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The parallel-flaked flint daggers of late Neolithic Denmark: an experimental perspective

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Abstract

The flint daggers of late Neolithic Denmark are some of the most technically complex stone tools in the world. An experimental approach was utilized to evaluate the production technology and related archaeological implications of the type Ic flint dagger, one of the earliest Danish dagger forms. The experiments suggest that although a relatively simple tool kit was probably employed to create these remarkable implements, a high degree of technical proficiency working flint was necessary to complete each discrete production step. Because of this technical complexity as well as the apparent staged nature of type Ic production, the makers of these daggers were probably specialists who participated in every aspect of the production process. Furthermore, the experiments indicate that sites where these specialist flintworkers produced type Ic flint daggers can only be identified using a broad suite of morphological debitage characteristics, and not the presence of any single debitage characteristic alone.

Keywords: Denmark; Neolithic; Flint dagger; Pressure-flake; Reduction; Bell Beaker

1. Introduction

Of all the varieties of stone tools found in northern Europe, few have held the attention of prehistorians like the bifacial flint daggers of southern Scandinavia. Large finely made daggers of flint appeared suddenly in northern Europe by 2350 BC, similar in scale and outline to contemporaneous metal daggers imported from central and eastern Europe. Aesthetically appealing and regionally restricted, these flint daggers straddle the boundary between the Stone and Bronze Ages in southern Scandinavia and, as such, provide a valuable class of data to elucidate how and why the transition from stone to bronze took place.

Although late Neolithic flint daggers are technologically intriguing, most scholars have focused on their typological variation over time and space. In 1973, Ebbe Lomborg published a study examining the relative chronology of flint daggers, essentially revising an earlier volume written by fellow Dane Sophus Müller in 1902. Lomborg argued that the north European flint daggers could be broken into six distinctive types based on morphology and that these types had chronological and, occasionally, geographical significance. More recently, elements of Lomborg's dagger chronology have been called into question, first by Madsen [13], later by Wincentz-Rasmussen [21], and finally by Vankilde [20]. Madsen's work in particular points out the degree to which daggers of different types overlap with one another chronologically, to a much greater degree than was realized by Lomborg.

But while the flint dagger typology and chronology are increasingly better understood, the production technology of the daggers and their technological and cultural relationships to earlier stone tool types remains largely unexplored. Recent contributions by the present author [17] and Vang Petersen [19] remedy this situation to a limited degree, but by and large there has been little effort dedicated to understanding the complex production technology (and the associated archaeological implications) of most dagger types.

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Fig. 1. Type Ic flint dagger found near Thisted, Denmark. Overall length is 38 cm. Danish National Museum photo.

As a means of addressing this shortcoming, the goal of this paper is to present and explore the complex production technology of the type Ic flint dagger, one of the earliest and most distinctive of the dagger forms (Fig. 1). Type Ic daggers were selected for a technological study for two primary reasons: (1) the techniques used to create their remarkably regular parallel-flaked surface finishes have never been described in detail, and (2) many technological characteristics of chronologically younger flint dagger forms appear first on the type Ic, suggesting a degree of technological continuity over time. Thus, if the production technology of type Ic daggers can be understood, the delineation of the technical elements and associated cultural implications of some later dagger forms might be significantly advanced as well.

In order to explore the production technology of type Ic daggers, a set of original examples (both finished pieces and preforms) were studied at the Danish National Museum in Copenhagen and a series of controlled replicative experiments were designed and carried out. The final outcome was the production of a series of full-scale, typologically accurate type Ic replicas in original material, manufactured using only tools available during the Danish late Neolithic (Fig. 2). Resulting data of particular interest included the identification of individual reduction stages, the time investment necessary for production events, the level of technological complexity inherent in dagger production, and the morphological characteristics of the resulting debitage.

Following a review of our current understanding of type I dagger morphology and the related chronology, the experiments and associated results are outlined in detail. A final section discusses type Ic dagger technology in light of the conclusions drawn from the experiments, including how production of these extraordinary stone tools may have taken place within the greater context of late Neolithic craft specialization in southern Scandinavia.

2. Type I daggers: typological variability and chronology

The production of lanceolate-shaped bifacial flint daggers marks the beginning of the transition from the Stone Age to the Bronze Age in Denmark. During this same period (ca. 2350 BC), the Bronze Age was already underway in continental areas to the south of Scandinavia. It is generally accepted that metal daggers produced by these Bronze Age groups, particularly the Unetice cultures of Germany and Poland and the more westerly Bell Beaker Culture of central Europe, were imported into Denmark and served as the stylistic inspiration for the production of daggers in flint (Fig. 3; [10]). Type I daggers represent the initial manifestation of this interaction and are the chronologically youngest of all the different dagger types (see [10,15]).

Morphologically, type I flint daggers are lanceolate in outline shape and typically have their widest point at the juncture between the blade and tapering handle. They range in size from approximately 15 cm in length to more than 45 cm. The blade and handle are generally similar in thickness, leading some to suggest (with some associated archaeological support) that these daggers may have been secured into formal handles of wood or leather [19]. Lomborg identified five subvarieties of type I daggers which are roughly contemporaneous in age, but differ in their distribution over the Scandinavian landscape. Based on these differences, Lomborg

Fig. 2. Two Danish flint dagger replicas made by the author during this study, a type Ic (bottom), and a type IVe (top). Material is Danish flint.

assigned letter codes to the five type I subvariants, from the letter "a" to the letter "e" (Fig. 4).

Of Lomborg's five type I subvarieties, all have a percussion surface finish with the exception of the type Ic, the subject of this project. Type Ic daggers are characterized by elegant, well-controlled parallel pressure-flaking on their broad faces, and can sometimes exceed 45 cm in length. The most visually striking examples have parallel pressure-flakes extending from margin to margin across both faces, although daggers of this quality are uncommon (see Fig. 1).

