Stone Toolmaking: Man's Oldest Craft Recreated

Don E. Crabtree and Richard A. Gould

From February, 1969, to September, 1970, the American Museum of Natural History presented an exhibit based on an idea which has become known to archaeologists and anthropologists as "Experimental Archaeology."[1.] This is not altogether a new idea, but the authors of this paper, along with Dr. Junius Bird, were privileged to be able to crystallize this concept and present it, for the first time, to large public audiences. The response from the individuals who saw the exhibit and the institutions which were involved with it was so enthusiastic that it seemed worthwhile to describe how the exhibit was planned and what it was intended to achieve.

The Idea of Experimental Archaeology

Anyone who has collected Indian arrowheads or seen ancient chipped stone artifacts in museum collections invariably finds himself wondering about how these stone tools were made and used. This is particularly true when the stone tools are well made. Stone tools are so remote from the existence of the average American living today that it takes a real effort of imagination to begin to picture a person making and using these implements, and most efforts of this sort fail because they have so little to guide them. In truth, they boggle the mind, and it is no wonder that many educated Europeans living as late as the 18th Century still regarded chipped stone tools as "thunderstones", created in some magical way by lightning.[2.]

1. As far as we know this term was first coined by John E. Pfieffer (<u>The Emergence of Man</u>, Harper and Row, New York, 1969, p. 353).

2. Antoine de Jussieu, "De l'Origine et des usages de la pierre de foudre," <u>Mémoires de l'Académie Royale</u>, Paris, 1723, pp. 6-9.

For some, the stone tools of ancient man are merely curios. But to archaeologists and anthropologists they represent fossilized human behavior (a happy phrase first coined by anthropologist S.L. Washburn). As most people know, stone artifacts generally survive the ravages of weathering and decay in archaeological sites better than artifacts of wood, bone, cloth, and other organic substances. Thus archaeologists have come to depend heavily upon stone tools in their interpretations of ancient cultures, since it is these tools that most often survive to be studied.

When considered in terms of the whole span of human culture-history, the discovery and use of metals is a relatively recent and rapid development, having occurred within the last 10,000 years along with other major developments like agriculture and urban life. Since present evidence indicates that tool-using man has existed for approximately 2,000,000 years, this means that tools of stone, wood, and bone have predominated for at least 99.5% of human history - and, of course, of these artifacts it is mainly those of stone which have survived to be studied and examined by scholars. Even after the invention and spread of metals there remained some isolated societies which continued to make and use stone tools. A few of these, like the Australian Desert Aborigines and certain groups of New Guinea natives, still use stone tools today. Thus it is that stone tools provide archaeologists with one of the most important bodies of evidence of human behavior over most of the span of human culture-history. Small wonder, then, that archaeologists are keenly interested in knowing all they can about stone tools.

Scholars today have three main avenues open to them for finding out how ancient stone tools were manufactured and used;

1. Stratigraphic excavations - This remains as the most orthodox archaeological approach, and it is still one of the best. Through careful,

systematic excavations, archaeologists often find stone tools and waste materials in association with dwellings, campsites, butchered animal bones or other features which give clues as to their function. To cite one famous example, the discovery at Folsom, New Mexico, in 1926 of a distinctive type of stone projectile point (a variety with a channel flake removed longitudinally from each side, since known as the Folsom Fluted Point) embedded among the fossilized bones of extinct bison, Bison antiquus, demonstrated at once both the great antiquity of this porjectile point type and its use as an instrument for killing big game. The main point to consider here, however, is the fact that archaeological excavations necessarily destroy the site where they are being carried out. It is always incumbent upon the archaeologist to keep detailed records, in the form of notes, photographs, and drawings of each layer he uncovers, since he will destroy it as he proceeds to dig down to deeper layers. Once an excavation has been made, there is no way it can be done over again. When most people think of archaeology, it is usually excavation they are thinking of. This aspect of archaeology cannot be called an experimental science, because experiments, if they are scientific, must be repeatable - and archaeological excavations clearly are not repeatable.

