

Guildford Fire Station and new Insights into the Late Upper Palaeolithic Creswellian of Southern Britain

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Abstract

Excavations ahead of construction of a new fire station at Guildford in 2013 revealed a large, homogeneous flint scatter of over 15,000 artefacts, including 235 retouched tools, from an area of c. 36 m², making it one of the densest Late Upper Palaeolithic scatters yet found in southern Britain. Spatial and refitting analyses enabled the identification of two discrete knapping concentrations (C1 and C2) separated by an area where tools were made, used, and discarded. They also revealed the presence of at least three flintknappers on site, including a novice. A *chaîne opératoire* approach provided further insight into blade production and tool lifecycles, while trace-wear analysis

identified damaged projectiles and the processing of both animal and plant materials. Techno-typological analysis of the flint assemblage and Optically Stimulated Luminescence ages place the site in the first half of the Late Glacial (Windermere) Interstadial (c. 14–15,000 BP). Guildford Fire Station shares affinities with other British Creswellian assemblages, showing variation from the classic Late Magdalenian. The potential importance of river networks is signalled in connection with Late Upper Palaeolithic mobility.

Keywords: Late Upper Palaeolithic; Creswellian; refitting; use-wear; Magdalenian; Azilian

<h1>Background

The Guildford Fire Station (GFS) site lies within modern Guildford, Surrey (Figure 1; NGR SU 9965 5081), on the left bank of the River Wey a few metres above the floodplain, north of where the river cuts through the chalk ridge of the ‘Hog’s Back’. The Wey is a main tributary of the Thames, navigable from Guildford to its confluence at Weybridge some 25 km downstream. Prehistoric flint artefacts at GFS were first recognised in late 20th-century surface collections (Jacobs 2012). In 2013 a large homogeneous scatter of Late Upper Palaeolithic (LUP) flints was discovered during excavations by Oxford Archaeology prior to construction of a new fire station (Barton *et al.* 2024). Over 15,000 lithic artefacts were recovered from c. 36 m². The assemblage was in exceptionally fresh and unabraded condition, mostly lying horizontally. The high frequency of smaller debitage confirmed minimal postdepositional disturbance.

<<Figures 1 and 2 here>>

Two subcircular artefact clusters were identified, each about 2 m² and about 4 m apart (Figure 2). Both were dominated by blades, rejuvenation pieces, small debitage (<10 mm), cores, and core fragments indicating areas of primary blade production. Of the 235 retouched tools recovered, some came from the area between the clusters, alongside a thin scatter of burnt flint possibly indicating the remains of a hearth. No bone was preserved. The assemblage’s unpatinated, fresh condition made it suitable for use-wear analysis and larger pieces were bagged unwashed to minimise handling before trace-wear and refitting work.

In this article, we assess the integrity of the flint scatter and identify the presence of a minimum of three flintknappers, including a probable novice, based on extensive lithic analysis, using *chaîne opératoire* approaches and refitting. Use-wear analysis further identifies a range of activities carried out on or near the site. Taken together, these approaches show how well-preserved sites like GFS can make an important contribution to understanding the Upper Palaeolithic in Britain.

<h1>Stratigraphy and dating

The archaeological horizon occurred in fine to medium sands (G2c) separated from similar sands (G2a) by a discontinuous cobble bed (G2b), overlying poorly sorted sandy flint gravels (G1) (Figures 3 and S1). Thin section (Macphail & Crowther 2024) and particle size (Marini 2024) analyses suggest that G2a and G2c were primarily deposited by alluvial processes of an active, likely braided, river channel. The large flint nodules in G2b appear to derive from local Head deposits laid down during periods of peak river discharge. Thin section analysis revealed incipient soil formation in G2c suggesting a stable land surface when the site was occupied. The basal gravels (G1) relate to the Kempford Park Gravel of Late Devensian age (Bridgland 1994; Gibbard 1985; Stafford *et al.* 2024).

<<Figures 3 and 4 here>>

Nine OSL (Optically Stimulated Luminescence) measurements from sediments above, within, and below the archaeological horizon provide the dating framework (Schwenninger 2024) (Figure 4).

The archaeological horizon (G2c) yielded an age of $15,105 \pm 1715$ BP (absolute years), sealed by upper sands dated to $10,150 \pm 915$ BP. Underlying sands (G2a) provided estimates of $20,345 \pm 1475$ BP and $19,880 \pm 1020$ BP, indicating aggradation ceased towards the end of the Last Glacial Maximum. Together with the assemblage's typological and technological characteristics, these dates are consistent with occupation during the first half of the Windermere Interstadial, roughly equivalent to the Late Bølling oscillation (Hughes *et al.* 2023; Naudinot *et al.* 2019; Walker *et al.* 2003).

<h1> Site formation processes

Various taphonomic analyses tested the *in situ* nature of the flint scatter (*cf.* Pope 2002). Size-class distribution, artefact fabric, vertical and horizontal distributions, and refit orientations were all examined to assess postdepositional disturbance and the implications for interpreting human activities (Hayden 2024).

A key question was whether the LUP flint scatter had been disturbed by postdepositional processes such as overbank flooding. Size-class distribution results were consistent with experimentally generated knapping debris (Bertran *et al.* 2012; Schick 1986), with all size classes represented in expected proportions. This indicates that even the smallest debitage (<10 mm) had not been significantly moved by postdepositional processes. Artefact fabric analysis (orientation and dip) tested for hydraulic processes, bioturbation, shrink-swell, or frost heave (Bertran & Lenoble 2002; Bertran & Texier 1995; Lenoble & Bertran 2004). Most flint lay flat with few pieces at angles over 45° . The strongly planar distribution with random orientation patterns suggests no disturbance from fluvial activity, debris flows, or solifluction (Hayden 2024).

<<Figure 5 here>>

Vertical distribution analysis across the scatter shows the flints occurred within a narrow band (Figure 5). The majority (95%) covered a 19 cm vertical spread, with 50% concentrated within 5 cm. No significant size sorting was evident and refitting artefacts occurred at similar depths (mean difference 4 cm). Statistical tests on refitting orientations (*cf.* De la Torre *et al.* 2019) showed no significant deviation from uniform distribution in larger refit groups, consistent with fabric analysis and minimal postdepositional disturbance. The vertical displacement probably results from trampling and minor bioturbation from earthworm and root activity.

<<Figure 6 here>>

Hotspot and centroid analyses confirm that the artefact distribution retains the expected characteristics of *in situ* knapping scatters (Hayden 2024) (Figure 6). Flint artefacts were concentrated in two zones about 4 m apart, representing contemporary knapping clusters. Densities peaked within areas 60–80 cm across, declining rapidly beyond. The smallest pieces were densest in the two main concentrations, consistent with minimal dispersal of knapping debris. Centroid analysis shows most refitting pieces lay close to each other, although some were dispersed up to 6 m, probably through human activity.

In summary, the taphonomic and stratigraphic analyses demonstrate that the GFS flint scatter represents a well-preserved *in situ* LUP occupation with minimal postdepositional disturbance. The constrained stratigraphic context within G2c, with incipient soil formation indicating a stable land surface at the time of occupation, combined with the fabric analysis, tight vertical distribution, high refit rates, and consistent artefact condition, is consistent with a single short-term occupation episode.