The production of type Ic flint daggers took place primarily in the Limfjord region of northwest Jutland, utilizing the rich Senonian flint resources from chalk at places like Hov and Bjerre (see [2]). Not surprisingly, the longest and most finely made examples come from this area. The distribution of finished type Ic daggers is markedly restricted, occurring primarily in Jutland and the northern German region of Schleswig-Holstein (Fig. 5). Although type Ic flint daggers have been recovered from parts of Norway and central Sweden, they are unknown from areas of Denmark east of the Great Belt [19]. Their primary recovery context is as grave objects or unassociated stray finds [10, p. 37].

The precise chronological placement of type I daggers relative to other flint dagger forms has been the subject of a long debate. Initial work by Müller [14] and Forssander [5] was greatly refined by Lomborg [10], who separated the Danish Neolithic after 2350 BC into three succeeding periods with non-overlapping flint dagger affiliations. Lomborg ascribed type Ic daggers (and all of the type I subvariants) to his late Neolithic "A" designation. Flint daggers of types II and III were assigned to the late Neolithic "B," and daggers of types IV and V were considered part of his late Neolithic "C" horizon. Lomborg considered flint daggers of the type VI variety to be chronologically part of the early Bronze Age, a temporal placement they continued to occupy.

Eventually, Lomborg's chronological scheme was criticized by Madsen [13] who used a broad suite of radiocarbon dates to conclusively demonstrate that flint daggers of types I and II, and III are in fact contemporary with each other, but in the case of types I and II, are regionally distinct. Based on this work, Lomborg's tripartite division of the Danish late Neolithic has largely been abandoned, and the current chronological scheme of dividing the late Neolithic into two discrete temporal blocks was put into place: (1) the LN I (2350 BC–1900 BC), comprised of flint dagger types I–III, and (2) the LN II (1900 BC–1700 BC), comprised of flint dagger types IV and V.

The division of the Danish late Neolithic into parts I and II is especially convenient because this approach to chronology corresponds neatly to the importation and development of metalworking in Denmark, particularly the shifting directions of influence through time on Danish metalworking. Because type Ic daggers are thought be inspired by metal flat daggers produced by the more southwesterly located Bell Beaker Culture, ascribing a more westerly influence in metalworking during the LN I fits nicely with the clearly western distribution of type Ic daggers during the same period (see Fig. 5; see also [20] for a detailed discussion of the geographical origins of Danish metal objects through time).

3. The production technology of Type Ic daggers

Type Ic flint daggers are both aesthetically beautiful and technologically complex. Archaeologically, a number of sites with percussion debitage from the production of type I daggers in Denmark are known

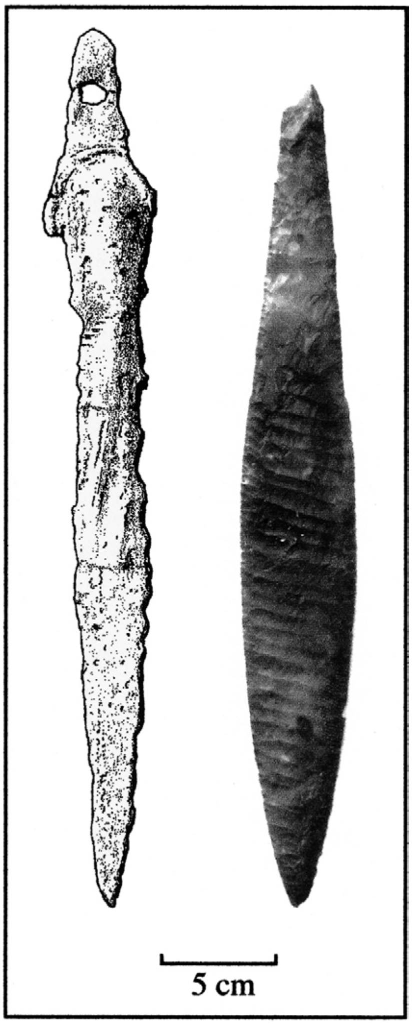

Fig. 3. A flat-tanged metal Bell Beaker dagger found in Kongens Thisted, Denmark (left), and a type Ic flint dagger from northern Jutland. Danish National Museum drawing and photo. Drawing adapted from Vankilde [20].

(e.g., Fornæs in eastern Jutland; see [7]) but locations where late-stage pressure-flaking reduction of type Ic daggers took place have proven to be elusive. Our understanding of type Ic production is bolstered, however, by finds of type Ic preforms, many of which display broad faces that are completely ground (Fig. 6).

It is widely believed that the elegant pressure-flaking which typifies the Ic dagger form was produced by pressure-flaking over a ground surface (see [19]). Numerous lanceolate-shaped ground preforms have been recovered, and some finished type Ic daggers have patches of grinding on their surfaces, complete with invasive parallel pressure-flakes. What these preforms and finished daggers cannot tell us, however, are the details of Ic production, and what that production event might be expected to look like archaeologically. We have no idea, for example, of how long the production of a single dagger might have taken, what level of skill may have been necessary, what tools may have been used, and what characteristics the resulting debitage might display. Also, it is assumed that the grinding traces noticeable on the faces of many type Ic daggers testifies to the importance of labor-intensive grinding to the overall production process, but this assumption has never been validated through controlled experimentation. All of these various issues are within the realm of what this modest study sought to address.

4. The Experiments and Resulting Reduction Stages

Based on the study of 20 original type Ic daggers and seven preforms in the collection of the Danish National Museum, a hypothesized set of broad reduction "stages" was formulated which could be evaluated experimentally. The intended outcome of the experiments was the production of a series of 15 typologically accurate, full-sized type Ic replicas made from Danish flint using only tools that would have been available during the Danish late Neolithic.

All reduction experiments were carried out by the author, an experienced flintworker. Records were kept regarding time investment for each reduction event, consistent shifts between various reduction techniques were noted, and all debitage larger than 1 cm^2 was collected from each discrete reduction stage and evaluated for distinctive characteristics. Based on these experiments, a set of distinctive reduction stages leading to successful type Ic production was developed. These stages are:

1. acquisition of suitable raw material
2. bifacial reduction and preform development
3. surface grinding and polishing
4. platform preparation and first series parallel pressure-flaking
5. final series parallel pressure-flaking and pressure retouch.

