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A Late Glacial family at Trollesgave, Denmark

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ABSTRACT

Microwear analysis is applied to reconstruct the function and social organisation at the Late Glacial site of Trollesgave, Denmark. As with Bromme Culture sites in general, the lithic assemblage consists of primarily three types of tools. There is a strong association between these types and their use: end scrapers for dry hide scraping; burins for working hard material, primarily bone; and tanged points primarily for projectile tips. Nearly all divergence from this pattern can be referred to as the activities of children, the products and workshops of which have previously been identified. Based on the combined information from microwear analysis, flint knapping and spatial distribution of artefacts, the assemblage is inferred as the traces of a single family hunting (and fishing) occupation.

1. Introduction

Late Palaeolithic sites from southern Scandinavia have, until now, been omitted from large-scale microwear studies. Initial attempts in the 1980s indicated that post-depositional processes of cryoturbation and solifluxion as well as soil chemical processes of bleaching and leaching had generally significantly hampered the effective use of this method on the flint assemblages available from settlements from this period of NW European prehistory (cf. Fischer et al., 1984). Among these attempts were two preliminary microwear studies of the Bromme Culture assemblage of the Trollesgave site. In the meantime methods, equipment, and microwear theory have improved (e.g., Burroni et al., 2002; Evans and Donahue, 2008). Revitalised research interest in the Bromme Culture and the Late Glacial occupation of southern Scandinavia (Fischer, 2013; Fischer et al., 2013a, 2013b; Pedersen, 2009) led to a reanalysis of the Trollesgave assemblage. This paper summarises the results of the present microwear study and aims to demonstrate how lithic microwear analysis, along with analyses of refitting and flint manufacture, can contribute towards understanding of the economy and social organisation at a European high latitude Late-Glacial site.

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2. Background

2.1. The site

The Trollesgave site is located in the young moraine landscape of southern Scandinavia (Fig. 1). Typologically it is representative of the archaeological techno-complex labelled Bromme Culture, which is by far the most numerous of the four Late Palaeolithic complexes known in Denmark (Fischer, 2013). Its territory comprises present-day Denmark, southernmost Sweden, northern Germany, perhaps parts of Poland and England (Sørensen, 2010) and, no doubt, areas that are now hidden under the Baltic and North Seas (Burdukiewicz, 2011; Clausen, 2003; Eriksen, 2002; Fischer, 1985; Fischer et al., 2013a; Pedersen, 2009; Petersen, 2009; Riede and Edinborough, 2012).

Like most sites from this complex, it is comprised mainly of worked flint, the majority of which can morphologically be classified as waste from the production of blades (Fischer, 1990a, 1990c, 1991). As with Bromme Culture flint assemblages generally, the technology reflects a relatively simple craft tradition where flakes and blades were detached exclusively with hammerstones (Fischer, 2013; Fischer et al., 1979; Madsen, 1983, 1992, 1996). In terms of the number of retouched tools, the Trollesgave assemblage is among the less rich assemblages (Fischer, 1991; Pedersen, 2009). Although the site is disturbed by ploughing, most artefacts lie in deeper sediments, where features and organic remains have also survived.

The activity area of the site is located on a sandy plateau next to a contemporary lake of more than 10 km^2 extent (Fischer et al.,

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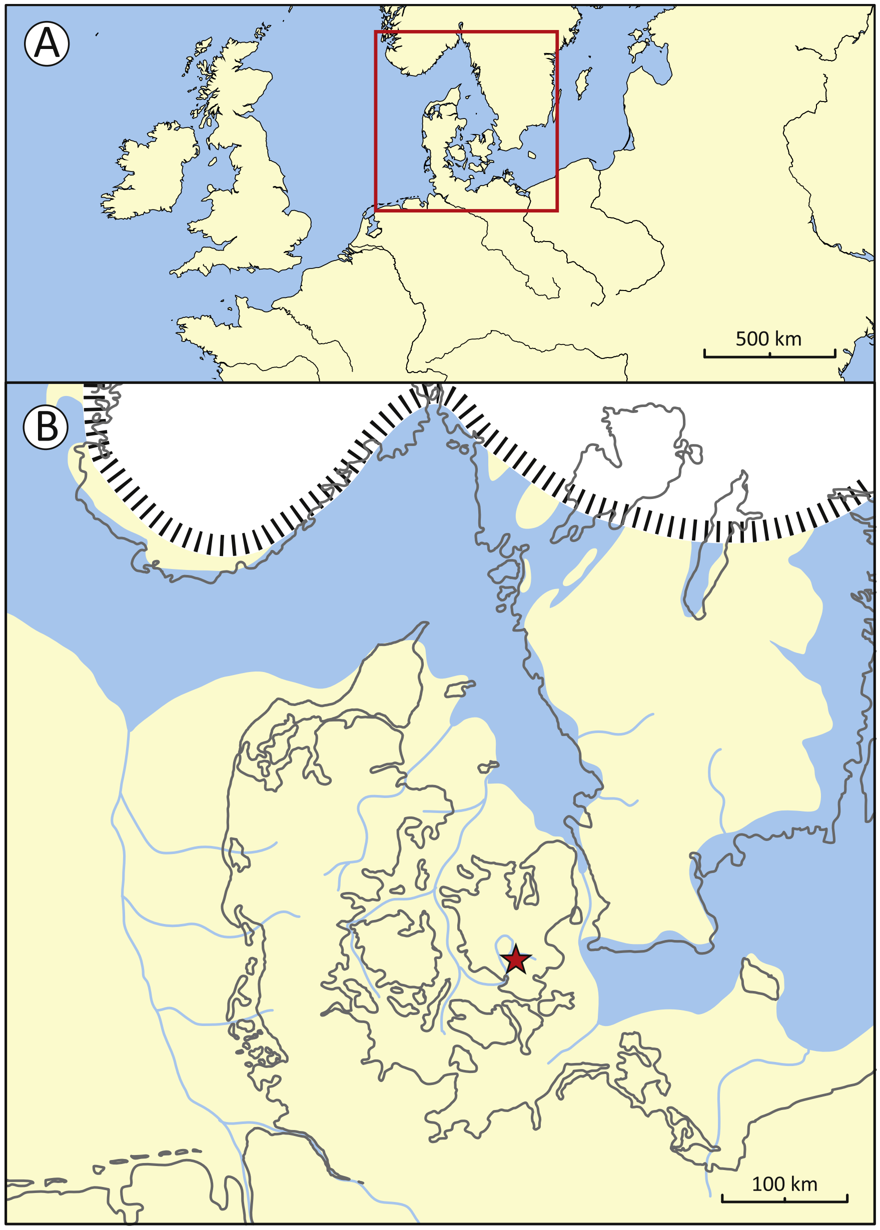

Fig. 1. The location of the Trollesgave site, relative to present-day geography and the extent of land, sea and ice cap during Middle to Late Allerød times. Drawn partly on the basis of Houmark-Nielsen 2012.