<h1> Lithic artefact assemblage

A *chaîne opératoire* analysis based on techno-typological categorisation and assessment of diagnostic pieces (Barton 1992; Pelegrin 2000; Pelegrin *et al.* 1988) was supported by refitting and use-wear analysis, allowing consideration of activities from raw material procurement and blade production to tool use and discard. Despite the absence of animal bone, site activities and broader mobility patterns could be inferred. The assemblage is technologically and typologically consistent throughout, supporting the evidence for a single occupation episode. Full details can be found in Nick Barton and colleagues (2024).

<h2>Utilised raw material

High-quality, semi-translucent grey-black Cretaceous flint with chalky cortex dominates the assemblage and is available locally in alluvial and colluvial contexts. The nearest primary sources lie c. 800 m north, although the Seaford Chalk Member (about 2 km south) is considered the most likely provenance. Some of the best-quality flint has reddish veins and comprises less than 1% of the assemblage, but 14% of retouched tools. Only one small core displays ‘chattermarks’ typical of river-gravel flint, consistent with the underlying cobble layer (G2b), though most flint from this deposit was too fissured for knapping.

<h2>Debitage and blade production

Debitage was classified using standard attributes for describing LUP assemblages in England and Wales (Barton 1986; 1992) (Table 1). The knapping objective was to produce fairly long, regular blades, as well as small straight blades. Three of the seven blade cores have opposed platforms, with one platform used preferentially for blade removals. These cores appear to have been abandoned at similar stages, often with small blades as the last removals. No diagnostic bladelet cores were identified and cores show few bladelet-proportion scars. There are 57 crested pieces, which evidence the reshaping and preparation of core faces, and 128 core rejuvenation pieces, most of which reflect platform adjustments during blade production.

<<Table 1 here>>

The assemblage contains 755 blades and fragments, 22% retouched or utilised. Most lacked cortex (72%), consistent with *plein débitage*. Butts were mainly plain or linear (57%), with significant faceted or dihedral forms (25.5%), 16 of the latter showing *en éperon*-related platform isolation (Figures 7–8)², about half occurring on well-made, slightly curved blades produced with soft organic hammers, six of which were tools. Platform abrasion on 59% of blades also indicates careful preparation. Blades were mainly detached with soft stone (72%) or soft organic hammers (19%)³, with soft stone correlating with mainly straight profiles (59%).

<<Figures 7 and 8 here>>

The assemblage contains 566 bladelets (width <12 mm, reduced to <9 mm when backed), mostly broken fragments. Their small dimensions and the lack of bladelet cores suggest bladelet production was a byproduct of core maintenance. Bladelets lack regular form and their distribution indicates minimal movement from knapping locations.

Of 2289 flakes, 1390 were complete or rejoined from refits, with 21 modified into tools.

Dimensions varied widely reflecting production at different stages of core preparation, reduction and maintenance. A further 11,004 small débitage pieces (<10 mm), including chips (<5mm), were recovered, consistent with on-site knapping.

<h2>Retouched tool assemblage

A total of 235 retouched tools were identified, excluding tool debitage (44 burin spalls, ten retouch flakes). Tools were subdivided into 'formal tools' and miscellaneous retouched pieces (Table 2), with 76% of formal tools on blades. The miscellaneous category includes 48 examples with substantial 'edge damage', though this is subjective as such damage could result from knapping, trampling, or deliberate use.

<<Table 2 here>>

<h3>End-scrapers

Ten end-scrapers (Figures S2–S3) were identified, six complete or rejoined from refitting fragments. Seven are simple end-scrapers, with two short end-scrapers (*grattoirs courts*) and one double end-scra- per. Two display invasive stepped *rasante* retouch (Bodu & Mevel 2008; Jacquier & Naudinot 2015), also present on ten other formal tools and ten blades. Scraper edges are formed by direct semi-abrupt retouch (Tixier *et al.* 1980) at angles mainly between 40° and 70°, occasionally more abrupt from resharpening (Figure S2, c.1625, c.2474). Use-wear traces occur on several scrapers but only one (c.485) shows visible edge rounding.

<h3>Piercers/perforators

Six small piercers and one perforator were recorded (Figure S4). All but one have distal retouched tips following the blank's central axis but varying in size.

<h3>Burins

Burins (Figures S5–S6) are the most numerous tool class (36), dominated by dihedral (12) and truncation types (9) (Table 3). All but one are on blades, with fairly short supports, and burin edges are usually simple with only four having three or more facets. Most burins (30) have no cortex or only minimal amounts, indicating manufacture on *plein débitage* blanks. Four dihedral burins display *rasante* lateral retouch (e.g. Figure S5, c.1204/c.9277), as do two truncation burins on substantial blades (Figure S3, c.19, 107 mm; Figure S5, c.990/c.992, 130 mm) and two other burins (one on a break and one unclassified). Six burins are on breaks, assumed deliberately snapped although lacking diagnostic features of intentional fracture (*cf.* Barton *et al.* 1983).

<<Table 3 here>>

<h3>Backed material

There are 20 backed tools, mainly on blades with direct semi-abrupt or abrupt backing retouch, all showing breakage (Figure 9; Table 4). Types include curve-backed points, straight-backed blade/lets, oblique points, broken fragments and four Krukowski microburins (two refitting) representing accidental breaks during backing. A proximal microburin with a faceted and isolated butt was also found. The most complete backed tool is a curve-backed bi-point (41 × 11 × 3.2 mm) with one tip missing, probably from projectile use (Tomasso & Rots 2024). The small size of the missing portion makes it unlikely to represent any other backed point type, such as a penknife point or curved and angle-backed piece. Two proximal blade portions with curved backing (c.508, c.7482) are likely similar types. Five oblique points and fragments, possibly incomplete parts of larger tools, all have distal retouch and straight profiles. Four backed tools are burnt: three backed blade fragments (two conjoining: c.4322, c.4328) and one curve-backed tip (c.7482). Although breakages may result from thermal fracture, the unburnt backed pieces show equally high breakage incidence. *In situ* production is attested by a refit between a broken backed point and an overlying blade (Figure S7, RG 43), and by the Krukowski and proximal microburins.

<<Figure 9 and Table 4 here>>

<h3>Other tools

Seven truncations comprise straight (4) and oblique (3) forms, all but one on blades (Figure S8). There are 22 notches and four denticulates (Figure S9), including single- and double-notched forms on both blades and flakes. Two rubbed end pieces – a patinated blade and a broken blade with a heavily abraded distal end (Figure 10) – were identified as strike-a-lights (*cf.* Stapert & Johansen 1999). Similar rubbing occurs on an end-scraper's distal arête (c.1315).

<<Figure 10 here>>

<h3>Miscellaneous retouched

Ten blades display *rasante* retouch characterised by distinctive flat, stepped, and scaled retouch on one or both lateral margins (Figure 11). Identical retouch occurs on 12 formal tools (see above), and some of these blade fragments refit those tools. Blades with similar retouch, described as '*une retouche rasante*', have been identified in the French Early Azilian of the Paris Basin, interpreted as deliberate resharpening of the edge (Bodu & Mevel 2008; Jacquier & Naudinot 2015). A further 46 retouched blades, bladelets, and flakes display discontinuous semi-abrupt or abrupt retouch on one or more edges but do not fit easily into the other tool categories. Another 20 blades and three flakes have discontinuous fine marginal retouch, some possibly spontaneous (*cf.* Newcomer 1976), others associated with utilisation damage. Forty-eight artefacts display significant edge damage possibly representing utilised tools based on experimental observations.