2. Living Archaeology - Sometimes called ethno-archaeology, this approach involves the study of living, present-day societies where stone tools are still manufactured and used. It also includes research into historic sources which give early accounts of people who made and used stone artifacts. Unfortunately, the references available about this sort of behavior in historic documents are limited. Even more important, the impact of Western technology throughout the world has been so great during the 19th and 20th Centuries that there are few traditional societies left anywhere that still do this, most of them having long since abandoned stone tools for metal ones. This line of research has

the quality of a race against time, as scholars try to find and study groups of this kind before they completely abandon the art of stone-chipping forever. Perhaps the most dramatic example where this approach has been tried recently is among certain isolated groups of Aborigines in the Western Desert of Australia, but other interesting cases are known in New Guinea, the Amazon Basin of South America, and Turkey. This approach, while yielding much valuable information, is observational rather than experimental.

3. Experimental Archaeology - While most people do not think of archaeology as an experimental science, recent work has shown that controlled experimentation can often provide information about the use and manufacture of stone tools that is simply not available in any other way. By attempting to make exact counterparts of known types of ancient stone artifacts, the experimenter, through both his successes and failures in the laboratory, reconstructs the possible ways in which such artifacts were made. By using these artifacts in a variety of ways and with a variety of materials, again, always under controlled conditions, and examining the results (usually under a microscope) he can infer the possible ways in which the ancient tools were used. Most modern textbooks in archaeology include at least a perfunctory discussion of how stone tools are made and used, but it has only been in recent years that the experimental approach to this question has received the careful and systematic treatment by scholars that it has deserved. The exhibit, which this paper sets out to describe, served both to show some of the earlier attempts in this direction and to present the results of more recent experiments which had hitherto been described only in specialized scientific publications or not at all.

Preparations for the Exhibit:

As with all exhibits at the A.M.N.H., preparations involved careful searching through the literature for useful information and checking of details for label copy. This task was ably performed by Miss Philippa Dunn, an undergraduate Museum Volunteer. However, the curators responsible for the exhibit (R. Gould and J. Bird) also felt that a firsthand acquaintance with the methods and problems of this approach was needed. Thus it was that in May, 1969, the authors along with Dr. Bird spent two weeks together in Mr. Crabtree's lithic workshop in Kimberly, Idaho, discussing, observing, and trying out experiments of our own.

As a result of this period spent together, "on the rockpile" as we called it, we realized fully for the first time several important facts about the art of stone chipping. To begin with, it is an art. Although there are many aspects to stone chipping that look mechanical and repetitive, there is scope for craftsmanship, too. There is a need for physical strength, co-ordination and intelligent planning, just as there is in becoming a skilled carpenter or bowler. And some people are better at it than others, or at certain techniques than others. For example, there is a tacit understanding between one of the authors (Crabtree) and French archaeologist and stone-chipper, François Bordes, that while one of them is slightly more accomplished at percussion-flaking, the other is somewhat better at pressure-flaking. Any analysis of ancient stone tools, particularly those of complex design, must take this fact into account. Ancient stone tools are not always as uniform in character as some archaeological typologists would have us believe, and some of this variability may be attributable to individual differences in skill and craftsmanship even when the same methods of manufacture were used.

Another basic fact to emerge from this 2-week session was an appreciation of the importance of the various kinds of raw material used in stone tool manufacture as well as the kinds of tools (i.e. billets, hammers, punches, and pressure-flakers made of bone, antler, wood, and stone) used to shape these raw materials. We found that a slight difference in the texture of the stone material or in the weight or shape of a billet could make a dramatic difference in shaping a stone tool. These variables had to be considered before we embarked upon any toolmaking experiments and, indeed, they were the subjects themselves of a number of important experiments which we found it essential to describe in the exhibit.

