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Experiments with Danish Mesolithic Microblade Technology

by ERRETT CALLAHAN

INTRODUCTION

In the 1960s Don Crabtree pioneered a series of papers on experimental replication in lithic technology (i.e. 1966, 1967a, 1967b, 1968; also 1973). These papers have served as both inspiration and procedural models for countless lithic experiments and experiences ever since (Johnson 1978). While some aspects of lithic technology have gained greatly in sophistication since that time, there are other areas which have remained relatively dormant. One such area is the structured replicative experiment, the "how to" of contemporary flintknapping. In this paper, which is directly inspired by Crabtree's early writings and dedicated to his memory, I have returned to this neglected format.

To date, many replicative experiments have not been reported in enough detail to allow other researchers to duplicate the specified results. It is generally understood that experiments which cannot be replicated have little claim to science (Callahan 1981a: 141; 1981b). In other words, the term "experiment" has been used too loosely, often being confused with the terms "experience" or "exercise." As one remedy to this situation, I suggest, as demonstrated herein, that the experimental procedure, inclusive of holding positions employed in knapping, be described in enough detail so as to allow replication of the results by others. It is only in this way that a true laboratory science may evolve.

It is further suggested that the experiment conclude with an inference. An inference is simply a statement of probability as to how well the hypothesis stands up in the light of the experiments (Callahan 1981c). Binford and others tell us that such probability statements are the aim of science (1968: 20; cf Ascher 1961: 810, 811, and Reynolds 1979: 23). Yet all too often experiements in lithic replication only serve to illustrate possibilities, not to offer probabilities. Such studies, while of some value, fail to provide inferences to guide either explanation of the problem or future research in the area. The present paper is intended as an example in this regard also.

As the above principles are implemented by other flintknappers, we should not only give increased credibility to the term "experiment," as used in replicative studies – and thus make for better archeological science – but we can best perpetuate the Crabtree legacy as well.

THE ARCHEOLOGICAL CONTEXT

The problem selected for this investigation is the microblade technology of the Danish Mesolithic. I was introduced to this problem during a recent seven-month stay in Denmark made possible by a grant from the Danish-American Council and the Lejre Center of Lejre, Denmark. Peter Vang Petersen of the Prehistoric Institute of Copenhagen showed me a number of small microblade cores from the Vedbæk site in western Zealand, asking me to interpret the associated technology. The cores were of the "handled" or "keeled" variety, as opposed to the earlier "conical" variety (cf Figures 2 and 5a), and were thought to fit into the late Kongemose phase of the Middle Mesolithic. (The Late Kongemose dates from 5000 to 4600 BC, by the conventional dating method.) These smallest of all Danish microblade cores are thought to represent the terminal microblade industry in Scandinavia and, if so, would accordingly fit within a material culture known to include some of the largest and finest macroblades of any period (to 22cm).

There is currently a controversy between the Zealand and Jutland archeologists as to whether or not any microblades should be claimed for the Kongemose culture. The latter claim that the microblade cores from the Kongemose type site were intrusive from the preceeding Maglemose or possibly the Maglemose-Kongemose transitional period (Jørgensen 1956, Henriksen

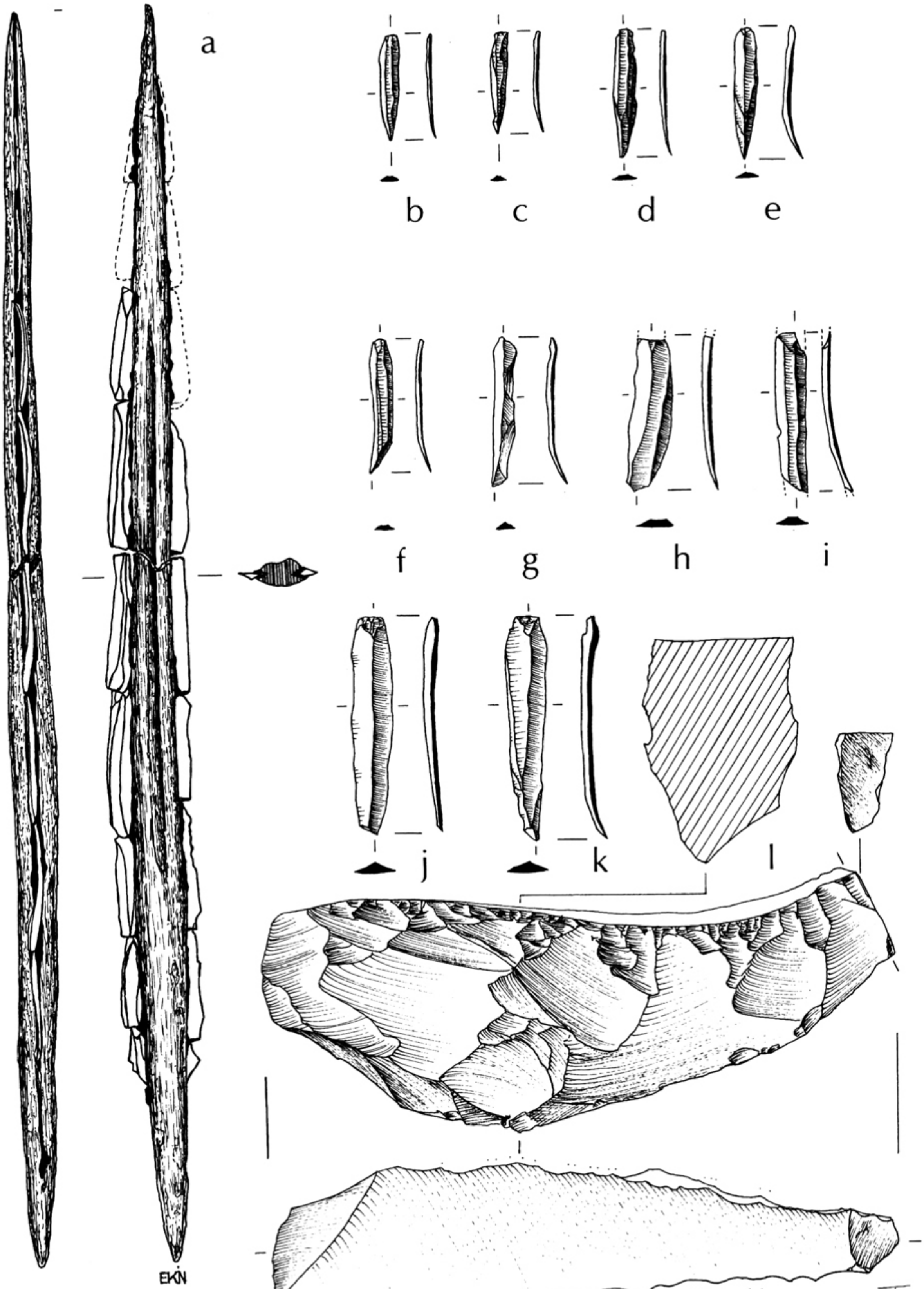


Fig. 1. Artifact materials from the Vedbæk site. a, slotted point with microblade inserts; b–k, microblades MGX491–518; 1, microblade core preform MGX356.

