context number. All other surface flints were assigned to the relevant 5 m grid square. Figure 2 shows the plan of these features, and the density of burnt flint in each 5 m grid square. Due to the *ex situ* nature of the prehistoric component, it was deemed an ideal case study for identifying key aspects of disturbed lithic assemblages.

A detailed metrical analysis was undertaken for all flints (Mudd & Lawrence, in prep.), summarised in Table 2. 5199 flints had been burnt (27% of all pieces recovered), of which 3248 (62%) had been visibly struck. A range of morphological signatures indicated burning, including pot-lidding, crazing, colour change, fissures and fractures, thermal gloss and thermal extractions (negatives of small fragments detached by heat) (Bordes 1969; Purdy 1974; Rick 1978; Olausson & Larsson 1982; Price *et al.* 1982; Schindler *et al.* 1982; Ahler 1983; Rick & Chappell 1983; Joyce 1985; Griffiths *et al.* 1987; Patterson 1995; Clemente-Conte 1997). Natural non-flint pebbles had been slightly rubefied, also suggesting burning. This initial analysis allowed us to devise a strategy for further study and answer some basic questions about the assemblage.

Table 1. A synopsis of Bailey's (2007) palimpsests with reference to Lyminge.

<i>Palimpsest Type</i>	<i>Explanation</i>	<i>Example from Lyminge</i>
<i>True Palimpsest</i>	The re-use of a space in such a way that evidence of former activities has been removed.	Sunken Featured Building (SFB5) in which purposeful demolition erased all evidence of activity within the structure.
<i>Cumulative Palimpsest</i>	A 'classic' palimpsest in which activities are performed in the same area over a long period of time and then mixed through taphonomic processes. With little to differentiate spatially, these activities appear contemporaneous.	Taphonomic processes have led to the mixing of flints from different periods.
<i>Spatial Palimpsest</i>	A cumulative palimpsest on a larger spatial scale in which activity throughout a landscape cannot easily be separated temporally.	When taking into account the stray Mesolithic findspots that cover Kent (Wymer 1977; Ashbee 2005), it cannot be determined whether these are contemporaneous with the Mesolithic of Lyminge.
<i>Temporal Palimpsest</i>	The purposeful curation of items of different ages.	Observed through the reuse of much older flints (retouch through patination).
<i>Palimpsest of Meaning</i>	The transformation of meaning of an object or place depending upon the people that used it.	The Lyminge site has changed meaning throughout time. Starting as a Mesolithic and Neolithic transient camp, it was changed into a small-scale Bronze Age ritual site that was re-appropriated in the Anglo-Saxon as a royal complex. Later Lyminge became a Medieval religious centre and then a modern village in the North Downs.

Table 2. Number and proportion of burnt flints for whole assemblage and selected tool categories.

Category	Total pieces	Burnt	% Burnt
Cores	503	196	39%
Debitage	13,010	2986	23%
Unworked	4222	1951	46%
<i>Early/Middle Mesolithic:</i>			
Blades	3	0	0%
Obliquely blunted points	6	0	0%
Horsham points	1	0	0%
Shouldered points	1	0	0%
<i>Late Mesolithic:</i>			
Bladelets	138	17	12%
Bladelet fragments	145	10	7%
Microburins	12	0	0%
Microliths	51	1	2%
Adzes	6	0	0%
Picks	1	0	0%
Tranchet flakes	6	0	0%
<i>Late Mesolithic/Early Neolithic:</i>			
Blades	250	4	2%
Blade fragments	376	25	7%
<i>Late Neolithic:</i>			
British oblique arrowheads	4	0	0%
Chisel arrowheads	2	0	0%
Transverse arrowheads	2	0	0%
Chamfered points	6	2	33%
<i>Late Neolithic/Early Bronze Age:</i>			
Scrapers	11	3	27%
Expedient tools	7	3	42%
Discoidal cores	8	5	62%
<i>Other Tools (undated)</i>	415	13	3%
Total	19,186	5199	27%

What was the cause of the burning? It is accepted from archaeological and ethnographic studies that siliceous rock may have been heated deliberately in antiquity to improve its knapping qualities, and to enable sharper or longer-lasting edges to be obtained (e.g. Griffiths *et al.* 1987 and references therein). This can be discounted in respect of the Lyminge flint: the majority of the burnt cores are calcined and fractured beyond the stage where they could be a source of blades and flakes.

Was the burning accidental or deliberate? There was significantly differential burning between categories of flint (Table 2). The types with the highest proportion of burning were unworked flints (46%), cores (39%) and debitage (23%). Only 5% of finished tools, and 2% of all pieces with retouch, were burnt. The burnt flints were predominantly waste products from knapping, and finished tools were not burnt. We conclude that the selective burning of artefact types was deliberate.

When did the burning happen? Virtually all the burnt flints were recovered from Early

Mediaeval features, particularly the fill of SFB5, an Anglo-Saxon sunken-featured building. If the burning had taken place in the Anglo-Saxon phase (for example, by fires on the ground surface or by deposition of flints and soil as capping for hot embers discarded in pits) we would not expect to see selective burning of artefact types. We assume therefore that the burning took place in prehistory. The selective burning also implies localised fire(s), such as domestic cooking, rather than large-scale burning for ground clearance or a wildfire. It is not clear, however, whether there was differential burning between the periods of prehistoric occupation. We would expect a much less differentiated pattern to the burning if the assemblage had been disturbed prior to the burning events. We therefore assume the assemblage was *in situ* before burning, and disturbed afterwards. Experimental methods were created to identify how the burning might have occurred, and to apply this information to the archaeological assemblage to throw light on phases of occupation and activities at prehistoric and later Lyminge.



Figure 1. Aerial view of the 2012 excavation at Tayne Field, Lyminge, looking east. Anglo-Saxon and Saxo-Norman features are visible. The three test pits which yielded Mesolithic microliths are at the top right. Photo: Lyminge Archaeological Project.

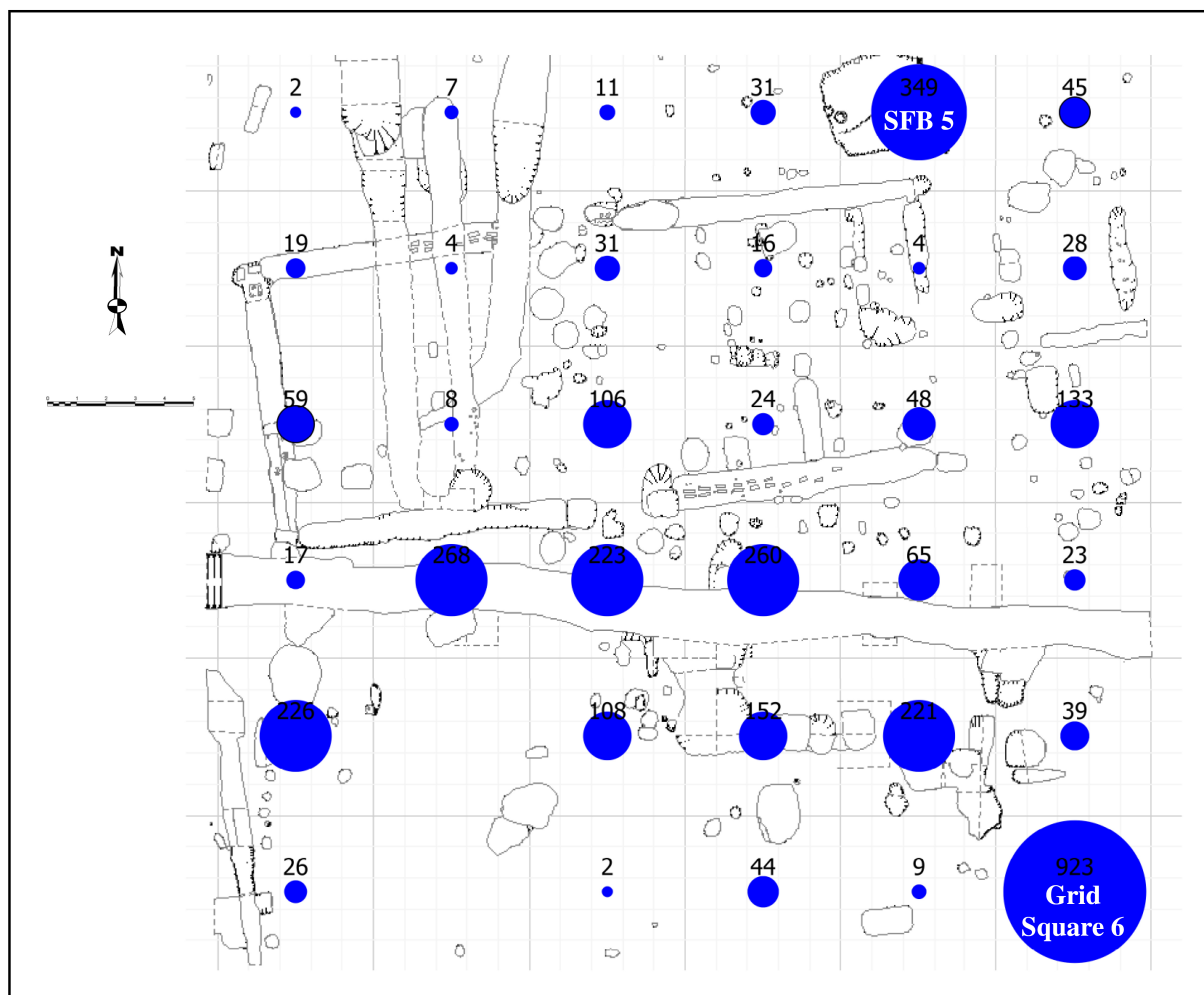


Figure 2. Plan of 2012 trench, showing Anglo-Saxon and Saxo-Norman features and an east–west ditch, possibly Bronze Age. Blue circles & numbers represent the number of burnt flints per 5 m grid square. Grid Square 6 at bottom right. Most of the burnt flints were found in these later features (e.g. SFB5, top right), rather than on the surrounding surface.

METHODS OF INVESTIGATION

Objectives and Methods

Our intention was to observe the effects of a small-scale single burning event, such as a cooking fire, on pieces of flint placed in, below, and adjacent to the fire. Five similar sets of flint were selected from debitage and unworked flints in the archaeological assemblage. Each set contained pieces of cortical, patinated and unpatinated flint in a range of sizes, from 0.1 to 0.2 m diameter. Our observation of the whole flint assemblage and unworked nodules found at the site was that the raw material was high quality, with few natural fissures. A shallow trench 1.8 x 0.4 x 0.1 m deep was dug, and filled with sand into which the flint sets were placed. One end of the trench was deeper (0.2 m), and above this a small fire 0.4 x 0.5 m was burnt

(Figures 3 & 4). The fire burnt for six hours, with more fuel being added at intervals, and then burnt itself out overnight. The experimental methods were designed to achieve a number of complementary objectives:

- To replicate the heat alterations seen in the archaeological assemblage. The flints were set in builders' sand (grain size 125–250 µm). The sand provided a consistent medium for heat transfer, and made it easier to identify and retrieve the flint afterwards. No chemical fuels were used to light or accelerate the fire. Small logs and seasoned wood offcuts of pine and alder were used for fuel, in accordance with assumptions about available timber during the Mesolithic in Kent (Kerney *et al.* 1980; Garwood 2011; Parfitt & Halliwell 2014).

- To establish whether heat alteration to flint requires direct contact with fire. Mercieca (2000) suggests that heat fracturing occurs through proximity rather than direct contact to heat. To test this, one set of flints was placed immediately below the fire on the trench surface, and four other sets at 0.3 m intervals horizontally.
- To establish the processes of vertical as well as horizontal temperature change, and its effect on flint. The rate of heat transfer through the ground is a fairly well understood process (Bradstock & Auld 1995; Canti & Linford 2000; March *et al.* 2014), but limited evidence is available for how heat affects flint across and below the ground surface. Sets of flints were therefore placed 0.05, 0.15 and 0.2 m below the fire, and four more sets, at 0.05 and 0.15 m depths, were placed at 0.3 m intervals, starting at 0.1 m from the fire's edge. These depths cover the range in which temperature falls exponentially in relation to depth (Bradstock & Auld 1995).
- To establish whether the fracture rate is related to the size of the flint. Mercieca & Hiscock (2008) demonstrate that larger nodules of flint crack faster than smaller nodules, and so each set contained flints with a range of sizes. Set 6, a large flint nodule (450 cm³), was placed on the edge of the fire to see whether a differentially heated flint would break differently to those placed completely within a fire.
- To replicate thermal alteration caused by the rapid cooling of hot flint. Two flints from the centre of the fire, heated to 500°C, were dropped into a bucket of cold water. According to ethnographic accounts, these temperatures are sufficient to boil water (Jackson 1998; Harry & Frink 2009), depending on the type of stone and amount of water.
- To test whether flints could have been burnt accidentally through the mixing of disturbed flints with hot fire sweepings during the Anglo-Saxon or later periods. The placement of small stones (too small for cooking – here defined as less than 80 mm long [Jackson 1998]) in the embers served as a proxy for understanding whether accidental burning took place. In the experiment, flints of various sizes were placed on the embers of the fire once it had burnt out.
- To test whether heated flints might have been used as cooking stones. Ethnographic studies of Native American groups indicate that larger stones were placed in fire embers for use as griddles. Food for cooking was laid on these heated stones and covered in upturned turf. Water was poured over the turf to generate steam to quicken the cooking process (Thoms 2008). Experimental and ethnographic studies identify a broad range of morphological features associated with cooking rocks. These include jagged edges, angular surfaces, crenulated surfaces, pot lid-covered surfaces and crazing (Jackson 1998; Thoms 2008 & 2009). The cooking experiment concluded with salmon steaks wrapped in leaves, placed on hot stones, covered with wetted upturned turf, and left for 35 minutes. The choice of salmon was felt to be suitably Mesolithic (Pickard & Bonsall 2007).

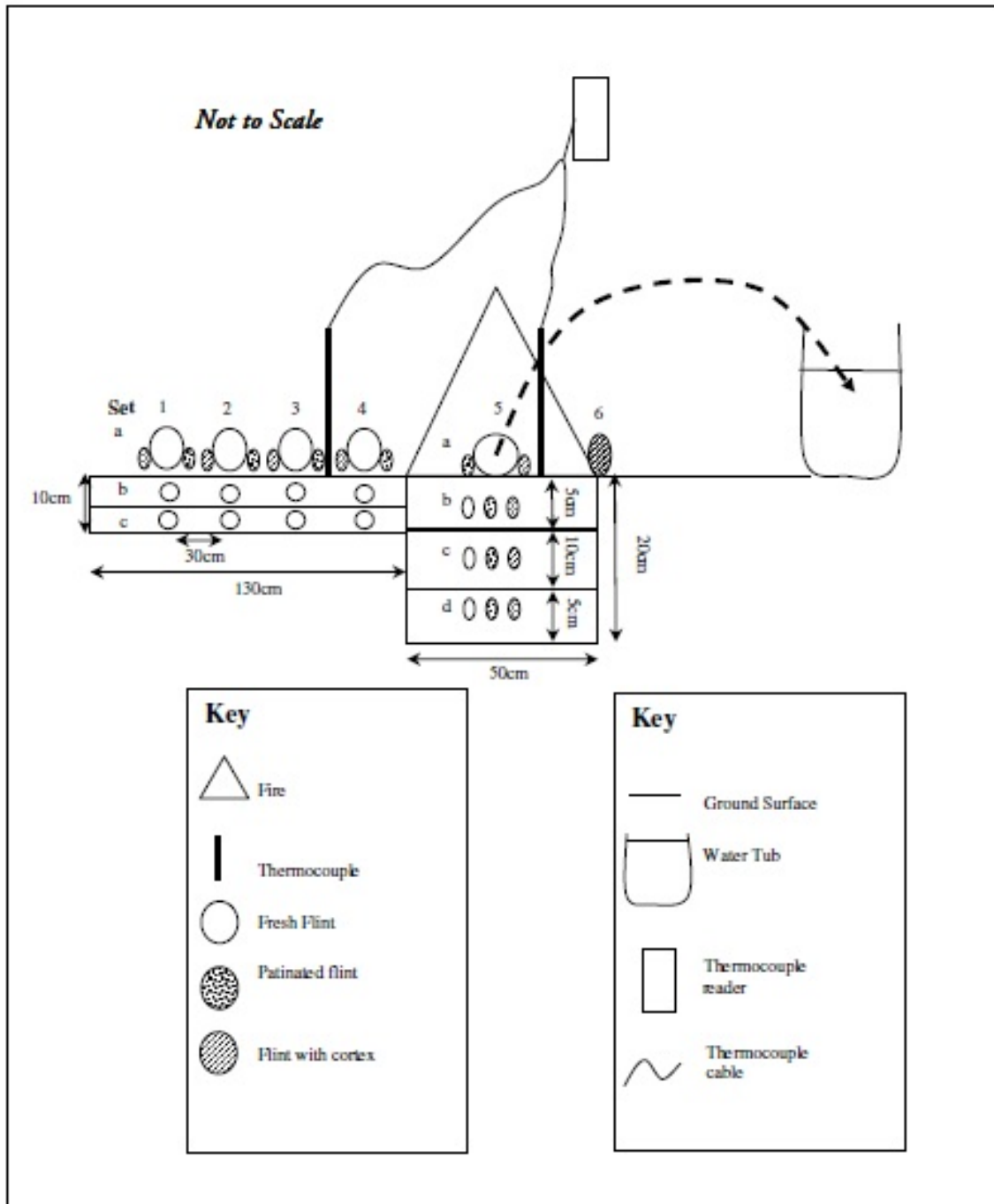


Figure 3: A schematic of the experiment.



Figure 4: The experiment in progress.

Observation and measurement

The starting temperature for the sand and the surfaces of the flints was 25°C, on a hot sunny day. The sand was slightly damp when removed from its plastic sack and put in the trench. The temperature of the surface of a flint in each depth and distance from the fire was measured at intervals with a thermocouple thermometer and 0.5 m probe (ATP Products, Type DT-610B), allowed to cool between readings. The maximum temperature reached at the base of the fire was 500°C. When the fire had burnt out and the trench contents had cooled, the fill was excavated stratigraphically by trowel. The fill was photographed to record colour changes, and sieved (2, 5 and 10 mm mesh) to ensure full recovery of heat-fractured fragments. Fragments were also recovered from the area around the trench. The flints were analysed with a low-powered microscope to look for any

significant morphological changes such as colour change, discolouration, fractures, thermal extractions (or pot lids), scales, fissure and thermal gloss (Clemente-Conte 1997). These observations gave ‘before and after’ observations of changes to the flint: it would not have been feasible to remove, observe and then replace flints whilst the fire was burning. The measurement of flint temperature during the fire gave a proxy for interim visual observations. Finally, the burnt flint from the experiment was compared to a non-stratified sample of burnt flints from the archaeological assemblage.



Figure 5. Fragment of heavily burnt flint (Set 5a, placed directly in the fire).

RESULTS

Direct contact with fire

Five of the flints placed directly in the fire (Set 5a) cracked violently during the first 30 minutes, occasionally throwing fragments up to 2 m from the fire. The thrown fragments were up to 1cm across. When excavated the following day, the remains of Set 5a had become heavily fractured grey and white fragments of flint, characteristics of heavily burnt artefacts as described in the literature (Figure 5).

Set 6, a large corticated flint nodule at the edge of the fire, broke apart gradually into thin layers. The surfaces of these layers were sometimes rough but never crazed and the orange band underneath the cortex had become visibly darker. This stone cracked sooner than any other. The cause of thermal fracture in flint is unresolved. The conventional explanation has been stress due to uneven thermal expansion after a too-fast rate of heating (Crabtree & Butler 1964; Patterson 1995; Mercieca & Hiscock 2008). Schmidt (2014) has argued more recently that fracture is due to pressure from fluid and vapour from within the rock,

which are unable to escape if the rock is heated quickly.

Vertical and horizontal transmission of heat

Bradstock & Auld (1995) showed there is an exponential relationship between temperature and soil depth in bushfires, although their selected distances and intervals are different from our study (Figure 6). A similar logarithmic pattern is seen in data collated from other works referenced in their study (Figure 7), with the Lyminge results superimposed (large dots). The Lyminge results fall into the same pattern of relationship between soil depth and temperature change. Temperature change was noted in the flints vertically below the fire, although at 0.2 m deep, the rise was no more than 2°C (Figure 8). Temperatures recorded on the same horizontal plane as the fire (Figure 9) showed a maximum of 50°C in the flints closest horizontally (Set 4) but little horizontal temperature change beyond a distance of 0.4 m (Sets 1–3). There were no hearthstones which might have affected horizontal heat propagation. At this distance away from the fire, heat transfer below ground level was also minimal.