Here, truly, was an activity in which one learns by doing. Films and demonstrations are always helpful, as are written descriptions, but in planning an exhibit of this kind we found that we had to work with the materials ourselves before we really understood the problems involved clearly. At the same time, this 2-week session afforded one of the authors (Gould) an opportunity to get specialized photographs of certain stone-working experiments for use in the exhibit, and it enabled us to make and organize various types of stone tools, flakes, cores, and blades specifically for the exhibit. In most museum exhibits one presents the specimens one already has, but we stood this approach on its head by making the specimens for the exhibit. To supplement the exhibit, we also arranged a loan of examples of work from earlier experiments from the Museum of Anthropology at Idaho State University in Pocatello (in which we were assisted greatly by the help of Dr. Earl Swanson).

It was also during this session that the basic plan of the exhibit took shape, and with it there developed an unusual division of labor regarding the actual preparations. While Crabtree prepared most of the materials used in the exhibit and the expertise concerning them, Gould assumed the task of selecting archaeological and ethnographic stone tools from different periods and localities from the A.M.N.H. collections, organizing them into display cases, and writing label copy for the exhibit. Since Gould had to leave New York in August, 1969, for a year of fieldwork in Australia, Bird supervised the actual construction of the exhibit, seeing that artifacts, photographs, and labels were arranged correctly and making last-minute changes when necessary. He also saw to the arrangements concerned with Crabtree's demonstrations for the public of stone-chipping for eight days at the start of the exhibit.

It had been hoped to use an edited version of the film, The Shadow of Man, showing Crabtree at work and made by Idaho State University, in the exhibit area following the series of live stone-chipping demonstrations. However, funds were not available for this, so a self-operating slide show of stone-chipping by Crabtree and by some Australian Aborigines was used instead. In retrospect, it still seems as if some kind of motion-picture film would have been preferable to the slides (although the slides were well received and fitted in better than originally expected). Our reason for saying this stems from the difficulties we experienced in describing the motor patterns connected with stone-working. These simply have to be seen to be understood, and no amount of verbal description or sequences of still photographs can communicate the true nature of these complex motions.

The task of organizing and installing the exhibit was made easier by the use of 23 display panels of uniform size and shape. These were simple in design and flat-backed, with easily detachable glass fronts (a tremendous advantage later on, as the Exhibition Department found, when they wanted to photograph the displays in place). The panels were arranged in a wide circle, facing inward, and were numbered sequentially from left to right from the point where the visitors entered. Crabtree presented his stone-chipping demonstrations within the area enclosed by the exhibit. Since an auditorium-style seating arrangement does not work well with this type of demonstration, it was found that the best arrangement was to allow the public (including press and television) to array themselves around the mat on which Crabtree did his work. This limited the number of visitors who could watch at one time, but, because most stone-chipping work occurs close to the body of the person doing it and cannot be seen except up close, it did not really matter. Unless one uses closed-circuit television, only about thirty people at once can comfortably watch a stone-chipper at work. Nevertheless, these demonstrations were all packed with visitors, many of whom no doubt had difficulty in seeing what was happening. The exhibit was designed by Mr. George Gardner of Yang-Gardner Associates, New York, and was built by Lynch Exhibits of Pennsauken, New Jersey. The total cost of the exhibit was approximately $28,000.00. The installation of the exhibit in the Museum took only four days, and dismantling at the end was accomplished in only one day.

Only one major problem was encountered during the exhibit. The individual display cases were not sealed, and there was enough of an opening on the sides to allow someone to slide his hand inside each case from behind. As a result, several specimens were stolen (one of these was recovered after a spectacular chase by a guard through the halls of the Museum) before this defect was remedied. These openings on the sides and also on the top of each case also meant that dust gradually settled over the materials inside. By the end of the exhibit this was quite noticeable. Any future attempts to present this type of exhibit must be checked for security, since objects like stone arrowheads and spearpoints are both tempting to the potential thief and relatively easy to conceal.