1976, Westerby 1927, and Bo Madsen, personal communication 1981). The Zealanders, however, while not denying the problems with the type site or the presence of handled cores in the preceeding period, claim over 130 distinctive microblade cores from the carefully excavated Vedbæk site and a total of nearly 400 similar cores from other locations in central Zealand and Scania (in adjacent Sweden) (E. Brinch Petersen et al. 1977, P. Vang Petersen 1979, 1984, and personal communication 1981). They further maintain that Jutland reflects more of a "Continental" influence, with microblade cores disappearing early, while the island of Zealand reflects more of a "Scandinavian" influence, with microblade cores disappearing significantly later (P. Vang Petersen, ibid). Earlier publications had characterized microblade cores as "keeled scrapers." (cf Brøndsted 1957: 112).

The Zealand cores are sub-divided into those made from flakes with a negative bulb and those made from flakes with a positive bulb. The former are placed in the Older Kongemose phase while the latter are placed in the Younger Kongemose (Vang Petersen 1984).

Be that as it may, while details of age may only be settled by analysis of excavated materials, it would seem that some details of technology might best be settled by replicative experiments. It seemed to me that if the technology of each core type could be closely defined and if it could be determined that each technology, or at least aspects thereof, was distinctive for each type, then this distinction might be used as an additional tool in relative dating and/or in deriving cultural inferences (Callahan 1975). With this in mind, I set about to make the first of what should be several series of experiments aimed, by a process of systematic elimination, at defining the production technology behind the relevant core types. The type which I selected to investigate was the Late Kongemose, positive-bulb-flake microblade core, the type initially shown to me by Peter Vang Petersen.

Observations

The Vedbæk microblade cores were found with a number of microblades (Figure 1 b–k) and with three slotted points, one of which is illustrated in Figure 1 a. (See E. Brinch Petersen et al. 1977: 159 for the others.) According to the excavators, there is no doubt that all of these artifacts share a similar temporal association (P. Vang Petersen, personal communication 1981). The slotted point is a long-bone with grooves along the lateral edges into which microblades are fastened. (This is similar to the razor-edged arrow-points which contemporary archers use in hunting and which is supposedly a modern invention.) The slotted point is thought to have been used for hunting land animals with the bow and arrow as well-preserved bows, arrowshafts, and similar points have been found from the earlier Maglemose period (Andersen 1978 and personal communication 1981; Clark 1983: 63, 89, 90, 95, 96, Plate VI). Unlike the retouched, microlith inserts used in the earlier periods, these microblade inserts were employed with no retouch at all.

The attributes of a small sampling of Vedbæk cores (all that were made available to me), are detailed in Table 1 (Figure 1 l; Figure 2). Here, I have divided the cores according to two stages of manufacture-preforms, in which no blades have been removed (unit MGX359 in Table 1 almost certainly being a reject because of its coarseness), and cores which are in the process of production (whether exhausted or not). A comparison between the preforms (Figure 1 l) and cores (Figure 2 a–d) indicates little variation in average width, a somewhat moderate degree of variation in average thickness, and a strong degree of variation in average length. In that the thickness, or depth, of the preforms is generally less than that of the cores, the possibility that these preforms were rejected, or set aside as "seconds," because they would have produced too short microblades, must be considered. The variation in length is easier to understand. The utilized cores are shorter because of prior blade removals. The difference in average length between preform and core would seem to indicate that an average of only about 1.4cm of material was used before discarding. However, Vang Petersen assures me that cores as short as 5cm – and as long as 10cm – are common at Vedbæk. If cores were used to about 5cm in length, then this would seem to indicate that up to about 5cm of length was used in microblade production.

The edge-angle on the platform of the cores varies between 68 to 108° and averages 95.3° (Table 1). This phenomenon of greater than 90° is characteristic of the Danish Mesolithic and is discussed at length in a separate paper (Callahan 1984).

The lateral edges of the cores and some of the pre-

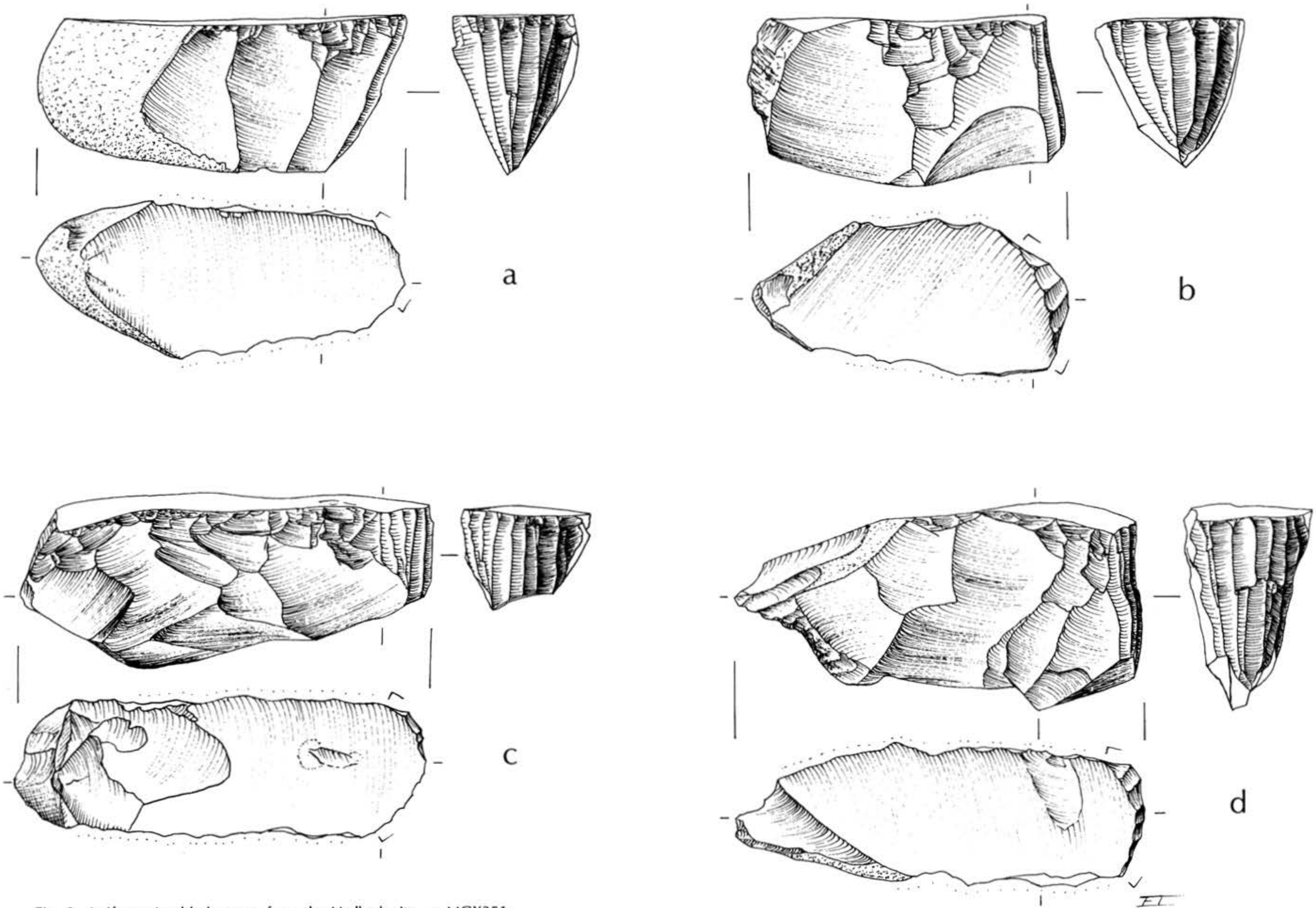


Fig. 2. Artifact microblade cores from the Vedbæk site. a, MGX351; b, MGX350; c, MGX354; d, MGX349.

forms are rather heavily abraded. The platform edge, on the other hand, is rather lightly ground.