<<Figure 11 here>>

<h2>Retouched tool debitage

<h3>Burin spalls

A possible 44 burin spalls were recognised, 12 refitting to burins, confirming them as byproducts of the burin blow technique. Primary and secondary spalls occur in roughly equal numbers. Eight spalls showed damage or retouch incurred before detachment.

<h3>Microburins

Although normally associated with Mesolithic technology, one large proximal microburin (14 × 10.8 × 3.3 mm) with a faceted butt was found within the LUP horizon in fresh, unpatinated condition. Similar artefacts occur in early Hamburgian sites (Weber 2012) and other British LUP contexts (see below).

<h1>Functional analysis

In advance of the other analyses, 237 artefacts were studied for use wear at TraceoLab, Liège, using Zeiss stereomicroscopy (8–180×) and metallographic microscopy (50–1000×) (full methodology in Tomasso & Rots 2024).

Examined artefacts included retouched tools, tool waste, and blades with visible edge damage. Although superficially fresh, 147 pieces (62%) were rejected for reflected-light observations due to mechanical (abrasion, friction; Bordes 1950; Levi-Sala 1986; Schutt 1979) or chemical alterations (gloss, patina; Plisson & Mauger 1988). In these cases, analysis was restricted to stereomicroscopy, allowing only determination of worked material hardness. The same applied to heat-altered tools. Positive results were obtained on about 80 artefacts, with interpretation aided by TraceoLab's extensive reference collection of experimental lithic tools (Rots 2021). A small-scale experiment

tested ambiguous wear traces using experimental retouched blades for cutting hide and leather, and sawing dry wood and bone. While exact reproduction of the archaeological wear traces proved impossible, several hypotheses could be dismissed.

Residues of plant tissue and relatively frequent iron oxide traces were observed on some artefacts and confirmed by elemental analysis using Scanning Electron Microscopy (SEM-EDS). These were mainly of taphonomic origin, except perhaps for a piercer (c.99/143) where plant residue was associated with edge wear (Tomasso & Rots 2024, 154). Analysed tools were divided into subsistence-related (hunting, butchering) and manufacturing/maintenance activities (woodworking, hide working, bone/antler working), with results organised by typological category. Confidence levels were scored from one (low) to four (certain) (Tomasso & Rots 2024).

<h2>Interpretation of tools in the subsistence-related category

Nine backed and two unretouched blades and bladelets were classified as potential projectiles based on fracture patterns and wear features. Characteristic damage included tip bending fractures with step-fissured or hinge terminations. Lateral edge damage included concentrations of bifacial or unifacial scars with abrupt and fissured terminations oriented parallel or slightly oblique to the edge. In five cases, macroscopic edge damage was associated with microscopic linear impact traces (MLITs) oriented parallel or slightly oblique to the edge (Figures 12 and S10). Wear patterns suggest mounting as tips or lateral barbs. Several backed pieces also showed basal damage, including proximal bending fractures and small burinations along edges from counter-pressure, typically caused by compression or flexion on impact. Little evidence of butchery emerged from the analysis. However, some blades and blade tools display wear and retouch patterns consistent with episodic resharpening termed *rasante* retouch. Some of these tools revealed complex life cycles, making it hard to ascertain each stage of use or whether this involved multiple tasks on different materials. In other artefacts, lateral edges sometimes showed rounding and polish perpendicular to the edge, suggesting transverse motion possibly in shaving or cutting hides. Alternatively, striations parallel to the lateral edge in some pieces may indicate repeated insertion in a leather sheath. At Early Azilian sites, similar *rasante* retouch has been compared to butchery knives (Bodu & Mevel 2008; Jacquier pers comm.), leaving open whether some GFS blades were used in processing and butchery.

<<Figure 12 here>>

<h2>Interpretation of tools in manufacturing or maintenance activities

End-scrapers are traditionally regarded as hide-working tools, although wear intensity and type depend on use duration, motion, pressure, processing stage, and hide positioning (Keeley 1980). At GFS, explicit use wear occurred on eight of ten end-scrapers, predominantly for processing dry or moistened (as opposed to fresh) hide. One scraper (c.2471) showed possible butchering evidence on lateral edges (Figure 13). Active parts of the tools were mostly scraper ends with use wear often cut by resharpening removals, attesting prolonged use. Scraper blanks were often slightly curved with concave ventral surfaces creating a hooked profile ideal for hide working. The more robust scrapers were used with considerable pressure on dry and moistened hides, while those on long regular blades were probably for final processing of dry hide. At least two scrapers (c.924, c.485) broke while hafted. One scraper on a long blade may have been used with leather wrapped around it. Use-related traces were recorded on 14 of 27 burins examined, with varying confidence. Some showed intense distal edge damage with crushing or abrupt scarring on tips and wear traces along burin facets. The traces are attributed to intense working of hard material by grooving and possibly

light percussion. Seven tools were examined by low-magnification analysis because postdepositional polish prevented detailed functional interpretation. Six showed no use-related traces. Of 14 well-preserved burin spalls (all primary) analysed microscopically, only one (c.692) showed use wear prior to spall detachment. Here, linear polish on the ventral surface with striations parallel to the edge indicated a cutting motion on soft material. The traces were too minimal to identify the worked material, but differ from those on other burins, implying multifunctional use of this class. Other tools analysed included piercers probably used for perforating tasks. This included a distal backed tool fragment (c.5032) showing heavy ventral tip rounding⁴, possibly from perforating dry hide. Several retouched blades displayed irregular scarring with varying orientations consistent with complex life cycles, ranging from cutting or sawing wood to rounding and polish perpendicular to edges. This suggests a transverse motion, possibly shaving dry hide or leather. Hafting traces were also observed (*cf.* Rots 2010). Hafting is also suggested by tools with mesial fractures, a typical location for hafting-related breaks (Rots 2002; 2010), often with edge damage such as lateral notches and scarring (Figure S11). Macroscopic edge damage can be associated with microscopic bright spots or polish, probably from friction between a tool and detaching flint particles within the haft at breakage (Rots 2002).

<<Figure 13 here>>

One rubbed end piece on a distal blade fragment (c.2555) displayed macro- and microscopic wear patterns characteristic of percussion against iron-rich rock, with heavy edge rounding and deep striations on its distal part consistent with strong friction (Figure 10). Whether the tool broke during use or was selected from fragmented blades, its robustness made it ideal as a strike-a-light (Sorensen *et al.* 2014).

<h1>Refitting study

Following the use-wear analysis a systematic programme of classification and refitting clarified the technological sequence and spatial organisation of knapping activities. Refits were divided into break refits (ancient snaps) and dorso-ventral refits (repositioning artefacts within knapping sequences), with a subcategory for tool debitage refitting to tools and documenting tool lifecycle modifications. Full details are available in Barton *et al.* (2024).