2013b). Its inhabitants would have had easy access to fishing, hunting, and provision of large flint nodules of good knapping quality (Fischer, 1985). Through pollen analysis and ^{14}C dates a lake deposit with dump material from the activity area can be dated to a late part of the climatically mild Allerød biozone, c. 10,830 ^{14}C years BP, c. 12,700 cal BP (Fischer et al., 2013b). As such, Trollesgave is the only well-dated site from the Bromme Culture – which is the northernmost extension of Late Glacial human habitation currently known in NW Europe (Fischer et al., 2013a). As a result of its preservation and the meticulous excavation, Trollesgave is one of the most informative sites of the Bromme Culture (cf., Eriksen, 2002; Fischer, 1990c; Fischer and Mortensen, 1977, 1978; Fischer et al., 2013b; Johansson, 2003; Pedersen, 2009; Riede, 2008; Riede and Edinborough, 2012).

In principle, the open air habitation sites of lowland northern Europe should provide favourable opportunities for the study of site function and social organisation because of their apparently relatively short duration of occupation. There would be limited trampling and little deliberate site clearing; a very different situation than at contemporary cave sites farther south as well as with the many large NW European open air habitation sites from the Mesolithic period (cf. e.g., de Bie and Caspar, 2000; Bosinski, 1970; Leroi-Gourhan and Brézillon, 1966). In southern Scandinavia this favourable situation, however, is in practise hampered significantly by the effects of periglacial soil movements, postglacial bioturbation, and recent ploughing (e.g., Andersen, 1973; Fischer, 2013; Holm, 1996; Mathiassen, 1948; Pedersen, 2009). Trollesgave has been impacted by all three kinds of disturbances (cf. Fischer et al., 2013b). As a consequence, approximately 30% of its flint assemblage ended up in sediments that also contain lithic material from Mesolithic activities and regular Neolithic habitation. Nonetheless, during the excavation of the site, it was possible to observe functionally specific areas such as a hearth, a possible dwelling and several small flint workshops of indisputably Late Palaeolithic age (Fischer, 1990c; Fischer and Mortensen, 1977, 1978). Based on intensive refitting of flint items the workshops were seen as contemporaneous products. Judged by the frequencies of instances of low craftsmanship (lack of core edge preparation, hammermarks, hinge terminations, etc.) the workshops were inferred to represent at least three individuals: a master-knapper, an individual with intermediate flint knapping abilities, and a "trainee" knapper, who was likely a young child (Figs. 2 and 3) (Fischer, 1990a, 1990c; cf. Bamforth and Finlay, 2008, 6; Högberg, 2008, 116).

The present study builds upon the previous inferences as concerns the number of individuals their standards of craftsmanship. As will appear from the following, the wear analytical results adds significantly to the impression that the persons behind the 'non-adult' flint workshops did not adhere to conventional (adult) behaviour.

2.2. Microwear analysis

Lithic microwear analysis is the microscopic examination of surface wear and fracture scars that form along the edges of fine-grained siliceous stone artefacts such as those of flint. Experimental studies demonstrate that microscopic wear and fracture scar characteristics resulting from tool use vary systematically according to the worked material (e.g., hide, wood, meat, bone) and according to the applied forces and motions such as cutting, scraping, and wedging (e.g., Donahue, 1988, 1994). Improved understanding of these principles and relationships permits microwear analysts to infer past uses of lithic artefacts with a greater degree of precision and accuracy than achieved through reliance on either macroscopic attribute analysis or ethnographic analogues of tool form. Following deposition, natural processes also produce wear features that may make inferences about tool use more difficult (Levi-Sala, 1986a, 1986b), but permits microwear analysts to contribute towards understanding of site formation processes (Burroni et al., 2002; Donahue, 1994, 1998; Donahue and Burroni, 2004).

3. Method

3.1. The lithic sample

The sample studied comprises all retouched tools of apparent or potential Late Palaeolithic typology. Some of those from postglacial disturbances can, through refitting, morphology and/or surface alteration (patina), be attributed with certainty or high probability to the Late Palaeolithic. In addition it includes a random sample of morphologically perfect blades as well as several long series of refitted production waste, including two prismatic cores, from the major flint workshops of the site. In total, the items studied for wear traces number 307. Fischer provided the lithic material to Donahue deliberately without any contextual or inferential information already derived by him via other kinds of analysis, and this information was withheld until the use-wear analysis was finalized and reported.

All artefacts were placed on trays and photographed. They were then gently washed in water with a soft nylon brush to remove adhering sediment. This was followed by a soaking of the artefacts in a bath of 10% HCl for 10 min, followed by rinsing in tap water and then soaking in a bath of water with running water for a further 10 min. They were then rinsed and patted dry with a clean, lint-free towel. During microscopic observation methanol was used to degrease artefacts when necessary.

3.2. Analysis

All 307 artefacts were viewed microscopically at magnifications between 100× to 500×. Wear features were recorded at 200× magnification with an Olympus KL-BH2-UMA metallurgical

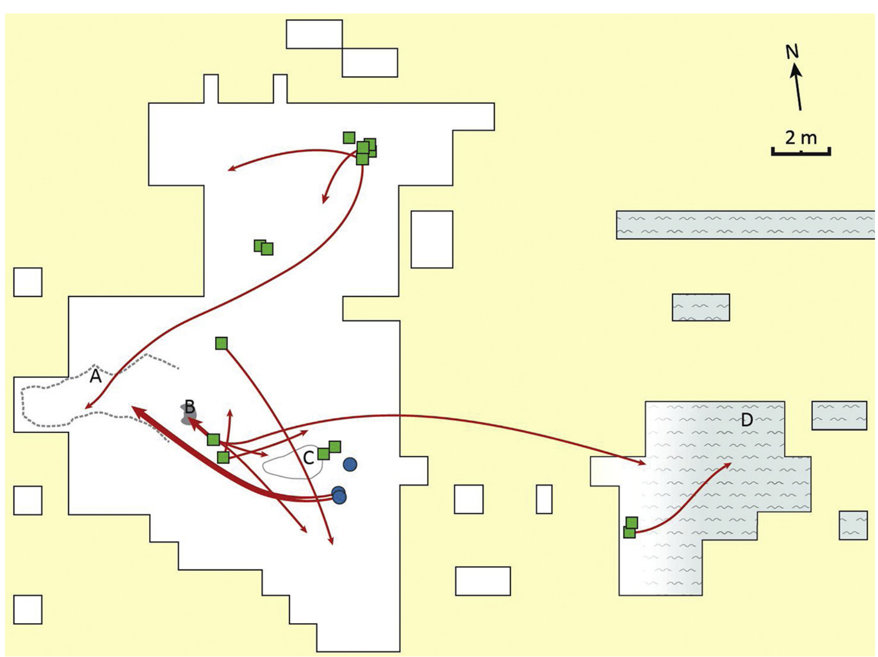

Fig. 2. The internal organisation of the Trollesgave site with the location of the major flint workshops and a possible dwelling structure (A), a hearth (B) a stone serving as seat for a highly trained flint knapper (C) and the contemporary lake (D). Based on refitting and technological analysis the workshops represent (at least) three individuals: master, medium-trained and inexperienced, probably a young child. The workshops of the latter are marked with round symbols, while the clusters of production debris of the other two are indicated by squares. The arrows illustrate main trends in the horizontal movement of items out of the workshops. As opposed to the other individuals, much of the results of the young child's flint knapping was deposited in the possible dwelling. A different kind of unusual behaviour was shown by the medium-trained individual, who worked at the lake shore, and tossed a number of the products into the water.