A depiction of all five stages is provided as Fig. 7, and Table 1 provides summary data on the time related to each reduction stage as well as any related debitage characteristics. A brief discussion of each discrete reduction stage follows:

4.1. Stage I: acquisition of suitable raw material

Acquiring suitable raw material is perhaps the most critical aspect to successful type Ic production, and the high concentration of type Ic daggers near primary flint sources effectively illustrates this point (see Fig. 5; [10]). As previously noted, type Ic daggers are most common in north Jutland, near the chalk-rich areas of Limfjorden. Becker [2] has discussed at length the extensive flint deposits of the Limfjord region, particularly earlier shaft mining for flint in Cretaceous chalk at Hov

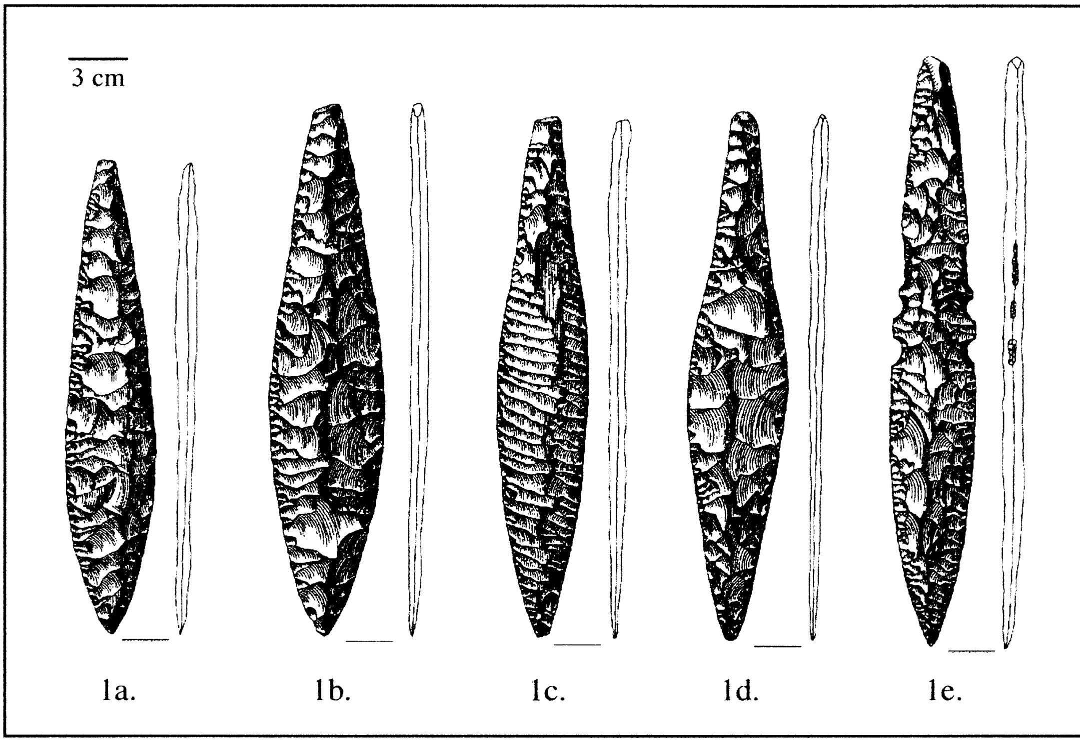

Fig. 4. Typological variation in type I flint daggers as defined by Lomborg [10]. Drawings adapted from Vang Petersen [19].

and Bjerre near the modern-day town of Thisted. Flint from this area is generally mottled black and somewhat translucent, and is of excellent quality. Pieces 1 m in length are not uncommon from modern chalk mines in the area.

In general, flint suitable for the production of type Ic daggers must be homogeneous and free of cracks and inclusions, and should possess a high degree of resiliency and workability. Lens-shaped pieces having natural ovoid or sub-ovoid transverse cross-sections are ideal, and tend to produce the most consistent preforms with a minimal loss of overall length and width. There is no evidence for the intentional thermal alteration of flint in Denmark during the late Neolithic, leading to the conclusion that a considerable amount of suitable flint was available to the dagger makers either through direct quarrying or trade.

4.2. Stage II: bifacial reduction and preform development

The initial formation of a bifacial preform for a type Ic flint dagger involves a series of broad percussion strokes that remove any cortex and help smooth irregular surface contours (Fig. 7, stage IIa). Flakes generated during these early removals tend to have low dorsal scar counts and heavily ground platforms. Early establishment of a lenticular transverse cross-section is critical to the success of later-stage reduction.

Following the establishment of a smooth, lenticular, cortex-free preform, the overall orientation of the dagger is established and the handle is formed (Fig. 7, stage IIb). Flakes from this point in the reduction have increasingly high dorsal scar counts and lightly ground or faceted platforms with soft-percussion ventral lips. Debitage from this point of the reduction is virtually indistinguishable from the late-stage reduction of contemporary crescent-shaped bifacial flint sickles. The final step prior to grinding is further refinement of the percussion preform's contours and overall shape through isolated pressure-flaking (Fig. 7, stage IIc). Flakes from this final step tend to be from 1–2 cm^2 in size, are extremely thin, and have small, concentrated platforms that typically display traces of platform grinding. In all, this stage of the production process took $2\frac{1}{2}$ h on average.

4.3. Stage III: surface grinding and polishing

In the grinding and polishing stage, imperfections in preform surface contours are ground, not chipped away, in preparation for the following parallel pressure-flaking stage. A preliminary experiment with the time necessary to remove the same amount of material via grinding versus chipping on bifaces suggests a ratio of approximately 15:1. Even if this figure was cut in half, the potential difference in time investment between chipping and grinding is staggering.