<h2>Break refits

There were 174 break refit sets involving 349 broken blades, bladelets and flakes (Figure 14), representing 17% of broken pieces. Most were flexional snaps from knapping accidents (Barton *et al.* 1983) or trampling and represented all knapping stages, including 18 related to core production or maintenance (crested pieces, core tablets, rejuvenators), 20 formal retouched tools, and 37 other retouched categories including edge-damaged pieces. Most breaks in formal tools probably occurred during use and resharpening, for example end-scraper c.924/c.558/c.559 (Figure S3). Little evidence was found for use of intentional breakage techniques (*fracture volontaire*, *cf.* Barton *et al.* 1983) to create tool blanks. Rejoined fragments mainly occurred within a metre of each other, with some further away. Fewer break refits than dorso-ventral refits were found, consistent with limited trampling or postdepositional disturbance of the assemblage.

<h2>Dorso-ventral refits and refitting core groups

Dorsal-to-ventral refitting reassembled 483 artefacts into 84 refitting groups of artefacts (RGs) ranging in size from two to 73 artefacts (Figure 15). Blade production methods can be inferred from 11 refit groups containing cores or fragments. On-site tool manufacture is confirmed by 44 tools in

27 refit groups. Larger RGs provided information on knapping strategies, smaller groups on specific techniques. Refitting also clarified spatial organisation, confirming two discrete knapping concentrations (C1 and C2) and an intervening area where tools were made, used, and discarded. Two smaller activity foci may have existed 2 m north-east of C1 and 2 m south-west of C2 (Figure 16). Few refit connections existed between the two main knapping areas.

<<Figures 15 and 16 here>>

Refitting of cores shows flint nodules ≤ 300 mm long were knapped on site with most *chaîne opératoire* stages represented, from initial reduction to discard. Some gaps in refitting sequences may reflect blade blanks set aside for later use and/or transport elsewhere. Most refitting artefacts were located close to one of the concentrations and/or the rest of their refitting groups.

Reconstruction of individual core biographies is described more fully in Barton *et al.* (2024).

The two artefact concentrations (C1 north-west, C2 south-east) show tight flint debitage clusters with artefact density peaks at 4000 pieces/m² (C2) and 2936 pieces/m² (C1) (Figure S12) (Hayden 2024). Most artefacts focused at the centre of each concentration, within diameters of just 0.6–0.8 m. The clusters likely resulted from the activities of two highly skilled flint knappers, probably working simultaneously, evidenced by many internal refits but few conjoins between clusters. Both clusters had similar composition: large quantities of blades, knapping debris, cores, crested pieces, core tablets, and rejuvenation products. Despite overall similarities in blade production, there were some small gestural differences between concentrations. In C2, an *en éperon*-related technique for isolating platforms was more frequently used. In C1, blade preparation had a slightly higher proportion of plain platforms, often with the bulb of percussion located precisely at the platform edge. These subtle variances could indicate differences in knapping style.

Refitting also contributed information on knapper positioning and activity. The refit pattern of RG 01 is consistent with the C1 knapper sitting facing the area between the scatters, with their back to the north. Most elements of this refit group were located in the C1 area with the only outlier, a *sous crête* blade (c.910), more than 2 m away between the two concentrations. A roughly linear arrangement of artefacts just east of C1 may represent pieces deliberately set aside. A second person appears to have been knapping at C2, where refit groups show both early core reduction stages (RG07) and core maintenance during blade production (RG08).

<<Figure 17 here>>

Refit Group 06 (RG 06; Figure 17) provides rare evidence for a less skilled, possibly novice knapper at the site, working under the guidance of a more experienced individual (Roberts & Barton 2021). RG 06 comprises a single-platform laminar flake core on a good-quality river cobble, a raw material not otherwise used on site. The group shows a curious mixture of advanced and basic knapping abilities and contains four flakes, two blades, and a core platform rejuvenation flake. Flakes are soft-stone struck with large plain butts and no platform abrasion. The rejuvenation flake shows considerable platform damage from repeated misdirected blows. One blade is nearly complete, lacking only the proximal end. The other blade is well made with careful *en éperon*-related butt preparation. Dorsal scars on the core show that the final removals were poorly controlled and apparently hard-hammer struck and/or detached with considerable force. The core, flakes, and blade fragment were found together just west of C1, while the rejuvenation flake lay within the concentration. The well-made blade was found about 3 m to the north-east. The knapping sequence suggests: 1) careful core preparation and blade removals by a skilled knapper located north-east of C1 toward the river; 2) several basic removals from the core in the area west of C1 before a series of unsuccessful attempts to rejuvenate the core platform; 3) successful removal of the platform rejuvenation flake within C1, probably by the experienced knapper; 4) poorly

controlled knapping in the area west of C1 before the core was abandoned there. This sequence gives the impression of a novice knapper under the instruction of a more skilled individual. Similar examples, although rare, have been observed in other Late Palaeolithic contexts (Fischer 1989; Grimm 2000; Roberts & Barton 2021, which also reviews the literature on children and novices in prehistoric contexts). We suggest a novice was given a set-up core as a practice piece and detached several flakes before a problem arose with the platform angle. This was corrected by the C1 knapper, after which the novice made a few more crude removals and abandoned the core. Comparable examples of ‘educational interaction’ in flintknapping have been reported by Lykke Johansen and Dick Stapert (2004). At Bradgate Park, Leicestershire (see below), an expertly reduced prismatic blade core appears to have been subsequently knapped by a person with little skill, with final reduction stages contrasting with the blade production and consisting of successive misdirected hits resulting in multiple hinge fractures. A similar ‘novice’ piece was noted at Wey Manor Farm (Jones & Cooper 2013, 21).

<h2>Refitting of tools and tool debitage

Refitting demonstrated conclusively that almost all tool classes were made on site, validated by 44 tools in dorso-ventral refit sequences, including backed points, end-scrapers, burins with *rasante* retouch, notched pieces, and retouched blades. Two refitting Krukowski microburins show successive stages of retouching the tip of a large backed point not otherwise present on site. Refitting of retouched tools and tool debitage also clarified individual tool histories and locational information. For example, one tool began as a retouched blade, became a burin on a break, then was transformed into a burin-on-truncation by removing the distal portion with a transverse blow (Figure 18). The two burins lay 3 m apart, suggesting separate but broadly contemporary tasks. In another case a dorso-ventrally refitting burin and end-scraper were found about a metre apart, probably used at a similar time in related activities (Figure 19). Twelve burin spalls refitted to nine burins (Figure 18), and evidence of edge damage on both spalls and burins confirms on-site resharpening.

<<Figures 18 and 19 here>>

Spatial distributions show some evidence for activities other than knapping. Most end-scrapers lay between the concentrations, except c.485 in C1, which probably broke during manufacture. Truncations and denticulates also lay between the concentrations, while backed blades were discarded mainly around C1. Away from the central area, a small group of burin spalls was found in an area north-east of C1 that lacked any burins, while five burins (two refitting) lay a few metres away (Figure S13) without any spalls. The spall area may have been an activity zone where burins were used and resharpened. Blades with *rasante* retouch cluster near some burins in the north-east area, including an unclassified burin (c.1370) and a dihedral burin (c.2451, Figure S14), both with lateral *rasante* retouch.