I am assuming, based upon my experience, that preforming of the core prior to blade removal was done by direct percussion, with a tool such as a pebble hammerstone. I am also assuming that the microblades were removed by pressure. That is, direct or indirect percussion may be dismissed outright as either necessary for or typical of microblade removal of these particular cores. What is not known, and this lies at the heart of this investigation, is whether such microblades were removed from a hand-held core or from a core supported in a holding device; whether an antler or antler-like flaker is capable of such microblade removal, as the copper-tipped flaker is known to be; or whether the hand-held fabricator is capable of producing such microblades, as the body-pressed chest crutch is known to be (Crabtree 1968).

Hypotheses

In contemplation of the problems just indicated, hypotheses were sought which seemed to offer the most likely explanations of the unknowns. The hypotheses which were selected were based upon the attributes of the cores, a consideration of the fabricator materials known or thought likely to have been employed in the past, and the experience which other contemporary flintknappers (notably Don Crabtree, Rob Bonnichsen (1978: 247), Jeff Flenniken, J.B. Sollberger, Marvin McCormick, and Bo Madsen: all personal communication) and myself have had with microblade removal.

The following hypotheses were constructed to guide the experiments in this study:

1) Microblades were removed from cores which were secured in a holding device.

2) Microblades were removed from their respective cores by means of a fabricator of an antler-like material.

3) Microblades were removed by hand-held fabricators.

In the experiments, efforts were aimed at invalidating, rather than verifying, these hypotheses. Such a strategy may require a much more rigorous investigation than does mere verification (Reynolds 1979). It was furthermore hoped that by systematically testing possibilities, the way would unfold for offering statements of probability and allow the creation of one or more inferences to guide future research.

EXPERIMENTS

A total of eight cores in various stages of reduction were prepared for inclusion in this study. (Numerous other "practice" cores were prepared as well.) Each core represented a single experiment. The entire run of experiments comprised the first of a potential series of tests, as indicated earlier. To this end, I have attempted to provide enough procedural details so that similar results may be obtained by other experienced knappers and so that the remaining series of experiments may be undertaken by other knappers.

Experiment 1 – core blank (Figure 3 a)

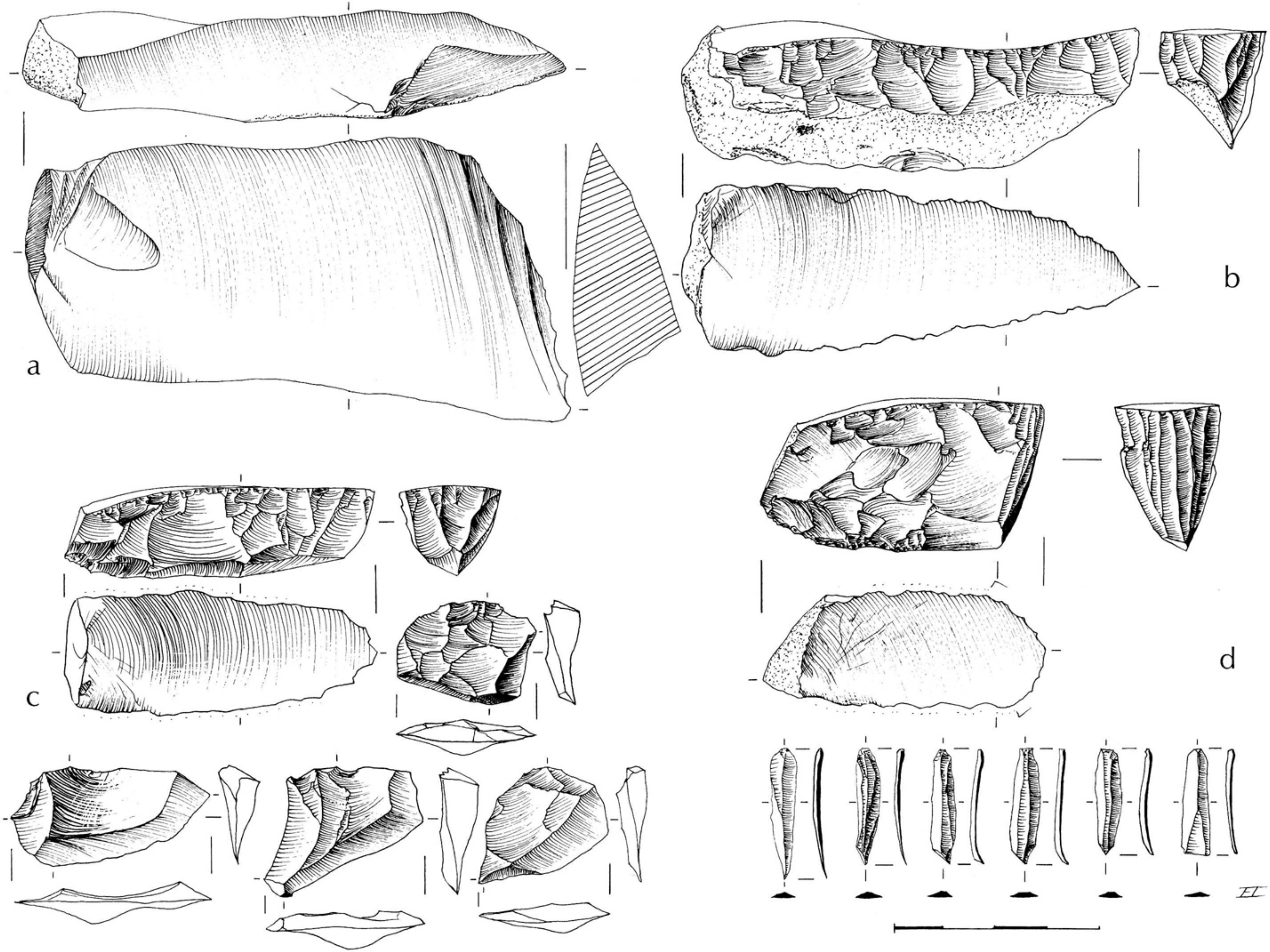
A blank was prepared by striking a flake from a larger flint core using direct percussion with a relatively heavy granite cobble. The mass, morphology, and ventral surface of the flake seem to have all the attributes noted on the original preforms, i.e. there are no attributes which would prevent the ready removal of preforming flakes and subsequent microblades. The flake, however, is a little thinner than the average core. (Assumption: the convex curvature at the distal end of this flake will have to be trimmed away before microblade removal may commence. Otherwise, the pressure tool might slip off the platform. A slightly concave or cupped distal curvature would have been more typical.) Whereas this experiment was repeated with each of the tests which follow, I felt it desirable to have an unworked core blank on hand for study and analysis.