The Displays:

It was in the display cases themselves that the essential nature of experimental archaeology became apparent. In this paper we would like to review a few of the more dramatic examples, treating them as case-studies of both this scientific approach and the ways it was presented:

<u>Artifacts of Man and "Artifacts" of Nature:</u>

As one of the authors (Gould) can attest, scarcely a week goes by in a large museum when someone does not bring in a bag, valise, or cigar-box full of stones to be examined by one of the curators. These people bring their stones to an archaeologist rather than to a mineralogist because they have reason to believe that these rocks were shaped by ancient man. Upon examination, however, most of these rocks prove to have been shaped by nature rather than man. Inevitably one is asked the question: "How can you tell a naturally-shaped stone from one shich was shaped or used by human beings?" This is a fair question, and it has concerned scholars as much as it has the small boy who shows up in a curator's office clutching a bag of stone arrowheads. There are many cases of archaeologists who have mistakenly identified natural rocks as human artifacts in their excavations and surveys; and the reverse situation, where archaeologists sometimes fail to recognize stone tools among the materials they are dealing with, is not unknown either.

In cases like these the experimental approach has proved of benefit. Because this is such a basic question, it seemed to us that this was a matter which should be dealt with in one of the first displays in the series. It is not enough to say that the stones in a given assortment were formed by natural processes. One must be able, eventually, to show how certain stones do indeed look like some man-made stone tools, and one must be able to understand clearly how they got to be the way they are without the agency of man as a factor.

In one series of experiments, Crabtree placed some pieces of suitable stone (flint, chert, etc.) in fires and kilns to heat them rapidly, causing a phenomenon known as "potlidding." Rapid heating and cooling of these kinds of stone can cause round, lenticular pieces to become detached from the main body of stone. These pieces, he found, can vary greatly in size, often occurring in sizes which we might regard as convenient for stone tools. Potlidded flakes (due mainly to solar heat) occur commonly in nature and comprise one of the most common classes of material claimed as human artifacts.

Stones which have been rolled downhill (as, for example, in rockslides and avalanches) or tumbled in water on a rocky beach or in a creek also are likely to show signs of breakage and chipping which are easily mistaken for human workmanship. Crabtree and others have found that in any collection of this sort there are always a few stone flakes which are indistinguishable from man-made flakes. At his laboratory he has recreated this situation by dumping loads of obsidian and other suitable lithic materials from the bed of a truck. In picking through this material afterwards he has been able to find a few flakes which, if they occurred in an excavated human habitation or quarry, would instantly be accepted as man-made. In cases like these it is the extremely low percentage of these flakes with respect to the amount of other material present that shows it is not worked by man. Also, in these "dumped" lots there can occur relatively large numbers of particular kinds of stone flakes which appear only rarely in human sites (where, as experiments have shown, they occurred as mistakes by the stone-chippers). Quantitative experiments of this kind can show archaeologists what to expect from sites in which only natural processes account for the materials present as compared with the situation in genuine human sites.

One of the authors (Gould) has even suggested the possibility that one day we will be told that there were once men living on the moon. Now that lunar exploration is underway, this possibility may not be as far-fetched as it sounds. Many of the natural processes studied by Crabtree in his experiments operate on the moon just as they do on earth. As lunar exploration becomes more intensive in the future we may hear of the discovery there of human artifacts of stone, and no doubt such a discovery can be counted on to generate much frothy debate in the press and news media. But experimental archaeology by then ought to have amassed a body of data sufficient to settle such debates, whether they occur on the moon or back on earth.

In the displays discussing this question, examples of "natural artifacts" produced in experiments were shown side-by-side with similar objects found in nature. This presentation set the stage for the further discussion of how to recognize man-made flakes and artifacts, even when the workmanship on them is minimal. Man-made stone flakes and cores were presented in such a way as to indicate their identifying characteristics and with explanations of how these characteristics arose during the processes of manufacture.