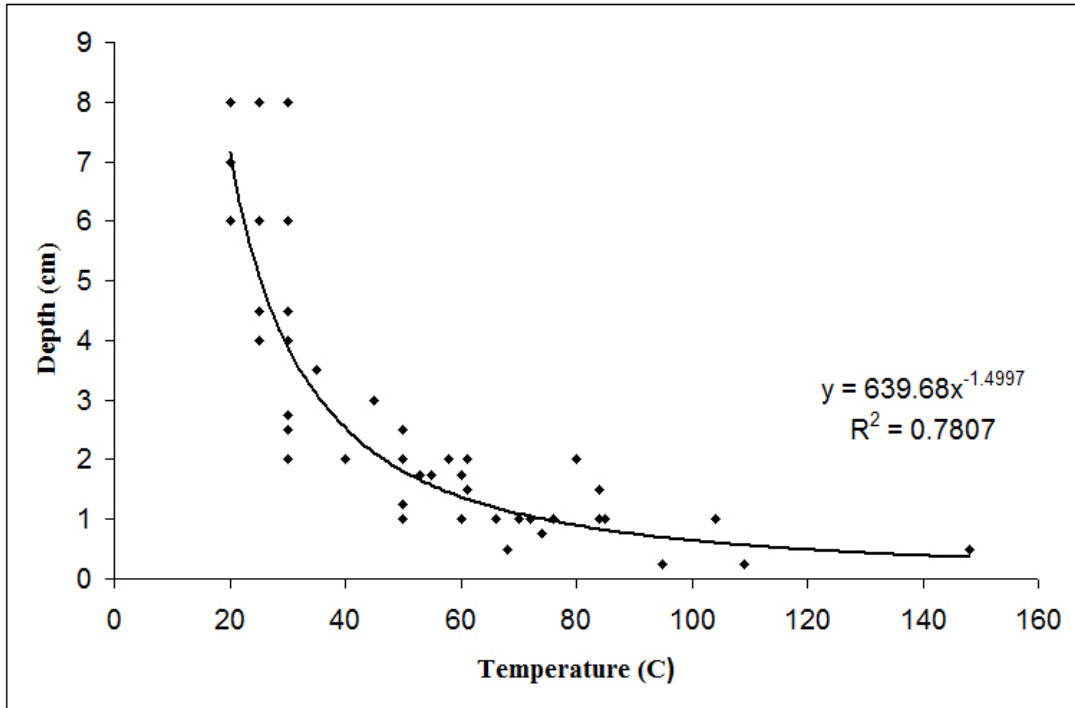


Figure 6. The pattern of heat transfer vertically through the ground in bushfires, using data from Bradstock & Auld (1995, table 1). The maximum temperature reached varies exponentially with proximity to the fire.

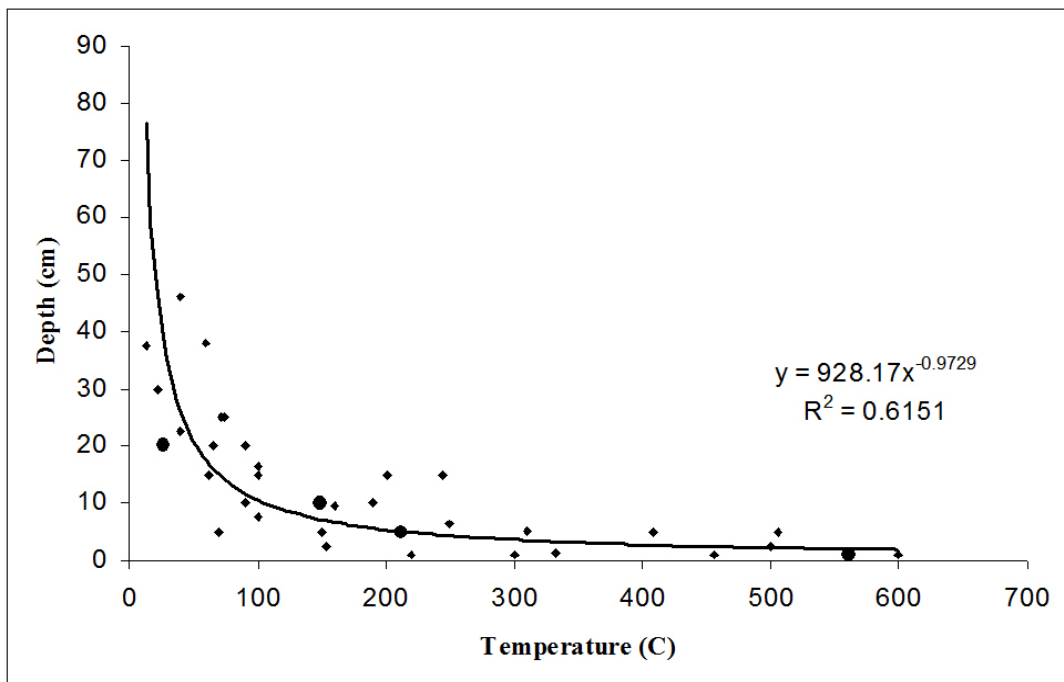


Figure 7. Relationship between maximum temperature and soil depth. Lyminge results (large dots) superimposed on data collated from Beadle (1940), Sweeney (1956), Roberts (1965) Lal & Cummings (1979), Ghuman & Lal (1989), Sackett & Haase (1992) Bennett (1999) and Canti & Linford (2000).

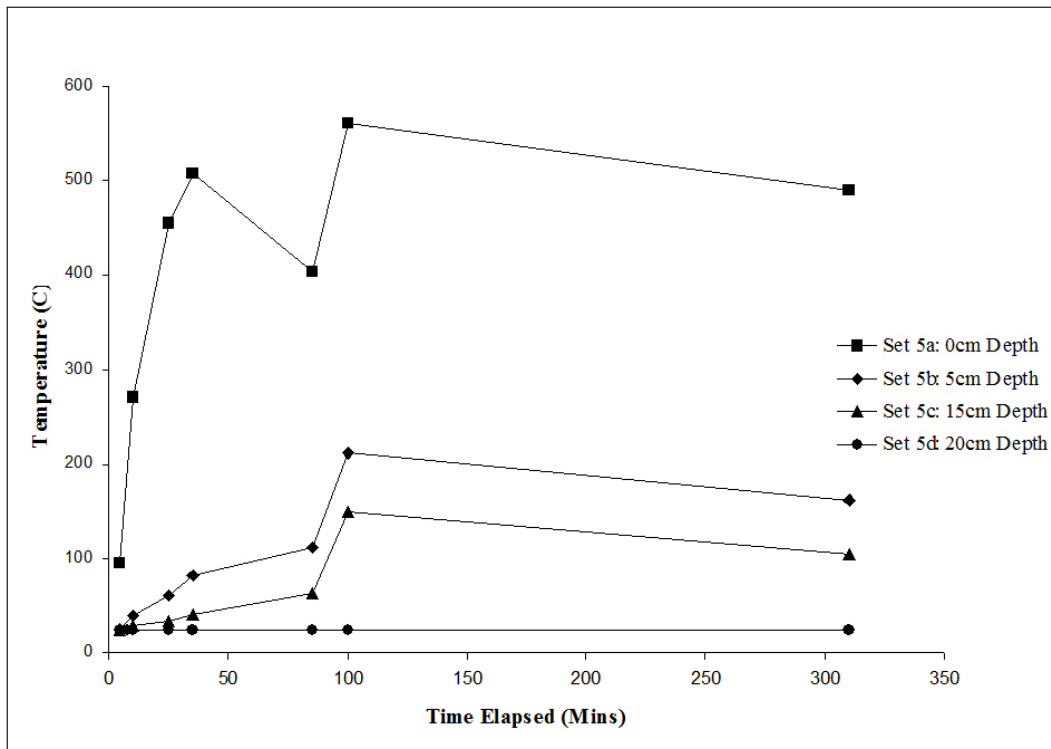


Figure 8. Temperatures recorded at different depths directly below the fire.

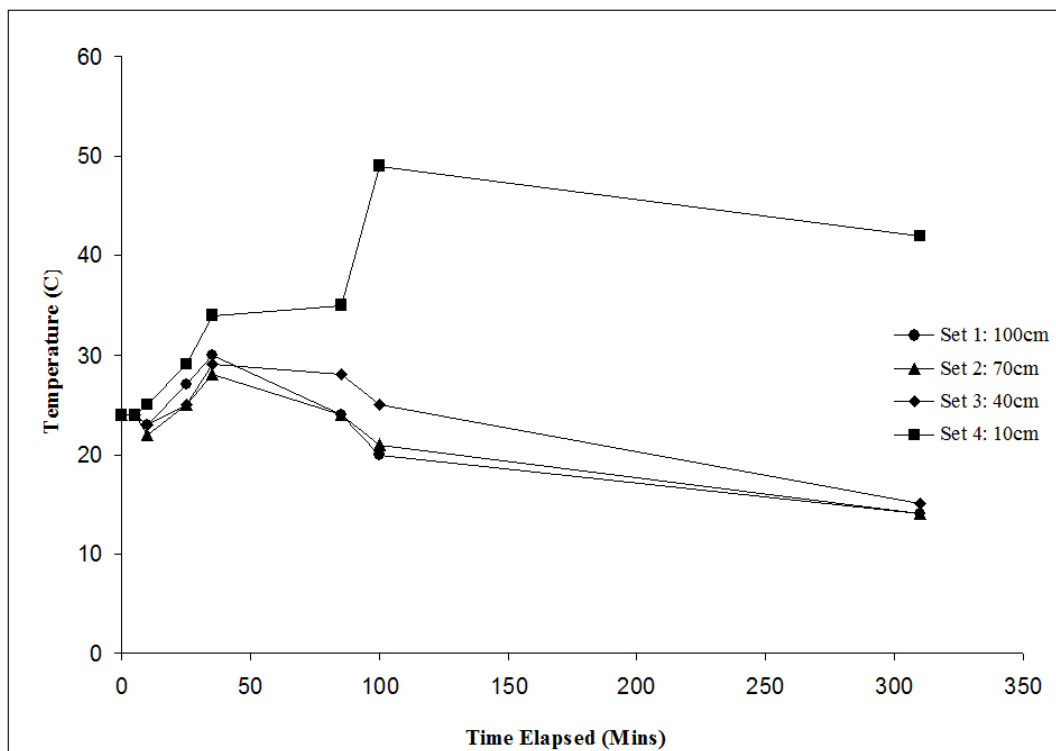
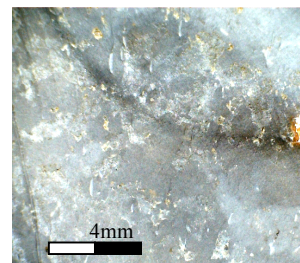
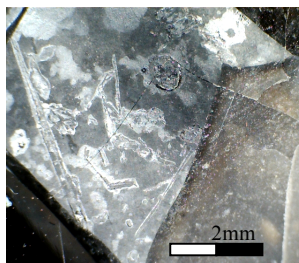


Figure 9. Temperatures recorded at the sets of flint on the same horizon as the fire.



Figures 10a & b. A patinated flint (Set 4a) placed on the ground 0.1 m away from the fire before (left) and after (right) the experiment. The white specks (right) are flecks of wind-blown ash deposited from the fire.



Figures 11a–d. A flint from Set 5c (0.15 m depth) before (11a, top left) and after (11b, top right) the experiment; note the pink tinge after it has been affected by heat. 11c (bottom left) a flint from Set 5b (50 mm depth) with patches of thermal gloss, slight crazing and fracturing. 11d (bottom right) a Neolithic scraper from the Lyminge assemblage that has similar, but worn, thermal gloss patterns.

Effect on flint of vertical and horizontal heat transmission

These patterns in heat transmission through the ground are mirrored in the effects on the flint itself.

The fire did not have the same effect on flints buried below the fire as those placed in it. Set 5b (50 mm depth) showed some very interesting

changes. Two small flints that previously had partial light blue patina now had none (Figures 10a & b). The colour on the surface of these two flints remained almost identical to that of unburnt black flint. These small flints had developed large patches of thermal gloss (Bordes 1969) on their surface (Figures 10b & c). A small amount of localised crazing was also noted. The larger white, patinated piece of flint had fractured into many small grey fragments

(2–5 mm diameter). In Set 5c (0.15 m depth) two of the flints had broken up and all had been tinged a slight pink-red in localised areas (Figures 10a & b). Some fresh surfaces still showed but some surfaces were more opaque than before being placed underneath the fire. None of the flint in Set 5d (0.2 m depth) had been modified at a macroscopic scale, unsurprisingly because it underwent no temperature change.

No macroscopic change was observed on flints from Sets 1–3. This suggests that the intensity of heat, from fires of this size, duration and temperature, do not affect flints on a horizontal plane. Heat-altered flints must therefore have been on a vertical rather than horizontal plane in relation to the fire. The temperature at Set 4a (0.1 m from the fire) did increase to 49°C (115 minutes into the experiment). At this temperature the heat was not enough to crack or craze the flint but resulted in the colour change from blue patina to grey (Figure 10b).

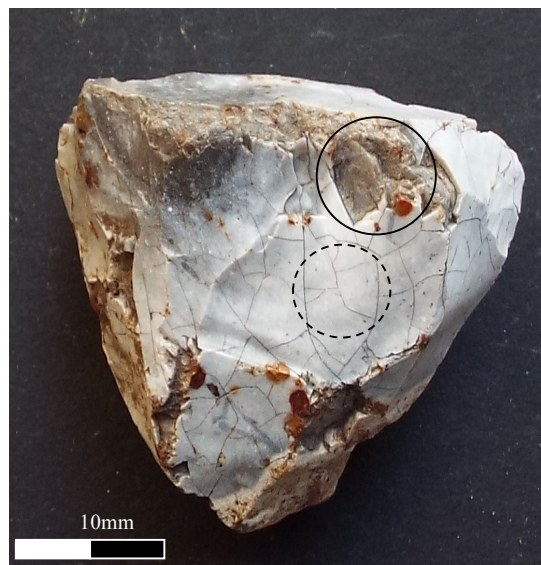
Rapid cooling

Two flints, one patinated, were placed in the fire and then placed in water in an attempt to replicate damage during pot boiling. The water did not boil but the stones did become slightly crazed (on less than 50% of the surface) and large fissures (up to 2 mm wide) were produced (Figure 12a). These are very similar to the

results produced by Purdy (1975) and Purdy & Brookes (1971). In the case of our patinated pot boiler, the flint shattered more violently, similarly to the white patinated piece in Set 5b. The fresh surfaces were revealed on the shattered parts of the flint. If one were to come across these features in the archaeological record, one would infer that the artefact had been knapped, with an interval before it was used as a pot boiler, during which time patination developed. The chemical processes of patination are complex, and the length of time for patination to occur will have depended on local environmental conditions (Burroni *et al.* 2002).

Flints placed in embers

The majority of flints placed in the embers had localised thermal extractions (negatives of fragments detached during heating). A patinated flint fractured in a similar fashion to the pot boilers, revealing a fresh, unpatinated surface. Black mottled patina on some flints turned red suggesting iron oxidation as part of the heating process (Stewart 1990). It is important to note that flints with both patinated and fresh surfaces (due to partial shattering) are important for determining the sequence of burning at an archaeological site. Flints with properties similar to these in the archaeological record must have been burnt after they had become patinated.



Figures 12a & b. (Left) a heated flint placed in water. One can see the first signs of crazing which may have developed further at higher temperatures. (Right) A flint from the archaeological assemblage with similar characteristics and clear evidence of thermal extractions. Both flints have a blocky appearance as cubic pieces are detached (solid circle), and crazing (dashed circle).

Cooking on hot stones

Success in cooking salmon on large stones placed in the embers demonstrates the practicality of heated flints as cooking stones in prehistory. The fish was cooked successfully but no alterations to the cooking stones were found.

Summary

These results may be summarised as follows:

Observation A: Flints directly within a fire of this size, duration and temperature will shatter heavily, craze and turn a white or light grey colour. Thermally fractured fragments may be thrown up to 2 m away from the fire at an early stage in the burning.

Observation B: Flints placed in embers may develop localised fractures where the flint is in direct contact with the embers.

Observation C: Large flints placed on the fire's edge will show changes on the side closest to the heat source. The surface will crack, and the colour of the flint may darken and become cloudy but the flint will not completely discolour.

Observation D: Flints 50 mm below a similar fire may fracture in some instances and show localised crazing. Light patination may be stripped and replaced by gloss. If they are not patinated, they may not discolour or shatter heavily but become slightly crazed.

Observation E: Flints 0.15 m below a similar fire will fracture in some instances and become tinged a pink-red. They may become cloudy. They will not fracture heavily or become fully discoloured.

Observation F: Flints 0.2 m below a similar fire may not be altered by it.

Observation G: Surface flints 0.1 m horizontally from a similar fire (Set 4) may change colour if already patinated. Flints more than 0.1 m horizontally from the fire, either on or below the ground surface, will not be altered.

Observation H: Flints used as pot boilers may become heavily crazed and fissures may appear on their surface.

APPLYING THE EXPERIMENTAL RESULTS TO THE ARCHAEOLOGICAL ASSEMBLAGE

A non-stratified sample of 203 burnt flints from the Lyminge assemblage was examined for these characteristics (Figures 13 & 14).

78 (38%) of the sample flints corresponded to heavily burnt flints in the experimental fire, those that had turned grey and fractured heavily (**Observation A**). The majority of flints showing signs similar to **Observation B** (11, 5%; burnt in embers) were too small for cooking and were mostly tools such as scrapers. 14 (7%) showed glossy patches and slight differential crazing similar to **Observation D**, 50 mm below the fire. 51 (25%) had macroscopic characteristics similar to those found in **Observation E** (0.15 m below the fire: clouding, slight differential reddening in some areas and no crazing). A few (22, 10%) were similar to **Observations C** and **G** (horizontally close to the fire). They had been previously patinated. They had been discarded and reused later as pot boilers or ember stones. Figure 13 demonstrates that, of the typologically datable flints examined, all those with features similar to **Observation E** belong to the Late Mesolithic or Early Neolithic. Bronze Age or Late Neolithic tools generally have patterns similar to **Observation D**, whereas **Observations A** and **B** are highly mixed.

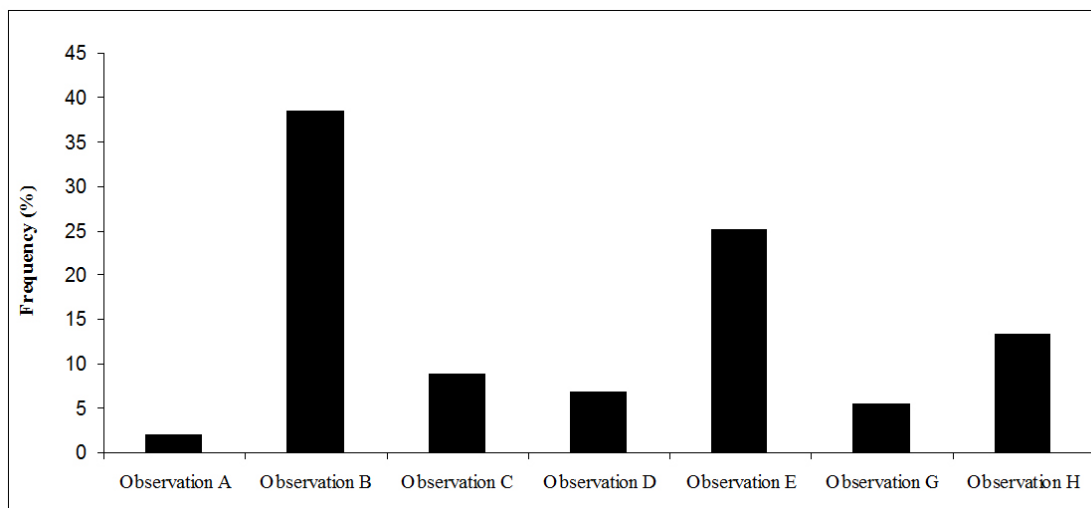


Figure 13. The percentage of burnt flints sampled ($n = 203$) from the Lyminge assemblage with characteristics similar to those observed in the burning experiment.

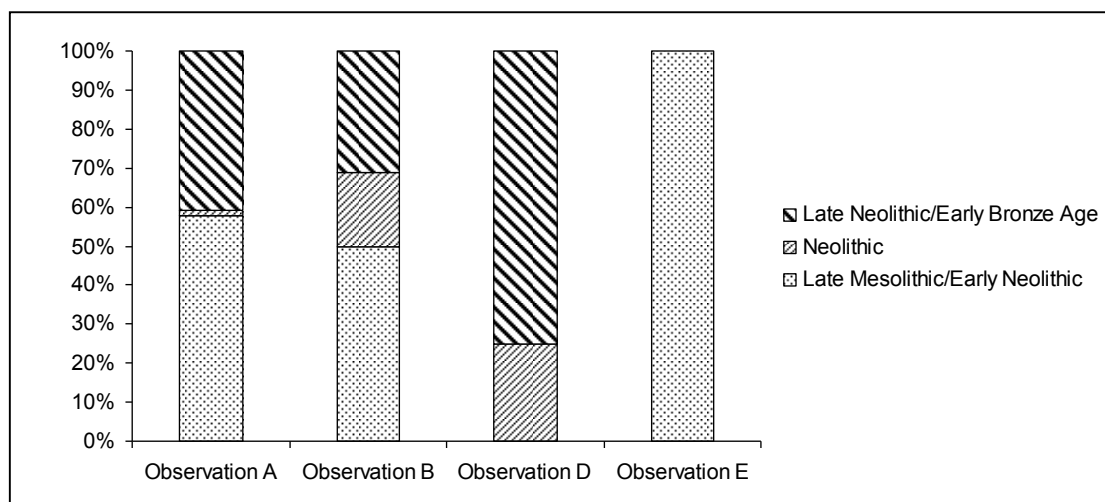


Figure 14. The relationship between flints from different periods and the types of burning associated with them.

DISCUSSION

The aim of this research was to reconstruct the prehistoric palimpsest of the burnt flint scatter at Lyminge. We wanted to identify whether burning was intentional or unintentional, how flint was burnt and, if possible, by whom (prehistoric or Anglo-Saxon). Further, we hoped to create methods for understanding similar disturbed palimpsests in the archaeological record elsewhere. These aims are inevitably entwined.

Our experiment modelled the effects of a single burning event of a certain intensity (561°C maximum) and duration (310 minutes), through a single soil medium on a flint assemblage. We must be cautious in applying our findings are

applied to the archaeological assemblage, which may have been burnt under different circumstances. Nevertheless, some conclusions can still be drawn.