Experiment 2 – core preform (Figure 3 b)

A core blank was preformed by direct percussion with a relatively small limestone pebble. The bulbar end of the flake was chosen as the proximal end of the core, as is typical of the artifact cores. The pointed distal end is also more typical than the squared end seen in Figure 11. (Assumption: the concave curvature of this flake unit should facilitate microblade removal). This experiment was also repeated on all test units.

Experiment 3 – core preform with all preforming flakes (Figure 3 c)

This unit was necessitated by the realization that there might be value in retaining the flakes derived from pre-


a
b
c
d
EL

forming of the core. The core was otherwise prepared the same as was unit 2. The resultant preform however, may be a little on the short side as it resembles cores which were apparently nearly exhausted, in this regard, more than it does the size of the typical preform (Figure 1 l). It is felt, nevertheless, that the preforming flakes (only a selected number of which are illustrated here) are typical of those experimental cores represented in the remainder of this study.

Experiment 4 – core flaked with copper-tipped tine and clamp (Figure 3 d)

For the blademaking experiments, I started with the technique with which I had the most experience and confidence. The object of this particular experiment was simply to test the feasibility of using a clamp and to re-familiarize myself with the process of microblade removal. These were both thought to be independent of the material used for the fabricator (copper). I reasoned that once I had grasped how to use the clamp and the copper fabricator, I could then convert to an antler fabricator with minimum confusion of critical variables. Thus 80 microblades were removed from a core secured in a small, hand-held clamp (Figure 5 f). The core was oriented in the clamp with about 2cm of the distal end of the core protruding beyond the end of the clamp. The core was repositioned in the clamp when less than about 1cm protruded in order to have sufficient room to work. The clamp was held across the lap in the left hand, while seated, with the platform area being between the spread legs and facing upwards. The legs were employed to assist in squeezing the two hands together (Figure 5 l/m).

Two holding positions for the pressure tool were tested. With the first, the fabricator (Figure 5 c) was pressed straight downward into the platform and parallel to the axis of the anticipated blade. (Figure 5 g, j). Once the maximum amount of downward pressure was obtained, a small amount of what could be described as downward-swooping, outward pressure was applied till the blade popped off. The downward pressure was generated to the maximum degree before any outward pressure was applied. The outward pressure, which was applied slowly and without a sudden "lunge," was made by moving the right wrist outwards, rather than inwards, as with most of my bifacial pressure work. Accordingly, the microblades flew – with a melodic "ping" – away from, rather than towards, the body. A hide-like sheet was used to cushion the fall of the blade.

With the second position, the near end of the fabricator was tipped outward from the core, with the blades being, as it were, "raked" off the platform by moving the wrist downwards rather than backwards (Figure 5 h, k). The second position, which was new to me at the time, allowed much more rapid blade removal than the first position and required little or no platform preparation. (This affected the platform attributes accordingly.)

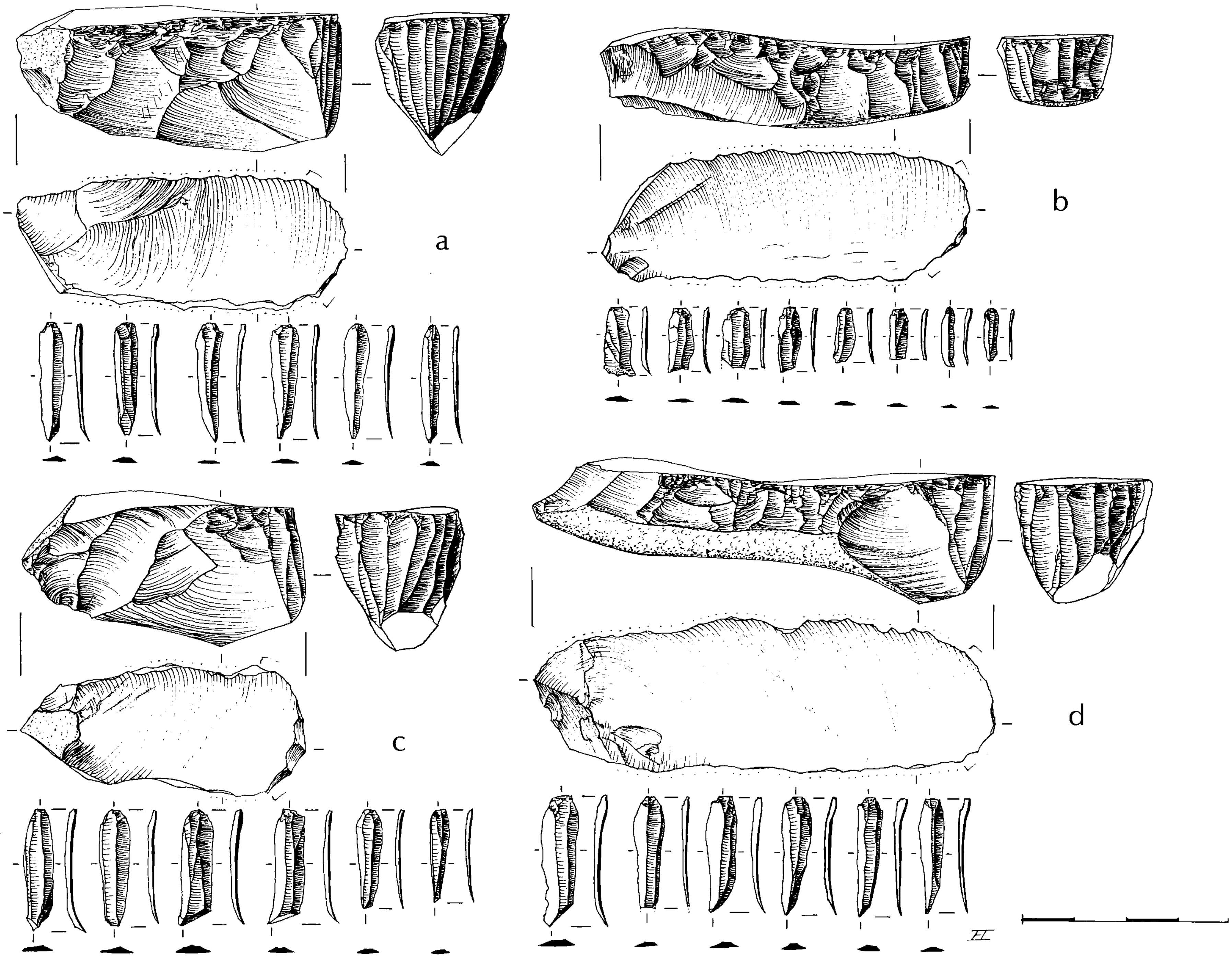
The core face had to be refurbished once during production due to crushed platforms, which prevented further blade removals. This was done with a small pebble while the core remained in the clamp. This action changed the platform angle from about 90° to about 70° and consequently allowed continued blade removals. (Assumption: the attributes of the blades themselves – except as to platform angle – did not seem to be affected by this change. Furthermore, the lowness of platform angle on the finished core should not be taken as representative of the use of a clamp.)

