Tools and technology

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av

Deborah S. Olausson
M.A., Malmö

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Abstract

Through practical experiments, edge-wear analysis, and the study of archaeological collections, the dissertation explores the complex relationship between style and function in a specific class of artifacts: the Neolithic axe. Since it was possible to show that thermal treatment of Swedish flint resulted in a greater susceptibility to wear, it was not surprising when examination by the scanning electron microscope showed no evidence for such a procedure during the Neolithic in Scandinavia. The results of the 3-part approach described above, when applied for instance to thin-butted axes from the Funnel Beaker Culture, indicated that there was no clear-cut class of unusable prestige axes, but rather that axe length more likely reflected practical rather than stylistic considerations. The ramifications which such a conclusion has for interpreting hoards containing thin-butted axes, and for assessing the role played by such axes in the Neolithic economy, are explored. The method was also applied to discovering the possible reasons behind the choice of flint or greenstone for the manufacture of certain types of otherwise morphologically similar Neolithic axes. The results of practical trials with axe manufacture and use, as well as a study of raw material availability, suggested that groundstone axes were tools in their own right, suited for primarily coarser tasks where there was a danger of bending stress. However, the predominance of flint axes in an area to which such tools had to be imported indicates that flint axes here represented an extra-ordinary investment beyond what would be required by practical necessity; i.e. wealth or prestige. An approach combining controlled experiments, edge-wear analysis, and examination of archaeological collections can profitably be employed on other classes of artifacts in order to study functional utility and social status in the past.

Key words

Lithic technology, edge-wear analysis, experimental archaeology, heat treatment, Neolithic axes, prestige objects, hoards, surface finds.

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Deborah Olausson, Institute of Archaeology, Krafts torg 1, S-223 50 LUND, Sweden.

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FOREWORD

A Master's Thesis studying burin edge-wear (Seitzer 1975) convinced me that edge-wear analysis without experiment was an empty exercise. Thus it is that a dissertation which was originally intended to be an edge-wear analysis of axes shifted emphasis and became an apologia for the use of experiment in archaeology. For me, making and using stone tools is the best way to understand and appreciate the past and the reasons why choices were made.

I have met with helpful people wherever I have shown up with my strange requests for stone axe handles, trees to chop, or computer programs for dealing with stone axes. Discussions with James Sackett, Errett Callahan, and Jeff Flenniken provided the impetus for the study and many of its central ideas. Without Hans de Haas' cheerful enthusiasm and vast knowledge of both the practical and the possible, I could never have carried out the experiments so central to this study. Ivan Andersen, Mats Johansson, Thor-Bjørn Petersen, Errett Callahan, and Sigvard Nilsson gave generously of their time and expertise in response to my odd requests when preparing the experimental axes. Lars Gårding and Leif Robertsson offered advice on the quantitative aspects of the study, while Bertram Broberg generously took the time to clarify some of the ideas of structural mechanics for an ignorant humanist. I would also like to thank those who steered me through museum collections in search of axes: Poul Otto Nielsen, Ingmar Billberg, Hans-Åke Nordström, Louise Cederschiöld, Christina Enhammar, and Björn Rosenberg. Göran Bylund, Björn Lagerblad, and Leif Johansson were kind enough to put their mineralogical knowledge and some of their equipment at my disposal, while John Coles, Svend Jørgensen, Harm Paulsen and Axel Steensberg took the time to share their knowledge of practical archaeology with me. Helle Juel Jensen and Kjel Knutsson were generous in sharing their experience of the high power approach to edge-wear analysis and in trying to locate polish on ground flint axes. I would like to thank my adviser Berta Stjernquist for unflagging support from the very beginning, when I showed up as an unknown quantity at the door of the Historical Museum in 1976. Lars Larsson and Errett Callahan also acted as my advisers, and to them I owe a special debt of thanks. The publications could never have been completed without the help of Inger Kristensson, Bertil Centerwall, Elisabeth Jasinska, Christina Borstam, Ulla-Britta Ekstrand, and Ingrid Granegård. But most of all I want to thank my husband Hans, whose healthy skepticism kept my feet on the ground while his supportive confidence finally made me believe that it all might be possible after all. It is to him and to our son Erik that I dedicate this dissertation.