Despite extensive evidence of site activities there is little to suggest more than a short-term or single occupation. No distinctive hearth settings or accumulated combustion zones were identified. No dense concentrations of burnt or heated artefacts or heated natural cobbles were found, and sediments showed no heating or rubefaction. However, signs of minor hearth activity were detected from the distribution of heated pieces. Figure 20 shows a contoured distribution of heated and burnt artefacts outside C1’s south-east edge, probably marking the remains of a small campfire. Amongst the artefacts in this area was the strike-a-light c.2555 (Figure 10).

<<Figure 20 here>>

<h1>Guildford Fire Station in its wider regional context and the Creswellian

The GFS lithic assemblage shares many defining characteristics of the British Creswellian, a LUP technology dating to the first half of the Late Glacial (Windermere) Interstadial. Supporting evidence is provided by the OSL age of $15,105 \pm 1715$ BP for deposits enclosing the lithic artefacts. The Creswellian (Garrod 1926a) comprises backed blade forms, including trapezoidal, bi-truncated blades retouched mainly on the shorter edge (Cheddar points; Bohmers 1956) and angle-backed, single-truncation forms backed on the shorter edge (Creswell points; Bohmers 1956), though some of Bohmers' Creswell points may be broken trapezoidal pieces (Jacobi 1991; for further definition of the Creswellian see Barton *et al.* 2003; Jacobi 2004).

Currently, 43 Creswellian findspots are known in England and Wales, with a possible Scottish example (Jacobi & Higham 2011). Most come from caves and rockshelters (only 14 open-air locations) and are identified typologically by the presence of Cheddar points and/or *en éperon* or *en éperon*-related blade butts (see endnote 2). At least 100 other findspots record a different LUP technology with morphologically distinct backed forms, including straight-backed blades and curve-backed mono-points, often with an added proximal oblique truncation creating a tang-like form (Garrod 1926a, 141; *cf.* 'penknife point'). These assemblages frequently include short, sometimes circular end-scrapers and burins on supports of varying thickness and length. Blades usually come from opposed platform cores with simpler platform preparation than the Creswellian. Many likely date to the second half of the Windermere Interstadial (Barton & Roberts 1996) and have a wider distribution, extending into Scotland (Saville & Ballin 2009; Saville *et al.* 2007) and the Scilly Isles (Berridge & Roberts 1986; Roberts 1999). These have been termed *Federmessergruppen* or Azilian to distinguish them from the Creswellian (Barton & Roberts 1996; Jacobi 2004; Jacobi & Higham 2009).

Despite the attractive simplicity of this division of the British LUP, recent discoveries at Guildford Fire Station and other open-air localities suggest a more nuanced interpretation of Creswellian assemblages and their NW European counterparts. GFS and other open sites – Wey Manor Farm, Surrey (Jones & Cooper 2013), Bradgate Park, Leicestershire (Cooper 2002; 2012; Cooper & Harvey 2014), and Farndon Fields, Nottinghamshire (Garton & Jacobi 2009; Harding *et al.* 2014; Kotthaus 2022) – were all systematically investigated using sieving, producing well-stratified, largely homogeneous LUP collections. Wey Manor Farm, located 17.7 km north of GFS in the same river valley, is particularly informative. Excavations by Surrey County Archaeological Unit in 2004 revealed a small undisturbed LUP scatter of 371 artefacts, including 44 retouched tools and byproducts (Jones & Cooper 2013, table 2.1). As at GFS, production focused on blade manufacture (30% of the assemblage) using broadly similar methods, including production of rectilinear blades, preferential core platforms, faceted butts (some *en éperon*-related), and predominantly soft stone percussion, although also including soft organic percussion for some larger blades. Tools comprise blade end-scrapers, burins, and a truncated blade with sporadic *rasante* retouch. Backed material includes diagnostic Creswellian points (one Creswell point, two Cheddar points, one distal fragment of either a Cheddar point or shouldered point) and, notably, a slender curve-backed bi-point similar to Early Federmesser or Early Azilian forms (Jones & Cooper 2013, fig. 2.10). A similar but smaller bi-point was recovered at GFS (Figure 21; Table 5). Curve-backed pieces are not unknown in Creswellian assemblages and may represent part of a continuum of backed blade forms (Jacobi & Roberts 1992). Indeed, Lynden Cooper noted that the Wey Manor Farm piece (Jones & Cooper 2013, fig. 2.10, no. 52) could fit the typology of a Creswell point based on the angularity of the backing. Krukowski microburins at both sites indicate on-site backed tool manufacture.

<<Figure 21 and Table 5 here>>

Cheddar points, Creswell points, and curve-backed bi-points have also been found together at Farndon Fields, as was a microburin with a faceted butt (Garton & Jacobi 2009). While most of the assemblage was surface finds, some LUP artefacts occurred in sealed deposits beneath Loch Lomond (Younger Dryas) coversands. The finds are bracketed by two OSL dates, one above (in coversands, 11.76 ± 0.79 ka) and one below (in laminated sediments, 14.8 ± 1.4 ka), demonstrating the likely Windermere Interstadial age of the assemblage (Garton *et al.* 2020).

The Bradgate Park collection, currently under post-excavation study (LPC), represents one of the richest Creswellian tool assemblages yet found, with approximately 400 retouched pieces and tool byproducts. Most of the tools are broken, perhaps through intensive hearth-side occupation. After refitting there are 84 abruptly modified pieces, including 12 Cheddar points, a Creswell point, and a shouldered point, the latter broken towards its mid-point during retouch and so possibly an unfinished Cheddar/Creswell point. Many broken pieces have the morphology of angle-backed asymmetric blades, suggesting that they were originally parts of Cheddar points (Jacobi 2004, 40). Several show distinctive projectile-impact damage fracture patterns. Additionally, 12 microburins were found, some with faceted butts, apparently used to manufacture some of the points. Two angle-backed pieces have trihedral points (microburin scar), and a trihedral point was also noted at Gough's Cave (Jacobi 2004, fig. 23.16). Krukowski microburins also occur.

Other tools include *becs* (borers), scrapers, retouched blades, and burins (although no dihedral forms), many found clustered around a probable hearth. The site is interpreted as a hunting location where antler working and projectile repair took place. It occupies a low rocky promontory at one end of a steep-sided gorge, perhaps used to channel and ambush herds of deer or wild horse. *Becs* are numerous, the most common formal tool after the points. Many long axial *bec* types are comparable to *Langbohrer* reported from Magdalenian sites in Germany (Hanitzsch 1972) and in the Cepoy-Marsangy facies of the Final Magdalenian in the Paris Basin, France (Schmider 1992a). Asymmetric offset types resemble *Zinken* from Hamburgian assemblages in northern Germany and the Cepoy-Marsangy facies. Both groupings also contain shouldered points (Weber 2012), noted as grading into some trapezoidal forms (Jacobi 1991), and perhaps curved bi-points. This does not imply direct links but suggests convergence in the development of polymorphic point types during an early Late Glacial Interstadial phase.