Processes of Manufacture:

The backbone of the exhibit consisted of a series of displays devoted to showing how experiments have led to the discovery of various ways in which different kinds of stone artifacts, known from different localities and time-periods, could have been made. Stone artifacts from the American Museum's collections were placed alongside examples of Crabtree's work. In some cases the various stages in the manufacture of a particular object were represented. The live demonstrations presented by Crabtree were mainly concerned with showing these techniques of manufacture, as were many of the slides later on.

Broadly speaking, these techniques comprise two main types; percussion-flaking and pressure-flaking. It is in this latter category that the experimental approach has offered some unique contributions. For example, there is the case of heat-treatment of lithic materials. In an important series of experiments, various kinds of lithic materials were placed in a kiln and subjected to controlled heating at different rates and temperatures. It was found that heating could alter certain stone materials in such a way as to change the stone's appearance and make it easier to pressure-flake. Certain cherty materials with a rather gritty, rough textured finish were rendered smooth and almost glassy in appearance. The removal of flakes from these stones by means of pressure was found to require less effort and produced more even and precise results than had been true for the same material before the application of heat. Examples of chert and flint which had been transformed in this way were presented in a "before-and-after" sequence in one of the cases.

This discovery, the result of laboratory experiments by Crabtree, became a hypothesis which accounted for the unique attributes of pressure-flaked stone tools found archaeologically at different periods in different parts of the world. For example, many of the fine, pressure-flaked stone projectile points made by the Paleo-Indians of North America were clearly prepared in this way. Awareness of the heat-treatment method has led to a new appreciation by archaeologists of the high technical skill of ancient flint-knappers, even, as in the case of the Paleo-Indians, over 10,000 years ago.

Along these same lines, there is a series of experiments aimed at reproducing exact replicas of the Folsom Fluted Point (the Paleo-Indian projectile point type mentioned earlier in this paper). The technical difficulties involved in making this particular type of stone point are formidable, particularly in the final stages when the longitudinal channel flakes are removed from each side. These experiments show that the removal of these flakes can be accomplished in at least two completely different ways. On the one hand, one can press the flakes off by using a shoulder-crutch with a hard, pointed tip. On the other hand, one can strike the flakes off by means of indirect percussion, using an antler punch to direct the blow struck by a hammerstone or billet. Both methods give satisfactory results and provide alternative explanations for how this technical feat could have been accomplished by the ancient Indian stone-chippers. Demonstrations and descriptions of both of these methods, with examples of the finished and semi-finished products, were presented in the exhibit.

Perhaps the most elegant series of experiments presented in this exhibit concerns the production of ancient Mexican blades of obsidian (a natural volcanic glass).[1.] Despite fairly detailed descriptions by Torquemada and other early Spanish observers, archaeologists have always found it difficult to understand exactly how these fine blades, many of them long, thin and of exceptional regularity of size and shape, were produced. In these experiments it was clear from the start that this blade production must have required a mechanical clamp of some kind, and the early Spanish accounts indicated that a chest crutch with a hard tip was used to press the flakes off from their stone core. After much trial-and-error a simple and successful clamp was constructed of two boards and some metal brackets which held the stone core firmly in place and which could be anchored securely by the operator standing on it as he worked. A clamp of this kind would have been easy for the ancient Mexican stone chippers to assemble and use. Working with the chest crutch and clamp, exact replicas of the ancient Mexican blades and blade-cores were reproduced easily and repeatedly, suggesting that this was indeed the way these blades were produced originally. Examples of Mexican

[1.] For a detailed account of these experiments see, Don E. Crabtree, "Mesoamerican Polyhedral Cores and Prismatic Blades," <u>American Antiquity</u>, Vol. 33, No. 4, 1968, pp. 446-478.

blades and cores from the American Museum's collections were exhibited alongside the results of Crabtree's experiments along with photographs and drawings illustrating the clamp and crutch method in use. This method was among those demonstrated by Crabtree at the beginning of the exhibit, and then, as throughout these demonstrations, examples of the finished products (blades, cores, flakes, handaxes, arrowheads, etc.) were passed around among the visitors so they could see the results more closely.