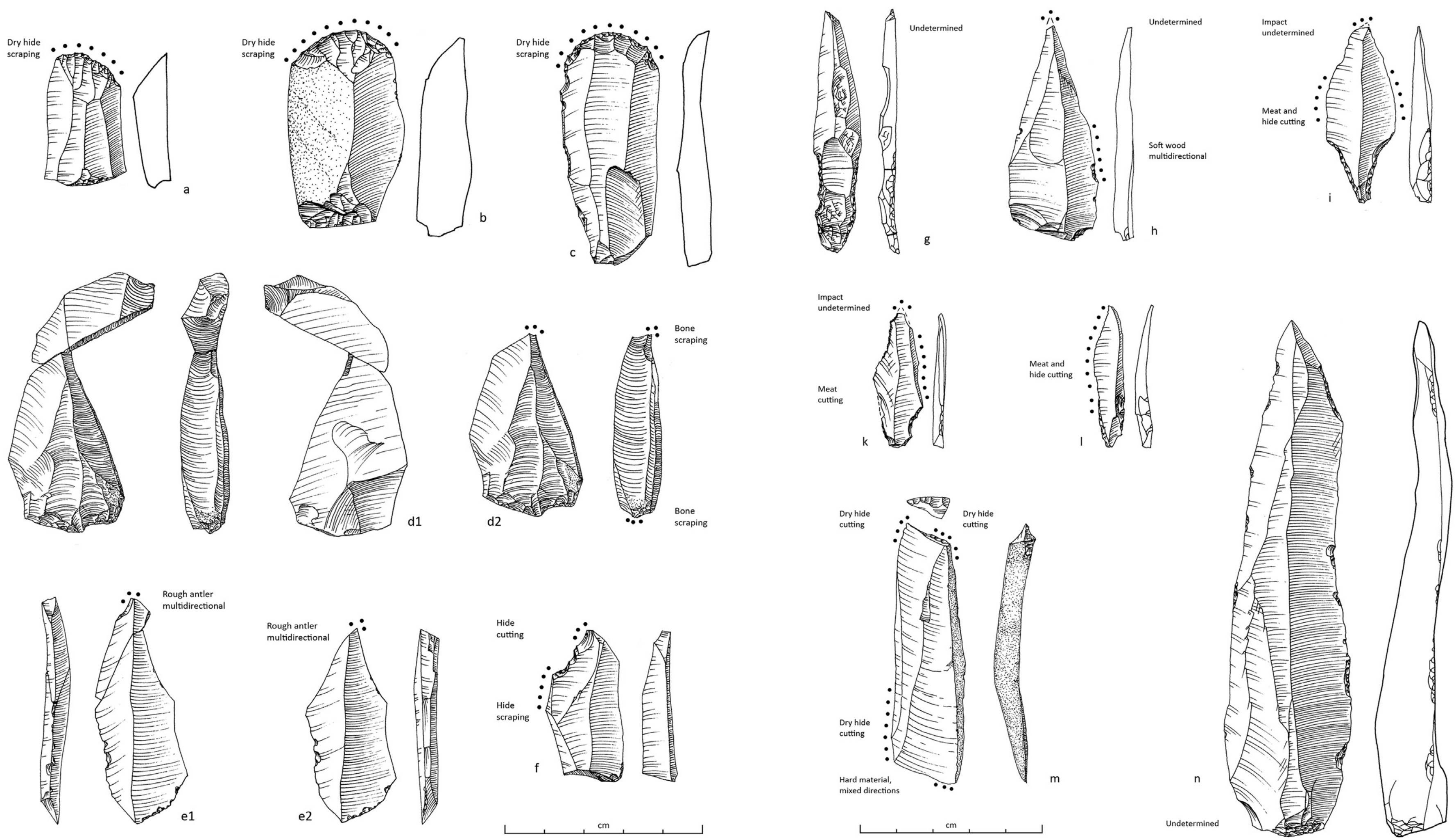

Fig. 3. Examples of location of wear and variation in technical performance of lithic manufacturing at the Trollesgave site: scrapers (a–c), burins (d–f, d and e in two stages of manufacture and use), tanged points (g–l), blade with irregular retouch (m), large and technically perfect blade, judged on the basis of raw material characteristics probably imported to the site in finished shape (n). Based on their horizontal location and low standard of technical performance k and l were on beforehand supposed to be the products of an inexperienced flint knapper. For the same reasons of low craftsmanship items f and m, found in the workshop area at the lake, were on beforehand inferred products of a not fully trained individual. In addition it was noted that parts of this production had been tossed some meters away into the lake. The aberrant use traces on the latter four items now stress the impression that the individuals behind these items did not follow standard (adult) procedures. There is no artefact j.

Table 1
Wear and fracture scar characteristics associated with different kinds of worked materials.

Raw material	Fracture scars	Striations	Surface polishing	Edge rounding	Pitting
Dry Hide	Small-Medium (scraping: bending initiations, step terminations)	Numerous; Deep and wide, shallow & diffuse, and wide linear depressions	Matt & flat, but never smooth; edge & face	Moderate to heavy	Common; Large hemispherical pits (>50 um dia.)
Fresh Hide	Small-Medium (Scraping: bending initiations, step terminations)	Numerous; Deep and wide, shallow & diffuse, and linear depressions	Rough; non-contrasting; edge & face	Moderate	Rare; Large hemispherical pits (>50 um dia.)
Meat & Hide	Small-Medium	Some; Deep and wide, shallow & diffuse	Greasy looking & Rough; edge & face	Mild to moderate	No pitting
Meat	Very small; point initiations & feather terminations	Rare	Greasy looking or lustrous; edge & face	Mild	No pitting
Herbaceous Plant	Small	Numerous	Smooth & flat; very bright; edge & face	Mild to heavy	Frequent comet-shape pits
Woody Plant	Medium	Common narrow striations	Smooth and doming; very bright; edge and face near edge	Mild to heavy	Occasional comet-shape pits
Soft Wood	Medium	Common narrow striations	Smooth and doming; very bright; edge and face near edge	Mild to heavy	Common and variably shaped pits
Hard Wood	Medium-large	Common narrow striations	Smooth and doming; Very bright; edge/near edge	Mild to moderate	Common and variably shaped pits
Smooth Antler	Medium-large;	Few striations	Undulating; "melting snow"; bright; edge & face near edge	Mild to moderate	None
Rough Antler	Large	Common; short and narrow and parallel striations with	Rough, bright, along edge	Mild to moderate	Few pits
Bone	Large	Common; short and narrow and parallel striations with	Rough, bright, protrusions	Mild to moderate	Common tiny pits (<5 um dia.)
Shell	Large	Occasional	Bright, large patches on edge and face near edge	Mild to moderate	Few pits

microscope with incident-light and long working-distance objectives. Most relevant wear features seemed best observed at this magnification. At lower magnification the wear attributes were not always discernable and at higher magnification, not enough of the surface was in focus. The wear characteristics used to discern artefact use are presented in Tables 1 and 2.