Dalby, March 1983

Debbie Olausson

The dissertation is based on the following six papers:

I. Olausson, D.S. 1980. Starting from Scratch: The History of Edge-Wear Research from 1838 to 1978. Lithic Technology, Vol. IX, No. 2, pp. 48-60.

II. Olausson, D.S. and Larsson, L. 1982. Testing for the Presence of Thermal Pretreatment of Flint in the Mesolithic and Neolithic of Sweden. Journal of Archaeological Science, Vol. 9, pp. 275-285.

III. Olausson, D.S. and Larsson, L. 1982. Heat Treatment of Flint in the Scandinavian Stone Age? Papers of the Archaeological Institute University of Lund 1981-1982, New Series Vol. 4, pp. 5-25.

IV. Olausson, D.S. 1983. Experiments to Investigate the Effects of Heat Treatment on Use-Wear on Flint Tools. Accepted for publication in Proceedings of the Prehistoric Society, Cambridge. 29 pages.

V. Olausson, D.S. 1983. Lithic Technological Analysis of the Thin-Butted Axe. Accepted for publication in Acta Archaeologica, Copenhagen. 153 pages.

VI. Olausson, D.S. 1983. Flint and Groundstone Axes in the Scanian Neolithic. An Evaluation of Raw Materials based on Experiment. Scripta Minora Regiae Societatis Humaniorum Litterarum Lundensis 1982-1983:2, pp. 1-66.

The papers are referred to in the text by the appropriate Roman numerals.

INTRODUCTION

Any object which is made or modified by man can be said to embody/incorporate two kinds of attributes: the practical and the social (or the functional and the stylistic) (cf. Sackett 1973; Binford 1972). Some objects, such as an unmodified hammerstone, are almost purely practical objects. They are used for a certain task, and their attributes (aside from their "natural" attributes) are suited to performing this task: there are no "superfluous" attributes. A king's crown, on the other hand, has no practical use. Rather, its atttributes embody qualities giving it a social function: as an identifying badge of rank, as an object of wealth, etc. Most objects with which man deals are complicated mixtures of both sorts of attributes: the practical and the social (or stylistic) (Moss 1981:88; Jelinek 1976:20). If for any class of objects the minimum requirements for the practical use of the object can be established, then the other attributes of the object should be due either to random or natural variation (in the case of natural objects used by man) or to choices influenced not by use but by individual or cultural selection (Pollnac & Rowlett 1977:170; Tringham 1972:144; Davis 1963:211; Close 1978: 223). (This of course assumes that the primary practical use of an object can be established. A king's crown could conceivably be used as a hammer, but practical trials would soon show the undesirability of such use.) The ability to identify attributes dictated by human choice rather than by practical necessity allows us to ask new kinds of questions of the artifacts; questions pertaining to style, cultural affinity, value, and social status (Hodder 1982:204ff.). The aim of this dissertation is to explore an approach by which to identify these aspects in a class of stone tools: in this case the Neolithic axe (Meltzer 1981:313).

The approach used in these papers has been called lithic technological analysis. There is no strict definition of what is meant by such an approach, but the scope of the articles in the journal Lithic Technology, or in the book Lithic Technology. Making and using Stone Tools (Swanson 1975) indicates what is meant. Lithic technological analysis in its most general sense means the study of the manufacture and use of stone artifacts (Knudson & Muto 1972:1; Knudson 1978:44; Callahan 1981:151). As used in the present analysis, it means applying experiment, edge-wear analysis, and natural science methods to studying the morphology of lithic (i.e. stone) artifacts. Through this combination of analytical approaches, it is possible to establish those aspects of the tool class "the axe" which are required for the tool's practical use. Having noted these minimum requirements, it is then possible to study those aspects of axe morphology which are superfluous to practical use. One can then postulate that these "superfluous" qualities represent cultural tradition or choice: that they endow the axe with value above and beyond its value as a tool (V and VI).

The approach suggested here is applicable to any class of objects, although the examination of traces of use is so far most well developed when applied to flint tools (I). There are several reasons why the ground stone and flint axes of the Scandinavian Neolithic are a suitable class of tools upon which to attempt such an analysis: 1) Their high frequency allows for good quantitative data (useful in edge-wear analyses) and suggests that they were a key tool in the Neolithic toolkit. 2) They represent a well-defined formal (and probably functional) class, some of whose morphological variations may be due to factors other than practical function. 3) There has already been some speculation in the archaeological literature about the meaning of some of the socio-cultural aspects to be discussed here, although these ideas have rarely been concretely stated and almost never tested (V).