Unravelling palimpsests at Lyminge

The findings confirm that heat penetrates to different depths at varying magnitudes, and affects flints differently depending on their vertical distance from the fire. The characteristics of burning are sufficiently distinct to enable us to assign the flints to a relative sequence of depths below the source of the fire. Different burning characteristics of flint therefore represent a fingerprint for now non-existent horizons of prehistoric activity. Burnt flints with characteristics similar to

Observation D (flints with gloss and localised crazing), for example, must have been placed on a stratigraphic horizon above those with characteristics similar to **Observation E** (slight pinkening with no other sign of burning). Thus, in accordance with the rules of stratigraphy, they must have been deposited at different times. This is confirmed by Figure 13 in which burnt flints dated typologically to Late Neolithic/Early Bronze Age have **Observation D** characteristics, whereas Late Mesolithic/Early Neolithic flints have **Observation E** characteristics. This shows that the site was occupied, or visited, over a longer period than just one event.

One can easily imagine mobile groups attracted to this site, drawn by the shelter of the valley, the fresh water spring and the availability of high-quality flint. The ratio of cores to Mesolithic tools is high, suggesting that the site was visited to obtain flint raw material, and the finished tools were taken elsewhere, perhaps for seasonal hunting. This pattern of repeated visits to Lyminge during the Mesolithic is strengthened by the large number of recycled flints found. Patinated flakes and cores that had been re-worked at a later date demonstrate that groups were returning to the site and re-using earlier tools. These indicators of recycling have also been noted at Middle Warren, Hartlepool (Waddington 1996; Waddington pers. comm.) and at the Mesolithic house at Howick (Waddington 2007), demonstrating that repeated visits to the same location were common in the Mesolithic period.

Many more flints in the archaeological sample were similar to those from Set 5c (**Observation E**) than Set 5b (**Observation D**). This suggests that there were phases of heavier intensity occupation (a greater number of flints with characteristics of **Observation E**) separated by at least one phase of lighter activity (a low number of flints from **Observation D**). This correlates from the findings in Figure 13 which suggest there was a more active Mesolithic period followed by a less active Neolithic then a more active Bronze Age.

From this, we can also suggest that the Bronze Age and Neolithic burning was in the same place as the Mesolithic activity because, to achieve **Observation D** and **E** characteristics,

heat propagation must have been vertical with little horizontal deviation.

Prehistoric activities at Lyminge

The experimental data and comparisons with the Lyminge assemblage demonstrate that not all flint is burnt in the same way. We can identify calcined flint that has been burnt directly in active fires (**Observation A**) and flints that have been placed in embers of fires (**Observation B**). Those placed in the embers have been differentially crazed and cracked (e.g. localised pot-lidding), whilst those placed in the flames have been heavily fractured, crazed throughout and discoloured. These may have been used as cooking stones, or small knapping debris discarded in the fire. It is clear from Figure 13 that the ratio of flints placed in the fire to those placed on the embers remains roughly equal throughout prehistory. Both the Late Mesolithic/Early Neolithic and Late Neolithic/Early Bronze Age data hint at a larger number of flints thrown into active fires rather than embers. This may suggest cooking practices remained similar throughout the early and middle Holocene (i.e. cooking took place on fire stones rather than in sealed cooking pits where embers cook the food [Thoms 2008 & 2009]). Alternatively, one can imagine the prevalence of flint knapping debris around an active fire while knappers socialised. It is also clear that pot boilers were in use when Lyminge was occupied in prehistory, though no typologically dated flints were found with these characteristics. Thoms (2009) has suggested that, for the most part, these would have been used to heat water for boiling or to steam cook foods.

We can also distinguish flints placed on the embers in the prehistoric period from those mixed in with hot debris in later periods. Differentially cracked flints that break the patina to reveal the natural colour underneath, were burnt some time after the flint was knapped. Two Lyminge flints deemed to have been placed in embers had patina growth disrupted by heat damage (see also Vaquero *et al.* 2012). These were found within an Anglo-Saxon feature containing charcoal and burnt bone, suggesting the now burnt flint had been accidentally mixed with other heated items. Most flints placed in the embers at Lyminge were too small to cook on and represent finished

tools such as scrapers. This suggests that activities, such as hide processing, took place around the dying hearth and that flint tools were tossed into the embers after use. This separation of actions contributes further to our understanding of prehistoric life at Lyminge.

Areas for further research

Heat transfer depends on the medium it is travelling through and its effect on stone depends on the internal structure of the stone (Domanski & Webb 1992). Canti & Linford (2000) have analysed the way heat travels through different soil media. It is clear from their experiment that the type of soil affects heat transmission at different depths. Brodard *et al.* (2015) have demonstrated that the soil's water content is another important factor in the rate and pattern of heat propagation. The soil medium is, therefore, an important consideration when examining burnt flints from greater depths. There is scope for further tests to investigate how heat would travel vertically or horizontally if the fire were larger, hotter, or longer-lasting, and what modifications to flint would be evident. The effects on flint of repeated burning events should also be investigated: if flint is repeatedly lightly burnt, does it look like flint which has been heavily burnt just once? What happens also when one has many fires on different levels of the stratigraphic sequence?

Related to this question is the interval between multiple burning events. The depth of the burnt flint below the fire source may be evident archaeologically, or from the method we have described, but the rate of sedimentation is a key variable in determining the elapsed time which this depth represents. This would depend on sedimentation from natural and cultural causes, including ash and debris from the fires themselves.

We have assumed that all flints were *in situ* before burning, then disturbed afterwards. To better identify whether this is the case, more statistical tests and experiments are needed to determine the make-up of the burnt assemblage to ascertain whether a single scatter or multiple, but disturbed, scatters had been burnt.

Last, it is unclear whether flint heated to high temperatures can patinate. It is widely accepted

that flint was heated in antiquity to temperatures of up to *ca* 200°C to improve its knapping qualities (Griffiths *et al.* 1987 and references therein), and that this may have affected the rate and nature of subsequent patination (Olausson & Larsson 1982), but we are not aware from the literature that the processes involved and the resulting morphological changes have been conclusively determined. There appears to be little published evidence about the possibility of patination after high-temperature burning.

CONCLUSION

Palimpsest data and disturbed sites have been great barriers to understanding prehistoric flint assemblages and human activities which fashioned them (Lithic Studies Society 2004). This work has aimed to break down these barriers by comparing experimentally burnt flint to those from the Lyminge assemblage. We have argued, from variation in thermal alteration, that one can identify different activities of prehistoric groups and separate phases in the sequence of prehistoric occupation at this disturbed site. By relating these to typological variability in the assemblage, we can make inferences about the prehistoric periods in which occupation and burning took place.

We have built up a landscape of activity from a jumble of disturbed stones. We have also, however, recognised that not all flint at Lyminge was burnt at the same time by identifying the characteristics in flints that are associated with indirect burning. This has helped us to untangle the taphonomic puzzle that hindered the understanding of how the Lyminge flint assemblage formed. We have been unable to decipher how frequently prehistoric groups came to Lyminge but we have been able to see that there are several episodes of activity during prehistory, and that the intensity of these phases of occupation varied. More experiments are needed to strengthen the results and more comparisons should be made to other sites but it is hoped that the methods presented in this research will contribute further to the understanding of activity dynamics and the unravelling of palimpsests at prehistoric sites with burnt flint. It can make use of the plethora of plough soil assemblages and disturbed sites that are such

major composites of the archaeological record in this period.

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THE PALAEOLITHIC IN WORCESTERSHIRE, UK

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ABSTRACT

In this paper we present the results of the first detailed study of the Palaeolithic archaeological record from Worcestershire. We demonstrate the presence of fluviially derived Lower Palaeolithic artefacts (mostly bifaces) associated with terrace gravels of the rivers Severn, Avon and Carrant Brook and identify the first possible evidence of earlier Middle Palaeolithic archaeology from the west Midlands. We also discuss the important, but largely overlooked, middle Devensian (~60–26 ky BP) archaeology from the Carrant Brook. Broadly associated with extensive palaeoenvironmental proxies and sizeable Devensian mammalian faunal assemblages, this contains evidence indicative of three phases of human activity attributable to the late Middle (~58 ky BP), final Middle (~38–36 ky BP) and early Upper Palaeolithic (~33–31 ky BP). Obtained from two localities (Beckford Priory and Aston Mill gravel pits), the three groups all contain artefacts which have undergone minimal reworking. They are indicative of a significant middle Devensian landscape associated with dynamic fluvial and geliflucted deposits within the Carrant Brook valley.

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Keywords: Lower Palaeolithic, earlier Middle Palaeolithic, late Middle Palaeolithic, final Middle Palaeolithic, early Upper Palaeolithic, Middle Devensian, bifaces, Levallois, blade production, Leaf Points, Aurignacian, Worcestershire.

BACKGROUND

Recent investigations carried out for the English Heritage-funded ‘Putting the Palaeolithic into Worcestershire’s HER: creating an evidence based toolkit’ enabled a reassessment of the Palaeolithic in Worcestershire. The programme collated extant information, updated it based on recent evidence and new interpretations, and placed the results within the Historic Environment Record (HER) to allow it to be interpreted and used by non-specialists (Russell & Daffern 2014). Previous investigations carried out as part of the Aggregate Levy Sustainability Fund ‘Shotton Project’ recorded 159 Lower and Middle Palaeolithic artefacts from Worcestershire (Buteaux *et al.* 2005; Lang & Keen 2005). These did not, however, include a full assessment of the largest collection of artefacts from the county, the Whitehead Collection ($n = 207$), nor did it include unassessed pieces recovered in recent times. Here we report on the results of this new holistic study and consider the Palaeolithic record from Worcestershire in the context of the Pleistocene settlement history of the UK.

The Palaeolithic in Worcestershire

A biface found in Worcester during the 1920s represents the first Palaeolithic artefact noted from Worcestershire (Smith 1922). This was followed by other finds (mostly bifaces) associated with Pleistocene river terraces of the Severn, the Warwickshire/Worcestershire Avon and the Carrant Brook (e.g. Burkitt 1934; Smith 1958; Grinsell 1960). Nevertheless, by the late 1960s only ten artefacts had been found (Roe 1968). This number dramatically increased during the 1970s, 1980s and early 1990s thanks to the work of P.F. Whitehead in the Avon and Carrant Brook valleys (Whitehead 1977, 1988 & 1992). He also recovered extensive mammalian faunal collections and a raft of other palaeontological datasets, including molluscs, coleoptera and ostracods (Whitehead 1977, 1989a, b, c & 1992).

Since the early 1990s there has been little systematic research, with the majority of artefactual finds being individual chance discoveries. In the English Midlands as a whole the focus of Palaeolithic investigations has been the pre-Englian record (>474 ky; >Marine

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Isotope Stage [MIS] 12), thanks largely to discoveries from Waverley Wood, Warwickshire (Shotton *et al.* 1993; Lang & Keen 2005). Currently Worcestershire has had little to contribute to this debate as no pre-Anglian archaeology has been recovered, although being situated between two major pre-Anglian drainage systems — the rivers Mathon and Bytham — the potential remains. Arguably this regional temporal focus has been detrimental to study of the Palaeolithic in Worcestershire, as the sizeable, and nationally important, middle Devensian (~60–26 ky, MIS 3) record has received scant attention.

The Worcestershire archaeological record fits within a Pleistocene framework based on the regional river terrace sequences (Table 1). It is divisible into four temporal units: MIS 12–8 (~474–244 ky), MIS 7–6 (244–130 ky), MIS 5

(~130–71 ky) and MIS 4–3 (~71–24 ky). Extensive glacio-fluvial archives attributable to MIS 12–9 are associated with palaeoenvironmental datasets (e.g. Bushley Green and Pershore: Bridgland *et al.* 1986; Whitehead 1989a), but no Palaeolithic archaeology. The earliest deposits with artefacts date to MIS 7–6 (e.g. Twynning: Whitehead 1992); all the artefacts are fluvially derived and could have been produced at any time during, or prior to, the deposition of the sediments. As elsewhere in the country, deposits from the last interglacial (MIS 5e) and early Devensian (MIS 5d–5a) reflect a dearth of evidence for human occupation (Ashton & Lewis 2002; Lewis *et al.* 2011; but see Wenban-Smith *et al.* 2010). The most archaeologically productive contexts date to the middle Devensian (MIS 3) (Whitehead 1977 & 1989a).

Table 1. Pleistocene terrace sequences of the Severn and Warwickshire/Worcestershire Avon.

Chrono-stratigraphic correlation (after Penkman <i>et al.</i> 2012)	Severn Valley Formation Member (after Maddy <i>et al.</i> 1995, Bridgland <i>et al.</i> 2004)	Severn Valley key biostratigraphical levels	Avon Valley Formation Member (after Maddy <i>et al.</i> 1991, Bridgland <i>et al.</i> 2004)	Avon Valley key biostratigraphical levels
MIS 2	Power House			
MIS 2	Worcester			
MIS 5a- 2	Holt Heath		Wasperton	
MIS 5a			New Inn	Fladbury
MIS 5d-5a				
MIS 5e		Stourbridge		Crophorne New Inn
MIS 6	Kidderminster Station		Crophorne	
MIS 7				Ailstone
			Strensham	
				Strensham
MIS 8	Bushley Green		Pershore	
MIS 9				?Pershore
MIS 10	Spring Hill			
MIS 11				
MIS 12	Woolridge Gravel			

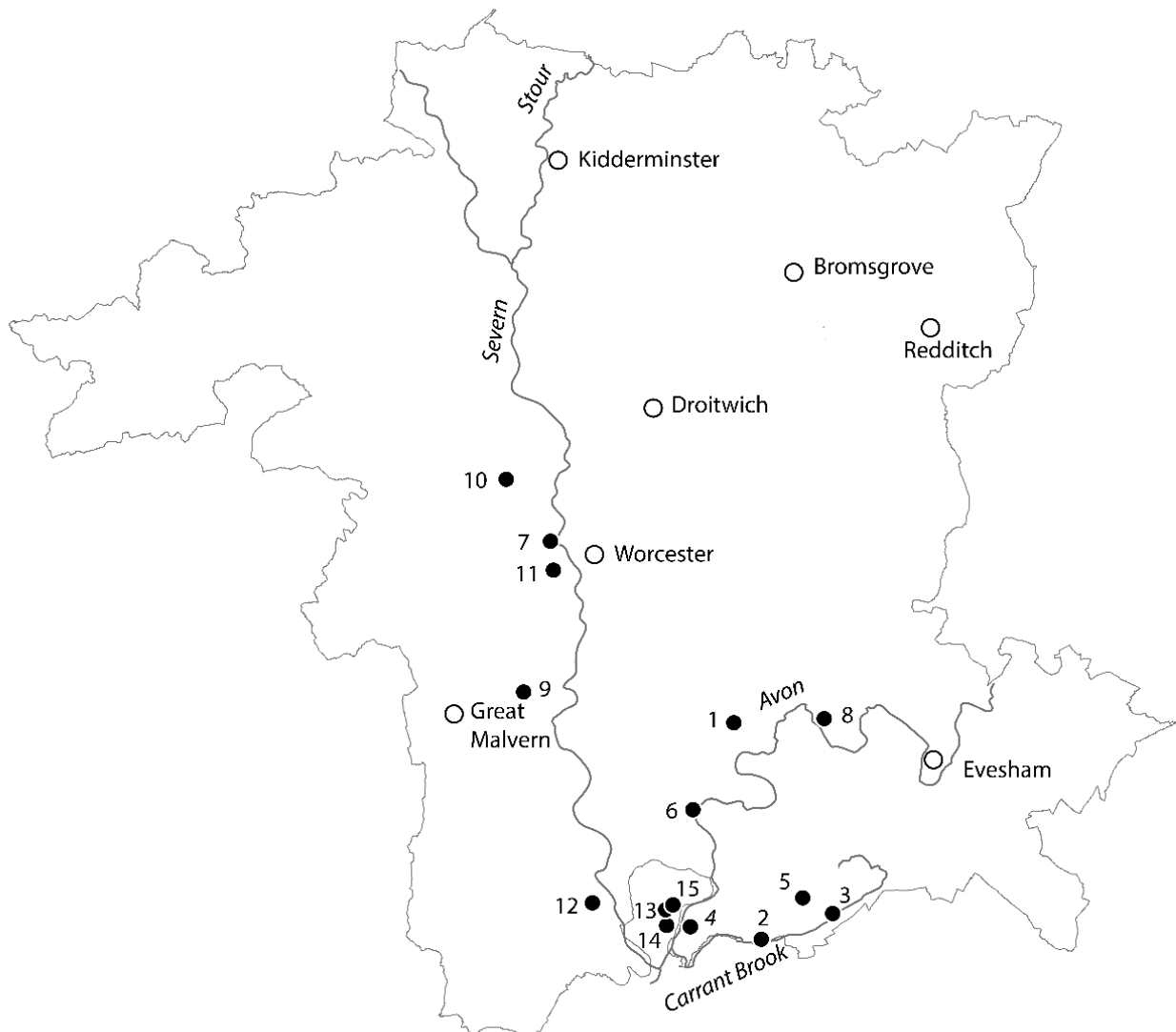


Figure 1. Location of Palaeolithic findspots in Worcestershire and north Gloucestershire:

- | | | |
|----------------------|--------------------------|---------------------------|
| 1. Allesborough | 6. Eckington | 11. Nursery, Worcester |
| 2. Aston Mill | 7. Henwick | 12. Queens Hill |
| 3. Beckford | 8. Lower Moor | 13. Twyning 'Terrace 4' |
| 4. Bredon's Hardwick | 9. Madresfield Park | 14. Twyning 'Terrace 2' |
| 5. Conderton | 10. Moseley Park, Hallow | 15. Twyning 'Solifluxion' |

The lithic assemblages considered herein are from the Whitehead Collection (curated in the British Museum, Franks House) and individual finds in museums and institutions in Worcestershire (Figure 1; Table 2). The Whitehead Collection consists of 207 artefacts collected between 1972 and 1989 from sand

and gravel quarries in south Worcestershire, and a small number from across the county boundary in north Gloucestershire. Chronologically the material as a whole can be subdivided between the Lower–earlier Middle Palaeolithic and the late Middle–early Upper Palaeolithic.

Table 2. Palaeolithic lithic assemblages studied

<i>Locale</i>	<i>OS Grid Reference</i>	<i>County</i>	<i>Collection</i>	<i>Flakes</i>	<i>Levallois Products</i>	<i>Blades</i>	<i>Non-Levallois</i>	<i>Levallois Cores</i>	<i>Blade Cores</i>	<i>Bifaces</i>	<i>Other</i>	<i>Total</i>
Allesborough	SO 9308 4640	Worcestershire	Worcester City Museum	0	0	0	0	0	0	1	0	1
Aston Mill	SO 945 349	Worcestershire	British Museum	47	2	6	10	5	8	23	0	101
Aston Mill	SO 945 349	Worcestershire	Almonry Museum, Evesham	0	0	0	0	0	0	1	0	1
Beckford	SO 984 363	Worcestershire	British Museum	37	1	8	7	6	7	17	2	85
Beckford	SO 984 363	Worcestershire	Almonry Museum, Evesham	0	0	0	0	0	0	2	0	2
Bredon's Hardwick	SO 908 356	Worcestershire	British Museum	1	0	0	0	0	0	0	0	1
Conderton		Worcestershire	Worcester City Museum	0	0	0	0	0	0	1	0	1
Eckington	SO 919 417	Worcestershire	Almonry Museum, Evesham	0	0	0	0	0	0	1	0	1
Henwick	SO 833 560	Worcestershire	Worcester City Museum	0	0	0	0	0	0	1	0	1
Lower Moor	SO 978 467	Worcestershire	British Museum	0	0	0	0	0	0	1	0	1
Madresfield Park	SO 833 560	Worcestershire	Worcestershire Archaeological	0	0	0	0	0	0	1	0	1
Moseley Park, Hallow	SO 8112 5933	Worcestershire	Worcestershire Archaeological	0	0	0	0	0	0	1	0	1
Nursery, St John's, Worcester		Worcestershire	Worcester City Museum	1	0	0	0	0	0	0	0	1
Queens Hill, Upton on Severn	SO 8555 3679	Worcestershire	Worcestershire Archaeological	0	0	0	0	0	0	0	1	1
Twynning 'Terrace 4'	SO 894 364	Gloucestershire	British Museum	10	0	0	2	0	0	8	0	20
Twynning 'Terrace 2'	SO 895 357	Gloucestershire	British Museum	1	0	0	2	0	0	1	0	4
Twynning 'Solifluxion'	SO 8965 3660	Gloucestershire	British Museum	0	0	0	0	0	0	1	0	1

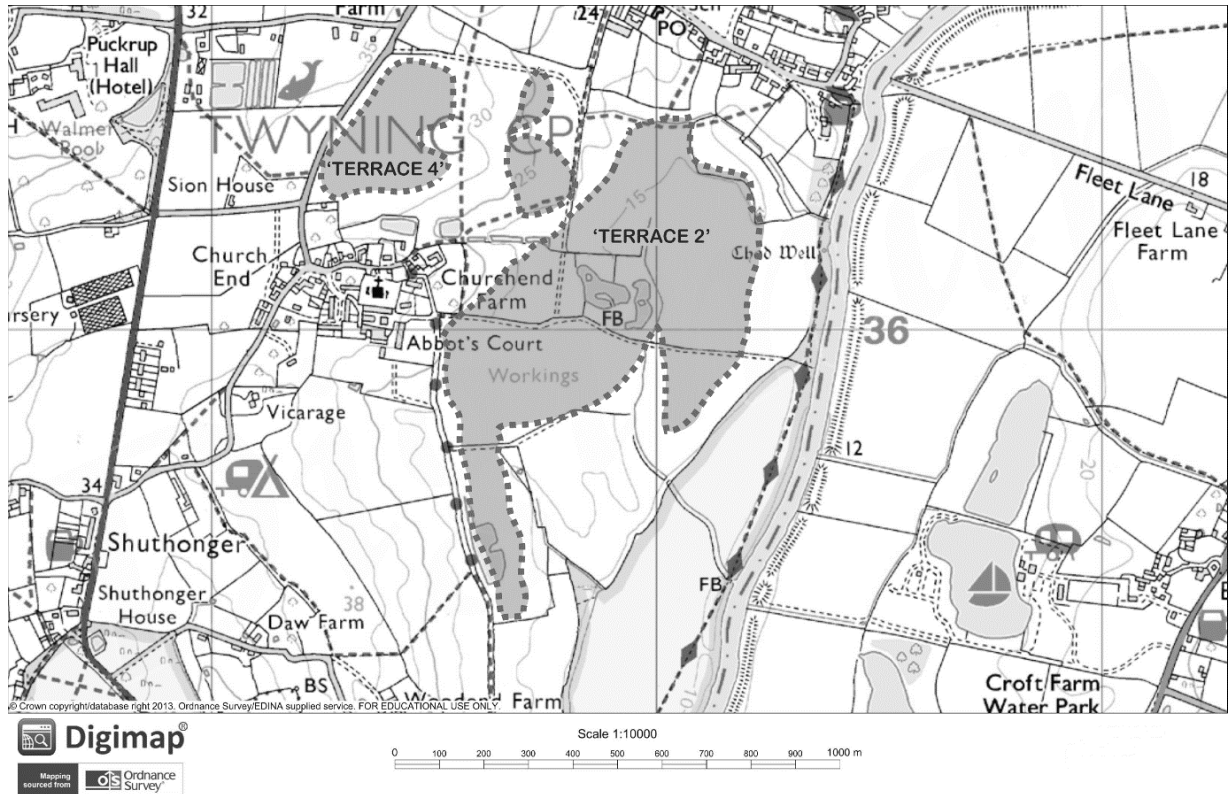


Figure 2. Location of gravel pits at Twyning illustrating maximum extent of workings. © Crown Copyright and Database Right 2015. Ordnance Survey (Digimap Licence).