Turning to the European archaeological record, some of the closest parallels for GFS and Wey Manor Farm occur in the Somme, Selle, Seine, and Yonne Valleys of northern France. Intensive research there over the last three decades has produced numerous Late Glacial open-air sites attributable to the Final Magdalenian, Federmesser, and Azilian traditions (Bodu & Valentin 1997; Coudret & Fagnart 2006; Fagnart 1997; Lhomme *et al.* 2004) (Figure 22). In northern France the terms Federmesser and Azilian are used almost synonymously; Federmesser is generally preferred in the Somme and Azilian in the Paris Basin. Closely related are assemblages of the Cepoy-Marsangy facies of the Final Magdalenian, distinguished techno-typologically from 'classic' Late Magdalenian assemblages (Valentin 1995). These groupings occur within a broader context of 'Azilianisation' (Fagnart 1993a; Valentin 2008; Valentin *et al.* 2006): the gradual transition from the Late Magdalenian, epitomised by flint armatures made on backed bladelets (*lamelles à dos*) with mid-point backing, to subsequent chronological groupings characterised by polymorphic backed blades, including curve-backed points (*pointes à dos courbe*), angle-backed and shouldered forms, but generally lacking backed bladelets.

<<Figure 22 here>>

The technological changes initiated during the Final Magdalenian (Early Bølling) are illustrated at sites like Belloy-sur-Somme (Fagnart 1993b). Here, although the principal reduction objective was

the production of long regular blades, most projectiles were made on short blades rather than backed bladelets and comprised polymorphic types, including backed points (*pointes à dos*), shouldered points (*pointes à cran*), and angle-backed, truncated forms (*pointes à dos à truncature*). The projectiles from Wey Manor Farm similarly included trapezoidal and shouldered forms, as well as a curve-backed bi-point, all on small blades rather than bladelets (Jones & Cooper 2013). The backed tools from GFS also include a curve-backed bi-point, and there are no definite backed bladelets, although three backed fragments have bladelet-range widths. Debitage from Belloy-sur-Somme shows the frequent presence of blades with *en éperon* butts, convex profiles, and soft organic hammer production (Naudinot *et al.* 2019, 11). Both soft stone and soft organic percussion occur in British Creswellian assemblages in varying proportions, with soft organic usually being associated with the production of longer blades, as at Wey Manor Farm (Jones & Cooper 2013), GFS, and Gough's Cave (Jacobi 2004) (see also Table 5).

The oldest phase (*phase ancienne*) of the Azilian/Federmesser in northern France, dated to the Late Bølling oscillation, reflects transitional characteristics with the Final Magdalenian (Coudret & Fagnart 1997). Such assemblages include Hangest-sur-Somme quarry III.1 (*niveau inférieur*; Fagnart 1997; Fagnart & Coudret 2000a; 2000b) and Saleux, Sector 3 (blue/grey patinated series; Coudret & Fagnart 2015) in the Somme Valley, Le Closeau (*niveau inférieur*) in the Paris Basin (Bodu 1998; 2000), and Grotte du Cheval at Gouy (Bordes *et al.* 1974; Valentin 1995) (Figure 22). In these Early Federmesser/Early Azilian assemblages the principal objective was production of blades with straight profiles, with prepared plain and faceted platforms and often made using soft stone hammers. Blades with typical *talons en éperon*, known from the Late Magdalenian, are rare or absent. Short blades and bladelets also occur. Interestingly, at Hangest-sur-Somme III.1, backed bladelets (*lamelles à dos*) still comprise a high percentage of retouched tools (37%) with macrolithic armatures (curve-backed single *monopointes* and *bipointes* on small blades) contributing 11%. At Le Closeau and Grotte du Cheval only large symmetrical curved forms pointed at both ends are present (*bipointes à dos courbe*) and no backed bladelets. The shouldered and truncated points in the backed tools at Hangest III.1 may be chronologically significant for the northern French industries (Fagnart & Coudret 2000a).

A puzzling feature of the British Creswellian is the lack of tools made on bladelets despite their occurrence in the *chaîne opératoire*. At GFS, bladelets form a significantdebitage component but only 11 were retouched or edge-damaged, eight of them broken fragments that cannot confidently be classified as bladelets. Most were detached using soft stone or indeterminate soft hammers, and were found within the main knapping concentrations, although bladelet cores are absent. As noted above, most were too small, narrow, or thin to serve as backing blanks and were likely incidental byproducts of blade manufacture – as also argued for comparable discrepancies in some Paris Basin assemblages (Weber 2012).

Another key feature is the presence of large blades with distinctive invasive stepped and scaled retouch on one or both edges (*lames à retouche rasante*) (Figures 11 and S3), resulting from a specialised resharpening method (Bodu & Mevel 2008; Jacquier & Naudinot 2015). Such tools first appear in European Late Glacial technologies in the Early Azilian (*Azilien ancien*), and are absent in the preceding Late Magdalenian (Bodu & Mevel 2008, 510). Examples described as *lames retouches Magdaléniennes* at Morin likely derive from Azilian elements within a mixed assemblage (Mallye *et al.* 2018). The term ‘Magdalenian retouch’, used in earlier British LUP literature for this type, is therefore a misnomer: the retouch is characteristic of the Azilian, not the Late Magdalenian (Bodu & Mevel 2008). Experimental and microwear studies suggest *rasante* pieces served as knife blades (*lames-couteaux*), extensively resharpened and associated with hide working (*peaux*) (Bodu

& Mevel 2008, 541). These highly recognisable pieces occur at GFS, Wey Manor Farm, and Bradgate Park, as well as other LUP assemblages in southern Britain.

Considering these attributes collectively (Table 5), GFS, Wey Manor Farm, and Bradgate Park appear to have more in common with lithic assemblages of the transitional Final Magdalenian (Cepoy-Marsangy *facies*) and Early Federmesser/Azilian (*phase ancienne*) (Bodu & Valentin 1997) than with the classic Late Magdalenian of north-west Europe. Comparisons may also be drawn with the Early Hamburgian of Germany which, alongside shouldered points, includes specialised borers such as *Zinken*, largely absent from the Early Azilian but present in some Final Magdalenian assemblages such as Marsangy (Schmider 1992b, figs 86–7). The presence of the microburin technique in the Hamburgian (Grimm *et al.* 2012; Rust 1943; Weber 2009; 2012) may also be significant, as these byproducts occur at Bradgate Park, Farndon Fields, and Guildford Fire Station. Differences between the lithic assemblages of the classic Magdalenian and the Creswellian were already recognised by Dorothy Garrod (1926a), who interpreted the Creswellian as a regional variant of the Magdalenian. Such divergences should also be interpreted within the framework of ‘Azilianisation’ at sites like Bradgate Park and Wey Manor Farm (Cooper 2012; Jones & Cooper 2013).

Questions remain regarding the chronological relationship between the Creswellian and the wider European Late Glacial archaeological record. This has been intensively studied since the late 1980s using British cave and rockshelter collections, where well-preserved bone and other organic remains could be radiocarbon dated by Accelerator Mass Spectrometry (Barton *et al.* 2003; Jacobi 1991; 2004). Recent advances in pretreatment for contaminant removal have allowed many British samples to be redated using ultrafiltration AMS (Jacobi & Higham 2009; 2011; Stevens *et al.* 2023), although this has introduced potential issues in comparing these results with earlier age determinations from the European mainland. The sites of Sun Hole, Gough’s Cave (both Cheddar Gorge, Somerset), and King Arthur’s Cave (Herefordshire) currently provide the earliest dates for human presence in Britain after the Last Glacial Maximum. All three yielded comparable bi-truncated trapezoidal backed blades and blades reportedly with *en éperon* preparation (Jacobi & Higham 2011 note typical examples seen only from Gough’s Cave). The age determinations are mainly on cut-marked wild horse and red deer bone.