Other Experiments:

Other topics presented in the display included; "Hafting", "Stone Tools to Make Other Tools", "Raw Materials and Quarrying", "Ground and Polished Stone", and "Virtuosity in Chipped Stone."

The exhibit also gave an opportunity to show some of the earlier and less well-known efforts which had been made in this direction, In particular, it was found that Dr. N. C. Nelson, who for many years was Curator of Archaeology at the A.M.N.H., had conceived and carried out several useful experiments. We were fortunate to possess the notes on these experiments as well as the materials produced during them, so they, too, became a part of the exhibit.

From a historical point of view, the most interesting of Nelson's experiments occurred in connection with his studies of Ishi, the last wild Indian of North America, in 1912. Ishi, the survivor of a small band of Yahi Indians, emerged from his hiding place in northern California in 1911. Until he died in 1916, Ishi lived at the Museum at the University of California in San Francisco supplying information about traditional Indian life to scholars and giving public demonstrations of his stone-chipping.[1] During the time he spent

1. For a readable and accurate account of this Indian's life, the reader should see Theodora Kroeber's Ishi in Two Worlds, University of California Press, Berkeley, 1961.

with Ishi in California, Nelson photographed him at work and learned directly from him how to make stone arrowheads and spearpoints. These photographs along with examples of both Ishi's and Nelson's work were displayed in the exhibit.

Later on Nelson carried out a series of experiments with some ancient Danish groundstone axeheads. He attached these to wooden handles and used them to chop down trees of various sizes, timing the results and observing the wear occurring along the working edge of the tool after use. One of these hafted stone axes along with the section of a tree he cut down with it in six minutes were displayed together in a case relating to ground and polished stone tools. Nelson, as a scholar, was often ahead of his time in the ideas he developed and tested, although his research results were not always too widely known. Thus we were pleased to be able to present these aspects of his research before the public for the first time.

Conclusions:

Above all, this was a teaching exhibit. Few of the artifacts displayed in it could be rated as art objects, so it would not be possible to justify the exhibit on artistic grounds alone. The exhibit was intended, instead to demonstrate to the public the validity of an idea which we here are calling Experimental Archaeology. The enthusiasm and interest shown by the visitors justified our efforts and may even have generated some interest among professional archaeologists and students of archaeology to pursue this approach in their own research. At this time the entire exhibit is being readied for shipment to the Museum of Anthropology at Idaho State University, where it will soon reappear.

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Experimental stone working archaeology is useful for it allows the experimenter to view theresults of applying force to flint-like materials. He can then analyze and evaluate the character of both the flakeand flake scar whether made by intent or miscalculation. It is not necessary to become proficient in the art of flintknapping to be able to identify flakes that result from certain conditions of the experiment and to note the wide range of different characteristics of flake styles. Even a try at working stone will help to identify a shell-like conchoidal flake which is characteristically different from a long parallel sided blade. Experimental flintknapping readily demonstrates that the method must be preconceived and the technique executed before the flake or blade is removed.

Experimental flintknapping archaeology also demonstrates the importance of recovering the flaking debris which results from the manufacturing stages. Then the flakes may be related to the stages of fabrication from its inception to completion; or from the rough stone to the completed product. Each stage may show one or more diagnostic traits, while the finished product will show only the final stage of flake scars on the finished artifact and one has to postulate the first and intermediate stages.

When one becomes familiar with flake characteristics, he may be ableto determine - or hypothesize - the implement used for flake removal; postulate the technique, and determine the direction of applied force as well as many other features useful to the prehistorian for interpretation of ancestoral traits in time and space.

Heating the material prior to flaking relieves internal stresses and strains and at the same time makes the material more vitreous and glassy than in its raw state. Glassy treated material is more elastic and produces sharper edges. Each material has a different response to the application of heat. Alteration temperatures and time periods of heating and cooling vary according to the kind and size of the lithic material. The thermal treatment process is considerably more complex and sophisticated than simply dumping the stone into a fire. But thermal alteration is not desirable for drill