The Lower and earlier Middle Palaeolithic

Lower Palaeolithic artefacts are all fluvially reworked and could be contemporaneous with associated deposits, or reworked from older sediments. The largest collections are from Twyning (Figure 2) where artefacts from two separate Avon terraces have been recorded (Whitehead 1989a). The earliest ('Terrace 4') deposits belong to the Crophorne Member of the Avon Valley Formation (Maddy *et al.* 1991; Maddy & Lewis 2005, 78). They have two lithological facies, a clast-supported fluvial gravel overlain by sands and gravels with syndepositional ice-wedge casts. The former contains a mammalian faunal assemblage with evidence for *Mammuthus primigenius*, *Coelodonta antiquitatis*, *Equus ferus*, Cervidae and Bovidae sp. indet. (Schreve 1998, 681); *Rangifer tarandus* has also been recorded (Whitehead 1989a). The lack of clearly temperate deposits, the faunal species' representation in the lower gravel and the presence of syndepositional ice-wedge casts in the overlying unit suggest the deposits date to MIS 6 (Schreve 1998, 688). The second, younger, suite of deposits ('Terrace 2') consists of orange/pink horizontally-bedded quartzose

sand overlying cross-bedded sands and gravel (Whitehead 1992) of the Wasperton Sand and Gravel, Upper Facet (BGS 1:50,000 Geology Digimap); this whole unit is thought to have been deposited between MIS 5a and 2 (Maddy *et al.* 1991; Maddy & Lewis 2005; Penkman *et al.* 2013, 124–127).

The collection from 'Terrace 4' consists of ten hard hammer flakes, one soft hammer biface thinning flake, two cores (simply flaked through discoidal and migrating platform reduction) and eight bifaces. Most are on flint (the exceptions being a quartzite core and a biface). That from 'Terrace 2' totals four artefacts on quartzite blanks: one flaked flake, two cores and a biface. All the material is fluvially derived and techno-typologically Lower Palaeolithic. Thus, both sets of artefacts could originate from older (pre-MIS 6) deposits. Those pieces from 'Terrace 4' have been suggested to be broadly contemporary with the associated lithological units as there are no remnants of earlier terrace deposits in the vicinity (Lang & Keen 2005, 77). This assertion is questionable as earlier terrace deposits are located just 2.5 km upstream to the south of

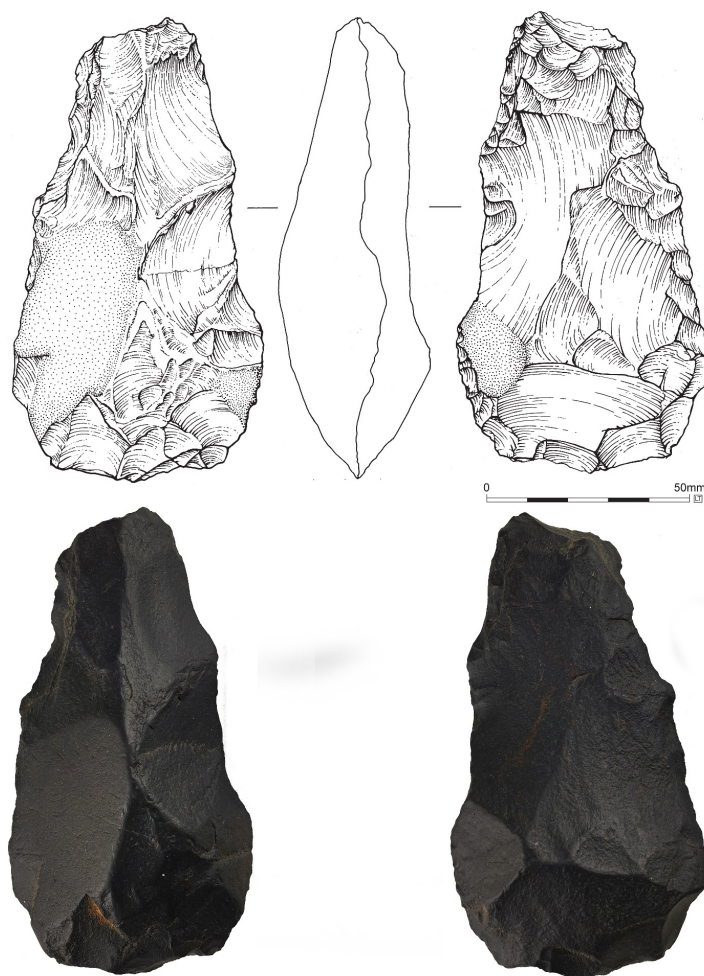


Figure 3. Biface from Allesborough (drawn by Laura Templeton © Worcestershire Archive and Archaeology Service).

Upper Strensham (Persnore Member), which are themselves adjacent to sediments equivalent to those at Twynning (Crophthorne Member). Consequently, there exists a mechanism for how material could be reworked from earlier terrace deposits into the Twynning ‘Terrace 4’ sequence.

Analogous artefacts were also identified from fluvial contexts at Bredon’s Hardwick (MIS 5a–2), Lower Moor (MIS 5a–2), Henwick (MIS 2; Devensian outwash gravel) and possibly Eckington (MIS 5) (Table 2). A moderately rolled quartzite biface comes from the modern land surface at Madresfield Park in an area underlain by Holocene alluvium (BGS 1:50,000 Geology Digimap). The nearest known extant Pleistocene deposits are located 1 km to the east, and belong to Bushley Green Member of the Severn Valley Formation dated to MIS 9/8 (Bridgland *et al.* 1986; Penkman *et al.* 2013, 124–127). A rolled biface made on an unusual

fine-grained volcanic clast from Allesborough is notable as such raw material does not occur regionally; the original clast may have been brought into the area as a glacial erratic (Figure 3). It was recovered as a chance find from a ploughed field adjacent to Avon deposits belonging to the New Inn Sands and Gravel Member. These are correlated with MIS 5 (Maddy *et al.* 1991; Penkman *et al.* 2013, 124–127) and, if indeed from this context, the biface is likely to have been reworked from earlier deposits.

A notable exception amongst these clearly derived pieces is a flint biface from a field at Moseley Park, Hallow. Although exhibiting some edge damage, incipient frost flaws and moderate patination, it is fresh and unrolled (Figure 4). It is pointed with secondary working on one face, one lateral edge and the tip, which is extensively thinned whilst the butt has been left thick and heavy. This findspot is on the edge

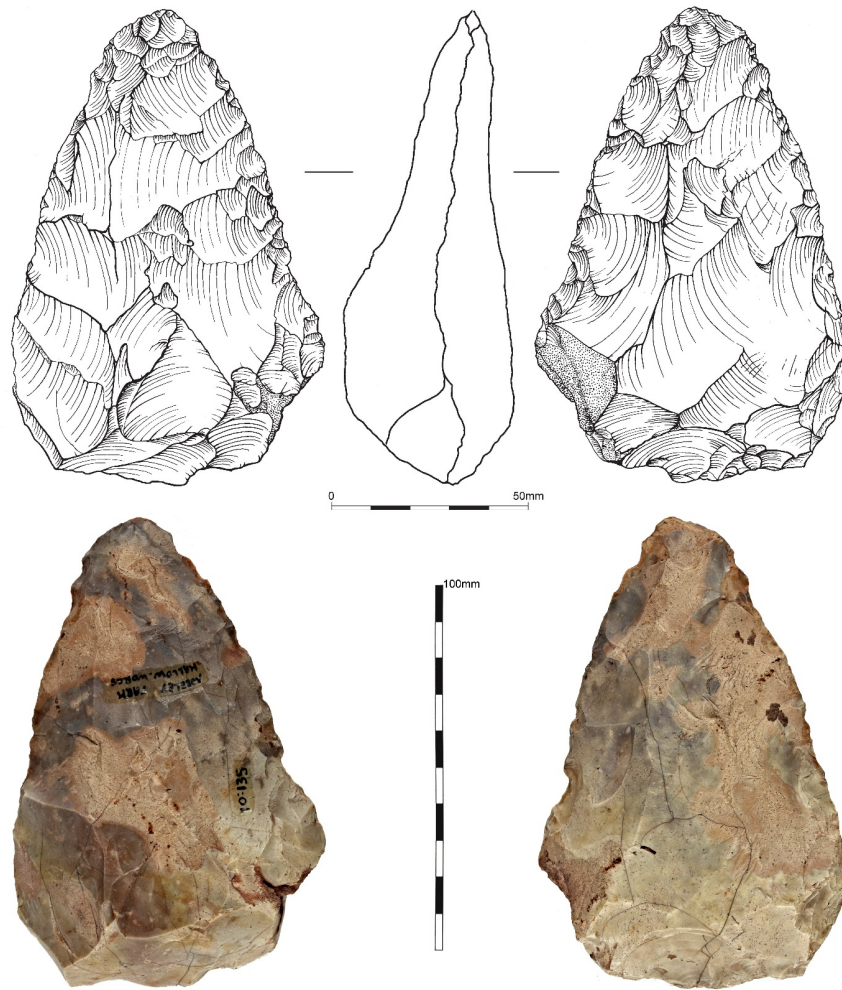


Figure 4. Biface from Moseley Park, Hallow (drawn by Laura Templeton © Worcestershire Archive and Archaeology Service).

of deposits belonging to the Kidderminster Station Member of the Severn Valley Formation (BGS 1:50,000 Geology Digimap) of MIS 7/6 age (Maddy *et al.* 1995). It is an intriguing artefact as it has not been reworked and may therefore be broadly contemporary with these sediments. If so, it would represent the first earlier Middle Palaeolithic findspot in the west Midlands. If it is not contemporary with the terrace it is nevertheless indicative of a unique occurrence of relatively undisturbed Lower or Middle Palaeolithic archaeology in this region.

Later Middle Palaeolithic and early Upper Palaeolithic

The largest and most significant collections studied are from the Carrant Brook, notably from gravel pits at Beckford and Aston Mill. Deposits here produced extensive

palaeoenvironmental datasets attributable to the middle Devensian (MIS 3), whilst the artefact collections contain pieces of late Middle, final Middle and early Upper Palaeolithic affinities.

Beckford Priory Gravel Pit, Beckford

The village of Beckford is located to the south of Bredon Hill, directly north of the Carrant Brook. Palaeolithic artefacts have been found here since the late 1950s (Grinsell 1960), and were extensively collected by Whitehead from Beckford Priory Gravel Pit, east of the village (Figure 5); the material was obtained both from exposed sections, modern surfaces and reject heaps (Whitehead ms. BM[FH]Whitehead). The sediments here belong to the local equivalent of the Wasperton Sand and Gravel, Upper Facet of the Avon (BGS 1:50,000 Geology Digimap) of MIS 5a and MIS 2 age (Maddy *et al.* 1991; Maddy & Lewis 2005, 79;

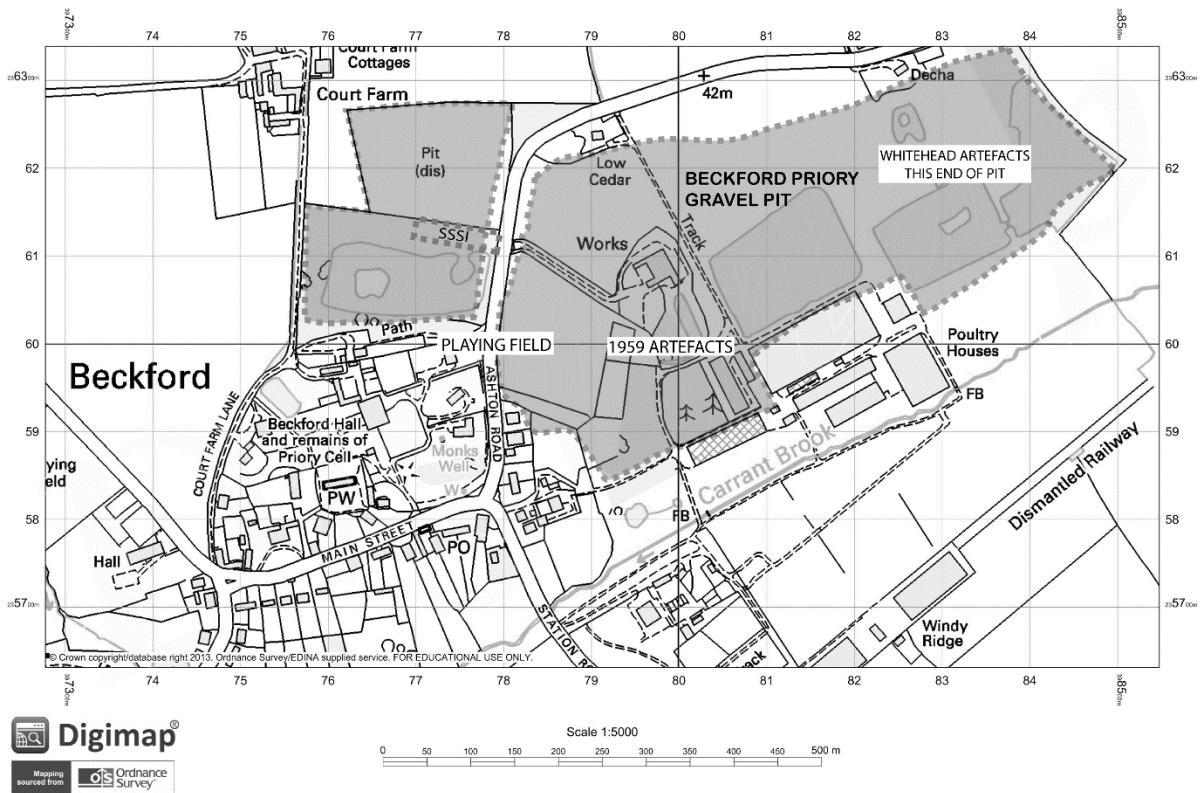


Figure 5. Location of Beckford Priory Gravel Pit illustrating maximum extent of workings. Crown Copyright and Database Right 2015. Ordnance Survey (Digimap Licence).

Penkman *et al.* 2013, 124–127). At Beckford they consist of well-bedded water worn gravel overlain by cross-bedded sands which, away from the Carrant Brook, are replaced by roughly stratified gravel. This reflects a transition from fluvial deposition to geliflucted material along the footslopes of Bredon Hill (Briggs *et al.* 1975). The sands and gravels contained periglacial structures indicative of two phases of activity — one during deposition and one post-dating the aggradations (Briggs *et al.* 1975). The deposits are uniformly overlain by brown silty clay loam derived as weathering products through gelifluction and aeolian deposition (Briggs *et al.* 1975).

Within the sands several beds of silt were observed which produced abundant plant, coleopteran and molluscan remains. They are interpreted as implying a local environment comprised of open, dry land, crossed by small streams and containing small, temporary, ponds. The climate represented by the fauna and sediments is suggested to be indicative of general aridity, with a larger annual temperature range than in the area today — mean summer temperatures below 10°C, with temperatures of at least -6 to -8°C during ice wedge formation

(Briggs *et al.* 1975). A mammalian faunal assemblage was recovered and is attributable broadly to the Beckford sequence, consisting of *Mammuthus primigenius*, *Coelodonta antiquitatis*, *Equus ferus*, *Bison priscus*, *Ovibos moschatus*, *Rangifer tarandus* and *Microtus gregalis* (Whitehead 1977, 45). These species are typically associated together within middle Devensian deposits (60–26 ky: Currant & Jacobi 2001 & 2011).

The collection studied consists of 86 artefacts including bifaces, Levallois cores and products, bifacial points, blade cores and products, non-Levallois and non-laminar cores and flakes. The bifaces subdivide into two taphonomically distinct groups. The first ($n = 15$) exhibits moderate/heavy fluvial abrasion, heavy patination and, frequently, moderate to heavy staining; these have undergone significant fluvial displacement. The second ($n = 3$) are heavily patinated, but only lightly abraded and unstained (or only lightly so) suggesting less reworking. Techno-typologically these also subdivide into two groups: those which could be Lower Palaeolithic or Middle Palaeolithic in age; and those with late Middle Palaeolithic features. The latter are associated with the

reoccupation of Britain by Neanderthals during early MIS 3 (~58 ky BP); the three lightly abraded bifaces all fall within this grouping. In total, seven exhibit features potentially indicative of this age attribution (*cf.* Boëda 2001; Cliquet *et al.* 2001; Halliwell & Scott 2011; White 2012) including several phases of shaping: retouch (or use-damage) to the butt; retouched or utilised portions opposed to a modified, blunted edge; and planoconvexity resulting from using an initial flake blank (or as is frequently the case with Beckford, tabular frost shattered blanks). There are, however, no typo-technologically distinctive *bout coupés* (*cf.* White & Jacobi 2002). The assemblage also contains six Levallois cores and one product. Four cores are unabraded or only lightly so, whilst two have clearly undergone some degree of fluvial transport. The product, a Levallois flake, is unabraded. The cores tend to reflect single phases of preparation and exploitation, probably due to the characteristics of the blanks — flakes, split cobbles and small, flat nodules; three are simple prepared cores which reflect the exploitation of natural convexities to exploit a flaking surface with only minimal preparation of the striking platform and/or flaking surface (White & Ashton 2003). Only a few of these pieces are associated with specific contextual information. These are four rolled bifaces which lack clear typo-technological affinities and a Levallois core; they are attributed to the base of the gravel and all are rolled.

Significantly the collection includes a fragment of a fully bifacial leaf point (Jacobi & Higham 2011). These rare and enigmatic artefacts are thought to date to ~38–36 ky BP and may represent the final presence of Neanderthals in Britain (Jacobi *et al.* 2006; Jacobi 2007). The Beckford example is a tip from a piece produced on a thin flake or tabular blank. It shows signs of light fluvial abrasion, is moderately edge damaged, heavily patinated and slightly stained. The collection also contains a second bifacial retouched point. This is of a mesial fragment of a partially bifacially thinned point on a thermal fragment. It is difficult to classify, but may be associated with the leaf point. Neither piece was recovered *in situ*.

Seven blade cores and eight blades are also present and are in broadly analogous condition — unabraded, or only slightly so, edge

damaged, heavily patinated and show little, or no staining, this suggests that they have not undergone significant fluvial transport. They are technologically consistent and reflect reduction through bipolar and unipolar blade production with a soft hammer. Blade production was initiated through cresting and there is evidence of platform rejuvenation through the removal of a core tablet. One bladelet core fragment is also present and two pieces of laminar debitage are retouched. Although none of these pieces display technological characteristics suggesting clear age attribution, it is notable that one core was obtained from the top of the Beckford gravels. This suggests it may derive from a different context to at least some of the bifaces and Levallois cores (see above).

The Beckford assemblage contains fluvially reworked material and pieces which have undergone limited or no fluvial transport. The latter contains Middle Palaeolithic material and includes pieces which are likely to be late Middle Palaeolithic, potentially from two chronologically distinct phases (early MIS 3: ~58 ky BP; and mid MIS 3: 38–36 ky BP).