Twenty-four artefacts were included for ridge rounding analysis (Keeley, 1980; Shackley, 1974). Ridge rounding is a good proxy for the amount of post-depositional modification that an artefact has undergone, however, the measure can be affected by the handling of a tool during its original use and during archaeological recovery and processing. As a result it is usually best to measure rounding on unmodified flakes with poor cutting edges. The technique entails positioning the artefact such that a dorsal ridge lies parallel with the microscope stage and perpendicular to the microscope objective. The light passing through the objective is focused directly on the ridge. Much light is reflected back through the objective from the apex of the ridge where the curvature is minimal, but the light striking the sides of the ridge is reflected away from the objective. With a very fine scale in the eyepiece, the width of the reflected band of light is measured. A very sharp ridge will produce a very fine line of light. With more rounded ridges, the width of the band of light increases. Because ridge width varies greatly one needs to take 10–20 measurements per flake to ensure a good representative average value.

Microscopic characteristics of edge fracture scars, striations, pitting, surface polishing, ridge rounding, plastic deformation and thermal alteration (micro-cracking, heat spalling, and crazing) were recorded and considered when deducing tool use and other causes for modification following Donahue (1994) and Burroni et al. (2002). These data provide information about tool use, tool resharpening, tool recycling and hafting, and site formation processes.

Use data are presented in terms of direction of use relative to the edge and the kinds of material worked. The category of "undetermined" indicates an inability to determine how an artefact was used or even if it was used. This is usually because the artefact underwent too much post-depositional surface modification or that it was used so little as to leave very little wear[2]. To be called "unused" an artefact must show no evidence of use and be in such good condition that post-depositional disturbance could not have removed all evidence of tool use.

4. Results – artefact use

The amount of ridge rounding observed on the Trollesgave flints indicates that the assemblage has undergone variable sediment movement. At 200× magnification the mean of artefact ridge means is 44.3 μm and the mean of standard deviations is 8.9 μm. The artefact means range from 5.42 to 66.05 μm. Under the best of these conditions wear from cutting meat (the most ephemeral use-wear) will remain identifiable and under the worst conditions wear from cutting silicious plants (the most tenacious of use-wear formations) may still be identifiable. Thus, the expectation is that the more ephemeral kinds of wear (primarily meat cutting and butchering) will be much underrepresented at the site. These results correspond well with other derived information that a minor part of the assemblage was found in solifluction layers and nearly all the rest was found in sediments where Late Glacial frost and thaw processes have probably caused some abrading (cf. Fischer et al., 2013b). Nonetheless, 97 artefacts show evidence of one or more of the following uses: bone/antler working, 47; hide working, 41; meat cutting (butchering), 7; projectile armatures, 4; wedging, 1; wood working, 1. There is also one artefact showing evidence of hafting, but its use is undetermined. The results of the ridge rounding study help explain two phenomena at the site. First, the relatively few butchering tools identified and second, why there are so few "unused" artefacts at the site (Fig. 4). Both of these categories

[2] During the initial use of an edge, there is rapid fracture scarring, which keeps removing wear characteristics from developing. When the edge fracture scarring has stabilized, which will vary according to use and the consistency of the applied force, wear characteristics will form fairly rapidly. This relationship between the fracture scarring and wear formation along the edge has been a principal cause for poor results in blind-test experiments because the tools are often used for very little time.

Table 2
Fracture and wear characteristics associated with the relative motion of the tool's edge.

Fracture size	Minute (very small)	Small	Medium	Large	Extremely Large
Fracture initiatons	Cone or point – indicates a strong compressive force	Bending – indicates a strong bending force			
Fracture terminations	Feather – indicates a strong compressive force	Step – Indicates a secondary bending force, flaw or insufficient pressure	Hinge – Indicates some bending force	Snap – occur only with bending initiations. Indicates a strong bending force or a tensile force perpendicular to the edge	
Fracture directions	Perpendicular to the edge	Oblique to the edge	Mixed		
Frequency of striations	None	Very few	Common	Dense (innumerable)	
Striation morphology	Deep and narrow	Broad and deep	Broad and shallow	Abraded line – only tops of topographic features effected	Linear depressions – more like troughs than striations
Position of striations	Edge	Edge and face near edge	Face	All over tool	
Directions of striations	Perpendicular to the edge	Parallel to the edge	Oblique to the edge	Mixed	
Polish (Wear) location	Edge	Edge/face	Face		
Vertical distribution of polish	Peaks of microtopography	High and middle contours	All over contour levels		
Reflectivity	Dull	Slightly bright to no contrast	Bright	Very bright	
Microtopography	Flat or smooth	Doming	Convoluted or undulating	Rough	Smooth
Texture	Smooth	Convoluted	Greasy or satiny luster	Rough	Matt
Abrasion (rounding)	Very mild	Mild	Moderate	Intense or heavy	
Pitting	Tiny and common	Medium size and comet-shaped	Large and hemispherical		