Experiment 5 – hand-held core flaked with copper-tipped tine (Figure 4a)

The object of this experiment was to test the feasibility of microblade removal without the use of a clamp. Again, using the copper-tipped tool with which I was familiar, 40 microblades were removed. Blade removal was stopped when it was felt that a representative sampling of blades was obtained. Upon termination, the core still had sufficient length for it to be gripped tightly enough to allow for even further blade removals (Table 2).

During fabrication, the core, with abraded lateral edges, was simply gripped in the padded left hand with about a centimeter of the platform protruding (Figure 5 i). With the assistance of leg squeeze, a backhanded motion was given the right wrist once maximum inward pressure was obtained, as with Experiment 4 (Figure 5 j). (Although an inward wrist pressure may have functioned – assuming that the core were re-oriented in

Fig. 3. Replica core blank, preforms, and core materials. a, Experiment 1: core blank; b, Experiment 2: preform; c, Experiment 3: preform with 4 representative preforming flakes; d, Experiment 4: core and 6 of 80 microblades flaked with copper-tipped tine and clamp.


a
b
c
d

the palm so that the platform faced the knapper and the bulbar end of the core were facing away – such as the holding position many use for biface projectile point manufacture, I preferred to use outward pressure. Not only do I feel that more pressure may be so exerted, but there seemed to be a greater likelihood that the blades would be removed unbroken – not being forced into the padded palm – and I could better compare the same flaking motion for both hand-held and supported cores. Nevertheless, other holding positions than those I employed might be investigated).

Experiment 6 – hand-held core flaked with short antler tine (Figure 4 b)

In this experiment I sought to determine whether the success I had with the last experiment could be duplicated by using an antler tine (red deer, Figure 5 d). This was a critical experiment because copper is not known from pre-Neolithic Denmark.

The core and fabricator were gripped and manipulated as they were in the last experiment. Despite the use of a shallow core (of minimum depth), it was exceedingly difficult to remove any microblades. A longer antler tine was used for awhile, being held in the same manner as the shorter one, but the results were equally poor. In actual fact, 65 microblades were removed; but as detachment required all the strength I could muster, with the antler tip slipping off the platform repeatedly – as well as considerable time (Table 2), and as the blades being questionably within the acceptable range of variation, and did not approach the length of the average artifact blade (Figure 1 b–i), I was quite skeptical as to the significance of this experiment. My inability to remove sizeable microblades surprised me because of the success with which I had removed relatively long blades with antler in the past with much smaller cores (Figure 5 a). These cores, however, while being flaked with the same short antler tine I was now using, had been secured in a clamp (Figure 5 f). This realization led the way to the next experiment.

Fig. 4. Replica core materials. a, Experiment 5: hand-held core with 6 of 40 microblades flaked with copper-tipped tine; b, Experiment 6: hand-held core with 8 of 65 microblades flaked with short antler tine; c, Experiment 7: core and 6 of 60 microblades flaked lwith long antler tine and clamp; d, Experiment 8: hand-held core with 6 of 30 microblades flaked with long antler tine.

Experiment 7 – core flaked with long antler tine and clamp (Figure 4 c)

The object of this experiment was to see if microblades could be removed with an antler fabricator from a core supported in a clamp. Following a few aborted attempts to remove blades with a short antler tine, I observed that a primary advantage of the clamp was to increase leverage by having the far end of the clamp resting along the left forearm, thus preventing hand/core movement (Figure 5 l). Accordingly, I reasoned that if I were also to use a long antler tine (caribou, Figure 5 e) so that it rested along my right forearm, I might obtain a similar advantage for the fabricator. (This was most successful when the antler rested along the inside of the forearm, creating increased leverage as leg and stomach pressure locked the fabricator in place, figure 5 m) (Crabtree 1967b:72). In short order, 60 microblades were obtained. There was no difficulty in obtaining sufficient pressure to remove blades the full length of the core. In fact, blades were removed when the platform angle was greater than 90° (Figure 4 c). Work on the core terminated because of crushing of the platform edge, not because of the shortness of the core. (The clamp would allow the use of a much shorter core; cf Figure 5a). (Note: P. Vang Petersen, personal communication 1981, tells me that the antler tines found on Kongemose sites are relatively long, whereas in the subsequent Ertebølle period, which lacks microblades, the tines are rather short.)

Experiment 8 – hand-held core flaked with long antler tine (Figure 4 d)

The object of this experiment was to test once again, this time with a long antler tine, whether or not an antler tine is capable, in my hands, of removing microblades from a hand-held core. This was, in effect, a retest of Experiment 6. Had the experiments been terminated with Experiment 7, one might be tempted to conclude that these cores must have been secured in a clamp if flaked with an antler flaker. As I still had reservations about this conclusion, given my recent experience with the long fabricator, I felt that one more test was essential.

Holding the core as in Experiment 6 (Figure 5 i) and the long tine as in Experiment 7 (Figure 5 m), 30 microblades were easily removed from the core. Although the core tilted downward somewhat when pressure was applied to the platform, there was more than enough core length to grip the core so as to prevent excessive tilting. Work on this core was stopped when it was felt that a representative sampling of blades was obtained. Because of the odd configuration of the bottom of this particular core, if many more blades had been removed it might appear as if the core were less thick than it actually was during production. Although it was far from exhausted, since the core face in its present form typified the appearance of the core during most of the blade production, it was decided to terminate work at this point.

DISCUSSION

There were several common factors running throughout the experiments which need discussion. These include the attributes on the raw material and the treatment of the platform. The lithic material used in these experiments was a blackish Senonian chalk flint which came from either Holtug beach in the Stevns area of Zealand or from a glacially deposited nodule found in a field in Gammel Lejre near Roskilde, also in Zealand. Both flints are of an identical nature and lithic grade (i.e. 3.0 on a scale of 1.0 to 5.0; cf Callahan 1979: 16) and approximate the artifact material in all evident attributes.

Platform preparation followed each blade removal and involved the elimination of overhang on the core face on one or both sides of the forthcoming microblade area. The fabricator and/or a sandstone pebble was used for this task. The upper platform face itself was modified only rarely and then only because the pressure tool slipped from the platform. (Such preparation is lacking on the artifact cores observed.) When blades were able to be removed in series, such as from left to right when looking down on the platform (Figure 5 i), as was often done in these experiments, then only the overhang on the top and near side of the anticipated blade was usually removed.