Aston Mill Gravel Pit, Kemerton

Aston Mill Gravel Pit is north of the Carrant Brook, 3 km west of Beckford (Figure 6). It contains sands and gravels belonging to the local equivalent of the Wasperton Sand and Gravel, Upper Facet of the Avon (BGS 1:50,000 Geology Digimap) of MIS 5a–2 age (Maddy *et al.* 1991; Maddy & Lewis 2005; Penkman *et al.* 2013, 124–127). The local geological sequence comprises basal clast-supported gravel, primarily of local origin, overlain by cross-bedded sands which interdigitate towards the valley sides, suggesting a degree of contemporaneity between the two deposits. The gravels may represent active channel zones, whilst the sands reflect aeolian derived sediments deposited, or reworked, during high flood events in areas adjacent to these zones (Dawson 1987, 272). The gravels have produced the remains of *Mammuthus primigenius*, *Coelodonta antiquitatis*, *Equus ferus*, *Bison priscus*, *Ovibos moschatus* and *Rangifer tarandus*, whilst channel silts produced a large number of elements from *Bison priscus*, with a smaller component of *Rangifer tarandus* (Whitehead

1977). This is a similar species range to that found at Beckford (see above).

The artefacts from here were recovered from localities spread across the workings (Whitehead ms. BM[FH]Whitehead); a total of 102 have been assessed. They belong to seven techno-typological groupings: bifaces, Levallois cores and products, blade cores and laminar products, non-Levallois and non-blade cores and flakes. There are 24 bifaces, which, as with the Beckford examples, subdivide into two broad condition states indicating derived and less reworked elements. The majority ($n = 19$) are moderately/heavily abraded, heavily edge damaged, heavily patinated and generally heavily stained, whilst five are unabraded/slightly abraded, and tend to be less stained. As at Beckford, the biface assemblage contains three examples which display features that may indicate a late Middle Palaeolithic age attribution (see above); all three belong to the less abraded collection. There are also three biface thinning flakes which are fresh or only slightly abraded, one of which is burnt at the distal end. Unfortunately, the bifaces lack detailed contextual information, one of the thinning flakes, however, was recovered from the base of the gravel.

The Levallois component consists of five flint cores, along with one definite flake. Two are classic cores (*sensu* Boëda 1995), the remaining three are simple prepared and reflect the exploitation of natural convexities to exploit a flaking surface with only minimal preparation of the striking platform and/or flaking surface. As at Beckford, their presence reflects the application of the Levallois concept to suboptimal raw material; two are on frost shattered clasts. All are fresh or only slightly abraded.

Eight blade cores and six blades were noted. All are unabraded/slightly abraded, and have not undergone significant fluvial transport. The cores are broadly analogous with those from Beckford. One of the blade products is retouched to produce a nosed scraper. It is a crested piece with a burin removal along one lateral which is truncated by steep retouch, and has been noted to have parallels with examples in continental European Aurignacian assemblages (Dinnis 2015). Additionally, the collection contains a shouldered scraper which has also been considered to be indicative of this period (Jacobi & Pettitt 2000). The Aurignacian in Britain is suggested to date to ~33–31 ky BP

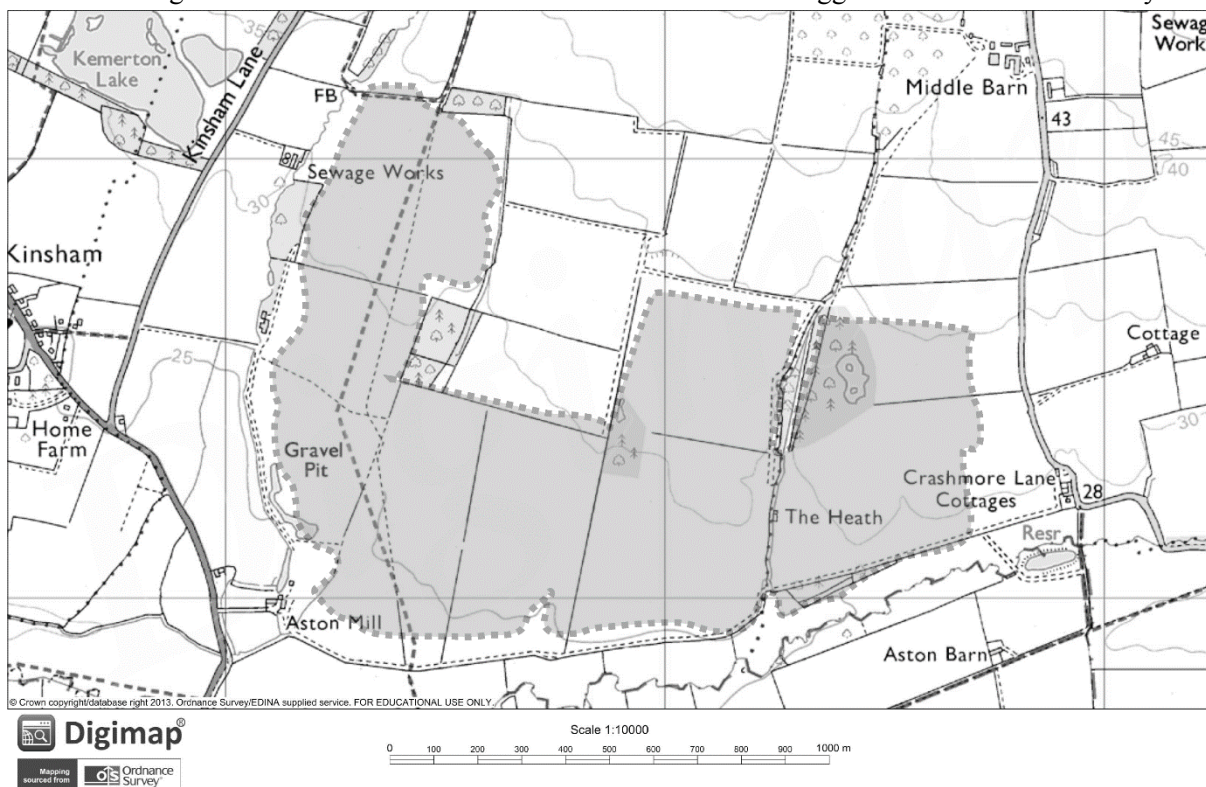


Figure 6. Location of Aston Mill Gravel Pit illustrating maximum extent of workings. Crown Copyright and Database Right 2015. Ordnance Survey (Digimap Licence).

(Dinnis 2012, but see Higham *et al.* 2011 & Dinnis 2015). Unfortunately, none of these pieces is associated with detailed contextual information, and it is not possible to assess the degree of association between the two scrapers and the other laminar pieces.

The Aston Mill lithic assemblage reflects and compliments that from Beckford. It contains rolled, fluvially derived pieces and fresher examples which have clearly undergone less reworking. As with the Beckford sample this latter grouping contains pieces indicative of at least two periods within the middle Devensian. The first of these is represented by bifaces and Levallois material which may be contemporary with similar pieces from Beckford (early MIS 3: ~58 ky BP), whilst the latter (as represented by the nosed and shouldered scrapers; ~37–32 ky BP) may be slightly later than that from Beckford (as represented by the bifacial leaf point; ~38–36 ky BP). Both localities have produced extensive mammalian faunal remains characteristic of the middle Devensian; it is currently unclear whether any human activity can be directly related to any of this faunal material (e.g. cutmarks or breakage for marrow extraction).

DISCUSSION

This study demonstrates that the archaeological record in Worcestershire subdivides between the Lower/earlier Middle Palaeolithic and late Middle/early Upper Palaeolithic. The former consist largely of fluvially derived artefacts (mostly bifaces) associated with deposits of the Severn, Avon and Carrant Brook. They indicate clear evidence for post-Anglian (MIS 12) occupation and may also include reworked pre-Anglian material — perhaps comparable in age to that from Waverley Wood (MIS 13; Shotton *et al.* 1993; Lang & Keen 2005) — but this cannot currently be demonstrated. The earliest potential evidence for relative undisturbed occupation is earlier Middle Palaeolithic, as represented by the biface from Moseley Park (?MIS7/6). The earlier Middle Palaeolithic record of Britain is dominated by sites from the Thames Valley. These are characterised by Levallois flaking with bifaces being largely absent (Scott 2011). It has, however, been suggested that sites from the west of Britain display an opposite trend with bifaces being present, but little Levallois material (Scott &

Ashton 2011). It is possible that the Moseley Park biface falls within this pattern, particularly as early Middle Palaeolithic assemblages (MIS 7), including bifaces, are found at Pontnewydd, north Wales (Aldhouse-Green *et al.* 2012). In order to demonstrate this, however, a specific context for the Moseley Park would need to be established.

The most extensive and informative material belongs to the late Middle/early Upper Palaeolithic. Found in relative abundance and often in generally fresh condition along the Carrant Brook, these lithic assemblages may belong to three chronologically distinct periods of the middle Devensian. The first is represented by technologically distinctive bifaces, apparently associated with Levallois material. These could be associated with the Neanderthal reoccupation of Britain during early MIS 3 (~58 ky BP) and be broadly contemporary with that from locations such as Lynford, Norfolk (60–53 ky BP: Schwenninger & Rhodes 2012; White 2012). The association with Levallois material is notable as it is currently not known from the small corpus late Middle Palaeolithic locales in Britain, but common amongst contemporary continental European sites (White & Jacobi 2002). The second grouping is marked by leaf points and characteristic Aurignacian material; they indicate an association with the final Middle and early Upper Palaeolithic. Leaf point industries have been generally associated with final Neanderthal occupation of Britain and are suggested to date to ~38–36 ky BP (Jacobi *et al.* 2006; Jacobi 2007) whilst the Aurignacian may date to ~33–31 ky BP (Dinnis 2012, but see Higham *et al.* 2011 & Dinnis 2015) and is thought to represent the earliest anatomically modern human presence.

The deposits within the Carrant Brook are therefore highly significant, having produced the full sweep of techno-typological groupings which define this important period. The specifics of how aspects of these typotechnological groups relate to each other is one of the vexed questions of the late Middle and early Upper Palaeolithic; for example, are all technologies with leaf points more recent than those with bifaces (Jacobi & Higham 2011)? Currently, the Carrant Brook datasets cannot answer such questions, but they do point to deposits with material which could. These are

part of a dynamic middle Devensian landscape formed through a complex interplay between fluvial deposition and gelifluction of material into the valley from Bredon Hill, and are associated with extensive palaeoenvironmental proxies, including mammalian fauna suggesting cool/cold, arid conditions. The associated archaeology, therefore, has the potential to investigate subsistence practices, and the use of place and landscape by late Neanderthals and early modern Humans during the changing environments prior to the Last Glacial Maximum.

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SAMPLING AT VIADUCT FARM, POLSTRONG, CORNWALL, UK: IDENTIFYING THE SOURCE OF GROUP XVI GREENSTONES

A.M. Jones,¹ H. Quinnell,² R.T. Taylor³ & A.C. Thomas⁴

ABSTRACT

Since petrological work in the 1930s enabled some Neolithic stone axe-heads to be defined as distinctive Groups which could be associated with their rock sources, it has been assumed that there were discrete ‘axe factories’ which could be pin-pointed on the ground for each Group. In some parts of Britain, fieldwork and excavation have confirmed the presence of axe production sites but, the source sites of the Cornish greenstone axe rock Groups have remained elusive. This is surprising as a large number of Groups have been assigned a Cornish origin with pin-point source locations provided. Recent work, however, on potential Group 1 sources and at an axe production site in West Penwith, has indicated that the picture is more complex than previously thought.

In this paper, the smaller Group XVI source is considered, and thin sections from locally found axe-heads, a significant number of which were from the nearby Neolithic tor enclosure of Carn Brea, are reappraised. A small inland greenstone site at Viaduct Farm, near Camborne, which has been identified with Group XVI, was focussed on to see if a discrete source could be established. Outcrops along the western side of the valley were sampled and examined against thin sections attributed to Group XVI to see if this material really was the source of Group XVI.

The results suggest that there was there was a low degree of matching between the axe-heads from Carn Brea and the outcrop at Viaduct Farm and that the axes themselves from were not derived from a single source. The variability instead suggests that the axes were made from a variety of materials from the Polstrong valley. In light of this, caution should be used in attributing specific source sites for Cornish axe rock groups.

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Keywords: Greenstone, Group XVI, stone axes, Viaduct Farm

INTRODUCTION

The greenstones of the southwest peninsula have long been known to have been significant in Neolithic axe-head production (Keiller *et al.* 1941; Cummins 1979). The term “greenstone” was introduced by the geological surveyors in western Cornwall in the early 1900s as a descriptor for the generally dark green coloured amphibolitic metabasic rocks of the area. Greenstone is retained as a convenient name which is in common use to describe stone artefacts from southwest England. Group I, which outcrops in West Penwith forms, the most widely circulated rock type but a smaller number are made from other sources, such as Group XVI which, since the 1960s has been identified as cropping out in the Camborne area (Evens *et al.* 1962) (Figure 1). The production sites for Cornish axes were longheld to be

unproblematic (Keiller *et al.* 1941; Cummins 1979; Mercer 1986). Samples taken from rock, sometimes from below current ground surface, were matched with thin sections taken from artefacts and the sites of potential ‘axe-factories’ were established. Then Peter Berridge (1993) pointed out the lack of evidence for actual axe working sites in Cornwall and called into question the existence of ‘axe factories’, although in fact, Cornish greenstones cannot be worked by flaking, which will leave obvious traces, but only by pecking and grinding. Experimental work (Mandal *et al.* 2004) has demonstrated that serviceable axes could be made from river or beach cobbles, indicating that extraction sites might be unnecessary for the production of greenstone axes.

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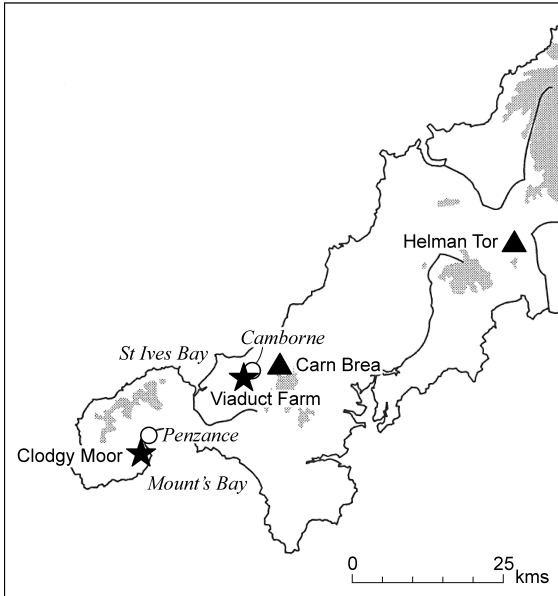


Figure 1. The location of Viaduct Farm in west Cornwall. Stars: axe production sites; triangles: tor enclosures.

Complexity of sourcing in Cornwall was reinforced by Mik Markham (2000) with several outcrops in West Penwith, including Gurnard's Head and Mounts Bay, indicated as the source for Group I axes. This Group 1 multiple sourcing is now supported by the artefactual assemblage from Clodgy Moor, near Paul in West Penwith, where greenstone axe rough-outs were manufactured from a range of beach and outcrop sources (Jones *et al.* 2013). Current data suggest that Group I axes are unlikely to have been produced in a single 'axe factory'.

It was now important to establish whether any of the Cornish greenstone axe Groups were made from a locatable and single source. One major problem here is the locating of rock crop outs on the surface which was available to both Neolithic people and modern archaeologists. Many of the samples on which the Cornish axes Groups are based, including Group XVI, have been taken from below-ground, or from quarried exposures which would not have been available to prehistoric people (Thomas 2005, 8). Also widespread quarrying across much of Cornwall has reduced the areas of greenstone rocks, available in the Neolithic, which can now be examined.

THE PROJECT

Group XVI: Viaduct Farm

Fortunately, Group XVI near Viaduct Farm in the Polstrong valley had a suggested inland source which crops out at the surface. Despite the loss of some greenstone for the railway viaduct, there are still a number of *in situ* outcrops which would have been available to Neolithic people.

The valley, to the west of Camborne (centred SW 162718 040296), is aligned north-south and bisects a broadly east-west band of greenstone, which otherwise lies below surface. In the immediate area of the railway viaduct the greenstone has been heavily quarried but greenstone boulders are visible all along the side of the valley. One prominent outcrop, now reduced by blasting, is known as the 'Giants Rock'. The placing of a Bronze Age stone battle axe and a hoard of 40 to 50 Late Bronze Age copper alloy axes at the base of the outcrop (Cornish 1880–1, 75; Hencken 1932, figure 18), indicates that it was a place of some significance in later prehistory.

The Carn Brea tor enclosure, some 5 kilometres east is the closest known major Early Neolithic occupation site to the outcrops, and Carwynnen Quoit megalith lies 2.6 km to the southeast. There are Neolithic lithic scatters from fields immediately west of the valley which include a significant quantity of nodular flint pieces (Thomas 2005, 16) obtained from networks of contact with communities in Devon (Tingle 1998) which might reflect the exchange of Group XVI for non-local flint.

There is a cluster of Group XVI axes from the Camborne-Redruth area mostly without associations. However, Carn Brea (Mercer 1981) has produced up to 18 artefacts, the densest known concentration of axes of this Group. Recent radiocarbon dating places the Neolithic occupation on Carn Brea in the period between 3900–3600 cal BC (Whittle *et al.* 2011, 509). Beyond Cornwall, Group XVI axes are found in small numbers across southern Britain (Evans *et al.* 1962), and as far north as the Midlands (Moore and Cummins 1974). Although close dating is limited, a radiocarbon determination of 3780–3370 cal BC was obtained from a pit at Hambledon Hill in

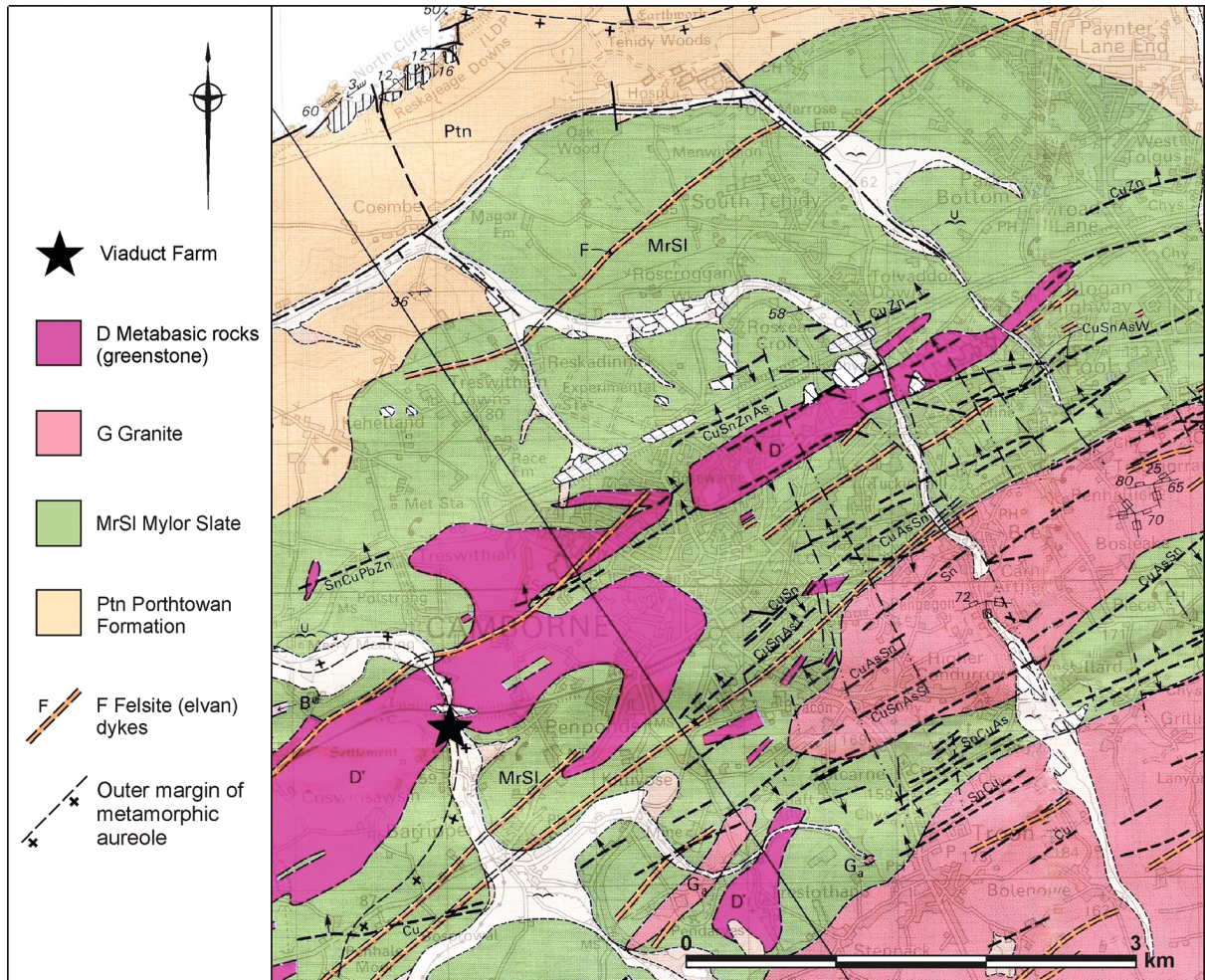


Figure 2. The geology of the Viaduct Farm area. Taken from the British Geological Survey 1:50,000 sheet Falmouth 352. Reproduced with the permission of the British Geological Survey © NERC 1990. All rights reserved.

Dorset, which contained a Group XVI axe-head (Healy & Mercer 2008, 387). This provides the most secure dating for axes of this group. The available evidence therefore suggests that, although not as important as the Penwith Group I greenstones, Group XVI axes were manufactured from the Early Neolithic period and were reaching Dorset and the Midlands in small numbers by the middle centuries of the fourth millennium cal BC.