The Early Creswellian assemblages also include worked organic objects resembling examples from the European Late Magdalenian (Garrod 1926b, 300), most notably three decorated batons (*bâtons percés*) of reindeer antler from Gough’s Cave (Garrod 1926a, 96; Lucas *et al.* 2019) and a biserial antler harpoon from Kent’s Cavern (Garrod 1926a, 41). Such associations are best represented in the south-west of Britain, although a bovid rib with a figurative engraving of a horse’s head is recorded from Robin Hood Cave, Creswell Crags (Mello 1877). However, the origin of this object remains controversial (Bahn & Pettitt 2009; Gilbertson & Jenkinson 1984; Sieveking 1992; Sollas 1915; White 2017). Despite these features inviting comparison with the Late Magdalenian of the Paris Basin, unambiguous backed bladelets remain absent from British Creswellian assemblages. At present, the earliest evidence for the British LUP comes from King Arthur’s Cave, Herefordshire, and Sun Hole, Somerset, where dates imply human occupation may have begun just before the onset of GI-1e warming at c. 15,000 cal BP (Jacobi & Higham 2009; 2011; Matthews *et al.* 2025). At Gough’s Cave, the oldest radiocarbon ages on butchered animal bone and teeth are slightly later, about 12,600 BP (14,950–14,750 cal BP), correlating with the beginning of Greenland Interstadial GI-1e and broadly aligning with the Early Bølling chronozone in the European terrestrial record (Björck *et al.* 1998). The AMS dates from King Arthur’s Cave and Sun Hole are also slightly older than those from Creswell Crags (Jacobi & Higham 2009).

Continuation of the Creswellian into GI-1e is confirmed by AMS dates on similar assemblages, including from the cave and rockshelter sites at Creswell Crags. New ultrafiltered radiocarbon dates from Three Holes Cave, Torbryan in Devon (R. Stevens, pers. comm.; previous dates in Barton 1996; Hedges *et al.* 1989) provide the clearest current evidence for a chronological separation between the classic Creswellian and an overlying Late Glacial industry with different point forms. Here, dates on horse bone associated with angle-backed pieces from the lower part of a Late Glacial hearth deposit are statistically earlier than those on red deer and a large cervid from the top of the deposit and associated with a penknife point industry, suggesting a separation of about 200–300 radiocarbon years. A similar separation may be indicated at Gough's Cave, where Roger Jacobi and Thomas Higham (2011) suggested that a small number of curve-backed bi-points may derive from a stratigraphically higher position than the main Creswellian assemblage with Cheddar points. This interpretation is supported by an outlying date of $12,245 \pm 55$ BP on a cut-marked red deer tibia, significantly younger than the main Creswellian dates cluster from the site, although this cannot be rigorously tested given the largely unstratified old excavation material.

The open-air assemblages from Bradgate Park, Farndon Fields, Wey Manor Farm, and Guildford Fire Station probably fit the same broad chronological pattern, although this rests largely on technological analogies with better-dated continental assemblages, and is additionally complicated by regional variation in lithic assemblages from the end of the Magdalenian. At Étigny-le-Brassot in the Yonne Valley, for example, the assemblage shares technological features with the British Creswellian: similar point types, end-scrapers and burins, and two blade morphotypes – longer blades produced with organic percussors, and shorter rectilinear-profile blades used as supports for backed points and made by soft stone percussion (Connet *et al.* 1999; Lhomme *et al.* 2004). Ultrafiltered AMS dating on associated reindeer bone gave an age of $12,630 \pm 90$ BP (OxA-10096 [Lyon]), placing the occupation close in age to British Creswellian sites such as Gough's Cave. However, other dates and the additional presence of red deer suggest the site may contain two successive occupations: one with shouldered and truncated points and organic soft-hammer percussion, and another with curve-backed bi-points and stone soft-hammer percussion (J.-P. Fagnart, pers. comm.). These observations raise the possibility of separate convergent developments in the European Late Upper Palaeolithic rather than direct cultural transmission, although this will require further testing and more secure dating of sites of the Cepoy-Marsangy facies.

Finally, the significance of river networks in facilitating mobility and communication among Late Glacial LUP hunter-gatherer groups requires consideration (Barton 1986; 2010; Bell & Leary 2020; Jacobi *et al.* 2001; Mills 2020; 2022; Pettitt 2008). Many southern British open-air LUP sites lie on or close to major rivers, often along the same drainage systems. Hengistbury Head, for example, occupies a promontory overlooking the confluence of the Stour and Avon in Dorset, with comparable finds further upstream along the Avon at Nea Farm (Barton 1992; Barton *et al.* 2009) and possibly at Churchfields near Salisbury (Harding & Barton 2021). The Avon would have provided a gateway for inland hunting, with riverbank or canoe travel an efficient means of transporting equipment, food, and supplies through an increasingly wooded landscape during the later Windermere Interstadial (Walker *et al.* 2003). A similar relationship may hold for Guildford Fire Station and Wey Manor Farm, the latter near the confluence of the Wey with the Thames. At both sites, comparable flint raw materials were exploited using very similar techniques. A similar range of blade tools also occurs, although differences in backed blade types suggest the occupations were not necessarily contemporary or functionally identical, and may be separated by years or even centuries. The Wey may likewise have served as a route marker or a means of easier access to high-quality flint. Comparable observations have been made for the Severn–Trent corridor (Pettitt 2008),

the Trent Basin (Garton & Jacobi 2009), and in connection with Creswell Crags. Riparian habitats in southern and midland Britain thus offered both access to essential resources and convenient routes across the landscape.

During GI-1e, sea levels were approximately 60–80 m lower than today (Lambeck 1995; Lambeck *et al.* 2014), and the southern North Sea Basin was partly exposed, with the Thames and the Rhine–Meuse–Scheldt flowing into the contemporary Channel River system (Figure 22). Creswellian affinities with the European mainland are also attested at open-air sites in the Netherlands, such as Zeijen (Barton *et al.* 2003), potentially accessible via river systems across this partly exposed basin. Further evidence for high LUP mobility includes long-distance transfer of high-quality flint to cave sites in the south-west (Jacobi 2004). Domesticated dogs, useful for hunting and transport, are also attested in Creswellian contexts at Gough's Cave and Sun Hole (Jacobi & Higham 2011). Genomic analysis now confirms that the Gough's Cave dog belonged to a genetically homogeneous population already widespread across Europe and Anatolia by at least 14,300 years ago, pointing to wide-ranging exchange networks among Late Palaeolithic human groups (Marsh *et al.* 2026).

<h1>Concluding remarks

Spatial and refitting analyses demonstrate that Guildford Fire Station is a rare, largely undisturbed LUP open-air site in Britain. The *chaîne opératoire* study indicates at least three individuals, including two skilled knappers and a probable novice, and clarifies tool use intensity and likely occupation duration. Without refitting, where and how knapping, tool production, resharpening, and discard took place could not have been established.