Occasionally, when the fabricator slipped from the platform, the platform edge was slightly ground with an abrasive sandstone. This slight scarring and, more importantly, I think, the residual grit left on the platform by the abrader allowed for more secure gripping of the edge by the fabricator and facilitated blade removal. (Such light grinding is found on the artifact cores.) With the antler fabricator, less abrasion was required than with copper. I suggest that this is because of two factors: (1) the grit is pressed into the antler tip and allows for more traction than with copper, which either crushes or slips aside the grit; and (2) fabricators of antler, the tip of which need not be very sharp (Figure 5 d, e) because only a corner is used, may be set on the very edge itself, while with copper, the fabricator tip, which should be rather sharp (Figure 5 c), must be placed slightly back from the edge (by 1mm or so) to prevent crushing of the platform.

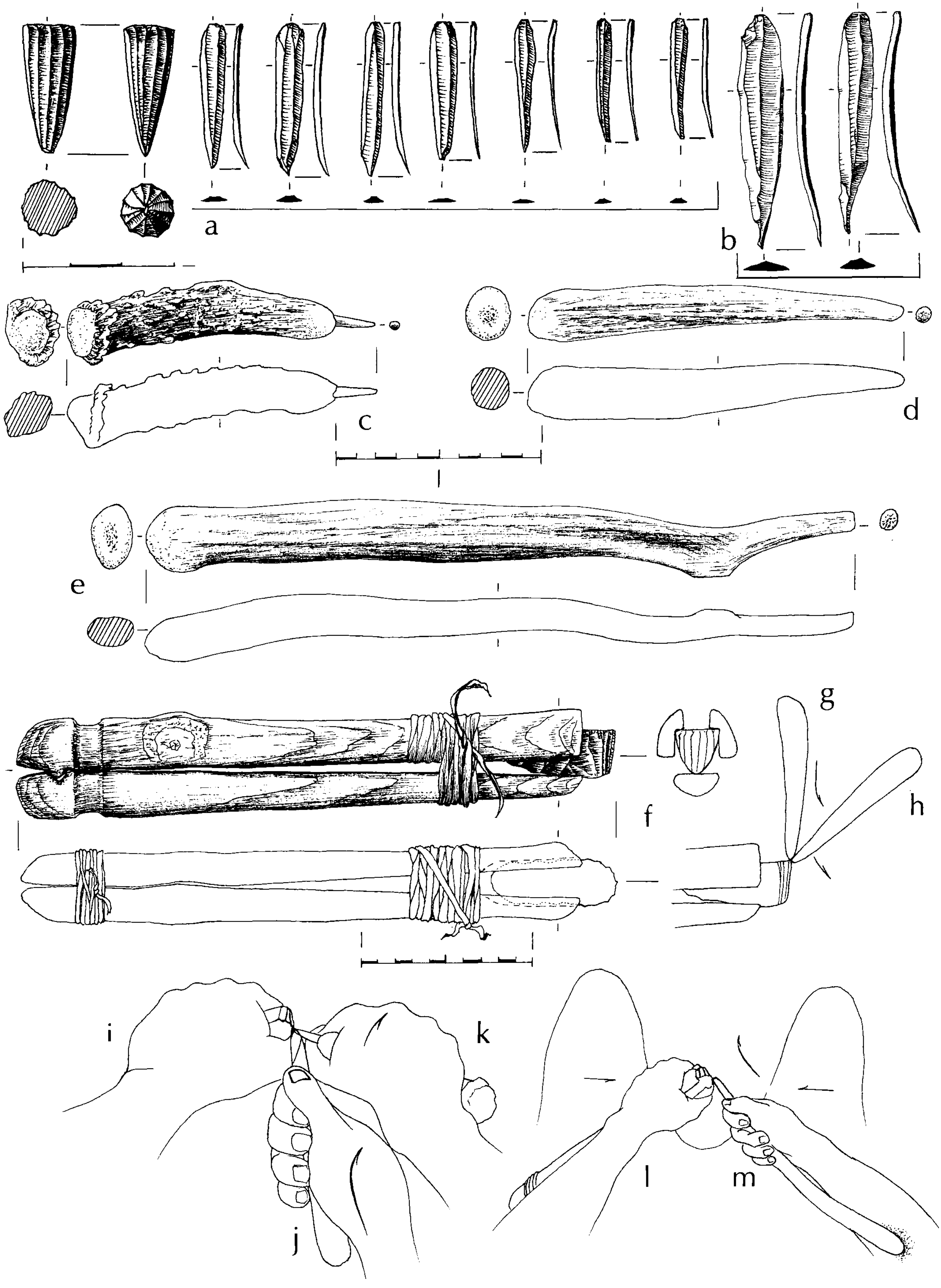
One consequence of the use of antler was a slightly more diffuse and flat bulb (Figures 4 b–d). The bulbs of the copper-flaked blades, on the other hand (Figures 3 d, 4 a), tended to be somewhat more salient.

In so far as was possible, the blade was oriented so as to follow two or more ridges rather than one. This replicated the majority of the artifact blades most accurately and would seem to allow for a more secure seating in a hypothetical bone shaft.

As indicated in Experiment 4, it was discovered that blade removal could be considerably speeded up by, in effect, "raking" the blades from the platform (Figure 5 h, k). This technique worked well with the copper flaker, but I could not make it function at all with antler. Therefore, pressure straight downward into the platform was the rule (Figure 5 g, j).

Several insights were obtained during the course of these investigations. These concern core attributes for both hand-held and clamped holding positions, the predicted size of the exhausted core for each position, platform angles, and work rates. The clamp which was used for these experiments (Figure 5 f) was inspired by a clamp which I witnessed J. B. Sollberger exploying for Folsom fluting at the Little Lake knap-in in 1980 (Hardaker 1980: 7). (I had previously used a clamp which gripped with two contact points instead of three.) For such a clamp, which is certainly not the only possible solution to the problem, it was necessary for the core to be quite parallel-sided for a secure seating in the

Fig. 5. Replica materials, fabricator tools, and holding positions. a, conical bullet core with 7 of 116 microblades produced with hand-held clamp and short antler tine; b, 2 microblades struck with hand-held technique and short antler tine; c, copper-tipped tine (roe deer); d, short antler tine (red deer); e, long antler tine (caribou); f, hand-held clamp (hickory); g–h, two possible angles of force application; i–m, hand-held and clamped holding positions with antler and copper tines.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ARTIFACT CORES