The archaeological source material used for the study consisted in most cases of axes from surface finds collections. For the kinds of questions asked, find context was the independent variable, used to confirm the tool's meaning after it had been suggested by means of the functional analysis of the tool itself (V, VI). Archaeological surface finds were used to provide data on morphological characterstics in order to establish metric limits for making experimental replicas and to test for functional significance (V, VI), and examination of wear on their edges formed the basis for the edge-wear analysis. The use of surface finds collections had the advantage of allowing for destructive analytical methods when these were appropriate (II, III, VI). Another advantage lay in the large quantitative base which sampling of such collections provided (V). Computer analysis was a swift and accurate means of processing these quantitative data (V, VI).

EXPERIMENT

> But we would define "experiment" in the social sciences, which include anthropology and its subdiscipline archeology, simply as a systematic approach to the explication of data. Operationally this definition encompasses tests of hypotheses, replication of activities, duplication of conditions, construction of explanatory models, manipulation of methodological variables, and simulation of data-based observations (Ingersoll & Macdonald 1977:ix).

The best means of determining which of a tool's qualities are necessary for its use is by trying to use the tool or a copy of the tool. Experiments with tool replicas were the major line of direct evidence used for testing the use of thin-butted axes (V) and for comparing the efficiency of certain types of flint and groundstone axes (VI). Experiment was also of major importance (although more indirectly) for establishing what factors lead to edge-wear on flint and stone tools (IV, V, VI) (Ranere 1975:208). As many variables as possible were controlled during the experiments, so that a true test of the hypotheses could be achieved. While each of the experiments was aimed at answering specific questions, their execution also provided a more general appreciation of the axe as a practical tool and of the problems as well as the practicalities of its use (Coles 1979:12; Callahan 1981:xi; Foxon 1982: 119; Crabtree & Gould 1970:183; Ingersoll & Macdonald 1977:xii; Tringham 1978:169-170; Ascher 1961:812). The experiments also provided some interesting information which was more peripheral to the main hypotheses, such as the causes of axe breakage (V), hafting difficulties (V, VI), a means of identifying resharpening on axes (V), or the likelihood of Neolithic knapping specialization (VI). Such information also proved to be useful in testing the hypotheses and to some extent in answering questions of a more socio-cultural nature (V).

The use of experiments (or at least practical trials) has a long tradition in Scandinavian archaeology. An early example of truly controlled experiment was for instance Sehested's attempt to replicate grinding striations on flint axes (Sehested 1884). An early attempt at living a stone age life for a summer can be found in Klein (1920). Moberg used mechanical aids to replicate the striations he saw on shoe-last celts (Moberg 1955), while Anders Kragh carried out early work replicating flint tools (Kragh 1952; 1964). The use of thin-butted axes to fell trees and the attempt at slash-and-burn agriculture at Draved was also a commendable example of practically testing archaeological and biological theories (Steensberg 1979; Jørgensen 1953). Steensberg himself has been particularly active in the field of experimental archaeology, beginning in 1937 with controlled trials with sickles (Steensberg 1943).

In spite of this tradition, however, the emphasis in Scandinavian archaeological research has generally been on formal typological ordering as an aid to chronology or for identifying cultures, and on studying the placement of sites in space and time. Recent trends emphasize ecological factors and analyses of prehistoric societies. Seldom has there been any large-scale and systematic attempt to apply experimental results to analysing questions of archaeological interest. In the present study, the elements of space and time are virtually held constant; instead emphasis is placed on the axe as a working tool seen in its social context.

EDGE-WEAR ANALYSIS

> ...microwear studies are those undertaken to collect, analyze and interpret data pertaining to the physical, observable features found on human artifacts which are a direct result of human utilization of these artifacts (Brink 1978:8).

Another approach for establishing use was that of edge-wear analysis (Meltzer 1981:315). Developments in the field have been increasingly rapid, so that the historical overview written in 1979 (I) is no longer up-to-date (cf. Odell 1982).

The most important developments since 1979 were the publication of the first books to deal solely with this field: Hayden's anthology of the papers from the Vancouver conference (Hayden 1979) and the publication of Keeley's dissertation (Keeley 1980). Hayden's book provides an interesting survey of varied topics of interest to edge-wear analysts, including some discussion of the mechanical processes at work and of specific applications to archaeological collections. The types of wear examined under low-power microscopy (e.g. striations and microscarring) as well as the polishes seen under high-power microscopy are discussed.