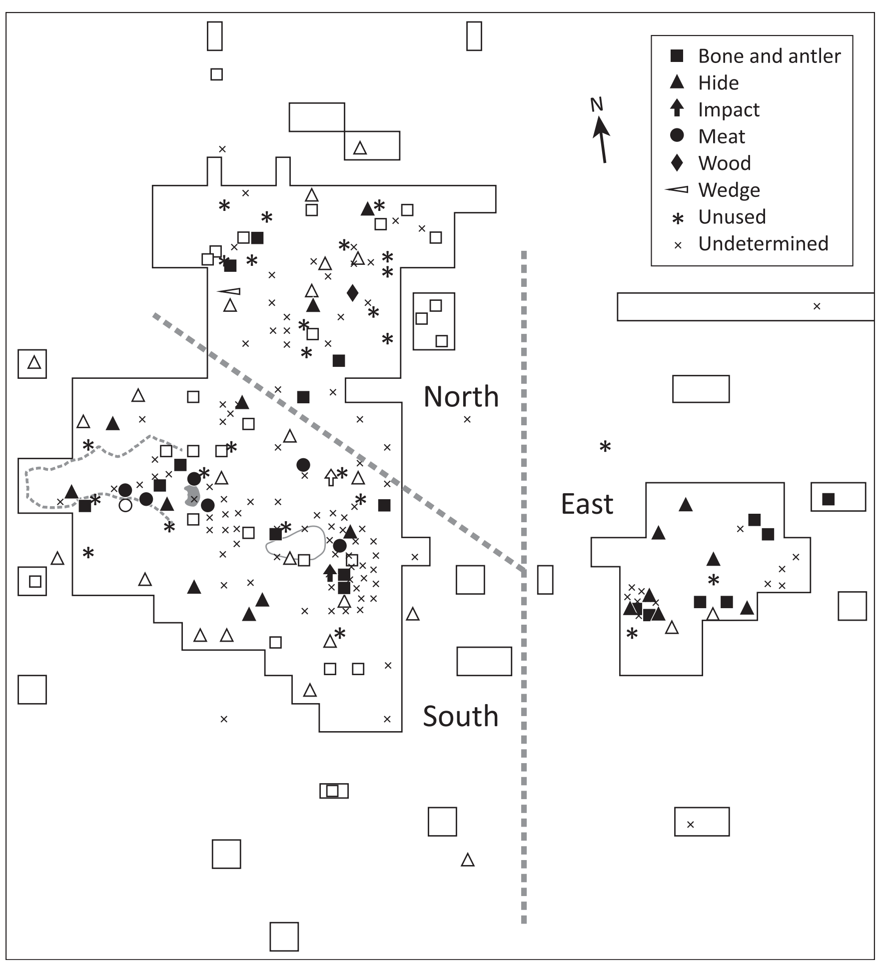

Fig. 4. The spatial distribution of all items studied, the types of wear observed, and the division of the site into three clusters: North, East and South (N, E, and S). In this and the following maps filled in symbols represent items found in undisturbed layers.

require artefacts in extremely good condition and the ridge rounding measures show that the Trollesgave assemblage in general does not meet this criterion.

The tool use frequencies given above provide general insight into the importance of these activities at Trollesgave. While it would be of much value if tool use frequencies were a reliable proxy for the amount of time spent doing these activities, it is not yet possible. There are various confounding factors: 1) not all tool use is done on-site; some tools are simply replaced (retooling) on-site; 2) post-depositional processes have affected the various kinds of use-wear differently (wear from meat cutting is very ephemeral while wear from siliceous plant cutting is extremely robust), and 3) some tools are resharpened and reused multiple times (e.g., hide scrapers).

There are three principal tool types recovered at the site: end scrapers, burins, and tanged points (Fig. 3). The only other formal tool form is a truncated blade, which could be a preform for a burin (Fig. 3m). A strong association exists between tool types and tool uses. This is best demonstrated by the 42 end scrapers, of which 36 were identified as used solely for hide scraping (6 had undetermined use; Table 3). Chi-square analysis with Yates Correction for Continuity and one degree of freedom gives a goodness of fit value (χ^2) of 91.601 and a p-value (significance) of less than 0.001 demonstrating the significant association between hide scraping and end scrapers. One artefact, an unmodified flake found in the plough zone, has also been used for scraping hide. The association between hide scraping and end scrapers has been acknowledged in numerous microwear studies (e.g., Ahler, 1979; Donahue, 1988; Donahue and Evans, 2013; Keeley, 1980; Knutsson, 1978; Moss, 1983), ethnoarchaeologically (Beyries and Rots, 2008; Rots and Williamson, 2004), and ethnographically (e.g., Frink and Weedman, 2005).

Microwear analysis indicates that most of the end scrapers were used for dry hide scraping (29 dry hide scraping and 7 either fresh or dry hide scraping; Fig. 3a–c). Wear from dry hide differs from the scraping of fresh hide by having a much more matte surface and the appearance of relatively large (50 μm diam.) hemispherical pits. Keeley hypothesized that these pits result from the localised high frictional heat that occurs at the contact edge (Keeley, 1982). Years of experimental research and wear theory development have not produced any reasons to reject this hypothesis (e.g., Beyries and Rots, 2008; Donahue, 1994).

Burins and burin spalls show a significant association with the working of hard organic materials; specifically bone and antler (see Table 4). Chi-square analysis with Yates Correction for Continuity and one degree of freedom gives a Chi-square value 73.847 with a p-value (significance) of less than 0.001, showing that there is a strong association between burins and burin spalls and the working of very hard materials. Only two of the 39 used burins and burin spalls were used on antler. Four additional artefacts may have worked bone: TG 104/100:170 is labelled a flake, but appears to be a burin technologically; TG119/102:5 is a flake that has a corner morphologically similar to a burin bit; TG 97/103:8 is a flake that has some wear indicative of bone cutting, but there is a good possibility that this may be in association with some other task, such as butchering where wear from meat is not adequately recognizable; and lastly, TG 104/100:117 is a flake that was used for scraping bone.

Table 3
Cross-tabulation of end scrapers and hide scraping.

Artefact use	End scrapers	Other artefacts	Total
Hide scraping	36	1	37
Other uses (inc. hide cutting)	0	60	60
Total	36	63	97

Table 4
Cross-tabulation of burins and burin spalls with working bone and antler.

Artefact use	Burins & burin spalls	Other tools	Total
Antler/Bone working[a]	42	4	46
Other uses	2	49	51
Total	44	53	97

[a] Includes "hard material".

Two burins were used for purposes other than working bone or antler. The lateral edge of one burin (Fig. 3f), which was the product of the medium-trained individual who worked at the lake shore, appears to have been used for cutting and scraping dry hide. The other one shows evidence that it was used as a wedge. In addition, one burin spall (Fig. 3d1) was used to work bone (either as a graver or as a drill) on its distal end including its ventral surface. This could have happened only when the burin spall was detached from the burin. All other burin spalls with use-wear show no evidence of use on their ventral face and associated edges – leading to the more common inference that they were part of a burin when used. On functional grounds, therefore, this is a tool although technologically it is considered debris.

Evidence for the working of antler is quite rare and the distribution of tools inferred to have been used on antler shows no clustering (Fig. 5). There are two artefacts thought to have been used on antler, located in the eastern area of the site (as defined in Fig. 4), with three additional artefacts interpreted as having worked either antler or bone spread across the southern area of the site.

In contrast, the distribution of items with evidence of meat cutting is quite localised (Fig. 6). All are found in the southern area of the site primarily around the hearth and within the possible shelter. The distribution of impact-damaged tools, most thought to have been used as projectile points, is also restricted to the central part of this area (Fig. 7).