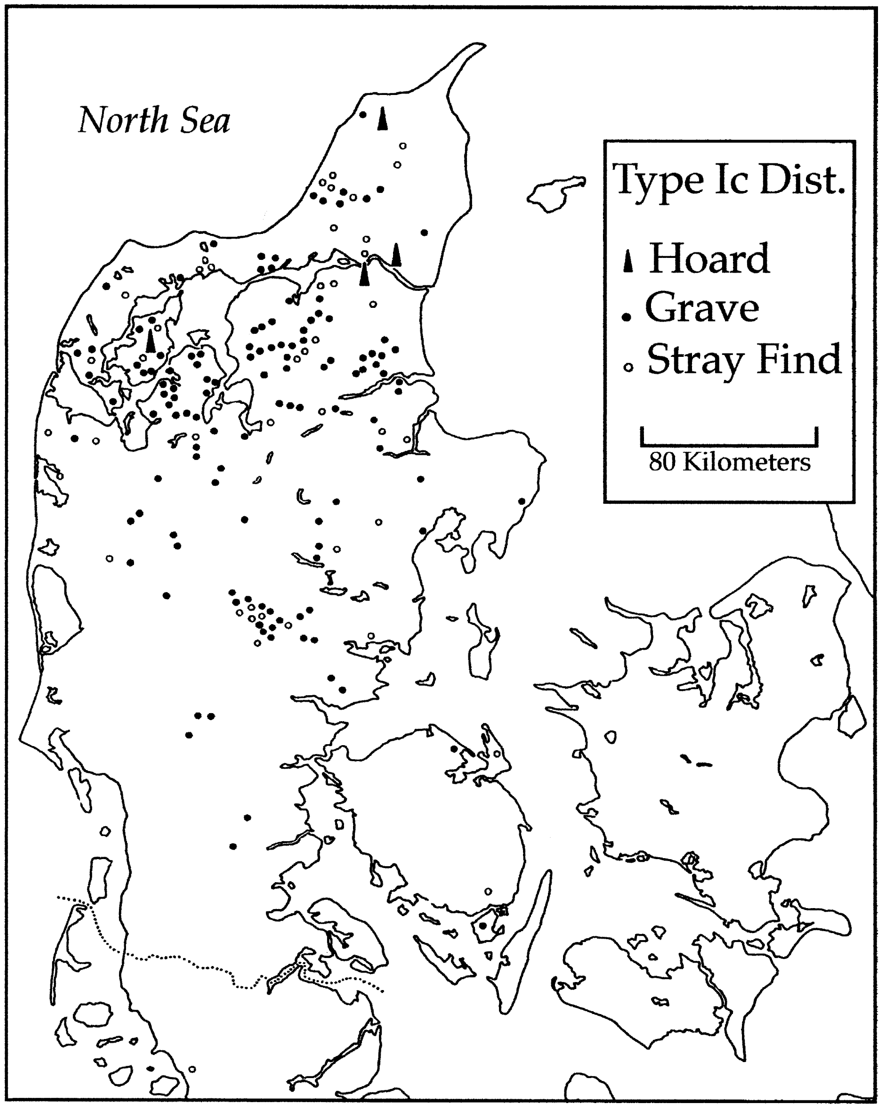

Fig. 5. The distribution of type Ic flint daggers in Denmark as of 1972. Data after Lomborg [10].

The grinding and polishing stage of the reduction experiments was done using large solid stone slabs and a sand/water slurry as a grinding agent. The resulting wear patterns on the grindstones are quite distinctive, and are not dissimilar from wear patterns observed on large grindstones used for grinding and polishing flint axes during earlier portions of the Danish Neolithic. During his experiments with grinding and polishing thin-butted flint axes, Madsen [12] had considerable success applying weight with log sections to the faces of thin-butted flint axes in order to speed the grinding process. Flint daggers are far too fragile for this approach, however, and as a result, grinding proved to be the most time consuming element of the entire production event, averaging nearly 5 h per dagger from start to finish.

4.4. Stage IV: platform preparation and first series parallel pressure-flaking

The experiments carried out here suggest that the long, remarkably regular parallel pressure-flakes exhibited on most type Ic flint daggers were produced through a carefully planned process of platform preparation and pressure-flaking. Without the utmost attention to consistency in these two activities, long, parallel-sided pressure-flakes like those observed on most type Ic daggers are nearly impossible to produce. Completion of this stage averaged nearly 3 h on each of the replica type Ic daggers.

Preparation of a suitable platform for pressure-flake removal seem to be best carried out through the establishment of a single beveled platform running the

Fig. 6. A type Ic flint dagger preform found near Viborg, Denmark. Overall length is 37 cm. Danish National Museum photo.

entire length of the sections of the dagger to be pressure-flaked. Consistency in the subsequent pressure-flakes removals is dependant upon this long platform having the same thickness and angle for its entire length. Because type Ic daggers have parallel pressure-flakes on both faces, a platform on each lateral margin of the dagger is necessary, each beveled towards a different face. A platform angle of between 80–85° seems ideal. As pressure-flakes are removed, much of this platform is obliterated, leaving very little platform remnant.

Parallel pressure-flaking is accomplished by removing pressure flakes down this beveled platform at equally spaced intervals, both down and into the edge (Fig. 8). Most type Ic daggers display pressure-flakes that run at a slight angle to the long axis of the dagger, suggesting that the flintworker gave considerable attention to removing pressure-flakes with a slightly offset forward or backward angle relative to the lateral margin of the dagger preform. The experiments here suggest that uniformity in the finished pressure-flaking was probably produced by careful attention to not only platform preparation, but an extreme degree of control over all aspects of flake spacing and the direction from which the pressure-flaking tool was applied.

The length of the pressure-flakes during this stage can be controlled by varying the amount of force applied, the contour of the ground surface, and the type of pressure-flaking tool used. Debitage from this stage of production is typified by long, parallel-sided flakes displaying grinding on their dorsal faces (Fig. 9). Platforms on these flakes tend to be surprisingly small, with highly accented ventral bulbs of force.