The Geological setting

The stream that flows north from Barripper (SW 382 633) to Polstrong (SW 628 393) west of Camborne cuts across the outcrop of an area of metabasic rock (greenstone) in the area of Viaduct Farm where it is confined to a steep sided valley with some greenstone outcrops still accessible (SW 391 630). This is part of a band of greenstone cropping out, depicted as sill-like

in the transverse section of the Falmouth 1:50,000 sheet 352 (Figure 2). The full history of these rocks is uncertain but it is likely that they were originally doleritic intrusions (Bristow 1996, 16). Some of the sections show faint textural features that may be relics of an ophitic texture characteristic of intrusive dolerites. The surrounding rocks are slates of the Upper Devonian Mylor Formation.

After their intrusion the dolerites were subject to multiple phases of folding and low grade metamorphism during the Variscan orogeny. Following the main phases of deformation, the intrusion of the granite masses of Carnmenellis-Carn Brea-Carn Marth subjected the surrounding rocks to thermal metamorphism. The thermal aureole is particularly wide north of these granites as they are linked and extend to the north at relatively shallow depth. The greenstones of interest lie within the extended

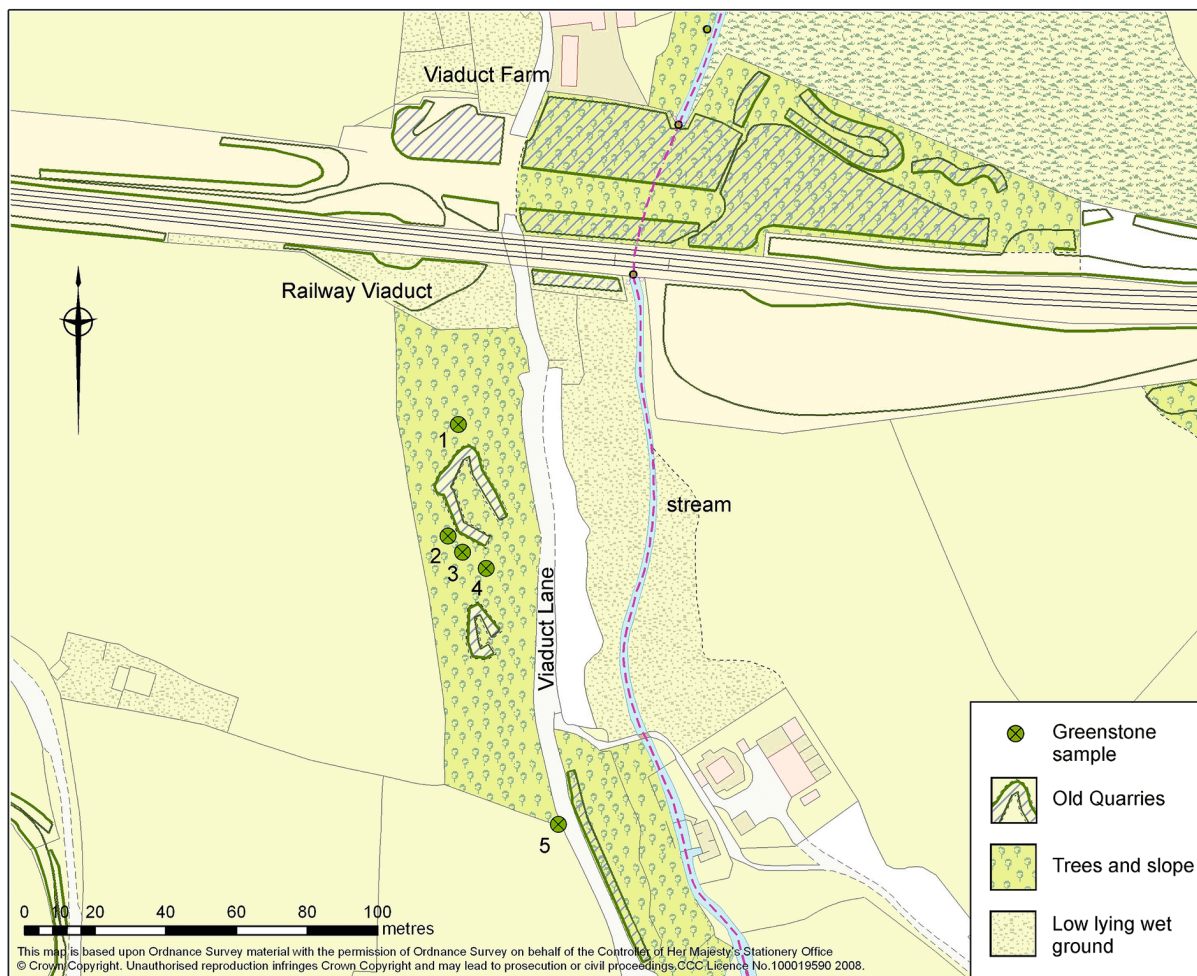


Figure 3. The locations of sampled outcrops.

aureole and were subject to contact metamorphism. A final phase of deformation followed producing a crenulation cleavage S_5 which can be seen to affect the contact metamorphosed rocks of the district (Leveridge *et al.* 1990).

Sampling

In 1970 five samples of greenstone taken from the Polstrong valley were submitted to the South West Implement Petrology Group (SWIPG) by Charles Thomas (2005). These were taken from locations around the valley, including a rock from the streambed. However, although these provided good matches for Group XVI, the submitted material either came from the quarried areas, or from loose blocks. (The thin sections of these samples are not included in the SWIPG lists published by Clough & Cummins [1979].) In 2008, further sampling took place, to obtain material from *in*

situ outcrops which would have been available to people in the Neolithic period. Five outcrops south of the viaduct were selected for sampling (Figures 3 & 4), their positions recorded to a 12-figure grid reference accuracy. These samples were submitted to the South West Implement Petrology Group who sponsored the preparation of thin sections and their identification by their petrologist Roger Taylor. These thin sections were then compared with 22 thin sections from greenstone artefacts, identified as Group XVI, held in the SWIPG collection at the Somerset Heritage Centre in Taunton (Table 1). To minimise the chances of misidentification, all of the thin sections selected for comparison were from artefacts from the Camborne-Redruth area, with the largest number being axes from the Early Neolithic enclosure on Carn Brea. The thin sections are held in the SWIPG archive at Taunton.



Figure 4: Site 3 outcrop being sampled. The photograph reveals the character and scale of the Group XVI outcrops in the Polstrong valley.

Cornwall No	Thin section No.	Find spot of sectioned axe	Notes	Taylor Variant
2	146	Penponds, Camborne	Axe or rough-out	Variant 4
5	149	Camborne, Weeth	Hone?	Variant 3
114	689	Camborne, Rosewarne Mill	Axe or rough-out	Variant 3
120	695	Camborne, The Gilley	Axe fragment?	Variant 3
111	682	Carn Brea	Axe or rough-out	Variant 2
167	762	Carn Brea	Axe	Variant 2
168	763	Carn Brea	Axe	Variant 4
173	776	Carn Brea	Axe	Variant 2
174	777	Carn Brea	Axe	Variant 4
175	778	Carn Brea	Axe	Variant 4
177	780	Carn Brea	Axe	Variant 4
178	781	Carn Brea	Axe	Variant 3
254	1206	Carn Brea	Axe	Variant 4
255	1207	Carn Brea	Axe	Variant 4
335	1560	Carn Brea	Axe	Variant 4
336	1561	Carn Brea	Axe	Variant 4
338	1563	Carn Brea	Axe	Variant 4
339	1564	Carn Brea	Axe	Variant 3
340	1565	Carn Brea	Axe	Variant 4
341	1566	Carn Brea	Axe	Variant 4
346	1571	Carn Brea	Axe polisher	Variant 2
372	1641	Carn Brea	Axe	Variant 1

Table 1. SWIPG thin sections used as comparison with the samples taken from Viaduct Farm (numeration follows Clough & Cummins [1988]).

RESULTS

Viaduct Farm Samples

The five thin sections (2009.15.1–2009.15.5) were examined and were found to be sufficiently similar that only one representative thin section is presented here. Descriptions are based on features of the complete slide and could not be shown effectively on a single photo-micrograph: the provision of photo-micrographs covering whole slides was beyond the resources of this initial project.

2009.15.1 ca 5.9 cm² in area. *Amphibole* – fine-grained fibrous to acicular more or less randomly oriented aggregates of slightly bluish tinged pale green actinolite. It is weakly pleochroic from pale bluish green to pale buff with individual grains up to 0.2 mm long and forms irregular concentrations. *Feldspar* – very finely granular feldspar concentrations, possibly much sericitised, penetrating and enclosing the amphibole. *Opaque ore* – a dusting of extremely fine-grained irregular equidimensional grains predominantly concentrated within the amphibole. *?Epidote* – colourless irregular granules with high relief and high birefringence scattered through the rock, individual granules are up to 0.01 mm. *General texture*. This is particularly noticeable in the macro appearance of the section with darker irregular, centimetre-scale, amphibole-rich areas are penetrated and surrounded by neutral to colourless areas rich in feldspar of indeterminate composition. This gives the impression that the rock has been brecciated (fractured) at some time in its history prior to its main recrystallisation.

All five sections show complete recrystallisation with loss of all traces of original igneous texture. The ‘greenstone’ sampled is shown on the Falmouth 1:50,000 geological sheet 352 (Figure 2), to lie just at the mapped margin of the thermal aureole. This is reflected in the very fine, and largely random, crystalline state of the amphibole in the rock. This texture would give toughness to this lithology and contribute to its suitability for axe manufacture. The sampling distribution indicates a degree of uniformity in the outcrop. Implements made from this rock should be readily distinguished in thin section.

Re-examination of Group XVI axe thin sections

The original description of Group XVI petrology (Evens *et al.* 1962, 220) runs as follows: *The rock consists of hornblende in considerable quantities mainly occurring as patches of felted green needles and often with parallel arrangement. Very ragged fibrous plates of hornblende are scattered through the rock. The feldspar is very decomposed, almost isotropic but occasionally recrystallised and clear. Pale brown mica as patches of short interlacing laths in the hornblende is present in varying amount, and black iron ore forms small grains or larger skeletonised grains. A little epidote in small grains is present.*

This description refers to the amphibole as hornblende, but the pale green colour and frequent occurrence of colourless amphibole together with the recrystallisation in the contact aureole suggests that the tremolite-actinolite range of amphiboles is more likely. The presence of biotite in some of the Group XVI thin sections re-examined probably indicates a source deeper within a granite metamorphic aureole than for the rocks used in the Group XVI description. There is some correspondence between the five samples examined and this description for Group XVI but it is not exact. The absence of brown mica or biotite and lack of foliation in the Viaduct Farm material is noteworthy.

The 22 thin sections from the SWIPG collection categorised as Group XVI are not homogeneous in terms of texture nor, to some extent, in terms of composition compared with the original, but not very detailed, defining description of Evens *et al.* 1962: no thin section number was included in this description. The small areas of many of the older thin sections means that they cannot show the possible textural characteristics seen in the Viaduct Farm sections (Viaduct Farm average 5.3 cm² : thin sections re-examined average 0.7 cm², but as little as 0.25 cm²).

An attempt has been made to place the SWIPG Group XVI sections in four subcategories as follows, with one section published for each. These variants provide a convenient way of presenting the thin section data, but it would be premature to regard these as ‘sub-groups’ of Group XVI.

Variant 1 Viaduct Farm texture (one example)
Fine-grained actinolite as fibrous randomly orientated aggregates.

Variant 2 Original Group XVI. Coarser ragged pale green amphibole grains in a felted matrix with biotite, comparable with the original Group XVI description (four examples).

Variant 3 Pale green amphibole, as larger ragged grains in a felted matrix but lacking biotite (five examples).

Variant 4 Colourless amphibole, as large ragged grains but lacking biotite (12 examples).

The reference numbers of the thin sections assigned to each Variant are given in Table 1.

Variant 1 Corn 372 Thin section 1641 Carn Brea, 0.8 cm² in area. *Amphibole* – pale green, predominantly as a randomly oriented fine acicular crystals up to 0.1–0.3 mm, some with a stellate arrangement. *Feldspar* – irregular low birefringent grains, some showing twinning, up to 0.75 mm, penetrated by acicular amphibole.

Biotite – pleochroic light brown to colourless, relatively common as single grains and aggregates, 0.1–0.5 mm replacing amphibole. *Opaque ore* – probably ilmenite, relatively coarse single grains and aggregates, some skeletal, up to 0.5 mm.

Variant 2 Corn 346 Thin section 1571 Carn Brea 1 cm² in area. *Amphibole* – pale green, ragged grains and aggregates up to 1.5 mm surrounded by fine, randomly oriented, acicular grains. *Biotite* – pleochroic pale brown to colourless irregular areas and grains some replacing amphibole, 0.1–0.2 mm. *Feldspar* – irregular patches of untwinned low birefringent grains. *Epidote* – clusters of very small grains with high relief. *Opaque ore* – irregular grains and aggregates, some elongated up to 0.2 mm.

Variant 3 Corn 120 Thin section 695 Camborne 0.25 cm² in area. *Amphibole* – pleochroic pale green to colourless with some larger ragged grains and aggregates up to 1.25 mm, set in more or less randomly oriented finer-grained amphibole. *Feldspar* – untwinned scattered grains and some distinct elongated areas of low birefringent grains up to 1.5 mm long. *Opaque ore* – common as elongated

strings and aggregates of irregular grains up to 0.025 mm. *Comment* Section too small to give an adequate description of texture. Possible trace of S₅ crenulation cleavage distorting amphibole crystals.

Variant 4 Corn 168 Thin section 763 Carn Brea 0.3 cm² in area. *Amphibole* – colourless and mainly as large ragged grains and aggregates up to 1.0 mm surrounded by a felted aggregate of randomly orientated amphibole laths. *Feldspar* – sparse areas of untwinned low birefringent grains, 0.3 mm. *Opaque ore* – probably ilmenite, a scatter of small equidimensional grains and clustered skeletal grains up to 0.15 mm. An irregular spaced cleavage is present.

Comment on the thin sections

Amphibole may be pale green pleochroic or colourless, biotite may be present or absent, epidote may be present or absent. Larger amphibole grains may be present or absent, foliation may be present or absent. Ghosting of relict ophitic igneous texture may be present or absent. Much of the group shows recrystallisation of amphibole in a manner suggesting thermal metamorphism. However, the thermal aureole to the north of the Carnmenellis Granite covers the main area of the greenstone outcrop and defines the source area for Group XVI to the north of Camborne suggested in Evens *et al.* 1962. Some sections show areas of brown staining (?ferruginous). This may result from post manufacture weathering of the implement, but is possibly the result of weathering of the rock prior to manufacture. The sections of axes that contain biotite are likely to be from greenstone most intensely affected by contact metamorphism from the Carnmenellis/Carn Brea Granite. The Red River cuts across the Greenstone outcrop in such an area and would be a potential source for cobbles yielding axes containing biotite.

The variations in lithological detail of the thin sections studied suggests that their parent axes had multiple sources. This seems at first unlikely given the lack of natural surface exposure on the outcrop of the greenstones north of Camborne. Indeed, the author's experience of geological survey in west Cornwall indicates that inland outcrops of unweathered greenstone are very rare. If such

outcrops were available a concentration of axes with similar petrography would be apparent. This is not the case with Group XVI and the proposed multivariant source is thus likely. Recent work on Group I material from Clodgy Moor (Jones *et al.* 2103) has indicated the use of cobbles from multiple sources. In the case of the Group XVI material it is suggested that the source of 'greenstone' for axe manufacture is from cobbles from the alluvial gravels of the rivers and streams flowing northwards across the greenstone outcrops. This would result in the mingling/a mixture of rocks from various parts of the outcrop as well as in the selection of sound, less weathered fragments.

CONCLUSIONS

The low number of close matches among the material studied echo the results from other recent and ongoing sourcing projects. Concern over the correct characterisation and classification of different axe Groups, and their attribution to a given source area, outcrop or 'axe-factory' are well-established and has led to the undertaking of work to address these issues and re-characterise certain Groups, including Group I Cornish axes (Markham 2000) and the Group XXXIV Carrock Fell gabbro axes (Davis *et al.* 2009) in recent years.

Petrological re-analysis of the sampled axes from Carn Brea has demonstrated that the axes attributed to Group XVI do not come from a single outcrop. This raises potential problems with Cornish greenstone axes that have been assigned to Groups without close inspection of the original source material on which a Group was first defined. In addition, the results indicate that a range of material was being used for the production of axe-heads. Petrological study has revealed that one of the Carn Brea axes had a match with the sampled outcrops, but all others are likely to have come from elsewhere along the length of the valley. As has been demonstrated at Clodgy Moor, potential source material could have included detached blocks, stream cobbles or other outcrops which have been removed or, like the Giant's Rock, unavailable for sampling.

This broad range of potential sources, both for Group XVI and for Group I (Markham 2000; Jones *et al.* 2013), contrasts with other parts of Britain, where there is good evidence for the

utilization of specific places in the landscape for axes, such as Langdale Group VI and Myndydd Rhiw Group XXI (Bradley & Edmonds 1993; Burrow 2011).

In light of the importance of greenstone for axe-making in the Early Neolithic and the results from Viaduct Farm, Polstrong, and from Clodgy Moor, there is a clear need for a much larger project to both sample and better characterise more of the suggested greenstone sources across Cornwall and their products, so that the variability in the resource is better understood. Further work would, as had been demonstrated for Carrock Fell (Davis *et al.* 2009), usefully include petrological, geochemical portable X-ray fluorescence data, and geochemical inductively coupled plasma-atomic spectroscopy data to establish a signature for both sources and artefacts.

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LETTERS AND NOTES

TWENTY-THREE PROPOSITIONS FOR STONE ARTEFACT STUDIES

M. Pope¹

FUNDAMENTALS

1. While we often consider a stone artefact as belonging to the sphere of technology, ultimately its beginning and end exists within that of geology and sedimentary process.
2. Between these end points we can attempt to understand the material's interaction with, and modification by, a biological agent.

THE ARTEFACT

3. The artefact can be thought of as a behavioural node: the meeting point of intention, culture and material. One must consequently understand the complexity of each artefact in isolation before attempting to relate artefacts to each other.
4. For this reason the artefact cannot be the fundamental unit of stone artefact analysis. Rather it is each gesture of procurement, manufacture, use and discard which, as an irreducible and observable elements, we attempt to bring under ultimate examination.
5. Stone technology is not therefore the ultimate goal of our analysis. It provides an avenue to a much wider understanding: that of individual, group and population behaviours across different scales of time and space.
6. We can also go further and attempt to theorise the intentions which lie behind these individual and collective gestures through a detailed understanding of artefacts in isolation, as assemblages and as wider collective datasets.

CONTEXT

7. Every artefact is on an arrested or interrupted trajectory towards destruction, usually though sedimentary processes.
8. Therefore, understanding the circumstances of preservation and how these might create a distortion of the past should always be the first stage of stone artefact analysis.
9. 'In situ' is an idealistic state, it does not exist in nature, every preservational environment involves modification, however small the degree. Determining the scale of transformation is the priority, the absence of transformation is a virtual impossibility.
10. The distinction between different sedimentary contexts (e.g. plateau, head or fluvial deposits) are useful as classifications, but must be considered to form parts of a single, phased and unified sedimentary system.
11. Understanding the past and ultimate future trajectory of each artefact within these systems allows a full appreciation of a stone artefact's value as a data point.
12. Distribution maps of artefacts and sites within regions are therefore not records of past landscape use, but a snapshot of the sedimentary processes and collection histories distorting the original patterns.
13. A single artefact, occurring in isolation as a surface find, has the potential to unlock an understanding of those

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processes when read correctly first as a sedimentary particle.

BEHAVIOUR

14. While stone artefacts have life histories, which are useful to reconstruct, these should always be subordinate to, or a means of access to, the aim of addressing the life histories of their makers.
15. An artefact exists on a trajectory incorporating at least three locations and behavioural phases: the origin of the raw material, the history of the artefact at the site of its last traceable use and the possible onward movement of products from the artefact or the modified artefact itself.
16. Understanding these trajectories provides a framework for understanding the movement patterns and the curation/discard decisions of the maker.
17. Artefacts are encountered in the archaeological record only after they have been discarded, after their last phase of interaction with human agents.
18. All assemblages are 'death' assemblages and may present profound asymmetries with their use and form in life.
19. Useful tools are less likely to be discarded and so are less likely to be recovered from the archaeological record.
20. Low-density scatters of small flakes from tool maintenance are the signature of the presence of useful, valuable objects.

ARTEFACTS AS TRIGGERS

21. Once discarded artefacts have potential to be re-encountered by their makers and those who come after them.
22. We should be aware of, and sensitive to, the potential of past human populations to recognise and interact with archaeological material within their own landscapes.
23. Our encounters with artefacts in landscape leads to changes in understanding and behaviour. We should consider this a possibility for people in the past too.

PETER ROBINS 1924–2015

T. Pestell¹

News of Peter Robins' death will be met with much sadness by all those who knew him, but his contribution to Norfolk's archaeology is assured. A gentleman of the old school, and one of the last true sons of colonial empire, Peter was active for many years in the Norfolk Archaeological Rescue Group and its successor organisation NAHRG, and of the Norfolk and Norwich Archaeological Society, serving on its Council 1993–1999. He will also be remembered for his longstanding contribution to the Archaeology Department at Norwich Castle Museum in which he worked for many years, officially as a volunteer but in reality often as an extra member of staff for which his title of Research Associate did not adequately cover. Peter was also very proud to serve on the Council of the Prehistoric Society, and was at that time the only amateur member.

