Fractures in Knapping

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Preface

The book is for students and practitioners of not only knapping, lithic technology and archaeology, but also of fractography and fracture mechanics. At the conferences on fractography of glasses and ceramics, I have been asked to demonstrate knapping as well as provide overviews of fractography learned from it. The first part of the book is intended to stimulate such interests further, in order to solicit contributions from a largely untapped pool of experts. Such contributions can advance significantly our understandings of knapping as well as fractography. In Part II of the book, fracture markings as the tools of fractography are introduced, with their formation, meaning and utility explained. Observations on the presence or absence of the markings in knapping are considered in Part III, along with a number of interpretations of fracture features.

The basic principles and concepts of fracture mechanics and fractography apply to fractures produced in any cultural context. It is therefore prudent to address most questions on fracture in a generic sense, independent of cultural contexts. In general, understanding of fractures provides a sounder basis for lithic analysis, and use of more recent scientific tools opens new avenues for lithic studies.

For stimulating my interest in archaeology, lithic technology and even fractography, I thank Ralph Solecki. Part II of this book is an expanded version of my lectures at Columbia. It was a pleasure to have many useful discussions on knapping with Jack Cresson, Scott Silsby, J.B. Sollberger, Errett Callahan and others

I am indebted to Don Crabtree for stimulating my interests in flintknapping, and putting me in contact with V.D. Fréchette to whom I am deeply grateful for many inspiring and enlightening discussions over 22 years. During my earliest years of pursuing knapping fractography, I had many fruitful discussions with Stephen W. Freiman. I am grateful for his insights and for his kindly pointing me in in the right direction with many ideas. Herbert Richter encouraged my attempts at fracture mechanics approaches to knapping, and Kouichi Yasuda occasionally steered me from the wrong paths in these attempts.

I gratefully acknowledge the receipt of some unusual industrial glass from Ernest Chrisbocker, the preparation of obsidian test specimens by Mark Green and the testing on obsidian by Kouichi Yasuda. I thank Ene Inno for editorial assistance and Sushant Singh for his help with the electronic version of the manuscript.

PART I: ELEMENTS OF KNAPPING

1. Knapping Past and Present

Introduction

Many species of animals not only use but also manufacture tools (Angier 2001, Beck 1980). For example, chimpanzees remove twigs from branches to “fish” for termites. They have also been observed to manufacture sharpened wooden spears, carrying them around and spearing bush babies in tree hollows. Tool manufacture by humans is vastly more complex, characterized by a greater anticipation of future needs and longer curation of the tools. So we humans see the difference.

For at least 99.5% of prehistory, artifactual remains consist primarily and often only of lithic remains. Archaeologists are greatly interested in extracting all relevant information from lithic artifacts. Understanding of flintworking (knapping) along with material properties can provide insights to functioning of prehistoric societies..

Knapping refers to the manufacture of artifacts by detachment of flakes. There are lithic artifacts whose manufacture involved significant pecking, grinding and polishing. Knapping by humans is not limited to manufacture and re-shaping of stone tools. It has also been used for shaping other, non-utilitarian artifacts (Fig. 1.1).

An understanding of knapping helps to distinguish characteristics of use-wear from those of manufacture on lithic artifacts. The principles involved in use-chipping are similar to those in flake production in knapping. But there are major differences in the scales involved, the manner of force application and the control of geometry.

Traditional Crafts and Industrial Society

At home I have lithic raw materials from five continents, including many states in the U.S. All transported by car or plane. Some mined with metal hammers and mining tools. My favorite hammerstones for obsidian are from Sun Valley, Idaho, some 3300 km away. Often I use antler from New England, the Midwest, Estonia or Sweden, as well as a zoo. I usually prepare antlers billets with a machine grinder, antler tines with a steel file. It requires little reflection to imagine how mind boggling the differences often are in practicing a traditional craft in an industrial as compared to a prehistoric society.

But that’s not all. Watching TV or using a keyboard, telephone or pen does not provide the manual dexterity or sense of craftsmanship useful for learning to knap and use proper precautions. At an obsidian conference in Pachuca, Mexico, a number of knappers were working with obsidian from large nodules. When a couple of small Mexican kids showed up to hammer at the nodules, I quickly asked the conference organizer to stop them,