Although it has been argued that Stone Age flint-workers in other parts of the world may have employed simple lever devices to aid in the removal of long flakes or blades (see [6] for one relevant New World example), the experiments carried out here suggest that the remarkably long pressure-flakes common to many type Ic daggers could be done simply by hand, provided that the preform is adequately prepared and that proper techniques and tools are used during the pressure-flaking process.

4.5. Stage V: final series parallel pressure-flaking and pressure retouch

The final series of parallel pressure flaking attempts to remove any remaining grinding traces from the faces of the dagger using a series of short parallel pressure flakes aligned in angle and width with the longer parallel pressure flakes produced during stage IV. These shorter parallel pressure flakes are executed from the margin opposite where the pressure flakes in the previous stage originated. In many cases, very little final parallel pressure-flaking is necessary because the parallel pressure-flakes produced during stage IV traveled nearly edge-to-edge (see Fig. 13). Most typically, production of a heavily beveled platform is not necessary for these shorter removals.

Following any necessary final parallel pressure-flaking, pressure retouch is applied using a small metal or bone pressure-flaking tool. A series of small, non-extending pressure-flakes on the lateral margins of the dagger are used to refine the final outline shape and remove any remnants of the platform used for the parallel pressure-flaking of the dagger's faces. Execution of this final stage of type Ic production averaged slightly more than 1 h for each of the replica daggers produced, and generated both small parallel-sided pressure flakes with some dorsal grinding (from any necessary final series pressure-flaking), as well as delicate, 0.25 cm sized flakes with high dorsal counts from the final pressure retouch.

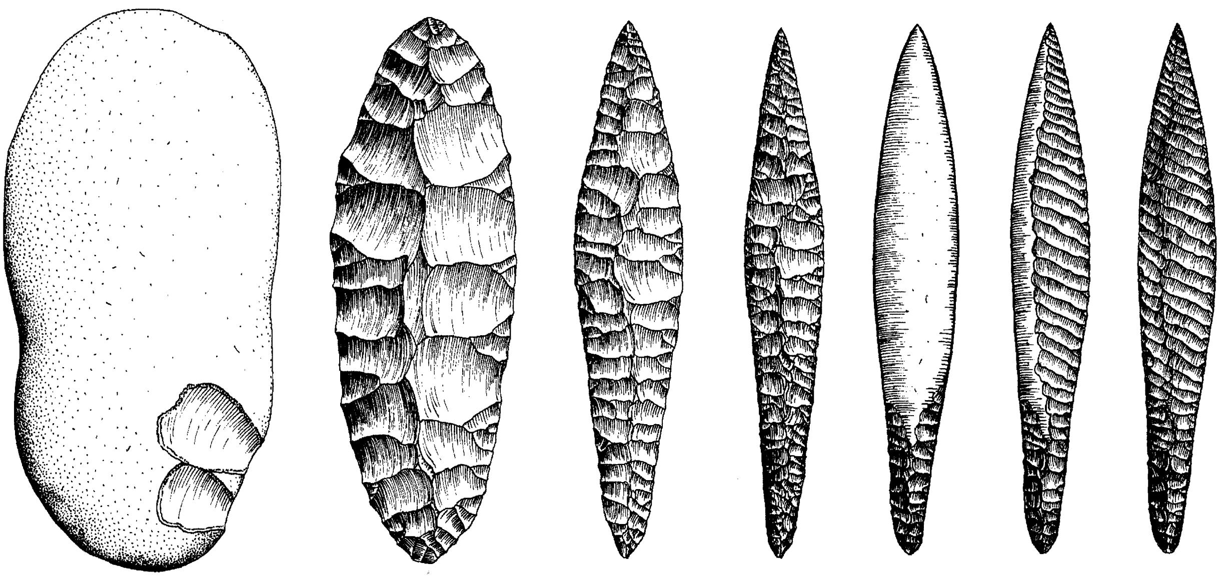

Fig. 7. The hypothesized reduction stages of a type Ic Danish flint dagger. Drawings by Valerie Waldorf.

Table 1
Type Ic reduction stage data and debitage characteristics (N=15)

Experimental reduction stage	Average time (hours)	General debitage characteristics
Stage II Bifacial reduction and preform development	2.5	Increasingly high dorsal scar counts (>3), although some flakes also have dorsal cortex; ground and lipped platforms, wide range of overall flake sizes
Stage III Surface grinding and polishing	4.9	No debitage produced
Stage IV Platform preparation and parallel pressure-flaking	2.8	Flakes with parallel lateral margins and ground ventral surfaces. Platforms may display small metal traces.
Stage V Final stage parallel pressure-flaking and pressure retouch	0.90	Short parallel-side flakes with some dorsal grinding. Also flakes 0.25 cm^2 or less in size having small, concentrated platforms and high dorsal scar counts (>3)

5. Discussion

5.1. Production tools, time investment and debitage characteristics

Although a variety of stone and organic fabricators used during flintworking have been recovered from many periods of the Danish Stone Age, tools used specifically for the production of flint daggers are unknown at present (see Vang Petersen [19] for a brief but useful presentation of reduction processes and related fabricators from the Danish Stone Age). The experiments carried out here, however, suggest that a surprisingly simple tool kit was probably used for type Ic flint dagger production during antiquity. Hammerstones and sections of moose antler for percussion, large antler tines (some possibly tipped with metal) for pressure-flaking, and slabs of soft stone for grinding comprise the necessary tool kit (Fig. 10). All of these materials were readily available during the late Neolithic either locally in northwestern Denmark, or through regional exchange networks to other parts of southern Scandinavia and northern Europe.