Microwear analysis reveals diverse hunting and processing-related activities, including working of hard organic materials (bone and antler) and dry hide. Off-site hunting is implied by backed blades with linear impact traces and bending breakages, suggesting broken hunting equipment was brought back to the site for repair. Several burnt, damaged backed pieces suggest adhesives were used for hafting and required reheating for removal, although no resin residues survive. Small-scale fire use is attested by a strike-a-light and a scatter of burnt artefacts. Despite abundant evidence for animal processing, little trace of primary butchery was identified, although resharpening retouch on *rasante* blades may serve as a proxy.

Comparisons with European assemblages suggest that Creswellian sites such as GFS share closer technological and typological affinities with the Early Azilian/Federmesser, Final Magdalenian and Early Hamburgian than with the classic Late Magdalenian. The distribution of these sites, especially in lowland southern Britain, may highlight the importance of river valleys as connective pathways for human groups in increasingly wooded Late Glacial landscapes. These issues are being further investigated as part of TAIHA (Le Tardiglaciaire dans l'Arc Atlantique : Interactions techniques, socio-économiques et graphiques entre communautés humaines et animales durant la transition Pléistocène-Holocène, 14,500 – 11,000 cal BP), an international collaboration involving three of the present authors (AJR, LPC, RNEB) examining Late Glacial cultural transitions and human-environment interactions across Britain, France, and Spain⁵.

Endnotes

1. Subsequent archaeological work immediately east of GFS produced no LUP worked flint (Egginton *et al.* 2019, 286). Modern damage occurred on the south side of the site from the recent detonation of World War II munitions, although apart from one small area to the south this caused no significant damage to the excavated scatter.
2. The *en éperon* platform-preparation technique involves creating a small projection or spur

(*éperon*) by removing convergent flakes to isolate the impact point (Barton 1990; Cheynier 1957; Inizan *et al.* 1995; Karlin 1972; Pelegrin 2000). The spur directs the percussive force down a central ridge of a core to produce regular blades. The resulting butt (*talon à éperon*) often has a steeply inclined *angle de chasse* (between dorsal face and butt). Typical examples occur at Three Holes Cave (Barton 1990) and Gough's Cave (Jacobi 2004). GFS and Wey Manor Farm examples are atypical, with careful faceting and/or an acute *angle de chasse* but no spur (Figures 7–8), referred to here as *en éperon*-related (*cf.* Jones & Cooper 2013). Both forms occur at Bradgate Park. Variation within the *en éperon* form was first noted by Claudine Karlin (1972) at the Late Magdalenian site of Pincevent, and has also been noted in Final Magdalenian and contemporary industries, including the Hamburgian (Weber 2012).

3. Some figures and percentages presented here differ slightly from Barton *et al.* (2024), as a few small retouched fragments were identified in sieve residues after the monograph went to press; the values given here supersede those.
4. A similar Cheddar point from Lound shows extreme distal rounding, presumably as a recycled tool (Jacobi *et al.* 2001).
5. TAIHA. 2021–26. <https://anr.fr/Projet-ANR-21-CE27-0007>

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Competing interests

The authors declare no competing interests.

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RÉSUMÉ

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ZUSAMMENFASSUNG

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RESUMEN

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Figure captions

Figure 1. Setting and topographic location of Guildford Fire Station, Surrey, SE England (© Oxford Archaeology).

Figure 2. Overall distribution of all artefacts. Those recovered from samples are located randomly within their grid squares (© Oxford Archaeology).

Figure 3. Section 1010 with OSL sample positions (© Oxford Archaeology).

Figure 4. Summary of OSL date ranges (© Oxford Archaeology).

Figure 5. Refits projected onto a north–south aligned section showing the vertical distribution of refitting artefacts. The y axis (depth) has been exaggerated by a factor of 5 in relation to the x axis (northing) (© Oxford Archaeology).

Figure 6. Heatmap of all flint artefacts (© Oxford Archaeology).

Figure 7. En éperon butt features on a blade from La Madeleine, France (Ashmolean Museum AN1927.281.a), and related examples from Guildford Fire Station (c.921, c.295) (© Ashmolean Museum, University of Oxford).

Figure 8. Single platform blade core (c.945) and blade debitage with isolated en éperon-like platforms (c.921/c.989/c.988; c.295), linear platform (c.147), large plain platform (c.1709), and punctiform platform (c.4201) (© Oxford Archaeology).

Figure 9. Backed blades, bladelets, and points. Oblique points (c.2378, c.4200, c.694, c.5787, c.5032); curve-backed bi-point (c.308); curve-backed point (c.7482, c.508); straight-backed bladelet with oblique truncation (c.948); backed blade fragments (c.4322/c.4328, c.4062, c.4486); partially backed and truncated blade (c.4735); two refitting Krukowski microburins (c.1732, c.4743); proximal microburin (c.7412) (© Oxford Archaeology).

Figure 10. Detail of rubbed end ‘strike-a-light’ (c.2555) showing a) macroscopic picture of the distal part of the blade (12.5×); b) microscopic detail of the used edge with intense rounding and striations (100×) (© Oxford Archaeology).

Figure 11. Blade tools with rasante (scalar) retouch: dihedral burin (c.1204), end-scraper (c.2471), rasante retouched blade (c.992, the proximal part of truncation burin c.990) (© Oxford Archaeology).

Figure 12. Backed blade c.4486. a) detail of the distal edge damage: distal and lateral bending fractures (20×); b) detail of the distal edge damage associated with MLITs (25×) (© Oxford Archaeology).

Figure 13. End-scraper on blade with rasante (scalar) retouch c.2471 with a) rounding from use, distal end (200×); b) scarring, proximal left edge (12.5×); c) microscopic detail of the lateral edge with rounding and polish (200×); d) microscopic detail of the lateral edge with striations (500×) (© Oxford Archaeology).

Figure 14. Distribution of all break refits (© Oxford Archaeology).

Figure 15. Distribution of all dorso-ventral refits (© Oxford Archaeology).

Figure 16. Overall distribution of all refitting artefacts (© Oxford Archaeology).

Figure 17. Photograph of Refit Group 06 (© Oxford Archaeology).

Figure 18. Burins. Double burin (dihedral and on a break) with three refitting spalls and part of the original blade blank (c.319/c.524/c.692/c.2802/c.7007); two refitting burins (on a truncation and on a break) and a refitting retouched blade fragment (c.699/c.2313/c.7448); burin on a notch with a refitting spall (c.1557/c.4158); double burin (on a break and on a truncation) (c.459) with a refitting part of the blade blank (c.1242) (© Oxford Archaeology).

Figure 19. Refitting blade end-scraper (c.1315) and burin (c.1564). Refit Group 56 (© Oxford Archaeology).

Figure 20. Contoured map of heat-affected flint. Blue indicates all flint; red indicates heat-affected flint (© Oxford Archaeology).

Figure 21. Curve-backed bi-points: Guildford Fire Station (c.308; 41 mm); Wey Manor Farm (#52; 67 mm) (© Oxford Archaeology).

Figure 22. Topographic relief map of south-eastern England and north-eastern France showing key sites mentioned in the text (© Oxford Archaeology).