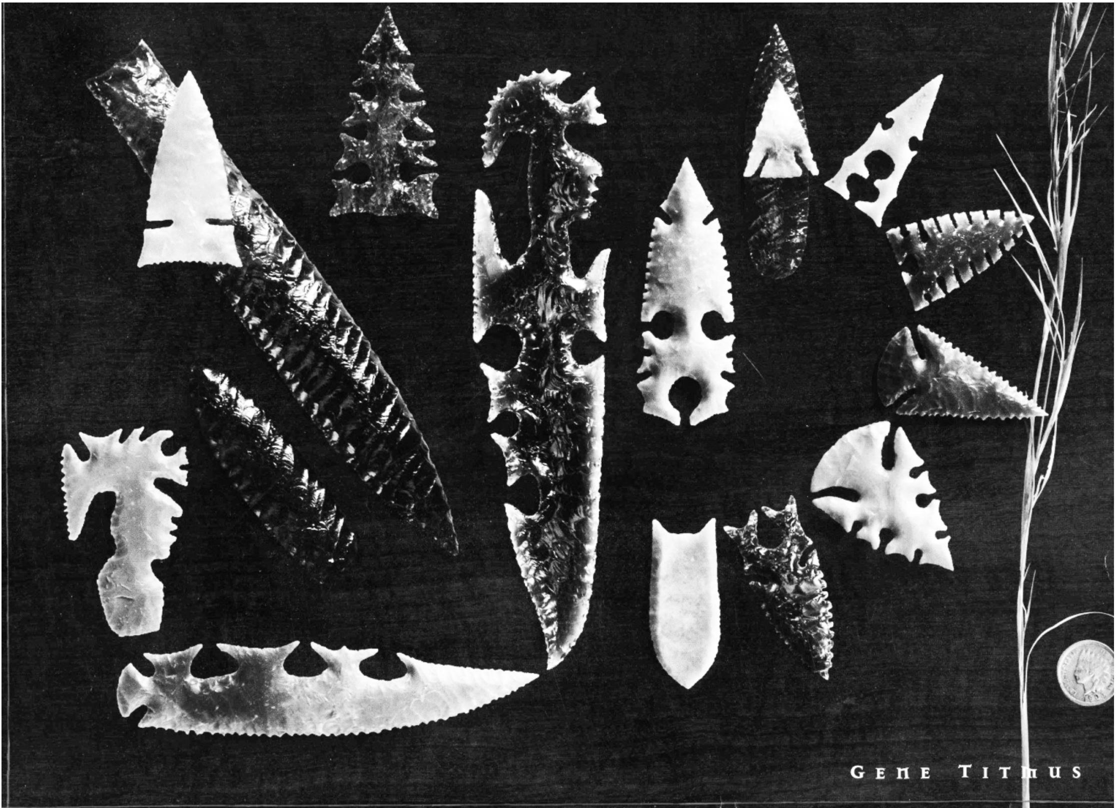

FIG. 1.1 REPLICAS OF SOME UTILITARIAN AND NONUTILITARIAN ARTIFACTS BY GENE TITMUS (PHOTOGRAPHY ©MCLEANDESIGN.COM; REPRODUCED WITH PERMISSION.)

fearing they might get hurt. Knowing better, he left them alone. Sure enough, they did not cut themselves. They had grown up in an environment where manual dexterity is more commonplace. A number of today's best knappers are also good with other manual skills, such as woodworking.

Today our apprenticeship in knapping may come not only through observation of other knappers, but also through reading or watching knapping videos, even on the Internet. Many contemporary knappers practice the craft after working hours with limited time. François Bordes once observed an Australian aborigine scrutinize a nodule some 45 minutes before striking the first blow. The meaning and organization of time in that society was very different.

Information on knapping in its broadest sense obtained from contemporary practice of the craft is necessarily limited, devoid of comparable cultural contexts. An old Spanish ethnographic description of some special blade production in Mexico noted that the knapper had to fast for five days. To the accompaniment of a chant, the blades were then pressed off. If a blade broke, it indicated the knapper did not fast properly. Such information can hardly be obtained from archaeological evidence or contemporary knapping experiments.

Prehistoric Knapping

Flintknapping has been practiced for at least a couple of million years, known from the Hadar and Gona sites in Ethiopia (Semaw et al. 1997). In the Old World, knapping in some form or other was still practiced during the Neolithic period and later. It was practiced by the American Indian after the European contact period, with some remnants considerably later. In a few societies in the world, it is still practiced today.

Interesting observations from prehistoric knapping can be made on the efficiency of material utilization. For obtaining a certain length of cutting edge per unit weight of material, blades (long, roughly parallel-sided flakes) are by far the most efficient. In one experiment, 2.1 cm of cutting edge per gram of the preformed polyhedral obsidian core was obtained with pressure flaked blades (Sheets and Muto 1972). Blade production at a high level of skill was practiced, for example, by a number of Upper Paleolithic and Mesolithic cultures. The changes in flintknapping technology during the Lower and Middle Paleolithic are evident even to the nonspecialist, as reflected in the changes from the crude choppers to thick bifaces to thinner bifaces. Some of the very finest flintworking craftsmanship ever, such as some of the Solutrean laurel leaves, is from the Late Paleolithic in France (Fig. 1.2).

Fig. 1.2 A Solutrean laurel leaf from Volgu, France. The cast is 27.4 cm long and about 7 mm thick. (The photo is of a cast from the Museum of Man in Paris.)