The debitage necessary to look for metal traces on flake platforms from type Ic production has yet to be recovered, but the experiments reported here suggest that the most regular, symmetrical pressure-flakes were made using metal tipped pressure-flakers (see Fig. 10). Previous work has conclusively demonstrated that pressure-flaking tools of copper or bronze were used during the production of the type IV dagger variant (see [17]), and although Denmark lacks the resources for the local production of metal objects and tools, it is nearly

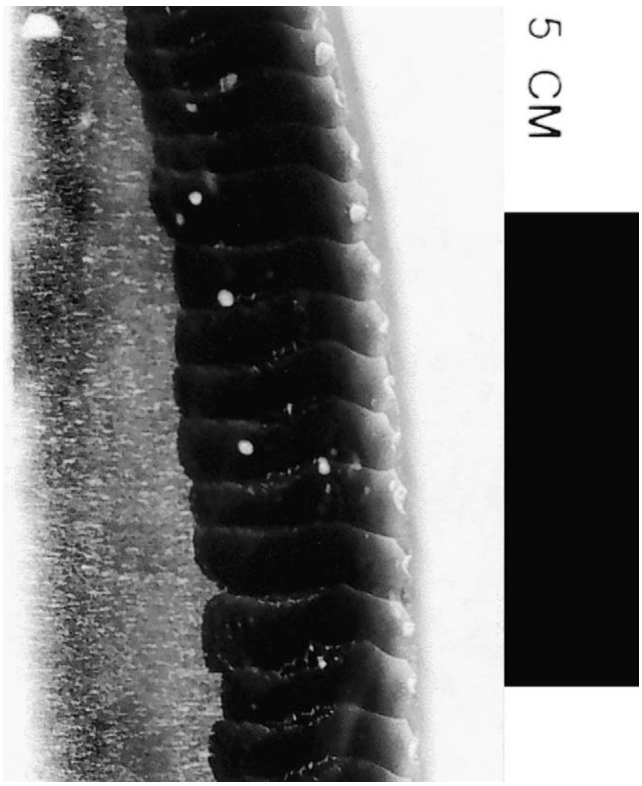

Fig. 8. Parallel flaking over grinding on a replica flint dagger made by the author. Note the regular, consistent spacing of the flake removals.

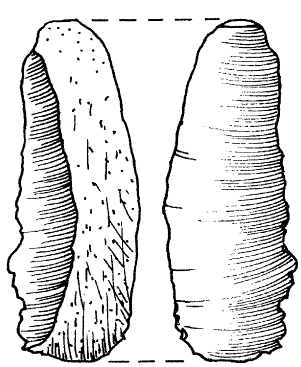

Fig. 9. A typical flake from the parallel flaking of a type Ic flint dagger displaying dorsal surface grinding. Shown full size. Drawing by Valerie Waldorf.

certain that late Neolithic specialist flintworkers would have circulated within a trade network where obtaining metals for use as flintworking tools (either copper or bronze) would have been possible (see [20] for a detailed discussion of the types of metal objects and their respective sources that circulated in Denmark during the final centuries of the Danish late Neolithic).

In terms of the time investment necessary for the production of a type Ic dagger on par with those produced during the late Neolithic, the average comes to 10.6 h from start to finish, including the grinding stage, which averaged nearly 5 h. The only unknown component that would impact this cumulative average figure is inclusion of the time investment necessary for the procurement of suitable raw material. Judging from the scale of the earlier Neolithic flint mines at places like Bjerre in northern Jutland (see [2]), it is probably fair to double or even triple the production time figure presented here when the securing of raw flint of suitable size and quality is taken into account.

Because the mining of flint was likely such a substantial component in the overall time necessary for dagger production, an interesting side issue is the development of labor-intensive mining in the Limfjord area considering all the flint available on the surface from erosion. The answer probably lies with flint quality, as it is widely accepted among modern flintworkers that flint fresh from an originating chalk deposit is more easily worked than flint that has been exposed to the elements for any length of time and has dehydrated. In reference to Danish flint from several moraine zones in southeastern Denmark and eastern Jutland, Madsen [11] notes that "fresh" flint from these areas undergoes a rapid color change when exposed to light. This is, in all likelihood, a function of the aforementioned dehydration, and is probably the reason flint was quarried in the Limfjord region during prehistory and not just surface collected. Simply stated, type Ic dagger production required the best quality flint possible, and the best quality flint was the moist, jet-black flint found below ground in the originating chalk.

With the exception of flakes produced during the main pressure-flaking stage, most debitage resulting from type Ic production is nearly identical in morphology to debitage produced during creation of other types of flint daggers as well as large flint sickles (see Table 1). Debitage displaying lipped, soft-hammer platforms is common from the Danish late Neolithic, and is typically non-diagnostic in terms of the type of implement ultimately manufactured. The experiments here, however, suggest that the overall *composition* of an assemblage, namely the presence of debitage displaying certain traits yet lacking others, can be used to identify type Ic production locales.

Debitage from type Ic production displays varying combinations of flakes produced by hard-hammer percussion, soft-hammer percussion, pressure-flaking over unground surfaces, and pressure-flaking over grinding. Type Ic debitage lacks, however, evidence for the use of a punch (as indicated by the presence of elongated, lipped platforms), application of a quadriface technique (as indicated by flakes with 90° distal terminations), or a sequence of pressure-flaked "stitched" handle seams (as indicated by overshot flakes exhibiting sections of alternate flaking on their dorsal surfaces). All of these types of debitage typify the production of other dagger forms (see [17]). Thus it is only based upon the presence

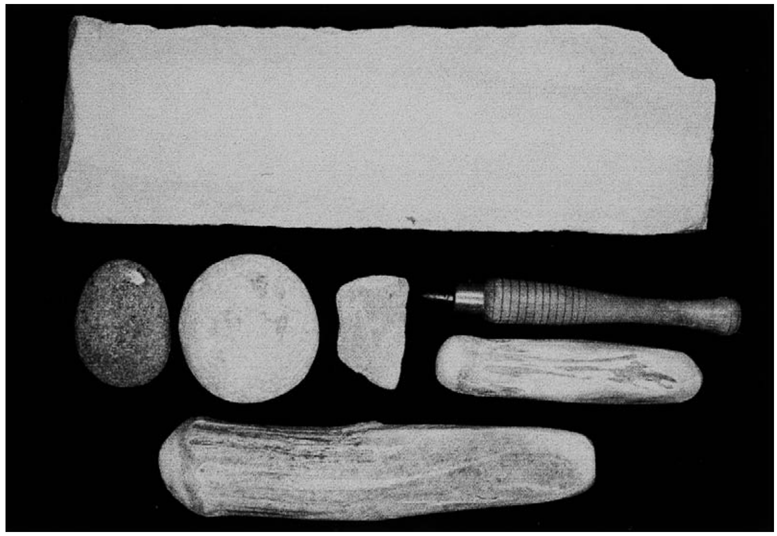

Fig. 10. Tools used to produce the replica flint daggers in this study. A grindstone (top), two hammerstones (middle row, left), an abrading stone (middle row, center), a copper-tipped pressure flaker (middle row, top right), and two antler batons.