Born 17 September 1924, Peter Alan Robins trained as a chemist; he was awarded his PhD in 1946 by The Royal College of Science (Imperial College, London). He continued as a Senior Research Fellow there, and then at the Colonial Insecticide Research Unit before moving to the National Institute for Medical Research. A lifelong love of Africa began in 1957 when he became a lecturer in Organic Chemistry at University College, Southern Rhodesia. Five years later he was appointed Professor in Chemistry at Royal College, Nairobi (subsequently the University of Nairobi) in Kenya. He held this position for twenty years before finally becoming Professor of Chemistry at the University of Botswana 1982–1985.

On retiring, Peter and wife Nell moved back to the UK and settled in Norfolk where, in what amounted to a second career, Peter worked on the county's prehistoric archaeology. Although a chemist, Peter had worked in Africa with the famous Leakey family of archaeologists and palaeoanthropologists, an experience that had



Figure 1. Peter Robins at Happisburgh.

fired his interest in stone tools especially of the Palaeolithic. Armed with this interest and knowledge, Peter soon became a recognised expert in the county, recording (and often illustrating) lithic finds for the Norfolk Historic Environment Record, as well as ordering the county collection of lithics held in Norwich Castle (often aided by Nell, who was drafted as his assistant). He also contributed notes and articles to various journals. While all this could have provided an ample monument to his efforts, Peter's most valuable contribution was fittingly international in significance.

Peter recognised the true interest of a perfectly fresh handaxe found on Happisburgh beach in 2000 by an eagle-eyed beachcomber (and swiftly ensured it was donated to the county collections): it had been stratified in its embedding clay, leading to the discovery of the site of Britain's, and northern Europe's, oldest hominin activity. Perhaps as important as his recognition of the handaxe's significance was that Peter's knowledge had earned him the respect of, and contact with, other Palaeolithic

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specialists and membership of the Ancient Human Occupation of Britain project (AHOB). The discovery led to seasonal work at Happisburgh by the British Museum and Natural History Museum, furthering our understanding of human evolution by pushing back occupation at this latitude some 200,000 years to 700,000 BP. It also led to the discovery of lithic assemblages elsewhere along this stretch of coast and even the recognition of early hominin footprints preserved in the clay below Happisburgh beach. The Happisburgh Handaxe has thus become a celebrated, indeed iconic, object and was selected as the most important British archaeological find of recent years by one television series.

Through it all, Peter was a modest figure, unassuming about his role in the story, but eager to participate in the subsequent excavations.

Despite being well into his eighties, all who participated remember that spirit of the colonies living on as Peter withstood the more temperate climate of the east coast wearing shorts and a safari jacket, yet putting in a shift the envy of many much younger than him. Inevitably, his final years in Norfolk saw both him and Nell suffer bouts of ill-health. With this in mind, they moved to Australia to live with their daughter Jane, where Peter was still active, 'working on the property', weeding and clearing up branches. A sudden illness overtook him, resulting in two heart attacks; he died on 17 February 2015. He leaves his widow Nell, two children, three grandchildren and the heartfelt gratitude of archaeologists not only in Norfolk but internationally.

JOHN WYMER BURSARY 2015

GEOCHEMICAL PROVENANCING USING INDUCTIVELY COUPLED PLASMA-MASS SPECTROMETRY AND PORTABLE X-RAY FLUORESCENCE: SAMPLE COLLECTION IN THE NORTH OF ENGLAND

Seosaimhín Bradley¹

In early 2015 I received notification that I had been awarded a John Wymer Bursary. With the available funds, I was able to plan and execute a trip around Lincolnshire and Yorkshire to collect samples of flint. This work was undertaken in March 2015 and has proved invaluable to my PhD research: investigating the geochemical variation of flint in Britain and Ireland, with the ultimate aim of provenancing artefacts.

Provenancing of stone tools has been undertaken in a variety of ways during the history of archaeological research. The most common approach is that of macroscopic examination (colour, texture and overall appearance) which, for the majority of lithologies in Britain and Ireland, is sufficient to broadly determine the source – particularly when the material has a limited geological occurrence. On the basis of macroscopic characteristics, it is possible to identify some raw-material sources such as porcellanite with a high degree of confidence. However, where a raw material occurs over large areas, determining the source can be more difficult. This is the case with flint. Determining provenance of flint is reliant on identifying discriminating characteristics or qualities of the raw material that are sufficiently limited in occurrence as to be representative of a source region. Macroscopic characteristics of flint are not generally this discrete, but are used frequently to assign source.

A more robust investigation of provenancing was conducted using geochemical analysis of flint samples from across Britain and Ireland.

One of the main aims was to identify geochemically distinct areas. Therefore, sampling locations were identified and a large number of flint samples were collected. These samples were analysed to determine their chemical composition. This was undertaken during the course of my PhD research, using two different analytical methods: inductively coupled plasma-mass spectrometry (ICP-MS); and portable X-ray fluorescence (pXRF). ICP-MS is a wholly destructive method, but detects a wide array of elements at very low concentrations (parts per billion). Alternatively, pXRF detects a narrower range of elements, at higher concentrations, but is non-destructive. Flint samples were collected from the south of England and north of Ireland on previous excursions; however I was still lacking samples from the Chalk of Yorkshire and Lincolnshire. Identification of source areas was reliant on having samples from areas of flint-bearing Chalk geology, so the absence of flint samples from the north of England had the potential to be a major limitation for my research.

Thankfully, the John Wymer Bursary allowed me to book car hire and travel throughout Yorkshire and Lincolnshire collecting samples of flint from the Wolds and along the coast. These samples are invaluable as they have allowed me to provide a much fuller picture of the geochemical variability of flint within Britain. With the information gleaned from the ICP-MS and pXRF analyses, I hope to provide a dataset which can be used by other researchers to provenance flint artefacts.

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JOHN WYMER BURSARY 2015

THE WESSENDEN HEAD RESERVOIR PROJECT

Katie Davenport-Mackey¹

Through the generous support of the Lithic Studies Society the author assisted three amateur archaeologists from Marsden, West Yorkshire, in analysing a lithic assemblage from a site at Wessenden Head Reservoir, Peak District National Park, Holmfirth, West Yorkshire (SE 0715 0765). A similar project, the Central Pennines Lithic Scatters Project has already been undertaken (Preston 2014). Therefore, the Wessenden Head Reservoir Project has sought to complement rather than duplicate previous efforts through a collaborative research project co-managed by the author and Preston.

The Wessenden Head Reservoir Project has four main aims. First, to deliver practical teaching on lithic analysis. Secondly, to provide guidance on the curation and conservation of the site archive. Thirdly, to create an engaging display at an appropriate institution. Finally, to publish a report.

The site occupies a small peat-covered prominence known as Gilberts Island which is occasionally exposed by low water levels close to the eastern shore of the Wessenden Head Reservoir (Preston 2013). It first came to the attention of archaeologists when Stonehouse (1982) recovered a total of 180 lithics from an area of 100 square metres on the island. The lithic assemblage consisted of broad blade microliths, piercers, scrapers and a tranchet axe sharpening flake. Stonehouse suggested that the broad blade microliths and the sharpening flake were characteristic of occupation during the Early Mesolithic and that the thumbnail scrapers were denotative of an Early Bronze Age occupation.

However, these claims need to be verified because Stonehouse undertook only a basic typological analysis of the assemblage and

made potentially erroneous observations based on a flawed classification scheme (Preston 2011). Therefore, the Wessenden Head Reservoir Project is both timely and necessary.

In summer 2014 amateur archaeologists Adrian Burnham and Dean Handforth visited the Wessenden Head Reservoir. On various trips they recovered approximately 500 lithics from the island and the adjacent shore. They also conducted a survey of a linear bank of stones which runs along the crest of the island. The lithic assemblage includes cores, manufacturing debitage (such as core rejuvenation pieces) and a large number of retouched pieces (such as microliths and scrapers). This assemblage is especially important because it is substantially more diverse than the previous one and offers much greater possibilities for a detailed technological analysis.

Even though Burnham and Handforth made comprehensive plans and took detailed photographs of the stone linear bank, the spatial distribution of lithics at the Wessenden Head Reservoir was not recorded. Notwithstanding this limitation, it has been possible to analyse the assemblage as a surface collection and to obtain additional information on the strategies of exploitation and reduction employed at the site.

In the beginning it was necessary to teach the group technological analysis because many amateur archaeologists tend to classify lithics according to their shape alone. Therefore, the project commenced with an introduction to the analytical and theoretical approaches used in lithic analysis. The group were also provided with equipment (e.g. calipers, loupes, scales) and manuals (e.g. Martingell & Saville 1988; Inizan *et al.* 1999; Preston 2011) with which they were able to undertake an exploratory analysis of the assemblage.

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The group was also provided with a manual of analytical protocols (including type and attribute definitions, decision trees and flow charts and full instructions for measuring and recording pieces) and a pro forma for recording each piece based on the Analytical Lithics Module (Preston 2011). The use of an explicit protocol facilitated the teaching of lithic analysis and yielded more accurate data. The data recorded on the forms were then entered into a relational database in Microsoft Access. At the time of writing the assemblage has been fully analysed and the data are being processed.

Preliminary analysis of the data has yielded some interesting results. For instance, the typological composition of the assemblage is broadly similar to, but slightly more diverse than, the one recovered by Stonehouse. However, some additional time periods are represented by the lithics. In addition to the Early Mesolithic date suggested by Stonehouse, the presence of straight backed and rod microliths implies a very Late or Terminal Mesolithic occupation. Furthermore, the site has yielded evidence of Neolithic occupation in the form of a linear bank of stones which has been identified as a long barrow (Yvonne Luke, pers. comm.) and a possible fragment of a green polished stone axe. However, preliminary analysis of the greenstone was inconclusive and it has been sent to the Implement Petrology Group for further analysis.

In addition to the lithics analysis, the group has been given practical guidance on the curation and conservation of the collection. This involved assigning each piece a number and placing it in a plastic bag in an acid-free box and teaching them to label bags with the appropriate provenance information. However, a decision was made to apply numbers to the bags rather than the lithics because the application of Indian ink and clear nail varnish often obscures important features.

To conclude, the analysis will be submitted to a journal, the data will be made available to the public and the assemblage will be displayed in a museum or other appropriate venue. It is hoped that the results of the project, when published, will include not only this assemblage but the one recovered by Stonehouse. This should provide a better understanding of the lithic reduction strategies that occurred at the

site. Possible future directions for the Wessenden Head Reservoir Project include an excavation of the site. This would provide the opportunity for survey and excavation training. An introduction to the concepts of stratigraphy and context would be particularly relevant because such information has not been recorded at the Wessenden Head Reservoir before.

ACKNOWLEDGEMENTS

I would like to extend my appreciation to Paul R. Preston for sharing his knowledge of the Mesolithic of northern England and for the use of his Analytical Lithics Module prior to publication. I would like to sincerely thank Yorkshire Water for allowing access to their land. I am indebted to Yvonne Luke for kindly identifying the long barrow. I am especially grateful to the West Yorkshire Archaeology Advisory Service (particularly Ian Sanderson and Jason Dodds) for providing funding for radiocarbon dating. I would like to thank Jo Heron and John Bowen of the Huddersfield and District Archaeological Society for their support throughout the project. Finally, I would like to express my sincere gratitude to the Lithic Studies Society for the award of a John Wymer Bursary for the Wessenden Head Reservoir Project.

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BOOK & CONFERENCE REVIEWS

A REPORT ON THE 'EXPERIMENTAL APPROACHES TO THE PALAEOLITHIC AND MESOLITHIC: POSSIBILITIES AND PROSPECTS' CONFERENCE 28 MARCH 2015, UNIVERSITY OF READING

R. Hosfield¹, C. Harris², K. Barr³, A. La Porta⁴, R. Davis⁵ & listed participants at the Experimental Approaches to the Palaeolithic and Mesolithic one-day conference

INTRODUCTION

This short note is derived from the discussion session at the recent *Experimental Approaches to the Palaeolithic and Mesolithic* meeting, co-organised by the University of Reading (Department of Archaeology) and the Lithic Studies Society, and hosted by the University of Reading on 28 March 2015. Attendees included academic staff and postgraduate students (research and taught), museum staff, bushcraft professionals and other members of the Society.

The discussions raised a range of issues for consideration with regards to the future practice and development of experimental archaeology, with specific reference to the Palaeolithic and Mesolithic periods, and divided broadly into the following categories.

Participation: collaborations and inclusivity

The discussions highlighted the important point that experimental archaeology is sometimes perceived as, and may well be, an overly male-dominated sphere of the wider discipline. It was noteworthy that at our own conference only one of the nine papers was presented by a female researcher (although the balance was reversed in the poster segment, with five out of six contributions from female postgraduate students). Suggested solutions to this issue were less clear-cut although it was agreed that emphasis should be given to the sheer diversity

of experimental activities which can be undertaken and the importance of techniques and knowledge over brute force. To use our meeting as an example, the fifteen papers and posters spanned lithic replication, plant fibre industries, burning, lithic and organic tool use, artefact taphonomy, footprint taphonomy and house construction, while the relationships between experimental and archaeological use-wear traces were also explored during the discussion session. Consideration should also be given to the illustration of experimental archaeology, in terms of both the activities and the participants represented.

There was also agreement on the clear research benefits of collaborations between academic and non-academic groups. The latter could range, for example, from open-air museums (including both permanent staff and volunteer groups) to bushcraft professionals to wood and textile workers. These benefits were felt to be a by-product of both the combining of different skill- and knowledge-sets, and the potential for non-academics, unconstrained by modern university demands, to think 'outside the box' and 'say the unsayable'. The former point was clearly demonstrated at the conference in Annemieke Milks and colleagues' paper (*Human Performance Trials: Spear Thrusting and Throwing*), which combined Palaeolithic expertise (Annemieke and Dr Matt Pope from UCL) with experience in ballistics and weapons testing (Debra Carr, Stephen Champion, Libby Cowper and David Parker from Cranfield

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Defence and Security and Loughborough University). In a similar vein, Alice La Porta (Exeter and Reading Universities) has developed contacts with university sport societies and the Professional Hunters' Association, as part of her ongoing research into Middle Palaeolithic projectile technologies. Discussion also focused on the practicalities of developing such collaborations, including the benefits of perseverance and regular discussions with potential collaborators when trying to build capacity, contacts, interest and involvement, and the importance of being able to offer clear benefits, such as research impacts, diversification and publication.

On a more academically focused point, the value of experimental archaeology in teaching was widely agreed upon, in particular its potential for engaging students with different skills, abilities and learning profiles (e.g. dyslexia) with the subject. It is also a valuable means of introducing students from a mainly humanities background to scientific approaches, and developing their confidence in doing science. It was also emphasised that these benefits could be extended to pre-university students, through collaborations with schools and other organisations (e.g. the Young Archaeologists' Club). Finally, there was a clear consensus of the potential of experimental archaeology to enhance public and school interest in both archaeology and the natural environment. The multi-sensory nature of archaeological experiments was highlighted by a number of participants. Graeme Warren and John Murphy's paper ("Building mesolithic": recent experimental reconstructions of Mesolithic houses in Ireland) included a video produced in collaboration with students from the Dún Laoghaire Institute of Art Design & Technology which was an excellent example of how the sights and sounds of experimental activities can be dynamically conveyed to the general public (the film can be found at: <https://www.youtube.com/watch?v=2O22LMgS4V4>). Perhaps as 3D printing technologies become more widely available and affordable there will be ever greater scope for digital models of experimental artefacts to be made available for reproduction and for use as teaching aids in school classrooms. On a more cautionary note, the need to consider the suitability of an experiment for a public audience was also highlighted, as activities such

as animal butchery may be upsetting to some individuals or groups.

With perhaps more immediate potential, it was also noted that experiments could be designed to enable a public contribution to their progression and/or recording, developing the recent themes of citizen science and perhaps also crowd-sourcing. To offer one example discussed at the meeting, could visitor numbers at an open-air museum or university experimental venue be used as an approximate measure of foot traffic over an experimental surface or floor? This, perhaps inevitably, leads into:

Experimental design: variables, venues and durations

Participants raised the point that experiments can be both tightly controlled with strictly defined variables, as is typically the case in academically led studies, but can also be more loosely structured, with the latter model giving more emphasis to experiences gained and lessons learned. As was observed on the day (with apologies to the individual contributor for paraphrasing): "there were probably not rigid rules of practice in the past". Such 'looser' experiments might also facilitate the type of active public roles outlined above. This is of course a potentially controversial area, since controlled variables and the replicability of experiments are central planks of good science, but as a whole there was agreement on the day that both models could have a complementary place in experimental approaches.

More specifically it was noted that many experiments are built on a comparison of the methods, gestures and products of participants with different levels of skill and experience. However, how the experimental archaeology community learns the skills and expertise to recreate past technologies was highlighted as a potential problem. One key aspect is the time commitment required; experts in the past would have acquired vastly more experience than most, but not all, modern experts. Many modern experts also benefit from an academic as well as practical understanding of a technology, and therefore operate outside of the cultural and social norms that may have influenced the way technology was learnt and produced in the past. A final consideration was whether

archaeologists can ever really be considered to be novices. For example, while an undergraduate student may have never tried flintknapping, they are likely to have read descriptions of the mechanics of stone fracture and seen formal demonstrations, thus gaining a different form (if not a level) of understanding that will not have been shared by the novices represented in the archaeological record, the latter of whom are likely to have experienced flintknapping through casual observation in infancy.

The question of experimental venues was also re-visited, not least in light of clear ‘venue envy’ (by Hosfield) for University College Dublin’s dedicated experimental space on campus. It was noted that the running of any experiments with a taphonomic element can become problematic at venues with other, potentially competing tasks and responsibilities, such as open-air museums. The availability of dedicated spaces, whether within university campuses or elsewhere, was therefore clearly recognised, and it was noted that progressive undergraduate and/or postgraduate cohorts (with staff support!) offered one means of running sustained, long-term experiments, with benefits ranging from student teaching and learning to taphonomic insights. This was clearly a common theme, as several participants highlighted the difficulties they had faced in finding suitable venues; however, others shared more positive experiences with local land owners and even their local town hall. Clearly the availability of suitable venues will vary across the country, however the general message was that goodwill and support is abundant and can be found in a variety of places.

However, the question of long-term experiments also highlighted the most frustrating aspect of the discussions: the issue of funding. It was noted that the current academic REF cycle, the typical duration of awards from Research Councils UK and other funding bodies, and the time constraints on modern PhDs all work against the running of long-term experiments, and at times even against the conducting of initial pilot experiments followed by second stage experiments with revised methods informed by the pilot study’s data and experiences. Perhaps unsurprisingly answers were not immediately forthcoming, although

the current funding landscape would seem to favour multi-staged experiments, where each funded stage produces outputs but also produces ongoing materials and process which lead into the next stage, supporting further funding applications. The role of a Masters dissertation as an opportunity for pilot study experiments which could lead into ‘second stage’ experiments within a PhD should perhaps also be emphasised.

Dissemination: publication and the sharing of best practice

It was agreed that too much experimentation remains unreported, either orally or in writing, and that this is a problem both for the development of experimental methods and approaches and for the wider acceptance of experimental methods as a valid analytical tool. While Britain continues to lack a dedicated journal focused on experimental archaeology there are, of course, a range of other, relevant, UK-based options (e.g. *Lithics*, *Mesolithic Miscellany*, *Human Origins* [<https://humanorigins.soton.ac.uk/>]) alongside international publications such as *EXARC*. There are also higher impact publications such as *Journal of Archaeological Science* and the *Journal of Archaeological Method and Theory*. The importance of presenting experimental research at appropriate conferences (e.g. the annual UK Experimental Archaeology meetings and the annual EXAR [*European Association for the Advancement of Archaeology by Experiment*] conference, but also subject-specific meetings such as the ‘Unravelling the Palaeolithic’ series and the Palaeolithic-Mesolithic meetings at the British Museum) was also highlighted.

It was also suggested that there was too much re-inventing the wheel with regard to methods and practices. This of course is partly a by-product of the limited reporting of experiments described above and is particularly frustrating in light of the range of information which could be shared: e.g. methods, sources of expertise and material resources. To offer a specific example from the meeting, it was noted that a wider range of animal carcasses than the seemingly ubiquitous deer could potentially be sourced via contacts with farmer groups, wildlife organisations, national parks, and/or zoos and safari parks. The potential value of on-

line discussion boards, perhaps hosted through an organisation such as the *Lithic Studies Society*, in facilitating the sharing of contacts, knowledge and practice was briefly explored, although a younger participant quickly highlighted a ‘social media gap’, emphasising the current existence of an Experimental Archaeology group on Facebook (www.facebook.com/groups/experimentalarchaeology); and there is also the list on jiscmail: arch-experiment@jiscmail.ac.uk). The benefits of the increasingly strong social media presence of experimental archaeology were emphasised, with members from across the world posting their current experiments, ideas and details of upcoming experimental events. It was noted that such groups can act as platforms for approaching other experimental archaeologists to ask for advice, thus addressing some the issues outlined above. It was felt that such groups bridge the gap between publishing researchers (whether in academic posts or not) and those interested in experimental archaeology but who do not publish their work, and provides an important insight into the experimental work being performed elsewhere in the world. One potential issue raised by such forums is the question of quality control and so, whatever the platform, a simple distinction between posts reporting peer-reviewed published experiments and non-published experiments would seem to be appropriate.

Summary

Overall the meeting discussions, and the meeting as a whole, highlighted the potential of, and enthusiasm for, diverse experimental approaches to Palaeolithic and Mesolithic archaeology. The scope and benefits of collaboration were self-evident, as were the importance of reporting and sharing our best practices and experiences. Thanks to all the participants for their many thought-provoking contributions on the day. See you at the 10th UK Experimental Archaeology conference!