The sample of tanged points shows less evidence of having a single function (Table 5), nevertheless, Fisher's Exact Test produces a significance value of less than 0.001 indicating that there is an association between tanged points and use as armatures (projectile points). Of the nine tanged points, seven have use wear with four points showing evidence for impact damage at the tip including: burinations, crushing, and striations parallel with the longitudinal axis (cf. Fischer et al., 1984). A fifth point shows some damage that may be associated with impact, but it is inconclusive. Six tanged points show other kinds of use, including meat cutting (4), hide cutting (1), and wood working (1). Because impact damage is not always produced from a point impacting a body, it is not known if these other uses were in addition to use as projectile points or reflect alternative uses of the tools. Finally, it is noted that impact scarring (large invasive scars) was observed on both lateral and the distal edges of a burin (TG 100,5/111,0:1001). It is inferred that the tool was used as a wedge, but there were inadequate traces to identify the worked material. While we recognise the problems with identifying wear relating to projectile point use (cf. Rots and Plisson, 2013), we also recognise the importance of the statistical association between morphology and wear. Thus, it is not just the impact traces seen on the four tanged points that is important, it is also that only one other artefact (a burin) has wear characteristics indicative of impact (numerous opposing invasive scars) and these characteristics are indicative of use as a wedge.

It is possible that the traces of meat cutting on tanged points are the result of successful strikes with wear produced by the locomotion of the animals before they dropped. This does not, however, explain the cutting of hide and wood. Alternatively, tanged points

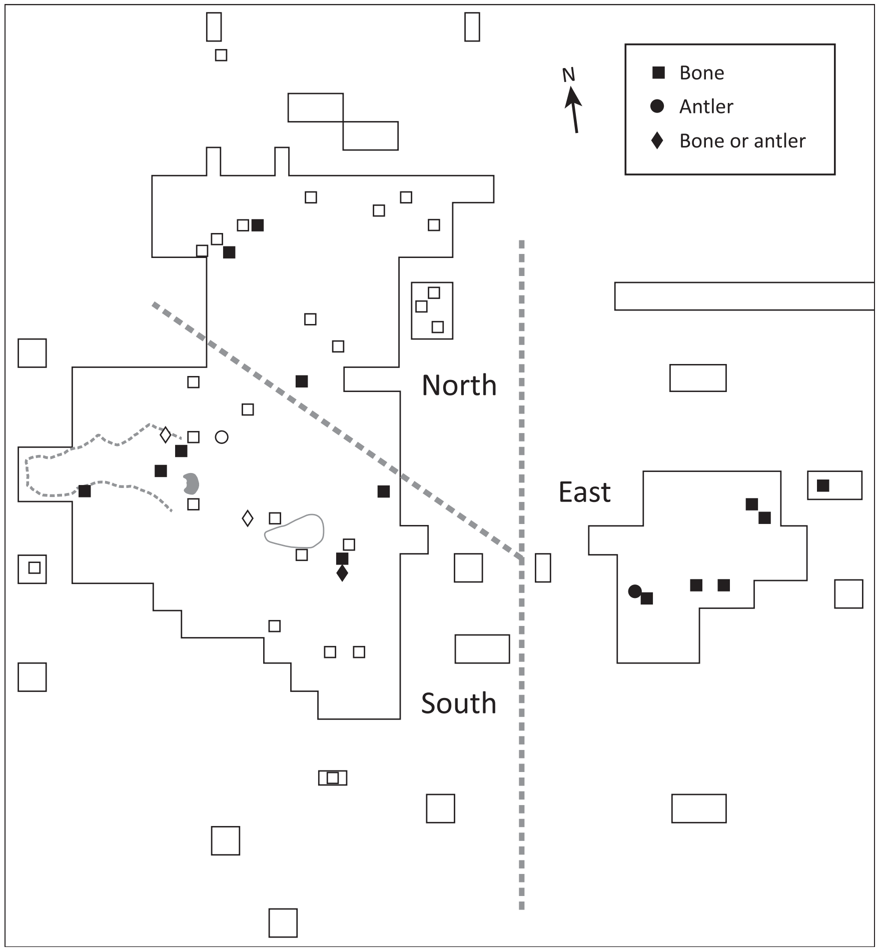

Fig. 5. Spatial distribution of wear relating specifically to the working of bone and antler.

may have been made principally for use as projectile points, but were also used, perhaps expediently, in a variety of other tasks. Interestingly, three of the cases of such 'diverging' wear is seen on tanged points of unusually small dimensions, produced in an unusually low scale of craftsmanship (Fig. 3k–l). From their location in the area of the possible dwelling and from their clumsy technological execution they were inferred beforehand to be the products of the previously mentioned young child (cf. Figs. 2 and 3).

Evidence for meat cutting is also observed on two flakes and four blades. Because wear from meat cutting is very ephemeral and will be eradicated by relatively little movement in sediment, the modest number of artefacts with wear from meat should not be taken as evidence for the amount of meat cutting that took place at the site. Finally, it is also possible that some or all of these meat cutting tools were used for the cutting of fish; the wear patterns of fish cutting are almost indistinguishable from meat cutting even under the best of conditions.

5. Discussion

5.1. Site organisation and group composition

Because of the chronological uncertainty of some artefacts in the upper layers of the site we focus on the spatial distribution of the studied artefacts from the deeper sediments whose association with the Late Glacial occupation is not in doubt (Figs. 4–7). A k-means cluster analysis was applied to the horizontal spatial coordinates of the artefacts. Three clusters (termed North, East and South) of approximately 7, 7, and 10 m diameters, respectively, encompass virtually all (95%) of the used artefacts across the site (see Table 6). The few outliers (which, in fact, lie close to at least one cluster) are grouped to the nearest cluster for evaluating the following hypotheses regarding what these clusters may represent:

1) three different social units (contemporaneous households);
2) activity areas of a single household;
3) different episodes of site occupation;
4) random variations in discard behaviour over the occupation period of the site; or
5) some combination of the above explanations.

Field excavations revealed only one Late Palaeolithic hearth and subsequent analyses of the spread of thermally altered flint have not changed this status. Since a similar assemblage composition and a hearth can be expected to be associated with each household (e.g., Yellen, 1968), Hypothesis 1, the site was formed by three households, can be rejected. Refit analysis by Fischer (1990c; this paper Fig. 2) indicates that all areas of the site were contemporary leading to a rejection of Hypothesis 3.

Table 6 shows that there are major differences in tool use among the clusters, which cannot be explained by random error. While hide scraping and bone graving appear distributed fairly randomly, nine tools used for meat cutting (as primary or secondary use) are only found in Cluster South, generally not far from the hearth.