of flakes displaying a suite of certain attributes and the absence of other types of flakes that type Ic production can be conclusively identified using flint waste.

5.2. Technological connections

Type I flint daggers represent the most accomplished bifacial reduction approach at any time in the prehistory of Scandinavia. Although the type Ic dagger has a pressure-flaked surface finish, the other type I variants (types a, b, d and e), can sometimes exhibit bifacial reduction bordering on the artistic (Fig. 11). Clearly, the application of a pressure-flaked surface finish on the type Ic was not due to an inability on the part of the Neolithic flintsmith to establish and maintain a smooth, visually appealing percussion surface finish.

An important issue relevant, type Ic Danish dagger production (and production of all of the Danish flint dagger forms for that matter), is how such a complex lithic technology could develop in such a short period with so few obvious technological precursors. With the exception of lance-shaped early Neolithic bifaces (so called "dolkstaves") and small late Neolithic flint sickles, there are few if any obvious technological forerunners to the advanced bifacial technique that typifies type I dagger production. Even fewer connections exist between earlier technologies (both locally and regionally) and the extraordinary parallel pressure-flaked finishes displayed by finished type Ic daggers. Although small randomly pressure-flaked arrowpoints occur contemporaneously with type Ic daggers in Denmark, none of their various forms exhibit the detailed flake-over-grinding work common to the type Ic. It is almost as if this strikingly creative approach to the production of artistically pressure-flaked surfaces developed independently in Denmark within the span of a century or two at most after 2200 BC.

The experiments carried out here strongly suggest that parallel pressure-flaking of the quality and scale of most type Ic daggers would not have been possible without the inclusion of a grinding and polishing stage. Few examples exist in prehistory of grinding as a reduction stage preceding pressure-flaking. Together with the Gerzean flint knives of Pre-Dynasic Egypt, type Ic Danish flint daggers are a notable exception.

Grinding the refined percussion preform prior to flaking removes all surface contour imperfections, on an extreme level. The goal of the grinding and polishing stage is the development of a preform with a perfectly smooth surface, and an even, consistent, lenticular cross-section over the area of the blade to be parallel pressure-flaked. Pressure-flaking over a fully ground surface having a lenticular transverse cross section permits flake removals of uncommon consistency and precision.

Although the application of pressure-flaking over a ground surface has few apparent ancestral connections in earlier Danish lithic technologies, the application of grinding and polishing as a *final* surface finish on flint and other types of stone pervades the Danish early Neolithic beginning as early as 3900 BC. A wide range of chronologically discrete polished flint axes and later varieties of non-flint ground and polished battle axes are common components of the material culture inventory throughout the Danish Neolithic. Considerable time and energy has been invested by Danish scholars and others investigating how such labor-intensive activities were carried out on such a massive scale by prehistoric Danish populations (see [12] for a particularly useful example).

It is highly likely that the flake-over-grinding technique that typifies the type Ic developed in a

Fig. 11. Two percussion-finished type I flint daggers, a type Ib (left), and a type Ie (right). Both are from Gjerslev in eastern Denmark. Danish National Museum photo.

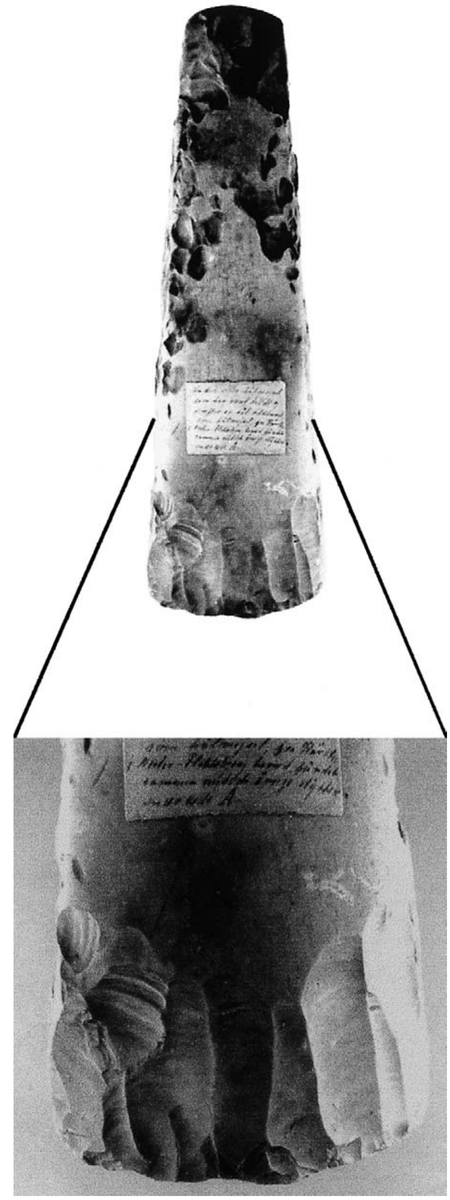

Fig. 12. A late Neolithic polished adze from Hårslev Sogn, Denmark, with parallel resharpening flaking over a ground bit. 16.4 cm in length. Danish National Museum photo.

technological sense out of the occasional reworking of ground and polished flint axes and adzes (Fig. 12). Polished flint axes of many types were frequently reworked throughout the entire Danish Neolithic for purposes of both repair and conversion to flake cores and other useful tools (see [18]). As a result of these activities, it is a near certainty that prehistoric flint workers in Denmark were aware that both percussion and pressure flakes behave differently when removed from a ground surface as opposed to a surface which is unground. This knowledge and experience probably served as fodder for a level of independent experimentation on the part of specialized Danish flintworkers. Particularly in northwest Denmark, the increasing availability of imported metal objects during the late Neolithic may have driven skilled Danish flintsmiths to develop novel surface treatments exhibiting high degrees of both esthetic appeal and technological prowess as a means to compete with exotic metal goods imported from afar.