Unit	Length	Maximum width	Thickness at maximum width	Maximum thickness	Width at max. thickness	Platform edge angle	Abraded lateral edges?
Preform							
8aIII M.V.							
MGX17	8.90	3.57	2.06	2.58	3.25	–	yes
*MGX356	10.96	2.56	3.77	3.88	2.48	90°	yes
MGX352	7.82	2.40	2.90	2.92	2.22	–	yes
MGX359	6.35	2.64	1.87	2.11	2.18	(reject?)	no
average	8.51	2.79	2.65	2.87	2.53		
Core							
MGX353	7.20	2.59	3.93	4.04	2.58	100–108° (av.104.5°)	yes
*MGX351	6.80	2.78	3.06	3.11	2.38	68–73° (av.70.5°)	yes
MGX358	6.05	2.36	1.92	2.10	1.75	105° (prob.rej.)	yes
*MGX349	7.50	2.56	2.92	3.71	2.35	105–108° (av.106.5°)	yes
MGX355	9.41	3.16	1.72	3.12	2.23	96–108° (av.102°)	yes
MGX357	6.64	2.26	2.31	3.65	1.94	85–91° (av.88°)	yes
*MGX350	5.77	2.83	2.95	3.10	2.68	86–97° (av.91.5°)	yes
*MGX354	7.45	2.62	2.74	3.13	2.46	92–97° (av.94.5°)	yes
average	7.10	2.64	2.69	3.25	2.30	range 68–108° (95.3°)	–

(* = illustrated)

Table 1.

clamp. Otherwise the core would tend to rock back or forth during the stress of pressing. On the other hand, it was found not necessary to abrade the lateral edges of the core as sharpness there neither interfered with the function of the clamp nor did any apparent damage to it. The cores which were hand-held did not have to be quite so parallel-sided, as the hand could accommodate some degree of irregularity here with no repercussions. However, it was necessary to abrade the lateral edges of the cores when holding by hand, even when several layers of leather padding were used. This prevented undue discomfort to the hand aswell as cutting of the leather pads.

The artifact cores are sometimes not quite parallel-sided and exhibit lateral edges which are rather heavily abraded (Figures 1 l, 2 a–d).

The smallest core which I could grip by hand tightly enough to allow the removal of blades was about 5cm in length. (This was determined by numerous experiments not incorporated into this study.) (My hand is said to be on the large side. I have no idea as to the hand size of the Mesolithic Danes.) Clamped cores, on the other hand may be used until their length is less than 1cm (Figure 5 a).

The artifact cores registered a length in excess of 5.77cm (Table 1).

The qualitative attributes of the core faces, the area of microblade removal, seemed to match those of the

REPLICA CORES

Exp. No.	Unit	Length	Maximum width	Thickness at max. width	Maximum thickness	Width at maximum thickness	Edge angle	Abraded lateral edges?	No. of blades	Knapping time (min.)	Knapping rate
	Flake Blank										
1	81EC20L	9.07	4.90	1.84	2.00	4.75	–	no	–	–	–
	Preform										
2	81EC21L	8.65	3.20	2.82	2.82	3.20	73°	no	–	–	–
3	81EC19L	6.08	2.43	1.78	1.78	2.39	90°	no	–	(3.42)	–
	average	7.37	2.81	2.30	2.30	2.80	81.5°	–	–	–	–
	Core										
4	81EC12L	5.27	2.25	2.66	2.98	2.13	79°	no	80	31.57	1.51/ min.
5	81EC13L	6.26	2.65	2.55	2.64	2.59	84–90° (av.87)	yes	40	14.06	1.74/ min.
6	81EC18L	7.18	2.57	1.70	1.68	2.57	74–78° (av.76)	yes	65	1.35.00	.93/ min.
7	81EC23L	5.40	2.51	2.55	2.75	2.28	89–99° (av.94)	no	60	1.01.18	1.02/ min.
8	81EC27L	9.01	3.05	1.75	2.48	2.76	88–97° (av.92.5)	yes	30	27.33	1.09/ min.
	average	6.62	2.61	2.24	2.51	2.47	range 74–99° (av.86.5)	–	–	–	–

Table 2.

archeological examples, although no structured comparisons were made. (Compare Figures 2 and 4).

The platform of the core in Experiment 4 (Figure 3 d), as noted above, was rejuvinated once during microblade production (note its similarity to Figure 2 a). Blade removals subsequent to rejuvination increased the platform angle of this core from 70 to 79°. With continued flaking I suspect the platform angle would have approached 90°. It could therefore be hypothesized that during the course of reduction, the platform angles of such cores undergo a gradual increase. No data were recorded to document this, but the tendency was noted to be consistent. Accordingly, it would seem that the platform angle of the core following blade removal would not quite reflect the platform angle evident before the removal. (This is apparently due to a greater thickness in the bulbar area.) Thus platform angles of just over 90°, for instance, do not necessarily indicate that the platform was this steep prior to the last blade removals. In actual fact, however, platforms of somewhat over 90°, more than would be accounted for by the above, were indeed flaked in these experiments with both antler and copper flakers used with and without a clamp and without flaking of the platform face (Table 2). (Flaking on the platform face on either side of the platform is known, by me, to increase the *apparent* platform angle.) This area needs further study (cf Bonnichsen 1978: 24).

From a look at the work rates recorded in this study, the most rapid blade removals occurred in Experiments 4 and 5 and the slowest in Experiment 6 (Table 2). The higher rates correlated with the use of the copper flaker and the lack of platform preparation; the slowest rate correlated with the use of the short antler tine and the difficulties I was having in making it function. Experiments 7 and 8 provide, I feel, the most reliable indices of the rates at which I worked during this study, i.e. an average of about one blade per minute. This figure should only be used to show the possibilities, not the probabilities, in the past. (The figures also seem to suggest that one may use less care, concentration, and perhaps understanding of platform preparation variables with copper than with antler in order to obtain suitable results. Copper would therefore seem to have an apparent adaptive advantage over antler, a factor many contemporary flintknappers rely upon today, unfortunately for replication's sake.)

In view of the large size of some of the microblades observed in the artifact sampling (Figure 1 j, k), (although no comparably sized core was observed), an attempt was made to remove microblades of maximum length using antler in both hand-held and clamped positions. Two blades so derived are depicted in Figure 5 b. It should be noted that these blades represent only the upper range obtainable by this knapper on this type of core at this point in time and applies to an unknown degree to the past. (Note: this core had a 2cm radius on the blade face. According to Bo Madsen and Jacques Pelegrin (personal communication 1981), a lesser radius would allow for longer blades were the core deep enough.) This experiment does, however, illustrate that it is possible for the largest size of the observed microblades to be removed according to the above system. Therefore, since the average-sized artifact blades fall noticeably beneath this length, it could be assumed that the attributes of the blades were influenced by their functional destiny rather than by the limitations of human strength.

A comparison between the replica and artifact cores, as indicated in Table 1 and 2, shows a close degree of conformity in all measurement attributes except maximum thickness. The replicas averaged .74cm less in thickness than the artifacts. In view of the preceeding paragraph, I do not feel that this should be taken to indicate that the system was not capable of producing thicker cores, but rather that the core units chosen for inclusion were inadvertently a little on the thin side. (If the tests with thicker cores had not been successfully accomplished, then this discrepancy would have been to be questioned.)

It will also be noted that the average edge-angle of the platforms of the replica cores was less than that of the artifacts but also that less of a range was subjected to testing. (The range for all units indicates the highest and lowest angles recorded.) Edge-angles of well over 90° (97 and 99°) were successfully employed for microblade removal. I tended to stop when blade removal became difficult; I did not thoroughly investigate maximum edge-angle possibilities. I did note, however, that by a combination of delicate flaking and abrasion of the platform edge, the seating of the antler fabricator on a thin layer of grit on the very edge, and a slight downward tilt of the wrist (or tilt of the core within the clamp), I could work with an edge-angle appreciably over 90°. (For a discussion of pressure flaking on a Danish Maglemose core with edge-angles of up to 113°, like Brøndsted 1957: 70g, see Callahan 1984).