Another significant advance in microwear analysis was Keeley's discovery that siliceous materials develop material-specific polishes during use which can be identified at magnifications of 100X-400X (Keeley 1980). This approach ignited the interest of many researchers, who then "apprenticed" themselves to those who had already learned to distinguish the polishes. The approach has been successfully applied to e.g. Mesolithic knives (Juel Jensen 1982) and flake axes (Knutsson 1982) in Scandinavia.

In the present studies, the emphasis was on what has been termed the low-power approach (Odell & Odell-Vereecken 1980; cf. Odell 1982). There were several reasons for this: 1) Because only a very small part of the tool can be observed at one time with the high-power approach, the study of each tool is a time-consuming process. For the kinds of questions asked in this study, detail was sacrificed in favor of a larger quantitative base. 2) It was difficult to isolate polish due to use from polish due to manufacture on the ground faces of the flint axes. Learning to separate the two would have required a large investment of time (V). 3) The coarse and weathered structure of the non-flint axes examined (VI) made it nearly impossible to investigate all but the coarsest forms of wear on these tools. 4) The appearance of such polishes indicates the objective material, the location of polish can tell how the tool was held, and the very presence of polish shows that the tool came into contact with the objective material. Usually the answers sought in the edge-wear analyses for this study were not the kind of answers which such information could provide. 5) Often the kind of wear which was considered important (IV, V, VI) was dulling and attrition, rather than the non-destructive additive polishes. For all these reasons, magnifications were held to 8X-16X and a quantitative approach was preferred.

The edge-wear analysis was used to provide a complement to the experimental evidence of use. In the case of the thin-butted axes (V), the presence of edge-wear was used to corroborate that even the longest axes had been used, and to suggest that axes of different lengths were used for different tasks (without taking the next step and determining <u>which</u> tasks). Because of problems caused by the influence of raw material quality on edge-wear patterns (IV) (Seitzer 1980; Masson 1981:68), this approach was used with caution when comparing flint and groundstone axes (VI). However it did provide a means of demonstrating that groundstone axes were probably used for heavier tasks than the more brittle flint axes.

The three short essays on heat treatment (II, III, IV) touch on this last problem. The changes induced by thermal pretreatment were demonstrated to the author at the Flintknapping Fieldschool in Washington, USA in 1978. A brief series of 20 controlled experiments (IV) showed that this process affected the intensity and appearance of edge-wear on flint. [1] In order for wear patterns on experimental tools to be comparable to those on archaeological specimens, the conditions under which both were formed should be as close as possible, Accordingly, an examination of four classes of stone tools from Mesolithic and Neolithic contexts, including one thick-butted axe, was carried out (II, III). Since the analysis showed that heat treatment was probably not used here during the stone age, it was justifiable to carry out the main axe experiments (V, VI) using only unheated flint.

The results of (IV) also illustrate the ideas voiced in the introduction. Paper IV showed that heat treatment decreases the practical utility of flint tools, making them more susceptible to tensile strains and breakage. In most cases, heat treatment was probably used to alter a raw material which would otherwise have been very difficult to make into a tool whatsoever, so that the decrease in usefulness was accepted in order to get a usable tool. However for those raw materials which could be worked without heat treatment, the presence of heat treatment suggests that the technique was used to improve the stone's flaking qualities so that a more regular (aesthetic?) tool (which was however less practically useful) could be made. A good example would be the Egyptian dagger, heat treated before receiving its final pressure flaking (Kelterborn, personal communication 1981). The "tool" acquires value precisely because it is less usable and represents a surplus of effort (V, VI). We suspected that such reasoning could also apply to pressure-flaked daggers of the Scandinavian Neolithic; however this proved not to be the case (II, III).

THE USE OF NATURAL SCIENCE METHODS FOR ANSWERING SOCIAL SCIENCE QUESTIONS

> Certainly, scientific aids no more make archaeology a "science" than a wooden leg makes a man into a tree --isotope dating, chemical analysis, and proton magnetometers remain adjuncts (Clarke 1978:465).