5.3. Type Ic production, craft specialization, and symbolism in South Scandinavia

In spite of their technological impression and the beauty of the resulting form, it is impossible (and perhaps inappropriate) to segregate the technological elements of type Ic production from the more dominant issues of late Neolithic craft specialization and the daggers' role within the context of the cultural shift from stone to bronze in south Scandinavia initiated after 2200 BC.

It has long been clear flint daggers were unique, highly coveted components of the late Stone Age Danish cultural landscape, and numerous scholars have echoed this conclusion (see [4,8]). The frequent recovery of type Ic daggers from graves in particular points to their unique role as objects whose value was defined in ideological rather than functional terms. In this light, perhaps the most thought provoking characteristic of type Ic daggers is the striking length and consistency of the pressure flakes displayed on their longitudinal faces (Fig. 13). Although Stone Age cultures from other times and places occasionally elevated precision pressure-flaking to a very high level (the Eden points of the North American Paleoindians and the Gerzean knives of Pre-Dynastic Egypt are two obvious examples), the type Ic flint dagger without question represents the most superlative example of pressure-flaking technology at any point in prehistory.

The precision pressure-flaked patterns displayed by type Ic flint daggers have no obvious technological purpose in terms of actually using a dagger for a cutting activity. It is far more likely that the value of the remarkable workmanship displayed by these daggers was ascribed to their role as symbols of value, wealth, or both (see [22] for a discussion of objects traits and their relative value as symbols). The fact that such a high level of technological development emerged so suddenly in southern Scandinavia with so few obvious technological precursors is testament indeed to the societal demand for such objects, as well as the rich raw material setting which made such technological innovations possible.

New perspectives on how the production modes and distribution networks of flint daggers fit into the greater system of late Neolithic and early Bronze Age society are only recently garnering heightened interest. Although scholars like Becker [3] and Lomborg [9] suggested decades ago that daggers made of flint were produced on a massive scale for primary export to other areas of Europe, it is only more recently that work by Vankilde [20], Oluasson [16] and Apel [1] has addressed the development and transfer of knowledge amongst the late Neolithic craftspeople who manufactured these daggers.

Based on her inspection of several hundred late Neolithic flint daggers of several types in the collection of the University of Lund in Sweden, Deborah Oluasson has observed that several systems of dagger production were probably in operation during the south Scandinavian late Neolithic including manufacture by both highly skilled specialists as well as less skilled local flintworkers [16]). The experiments here agree with this assessment, and point to the likelihood that the production of high-quality type Ic daggers was probably beyond the abilities (and possibly the available time investment) of most cottage-based utilitarian flint workers. Although it is not unreasonable to think that non-specialists could assemble the relatively simple tool kit necessary for type Ic production, the technical proficiency necessary to execute the pressure-flaking stage alone likely took years (and tens of dozens of practice preforms) to master.

Fig. 13. Blade section of a type Ic flint dagger from exhibiting edge-to-edge parallel pressure flaking. Finding place unknown. Danish National Museum photo.

It is tempting to suggest that the preforming and grinding stages of type Ic production could have been carried out by non-specialist flintworkers, but the experiments here suggest that even these stages of the production process require an intimate knowledge and control of factors that can influence later steps in the reduction process. Based on this perspective it is argued that the overall production process leading to a finished type Ic dagger occurred via one of two possible production modes: (1) production from start to finish by a single craftsperson who personally carried out all reduction steps with the possible exclusion of flint procurement, or (2) production of a completed dagger by a group of craftspeople who, although each was responsible for a specific stage in the reduction process, shared amongst themselves an intimate level of knowledge about the entire production process.

In regard to how knowledge leading to the production of high-quality flint daggers may have been developed and transferred, a remarkably useful work by Jan Apel [1] offers insight that dovetails nicely with the conclusions drawn from this study. Apel argues that the knowledge to produce complex daggers in flint, including those produced by specialist flintworkers, was based in an apprenticeship system functioning with the realm of lineage or clan membership. Because the experiments here suggest that an overall understanding of the complete production process is a key factor to successful type Ic production, Apel's social model of shared knowledge supports the technical-based conclusion presented here that individual stages or "blocks" of technical know-how are also closely related and cannot be separated. Clearly, however, such discussions will be greatly clarified if and when locales associated with the final production stages of type Ic dagger are discovered and evaluated.

5.4. Conclusions

This project sought to explore the production technology associated with type Ic flint daggers and offer some related insight into the cultural implications of these remarkable stone tools. Discovery of more sites having components of the type Ic reduction sequence is necessary to evaluate the validity of many of the perspectives offered here.

What is certain, however, is that the type Ic flint daggers of late Neolithic Denmark are among the most technically complex stone tools produced anywhere during prehistory, and the specialized Stone Age flintsmiths who produced them practiced a degree of prehistoric craftsmanship that few in the distant past could match. The combination of social demand, simple tools, abundant resources and a considerable degree of creative ingenuity resulted in the creation of a group of flint objects that likely functioned as important ideological symbols of wealth and social standing to prehistoric Danes and others who lived on the edge of the Bronze Age. Although replicative studies like this one have inherent interpretive limitations, it is hoped that this modest study offers yet another building block towards the construction of a more complete and meaningful perspective on the cultures who interacted and flourished during one of the most significant periods of transition ever to impact the south Scandinavian cultural landscape.

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