A factor which was inadvertently not tested in this study was the number of microblades which could be expected from each core or from each centimeter of core length. Such information would allow for important inferences and I apologize for its omission. I suggest that such be incorporated into similar future studies.

SPECIFIC CONCLUSIONS

Concerning the first hypothesis cited earlier, I was able to remove microblades of the correct attributes by both hand-held and clamped holding positions. However, considering the length of the exhausted cores, the degree of dulling of the lateral edges, the degree of parallel-sideness of the cores, the appearance of the core face, and the feasibility of removing microblades of the proper attributes by either method, the preponderence of evidence seems to be that the archeological cores were hand-held rather than clamped. (It is felt that the greater likelihood should be assigned the simpler holding position when each of two positions functions.) Because of the above realizations, the first hypothesis could said to have been invalidated.

Concerning the second hypothesis, I was able to demonstrate that microblades of the proper attributes could indeed be removed with an antler fabricator. Although this does not necessarily eliminate other kinds of fabricators (except copper, which was not available at that time), it does place a high degree of probability upon antler or an antler-like material having been used. (Other "antler-like" materials include bone, tooth, horn, ivory, and hard shell. Non-antler-like materials include wood, stone, and soft shell. From my own past experience, I feel it highly unlikely that the latter group would function for microblade removal on these cores, although this has not been systematically tested.) Therefore, I was not able to invalidate the second hypothesis.

Concerning the third hypothesis, the tests showed that simple hand-held fabricators allow more than enough force to be generated to create typical microblades. As with most of my hand-holding techniques, the body was employed to a greater of lesser degree in manipulating the hands (using the legs and/or stomach to squeeze the hands together: Figure 5 l/m). This, however, is quite different from the employment of body weight to manipulate a T-shaped chest crutch such as Crabtree endorsed (1968). However, although the chest crutch will allow the removal of both delicate microblades (personal experience) and large macroblades (over 20cm in obsidian (Flenniken, personal communication 1980) and over 10.5cm in Danish flint (personal experience), such tools and techniques are *not necessary* for the removal of typical microblades. Considering the principle of least complexity as indicated above, the greater probability should be assigned the simpler position. The third hypothesis, therefore, could not be invalidated.

In the beginning of this paper, assumptions were made that initial preforming of the artifact cores was done by direct hammerstone percussion and that the microblades were removed by pressure. The tests done in this study, while not comprehensive in this regard, do not invalidate these assumptions. The assumptions, therefore, could be said to have tentatively been demonstrated and not merely assumed. The other assumptions (Experiments 1 and 2) concerning degree of curvature of the flake blank/platform surface, while not systematically tested on the particular units under consideration, were demonstrated repeatedly on the cores which were subsequently rejected and on those selected for the remaining experiments.

It should be noted that extensive testing of both the second hypothesis and the above assumptions was not done. It might seem, therefore, that I was not attempting to invalidate my suppositions concerning these variables. It is felt that in this case, the 25 years of experience I have had with making stone tools has equipped me with enough information concerning the capabilities and limitations of the materials which were not systematically tested to substitute for direct, structured experiment. In cases where there is doubt, experience may be no substitute. There was no such doubt in this case. To run experiments with the obvious may be a waste of time.

It should also be mentioned that, in the months following the above tests, numerous similar cores and structured experiments were run through the system by the writer. The findings indicated herein were repeatedly confirmed. Furthermore, Danish and Dutch flintknappers who participated in a semi-structured flintknapping seminar at Lejre independently confirmed these findings.

INFERENCE

Considering the goodness of fit between the hypotheses and the experiments, and considering all intervening information, the following inference is posed:

There is a high degree of probability that, on the observed microblade cores, blade removal was made on cores which were hand-held and was effected by pressure with a hand-held fabricator of antler or an antler-like material.

GENERAL CONCLUSIONS

This study has not provided proof of how a particular type of tool was made; but it has provided a probability statement concerning manufacture. If probability statements are the aim of science, as Binford claims (op. cit.), then my task, for the moment, is done. It now remains for other researchers to take this inference as a starting hypotheses and to repeat the experiments, if desired, in an attempt to invalidate – or furher specify – the above conclusion.

Concerning the archeological remifications of this study, it should be made clear that these experiments did not serve to clean up the archeological problems. As stated earlier, before cultural inferences may be made, it is first necessary to define and compare the relevant technologies. This present study is but one of a series which should be undertaken in order to define the production characteristics of each of the types of microblade cores under consideration. In this study, I have only defined one of these types. It will now be up to other experimentors to define the other types, after which comparisons may be made and inferences offered.

As a further cautionary note, I should mention that this study was done in isolation, without a clear understanding of the microblade technologies which preceeded. In some cases, this knowledge may be irrelevant; but, after considering the somewhat larger and generally more obtuse-angled platforms on the Maglemose microblade cores which supposedly preceeded those tested in this study, I hesitate. Although I have not systematically tested it, I strongly suspect that the explanation of the technology underlying these high-edge-angled cores lies in the use of a clamp of some sort. If clamps were in common use in the preceeding period, then the strength of the inference resulting from this present study may be somewhat weakened. Thus, it may be that when the entire series of experiments has been completed, some earlier inferences may have to be revised. Such is the nature of science.

In these experiments, I have shown, by example, the value of attempting to invalidate rather than to verify an hypothesis. It would have been quite simple to show, for instance, that microblades could be removed from cores which were secured in a holding device, as stated in the first hypothesis. This would seem to have verified the hypothesis. But because of the doubts I had about this conclusion, a further exercise was felt necessary. The results of this additional experiment contradicted the previous conclusion. This illustrates that not only is invalidation a more rigorous exercise than verification, but it is more accurate as well. This process is akin to our legal system in which guilt, rather than innocence, must be proven.

It is hoped that enough procedural details have been provided herein that the experiments may indeed be replicated, as admonished by Hansen (1972: 11). This aspect has been notably lacking in previous reports of replicative work. It is especially hoped that the beginnings of a true laboratory science may get underway so that such experiments may be repeated on a systematic basis. This is the way in which true laboratory sciences operate, from the high school and university classroom to the basement laboratory or workshop. It would seem that such systemization of replicative procedures would be a fitting homage to Don Crabtree, both for its utility as an educational tool and for its impact on science.

Errett Callahan, 36 Easton Avenue, Lynchburg, Virginia 24503, USA.

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The conical microblade bullet core illustrated in Figure 5 a was prepared as a gift for Don Crabtree. It was made as a small token of appreciation for his years of inspiration and moral support and in return for some replicas which he had given me some years before. The desire to give him a gift equal to his led the way to the skills and attitudes required for this present study. The gift was sent to him while on his deathbed, a fact of which I was not aware at the time. I do not know if he ever saw it.

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