Because much of the study involved an investigation of the properties of raw materials and their reaction to stress, information and analytical tools were also sought from the natural sciences. For explaining the causes of edge damage and axe breakage, and for exploring the necessity of grinding axes (V),

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[1] In view of the fact that axes were the focus of the study, it would have been logical to have tested the effects of heating on wear on axes. However these experiments (IV) were designed to be as simple as possible, keeping the effects of "tool" morphology to a minimum. Therefore only flakes were tested. An unpolished thick-butted experimental axe was later heated, following the schedule in (III). There was no visible damage to the tool due to annealing; however no attempt was made to use the axe after heating. Based on the results of the experiments (IV, V), it can be suggested that a heated axe subjected to bending/compressive forces will be even more likely to break than one which is unheated.

theories of structural mechanics were consulted. The magnifications possible with the scanning electron microscope provided a simple means of determining the presence of heat treatment (II, III). Mineralogy and petrology provided information for discovering the availability of raw materials and their properties for manufacture and use (VI). The increasing number of interdisciplinary projects in archaeology today (e.g. Stjernquist 1981; Stjernquist et al. 1982) testifies to the recognition by both the natural sciences and the social sciences of the artificiality of divisions into disciplines, and of the usefulness of an approach combining both. It is possible to make more convincing statements about social factors once the "hard" data have been established For instance, the recognition of the cause of axe breakage and wear allowed for a clearer evaluation of the importance of the flint axe in Neolithic forest clearance (V, VI). How much axe grinding is dictated by practical necessity and how much is "superfluous" (aesthetic) can be established by reference to fracture mechanics (V, VI). On the basis of such information, statements about axe value can be made.

IN RETROSPECT -- AN EVALUATION

The use of practical experiments, supplementary edge-wear analysis and natural science methods made it possible to make statements about which aspects of axe morphology are dictated by practical use and which fulfill some social function. In the case of the thin-butted axe (V), it was possible to show that axe length is primarily due to practical function. One of the morphological characteristics which is most important for the use of the axe is its weight (Dickson 1981; Odell 1977:412). A long axe insured that weight was maintained, at the same time as an effective cutting edge which is not too wide could be provided (Højlund 1975:184). A long axe could also save time, since it might be possible to rework a longer fragment into a usable axe, thus obviating the need to make a whole new axe if breakage occurred (V, VI). The analysis also demonstrated that the finest polishing present on some axes is probably an indication of value. Fracture mechanics theory shows that the smoothing out of irregularities on the surfaces of the axe would have reduced the risk of axe breakage (V). However, once grinding removes chipping scars, the additional time spent in polishing the axe to a mirror-like surface would not have been necessary for the use of the tool, but must instead represent a surplus of energy: the object has value beyond its value as a tool (Cf.Malmer 1962:393-394).

Similarly, experiments with axe manufacture and use showed that groundstone axes were practical tools and not merely less valuable copies of flint axes (VI). This explains why both kinds of axes are found in both flint-rich and flint-poor areas (Malmer 1962:549). Nevertheless, the limited availability of flint probably helped to set the value of a given axe in any particular area. Since both groundstone and flint axes were practically useful tools, the predominance of the latter over the former in a flint-poor district should represent an investment above and beyond what is required by practical necessity: e.g. an indication of wealth or status (VI).

The detailed nature of the analyses and their basis in the artifacts means that no sweeping statements about culture change have resulted from the study. However, the method using carefully controlled experiments to establish use and from there inferring social values should be one which can be applied to other questions pertaining to the organization of societies. As archaeologists, our main form of evidence is of necessity the "material remains of the human past" (Foxon 1982:114) and our major concern is using these remains to define and explicate the social context of technology (Rathje 1981:51-52). Taken in this broad sense, archaeological methods can include experimental archaeology (e.g. Callahan 1981), studies of modern material culture (e.g. Rathje 1981), and edge-wear analysis (e.g. Keeley 1980), as well as the more traditional methods of classification for chronological ordering. Given the vast numbers of artifacts stored in our museums, and the fact that the number of archaeological sites is continually decreasing through exploitation and excavation, the trend may be toward more studies of this type, in which attention is concentrated on obtaining socio-cultural information from the detailed analysis of a class of objects. By focussing on a tool, it is possible to see in an object influences beyond the merely practical (Callahan 1982:23). It is in the leap beyond practical function that interesting clues to past behavior can be gained.

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