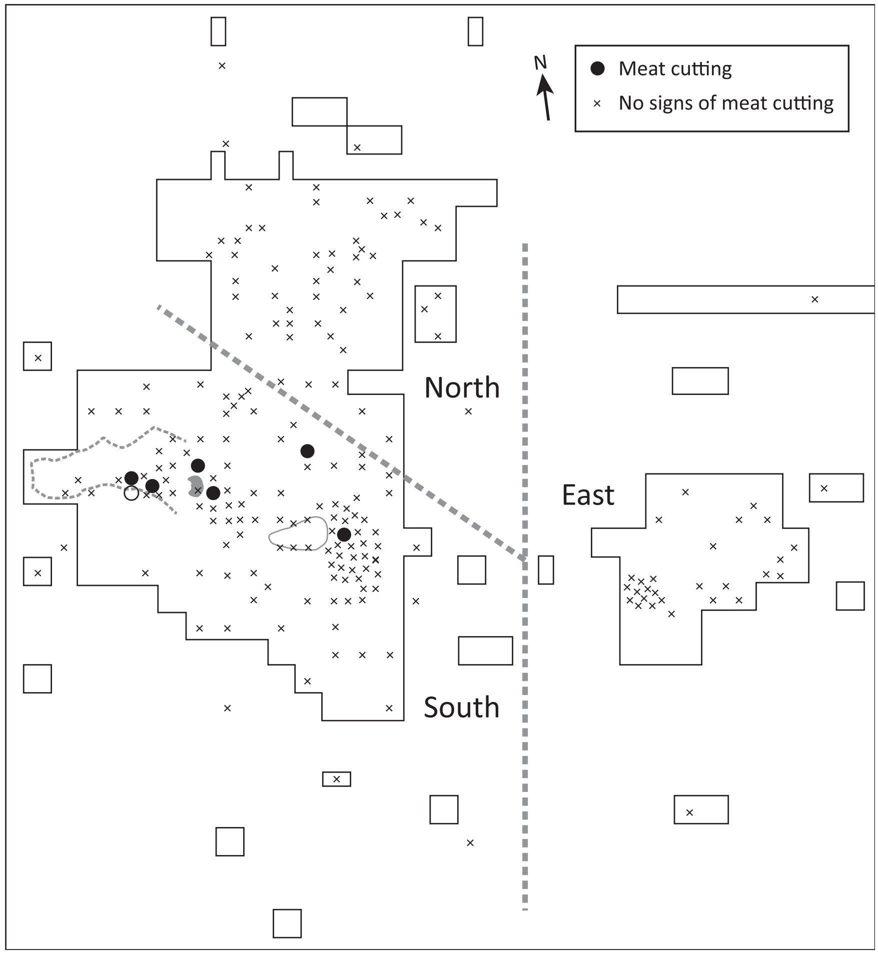

Fig. 6. Spatial distribution of meat cutting tools based on wear traces compared with all other artefacts studied.

Likewise, the two piece-plotted armatures are also found in this area. The two tools used for wood working and wedging, however, are found in Cluster North. These results indicate that Hypothesis 4 can be rejected and Hypothesis 2 is supported. Based on these results it is concluded that Hypothesis 2 best explains the spatial patterning; Trollesgave is a single household occupation site with variation in the differential distribution of activities occurring across the site.

Based on the spatial pattern of items studied for microwear we conclude that all three clusters are focal areas for production and discard. Clusters N and E served relatively narrow sets of activities, mainly flint knapping and bone and hide working. Cluster S had a wider array of activities, which included food preparation (meat cutting) alongside modest proportions of flint knapping and bone and hide working. Five out of seven piece plotted tanged points also belong to Cluster S.

The previous technological analysis and refitting (Fig. 2; Fischer, 1990a, 1990c) indicated that the activities in Cluster S involved one expert knapper and one trainee or inexperienced knapper, probably a young child, while Cluster N was the product of a moderately qualified knapper. In Cluster E the same (or an equally medium trained) individual worked side by side with a person performing expert craftsmanship of the same kind as seen in Cluster S.

The above inference of the group composition at Trollesgave finds support in a study based on a survey of the ethnographic literature by Keeley (2010), showing that there was sexual division of scraping hides by some hunter-gatherer cultures. This has been supported further by research on gender and hide production (see the various papers in Frink and Weedman, 2005), although it is not a simplistic relationship. For example, Cassell (2005, 107) referencing Giffen (1930, 33-34, 88) reports that in Iñupiat Eskimo society, “Working skins”, especially skin scraping, tended to be a female gendered activity. Women tended to work dry hides in societies where hides were used for clothing and for covering shelters. There is recognition, however, that such a task could be undertaken by any family member if the task required additional support or if a person simply wanted to relieve boredom. Kehoe (2005,134) notes that, “Tanning hides is a chore commonly performed by women where this was a household task”. She notes that Jarvenpa and Brumbach (1995,66) and Sharp (1991) observed that among the Chipewyan Dené hide working is more rigidly defined as a female activity.

Keeley (2010) observed the sexual division of hide scraping as occurring primarily, but not exclusively, in high latitude regions and it does not preclude men from engaging in this activity. For example, men tend to seek time-wasting tasks to do while waiting for game at intercept locations or blinds (Binford, 1980; Brookes and Yellen, 1987). Keeley (1988) suggested that men would often work fresh hides while at a hunting camp. It seems that at least 33% of the hide scrapers would be used on fresh hide at a hunting camp, while dry hide scraping is evident on more than two thirds of the scrapers at residential camps.

At Trollesgave there are 29 scrapers that were used to scrape dry hide and none that can be definitively identified as having scraped

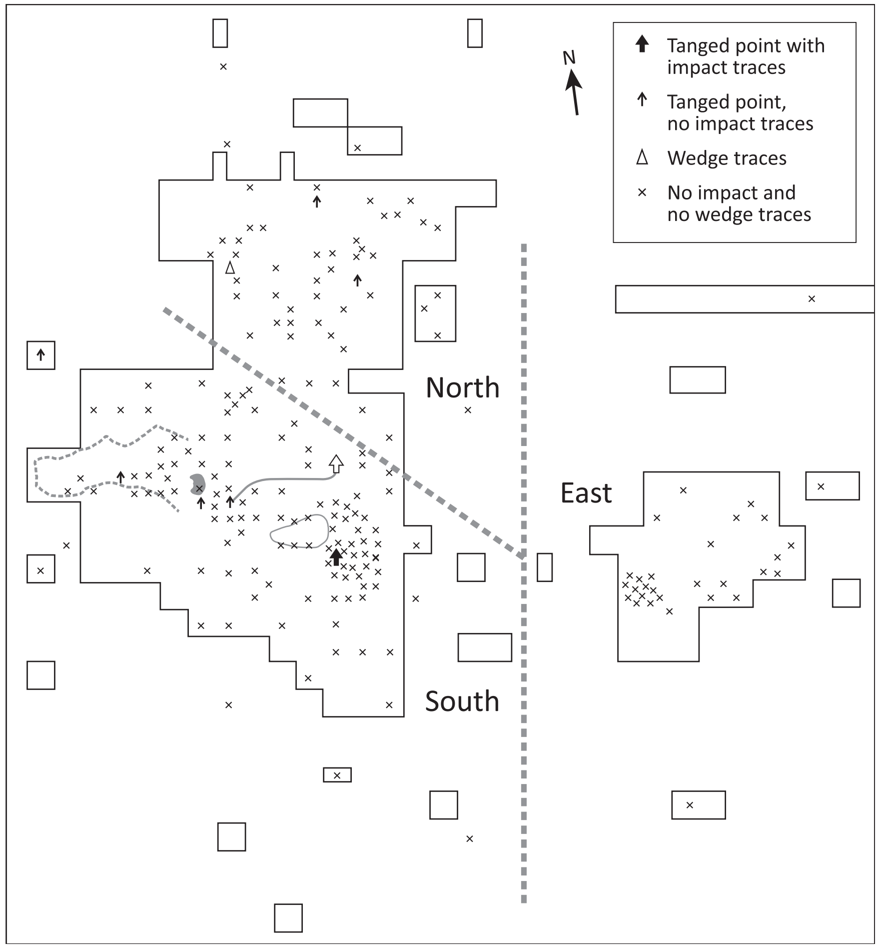

Fig. 7. Spatial distribution of tanged points and a wedge compared with all other artefacts studied for usewear. The curving line combines two fragments of a tanged point. Both of these are fire crazed, indicating original contact with the hearth.