Conference Participants

Pete Alfano, Adrian Arroyo, Eleanor Barnes, Kirsten Barr, Laura Basell, Martin Bell, Lucie Bolton, Keith Bradbury, Chris Brown, Rachel Bynoe, Briony Clifton, Julie Cormack, Cory Cuthbertson, Patrick Cuthbertson, Alice Day, Rebecca Devaney, James Dilley, Philip Dolman, Janet Eastment, Frederick Foulds, Bernard Gilhooly, Peter Groom, Geoffrey Guy, John Handley, Terry Hardaker, Claire Harris, Ian Herbertson, Christian Hoggard, Diane Holmes, Rob Hosfield, Richard Hughes, Rhodri Kemp, Alastair Key, Alice La Porta, Karine Le Hegarat, Graham Lodge, Robert Maurer, Annemieke Milks, Linda Mills, Valerie Moore, Clifford Moth, Molly Pearce, Stephen Poole, Tomos Proffitt, Alex Pryor, Samantha Rogerson, Hannah Simons, Jacky Sommerville, Graeme Warren, Peter Webb and Andrew Woodcock.

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(PB/EP, xii + 261 PP., 138 FIGURES, 27 TABLES. B/W ILLUS. PB £25, EP £19.99)

This book outlines the basics of fractography and fracture mechanics from the premise that these are essential to lithic research. That is, understanding the formation, meaning and analytical potential of fracture markings (Tsirk 2014, ix & 1) — known to lithicists as attributes (*sensu* Odell 2003, 87; Hranicky 2013, 101) — is fundamental to a complete comprehension of lithic *chaîne opératoire*. Consequently, Tsirk distilled his teaching notes (Tsirk 1997) augmented with his published work into a summary (Adams 2015, 135–136). However, a few issues make it less presentable.

One issue is its structure. There are 14 chapters grouped into three parts: Part one (chapters 1–3) provides a survey of knapping; Part two (chapters 4–8) introduces the fundamentals of fractography; and Part three (chapters 9–13) explores how fractography relates to knapping. Chapter 14 concludes the book. This structure is confusing, as it would appear that he wrote these parts as if they were the chapters themselves. The appearance of parts as chapters may explain why Tsirk wrote Part one as the introductory chapter, Part two as one explaining what the markings are and Part three as why they are important. Also, with few exceptions (e.g. Tsirk 2014, 232), there is a paucity of signposts, introductions (e.g. outlining aims and objectives) and conclusions to lead the reader. Consequently, the absence of standard structure obscures and disjoins Tsirk's arguments by spanning them across the book rather than together in single chapters.

Similarly, there are three content weaknesses. First, the book is limited as it is from solely an American knappers' and fractographers' perspective. For instance, he misses the opportunity to show how fractography and fracture mechanics elucidate both *chaîne opératoire* (*sensu* Inizan *et al.* 1999, 14; see also Leroi-Gourhan 1943) and reduction trajectories (Odell 2003, 87). Secondly, given that raw material variability plays a significant role in affecting knapability, the survey of types in Chapter 3 is too small and non-geological. Furthermore, more could have been made of his discussions on mechanical properties. For

example, he misses the opportunity of a detailed discussion of flaws and inclusions that can interfere with Hertzian force waves, thereby affecting the predictability of fractures of the raw material. Thirdly, Tsirk over-relies on jargon, and while he defines terms clearly and concisely in some figure captions and the glossary, he inadequately introduces them fully in the text. Rather than listing the terms in tables (i.e. Tsirk's tables 4.1–4.5) and providing their definitions separately in the glossary: he should have subsumed these together as well as fully defining the concepts in the main text. Thus, the issue is not one of content, but rather of structure. For instance, a single chapter containing what a feature looks like (definition), how it forms (mechanism), what it indicates and how one measures it, would have been more desirable.

Likewise, while Tsirk (2014, 232) claims to rely on an empirical rather than a theoretical understanding of fracture, the book is largely theoretical. This data-theory polemic is interesting for five reasons. First, this polemic misunderstands the scientific method that necessarily uses theoretical lenses (*sensu* controlling models, Clarke 1972) to interpret data after acquisition. Secondly, although Tsirk re-examined thousands of fracture samples (Adams 2015, 136), he provides little data to elucidate the concepts involved other than the micrographs of attributes and a few occasional tables. Thirdly, other than a few brief sentences (Tsirk 2014, 56), he does not share the method he used. Fourthly, the data descriptions are intermixed with interpretation. Fifthly, a work through of the formulae with data would have been more useful in explanations. These issues leave the reader unable to replicate and hence ascertain the veracity of his conclusions. Therefore, the book would have benefited from precise methods, more data and their separation from interpretations.

Notwithstanding data issues, the figures and tables (especially their captions) greatly elucidate and enhance the explanations. Also, the micrographs, a highlight of the book, are very instructive and well annotated. However,

in text references to them are too infrequent, and their placement is often well after the associated text. Moreover, some diagrams are put together from other sources with a mixture of crude pen and computer annotations (e.g. figures 3.2, 6.1 & 6.2), hand drawn with previous pencil markings, inked lines that have bled (figure 6.2) or poorly reproduced from graph paper (figure 6.1). The use of graphics software would have eliminated these issues. Therefore, the quality of some of the diagrams significantly detracts from the book.

Likewise, it is also problematic that the intended audience is too diverse, each with different needs. For instance, Tsirk (2014, ix & 232) aimed to stimulate knapper's interests with an introductory text in the interpretation of fractography and fracture mechanics, draw the attention of fractographers' to knapping, and facilitate communication between them. This identity crisis is compounded further by the fact that he aims each part of the book at different audiences underlines this conflict. For example, he aims Part one at fractographers with a very cursory introduction to knapping. Part two is for knappers — to clarify and explain the mechanisms involved in knapping — but also for fractographers to acquaint them with the fractures involved with lithic artefacts (Tsirk 2014, 232). Tsirk aims Part three at both fractographers and knappers with the objective of outlining knapping fractures and clarifying fracture mechanisms. However, the overall, emphasis is primarily a fractography one (and rather than knapping with an almost complete neglect of an archaeological/cultural perspective).

Consequently, Tsirk ignores lithicists. On the one hand, this is because he assumes that knappers and lithic analysts are the same. While many lithicists knap, not all knappers are lithicists. On the other, although Parts two and three are useful for lithicists, Tsirk does not outline how he envisaged the integration of fractography into lithics analysis and theory. This omission is a significant weakness compared to other books that discuss how to integrate both (e.g. see Andrefsky 1998, 23–37; Odell 2003, 45–80).

Furthermore, contrary to Tsirk's (2014, ix) claim, this book is not an introductory text for students (novices), just like Andrefsky's (2005)

Lithics: Macroscopic Approaches to Analysis is beyond an elementary level. A case in point is there are no illustrations of basic objective or detached piece anatomy (as can be seen in Whittaker 1994, figures 2.2 & 2.3, 15–16; Inizan *et al.* 1999, figure 5, 33; Waddington 2004, figure 22, 14). Therefore, Tsirk assumes the reader already knows this basic information. Consequently, this book appears to be more suitable for seasoned researchers. Therefore, it is evident that the author subconsciously wished to write an advanced textbook/manual for experienced researchers.

Therefore, in attempting to cater to diverse audiences, the book is an unhappy compromise. Consequently, Tsirk ultimately fails to deliver the required detail as they all have diverse knowledge bases, each needing different levels of information and supporting evidence.

Notwithstanding the issues noted above, this is Tsirk's most comprehensive work, and it demonstrates he had an extensive knowledge of the subject. While, this book requires effort from the reader, it provides a deeper insight and understanding that informs on the mechanisms involved, the signs of fractures and their interpretation. Thus, despite his ignoring the constituency of lithicists (noted above), the book is useful to them for two main reasons. First, although, a greater emphasis on the integration of fractography into lithics analysis and theory would have been beneficial, no one has hitherto solely dedicated a book to marrying an understanding of fractography, fracture mechanics and knapping. Secondly, the detail of the explanations, the diagrams, and micrographs make this a useful manual for experienced researchers. Therefore, this book is an essential read for advanced researchers and represents a significant contribution to the field.

Finally, the book is timely for two reasons. First, archaeologists have tended to afford a precedence to bio-archaeological and environmental evidence (Evans *et al.* 2007, 2161). Secondly, there has been a failure by many to appreciate basic technological principles, and a concomitant assumption that 'classification' through 'shape matching' artefacts with holotype illustrations is sufficient along with unjustified interpretations of form equals function. In contrast, this book shows that lithics research is a specialist domain

requiring a high level of knowledge that extends beyond typological counts. Moreover, it shows that understanding fracture mechanics with the ability to analyse in a replicable way the fractographic attributes underpin lithics research as a science. Thus, this implies that one cannot simply become a lithicist overnight but, like Tsirk, it takes a long apprenticeship and years of training to achieve (for discussion see Hranicky 2013, 45). The fact that Tsirk took 40 years to write this book is a testament to the complexity of lithic analysis, fractography and fracture.

Paul R. Preston

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BUTSER KNAPPING WEEKEND 2015

R. Banbury, Publicity Officer

For the seventh year in a row, the Society was invited to hold its annual weekend of flint knapping at Butser Ancient Farm, south of Petersfield, Hampshire. In contrast to last year's storm-curtailed event, the weather turned out to be perfect with sunshine throughout both days (1–2 August).

A mix of experienced and novice knappers assembled early on Saturday morning ready to practice their skills and learn new techniques. We were pleased to have Paul Saddleton and Antony Whitlock on hand to give everyone the benefit of their combined knowledge and to demonstrate their expertise with flint.

With several long-established quarries having closed in recent years, it has become increasingly difficult to secure quality raw materials. We decided this time to buy a larger amount than usual—two tonnes of prime Norfolk nodules. To ensure that there was enough, we restricted the number of participants to 20. However, there were fewer attendees than expected so we have a surplus for the next event.

To offer a broad range of activities, Paul brought other materials such as antlers, hafting resins, twine and heat-treated flint. However, these went largely unused as knappers preferred to focus on improving handaxe skills or working on their own individual projects.

Courtesy of Antony and others, we were able to show a range of replica tools, handaxes, cores and arrows. This attracted a good deal of attention from the general public and many stopped to watch the knapping, handle the items on display and to ask questions. Several people mentioned that they had come specifically because they had seen the event advertised by Butser.

Following a request from the team running the venue, Mike Trevarthen kindly agreed to produce various flint artefacts to go on display in Butser's visitor centre. More of the Society's membership leaflets were also requested as these are the most frequently taken by visitors!

After the first day's exertions and with the visitors gone, we were able to relax and enjoy the traditional barbecue and drinks together. The fire in the large roundhouse was lit for our benefit, and was welcomed as the night cooled under a clear sky. Most people camped outside, but one intrepid committee member had the roundhouse to herself.

A misty dawn heralded the Sunday morning sunrise and another day of knapping was underway.

The site provided a relaxing environment to work in. For those who wished to pursue their own interests, there was time and opportunity



Butser knapping weekend 2015.

to experiment with different techniques and materials. The schedule was kept deliberately flexible to allow everyone to pursue their own interests, whether they required expert assistance or preferred to perfect their skills on their own.

We were appreciative of Paul's and Antony's efforts—their guidance, patience and expert knowledge made it an enjoyable event for everyone.

One student produced a discoidal knife and worked to bifacially polish the cutting edge using an abrasive rubbing stone.



Melissa Metzger polishing a discoidal knife.



Antony Whitlock was able to reduce large nodules to substantial flakes for handaxe production.

We would like to thank the staff at Butser Ancient Farm who helped to set up our work area; they were friendly and accommodating throughout the weekend. We look forward to going back again.

The Butser staff also commented favourably on the positive feedback that they had received from visitors who had seen the knappers in action, and were also keen to have us back again next year.

To that end, we have agreed to return on the weekend of the 6–7 August 2016. Put it in your diaries now.

MINUTES AND FINANCES

Minutes of the Annual General Meeting of the Lithic Studies Society held on Friday 6 November 2015 at 12 noon at Franks House, 38–56 Orsman Road, London, N1 5QJ

Present: Olaf Bayer (**OB**), Claire Harris (**CH**), Robert Banbury (**RB**), Rob Davis (**RD**), Ella Egberts (**EE**), Josie Mills (**JM**), Sam Griffiths (**SG**), Tabitha Paterson (**TP**), Francis Wenban-Smith (**FW-S**), Hazel Martingell (**HM**), J. Edwin Jarvis (**JEJ**), Rebecca Devaney (**ReD**), Frank Beresford (**FB**), Jacky Sommerville (**JS**), Geoff Halliwell (**GH**), Ivana Jovanovic (**IJ**), Christopher Taylor (**CT**), Richard Wilson (**RW**), Paul Whitcombe (**PW**)

1. **Apologies:** Alan Saville (**AS**), Wei Chu (**WC**), Laura Basell (**LB**), Terry Manby (**TM**), Peter Hoare (**PH**), Paul Preston (**PP**), Kate Davenport-Mackey (**KD-M**), Hannah Fluck (**HF**)
2. **Minutes of the Last Meeting:** unanimously approved.
3. **Matters arising:** none.
4. **Chair's report for the year 2014–15:**

- Events in 2014–2015 began with a lecture series at Franks House focused on the prehistory of the English Channel.

- Following this a conference was held in Reading exploring experimental archaeology in the Palaeolithic and Mesolithic. This event attracted 50 attendees (a full house), with a mix of academics, non-academics, specialists and students. The format was based on lectures in the morning and discussion groups in the afternoon. There will be a report on the conference in the next issue of *Lithics*.

- The knapping weekend held at Butser was very successful, thanks to **RB** for stepping in to organise the event. It was particularly well planned leaving enough flint raw material for next year's event, which will take place on 6–7 August 2016. A focus for the future of this event is to publicise it earlier in order to get more attendees.

- A Lithic Illustration workshop was organised by **CH** and taught by Craig Williams at Franks House, this was well attended and will be offered again in 2016.

- The Wymer Bursary was awarded respectively to Seosaimhin Bradley for work on new techniques for flint raw material sourcing and also to Katie Davenport-Mackey who is running a capacity building volunteer project in the Peak District looking at multi-period lithic assemblages. Additionally, three small grants were given to support student posters at the ESHE 2015 conference held in London. This money went towards travel cost and printing, and will be reported on in *Lithics*.

- The Jacobi *festschrift* was published in 2015, edited by **CH** and Nick Ashton, and has sold enough copies to supply five years' worth of bursaries for the Society in the

form of the Jacobi Bursary. We still have copies for sale, these are being publicised through our normal email lists and will be advertised on the website.

5. **Election of Officers and Committee for 2015–16:**

Several longstanding committee members have come to the end of their terms of office this year:

- **LB** is standing down as vice chair (formerly chair);
- **HF** is standing down as joint events secretary;
- **DU** is standing down as web officer;
- **Lynden Cooper** has had to stand down as deputy editor.

The committee would like to thank all of the outgoing committee members for the hard work they have put into the Society.

- Due to personal circumstances Molly Pearce has been unable to carry out the role of secretary over the last year; the committee therefore agreed to co-opt **JM** as acting secretary.

6. **Committee Elections:**

- a) **Dr Claire Harris**, standing for vice chair, proposed by **OB** and seconded by **LB** – unanimously approved.
- b) **Sam Griffiths**, standing for web officer, proposed by **DU** and seconded by **OB** – unanimously approved.
- c) **Tabitha Paterson**, standing as events secretary, proposed by **CH** and seconded by **RD** – unanimously approved.
- d) **Dr Peter Hoare**, standing as an ordinary member/ deputy editor of *Lithics*, proposed by **WC** and seconded by **CH** – unanimously approved.
- e) **Katie Davenport-Mackey** – standing for ordinary member, proposed by **OB** and seconded by **RB** – unanimously approved.
- f) **Seosaimhin Bradley** – standing as an ordinary member, proposed by **OB** and seconded by **RD** – unanimously approved.
- g) **Dr Paul Preston** – standing as an ordinary member, proposed by **LB** and seconded by **OB** – unanimously approved.

7. **Treasurer's report for the year 2014–15:**

- We currently have 406 members, 14 institutional members and 124 suspended members. Suspended members are those whose subscriptions are more than three years behind and will therefore not receive a copy of *Lithics* 36.

- 26 new members have joined and four members have retired.

- Currently 120 pay via PayPal, 220 by standing order and 66 send a cheque to Franks House.
- PayPal members need to ensure that there is enough money in their account on 1 October when payment is taken out.
- On top of the 124 suspended members a significant number of people are currently in arrears but have not yet reached the three-year cut-off point. At this stage there is no formalised reminder process prior to this time; however, the committee has decided to send a reminder email, or letter where appropriate, with the annual AGM notification.
- It was agreed that this is a priority and we will also perform a yearly audit for arrears. In future years notification of membership status will be included in the AGM mail out.
- **RD** reported that the Society has made an overall loss of £1289.28; however, we had the publication of the Jacobi *festschrift*, which we are likely to make further profit from. Removing the publication from the equation we made just under £500 loss for this year, which is concurrent with previous years. Additionally, we will not need to buy any more raw materials for the Butser weekend in 2016. Overall the account is healthy and we have scope in the next year to be imaginative about possible new events that we want to put on.
- At this time we have accrued £1200 profit from the *festschrift*, which has been ring-fenced for the new Jacobi bursary.
- The committee agreed that focus needs to be put on increasing attendance for events by announcing them earlier and higher publicity levels.

8. Secretary's report for the year 2014-15:

- Due to absence of Molly Pearce we do not have a report this year.

9. Editor's report and publications for the year 2014-15:

- *Lithics* 36 is underway with four research articles and three letters/notes. One author is already in the proofreading stage. We are still awaiting the Wymer reports. The volume will be completed by **WC** in December 2015 and circulated early in the New Year.
- We are making an online website to view *Lithics*. There will be a one-year pay wall with the most recent edition for members only. The back catalogue will remain freely available. Additionally, we will be adding DOIs to new articles, making them much easier to search for and find online.
- We have decided to continue self-publishing *Lithics* and will make a renewed effort to sustain and promote the journal whilst maintaining and expanding our readership.

- **SG** will organise PDFs of back issues for members only and facilitate putting the 'Great Prehistorians' issue online. This will counter any current problems members have with access.

10. **Events programme for 2015–2016:**

- We are sponsoring a conference in Manchester called 'Immersed in Lithics', which will take place in February 2016.
- Butser knapping weekend will run again in 2016 on 6–7 August. There was a suggestion that attendees pay a deposit for this event to secure their commitment. We will make sure that this happens in future years. Additionally, **RW** noted that advertising the weekend with 'limited places' may reduce the number of applicants, therefore we perhaps need to think about how we promote the event itself.
- The Society will hold a day conference themed around 'Lithics and Landscape' in 2016. The conference will be held in Oxford on a Sunday in May/June with the date and venue to be confirmed. The day will be themed around lithics in the landscape and our priority is to encourage participants from all sectors of archaeology. **OB** will confirm a date and venue and the committee will begin the organisation process by the end of 2015.
- The illustration workshop will be organised again by **CH** at Franks House.
- Overall our aim is to promote events early across many different platforms in order to maximise attendance and make sure that everybody is aware of what is going on.

11. **Website news:**

- Our web host has switched to a new server and no longer allows real-time updating of content. **SG** is going to switch hosts to a different provider; as soon as this is done he will move the new site (created by **DU**) over to this server and it will be up and running.
- An additional aim of this new website platform will be to allow committee members to update their own committee pages and create personal blurbs.
- Putting together the back catalogues of *Lithics* will take some time; however, **SG** will begin to collect them, additionally the new website will make it easier to find them through Google.

12. **Any other business:**

- The committee recognised concerns held over content posted on our Facebook page, this led to a discussion about how to manage current issues, such as legal implications of surface collections made in the USA and the promotion of artefacts that may have been excavated/collected without permission. The decision was made to develop guidelines within the Society based on brief policies with clear objectives to put both on the Facebook page and the website. Additionally, both committee and general

members will regularly moderate the page in line with these guidelines; **ReD** has agreed to begin this admin process.

- The other option discussed was to change the Facebook into a publicity group rather than a public forum; however, we agreed that the page provides a positive discourse between academics and non-academics internationally therefore we have decided that it will remain in this style.

13. **Date of next meeting:** – Friday 4 November 2016 at Franks House.

Treasurer's Statement of Accounts (30th September 2015)

2014/2015

INCOME

Subscriptions	£4.164,04
Subscriptions (Paypal)	£1.519,59
Publications and back issues	£2.237,00
Publications and back issues (Paypal)	£117,95
Interest on NatWest reserve account	£1,29
Interest on NatWest current account	£0,00
Events	£668,85
Other*	£1.000,00
	£9.708,72

EXPENDITURE

Events	£1.988,73
Travel	£871,74
Postage	£10,36
Printing	£135,00
CBA affiliation	£60,00
<i>Lithics</i>	£2.862,52
Jacobi <i>festschrift</i>	£4.040,50
Wymer bursary	£500,00
ESHE poster bursary	£300,00
Butser refunds	£80,00
Subscriptions refunds	£45,00
Paypal charges	£77,99
Paypal refunds	£26,16
	£10.998,00

Surplus/Deficit **-£1.289,28**

Bank Balances

NatWest current account	£14.108,59
NatWest reserve account	£2.743,15
Nationwide	£1.054,51
	£17.906,25

Less Creditors	-
Plus Debtors	-
	£17.906,25

Decrease on previous accounts **£1.289,28**

* Donation for contribution towards cost of Roger Jacobi *festschrift*