fresh hide. In addition, there are seven tools which cannot be ascertained if they were used on fresh or dry hide. Even if these seven scrapers were all used on fresh hide, they would still represent less than 25% of the hide scraping tools. Consequently, Trollesgave easily fits Keeley's criterion of a residential camp.

5.2. Bromme Culture settlement pattern

The Bromme Culture sites from all over southern Scandinavia fall into two discrete clusters according to their artefact composition as well as their topographic characteristics (Fischer, 1991; cf. Pedersen, 2009). "Group One" has tool inventories dominated by scrapers and burins. Its members are rich in flint knapping debris, and they have all been located close to major bodies of freshwater at the time of occupation. The previous interpretation of the members of this group is "multi-activity sites which were probably inhabited by nuclear family groups" (Fischer, 1991), possibly subsisting on a combination of hunting and fishing (cf. Fischer, 1985). The inventories of "Group Two" sites have tool inventories dominated by tanged points. Lithic debris is scarce or nonexistent, and these sites are often lying relatively high in the landscape, typically at the foot of hills with long distance views.

Trollesgave belongs to Group One. The present study supports the initial interpretation of these sites as the traces of residential family settlements (cf. Binford, 1980). Group Two, with its more specialised assemblage composition and activity spectrum, should obviously be taken as the traces of specialised task groups focused on the hunting of large game.

Trollesgave thus appears to be a nuclear family settlement. Only further comparative work will assess if it is typical or unique as a single family hunting (and fishing) camp. There are numerous ethnographic analogues in the high latitudes for the patterns we are observing among the Bromme Culture sites and at Trollesgave. We are not suggesting that the hunter-gatherers at Trollesgave were equivalent to the Algonkian family moose and caribou

Table 5
Cross-tabulation of tanged points with use as an armature on a projectile (principal use).

	Tanged points	Other tools	Total
Armature	4	0	4
Other uses	3	90	93
Total	7	90	97

Table 6
Percentages of different kinds of tool use associated with each cluster.

Percentages (%)	Hide	Bone/Antler	Meat	Armature	Wood	Wedging	Total (%)
N Cluster (n = 27)	29.6	63.0	0.0	0.0	3.7	3.7	100.0
E Cluster (n = 16)	56.3	43.8	0.0	0.0	0.0	0.0	100.0
S Cluster (n = 57)	43.9	36.8	12.3	7.0	0.0	0.0	100.0

hunting bands of the northern Boreal forest with associated territorial ownership made famous by the work of Speck (1915). They may be more similar to the northern Athabascan hunting bands of Canada and Alaska, which can break down to family hunting units in order to cover huge expanses in the search for caribou (e.g., Sharp, 1977). Elk (*Alces alces*) and reindeer (*Rangifer tarandus*) also seem to have been the principal terrestrial game for the Bromme Culture hunter-gatherers. In seasons when reindeer were not migrating, the reduction of the size of the bands to nuclear families and the resulting increase in the number of independently operating units would have allowed much more territory to be searched for game. Nuclear famelies could have come back together when herds formed or other times when the location of food resources would be concentrated and predictable.

The extraordinarily narrow type spectrum of the assemblages from typical Bromme Culture sites like Trollesgave and Bromme *locus classicus* (Fischer and Nielsen, 1987) as compared to other North European archaeological Stone Age ‘cultures’ may lead to the question whether these sites were produced by people who also used other morphological tool types during other parts of their annual cycles. Two hypothetical models can be suggested:

1) The Bromme Culture population spent parts of the year in the more densely forested lowlands further south where their habitation traces are now referred to as *Federmesser Gruppen* or backed blade complex (ex., de Bie and Casper, 2000; Schwabedissen, 1954).
2) The Bromme Culture represents an inland hunting and fishing aspect of an adaptation that also included settlements at the coast and exploitation of marine resources such as molluscs, seal and whale (Fischer et al., 2013a; cf. Houtsma et al., 1996, 142).

The former scenario (cf. Bokelmann, 1978) has gradually become harder to defend as clarity on absolute age of the two archaeological complexes have begun to emerge – indicating the Federmesser complex of the north European lowlands to be generally earlier than the Bromme Culture (de Bie and Casper, 2000; Fischer et al., 2013b; Holzkämper et al., 2013; Sørensen, 2010; Riede and Edinborough, 2012). In addition the technology and *chaîne opératoire* of flint working, for instance, at the Federmesser site of Reckem in Belgium (de Bie and Caspar, 2000) and the Bromme Culture site of Trollesgave (Fischer, 1990c) has turned out to be significantly different (cf. Fischer, 1990b). The latter model cannot presently be evaluated because nearly all relevant coastlines are now deeply submerged and have not yet been inspected by archaeologists.

6. Conclusion

Contrary to what was previously believed about Late Palaeolithic settlement assemblages from southern Scandinavia, the flints from Trollesgave served reasonably well for microwear analysis. Our study provides insight into the activities and social organisation of this site, and suggests that future wear analyses of other assemblages from this period and region will be worthwhile, albeit challenging.

Besides flint knapping and retooling of projectile points, there are only a few activities represented at the site. They can all be grouped within three categories: scraping and cutting hide, graving bone and antler, and cutting meat/fish. These functions are strongly associated with specific tool types. End scrapers were used for scraping hide, burins for working bone and some antler, tanged points for tips of hunting weapons. Nearly all divergence from this pattern can be explained as the products of two children, who had their own ways of producing, using, and discarding flint items.

The horizontal distribution of the various categories of tools in combination with the fact that the site includes only one hearth leads to the interpretation that the assemblage represents a single occupation episode. The predominance of dry hide scraping over fresh hide working indicates that the assemblage was produced by a residential group, and not a task group. The results from microwear analysis and from refitting, indicating an inexperienced (young child) knapper on-site, indirectly support that there was at least one woman among the residents. Based on the sum of observations and inferences, we conclude that this typical Bromme Culture settlement is a residential site of a single family hunting unit that engaged in various maintenance activities, hunting, and probably fishing.

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