In the New World, some of the finest flintworking is from the Paleoindian period (Fig. 1.3). Some very fine craftsmanship in the New World can also be seen much later, at times with wide trade networks for nonutilitarian goods. These also suggest knapping craftsmanship beyond utilitarian needs. A word of caution, though: Extremely fine craftsmanship in itself does not imply a nonutilitarian function, as demonstrated by some Paleoindian points. Perhaps we tend to prejudice our hypotheses by our own notions of time and its organization. Examples of extremely fine craftsmanship can also be seen in the Gerzian flint knives from Egypt (Fig. 1.4) and the flint daggers from Denmark (Fig. 1.5). For the Gerzian knives, as well as for the Type IC Scandinavian daggers (Fig. 1.6), surfaces were ground in order to achieve best control in flaking. On the Egyptian knives, only one face was flaked. A nonutilitarian function is suggested for these artifacts.

A specialized technique was used for the manufacture of the Neolithic square section axes of Denmark (Fig. 1.7 and Vang Petersen 2008). After flaking to a square cross-section, they were ground. The axes as well as the daggers were traded very widely (Apel 2001). Not all of the axes were utilitarian. Some exceptionally fine ones, probably prestige items,

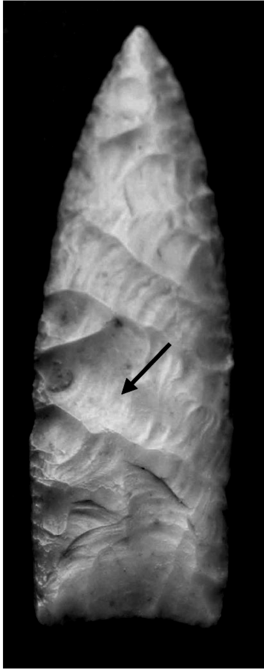

FIG. 1.3 A PALEOINDIAN CLOVIS POINT FROM BLACKWATER NO.1 SITE. 10.6 CM LONG. THE ARROW INDICATES A FRACTURE MARKING KNOWN AS A SPLIT RIDGE (CHAPTER 8), SEEN POORLY. (PHOTO IS OF BOSTROM'S PLASTIC CAST BY KRISTIAN METS.)

have been found in caches. There is a specimen 46.5 cm long at the Danish National Museum in Copenhagen. This could not have been utilitarian.

There are numerous other examples of nonutilitarian flaked stone artifacts from prehistory. From the New World these include flaked animal representations and the Mesoamerican, Hohokam and other eccentrics (Clements and Reed 1939) (Fig. 1.1). From Vietnam, there are two unusual examples of "lithophones" (lithic xylophones), with extremely large bifaces of variable sizes to produce the different notes. The longest of the bifaces measures about 90 cm.

From prehistory there are numerous examples of ground and polished implements of obsidian, flint and other stone materials. From Mesoamerica, unusual examples from obsidian include large mirrors, extremely delicate earspools (Thomsen and Thomsen 1971) and an exquisite vase with a monkey for decoration. Both in the New and Old Worlds, the decline in prehistoric flintworking reflects changing lifeways and a shift in emphasis to other crafts and activities. Many examples of prehistoric knapping are illustrated in Bordes (1968) and Bordaz (1970).

Recent and Remnant Knapping Traditions

The last American Indian to retain (until 1911) traditional lifeways, as a lone survivor of his tribe, was Ishi, a Yahi Indian (Holmes 1919, Heizer and Kroeber 1979). Remnants of some knapping among American Indian include the Maya in Guatemala (Hayden 1987) and the Xêtá Indians in Brazil (Miller 1979). Hayden discovered use of flaked basalt chopping tools in making of metates (grinding stones). Miller reported on use of flint flakes among the Xêtá, a tribe with only six survivors at the time.

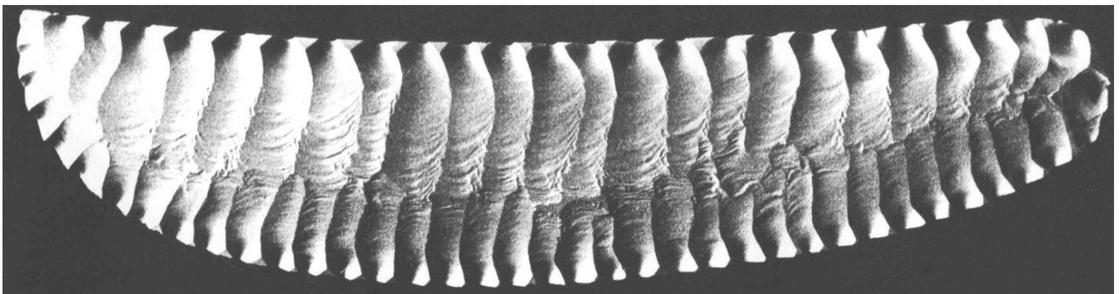

FIG. 1.4 REPLICA OF AN EGYPTIAN PREDYNASTIC GERZIAN KNIFE. FLINT, 25.2 CM LONG. (KELTERBORN 1984. REPRODUCED WITH PERMISSION)

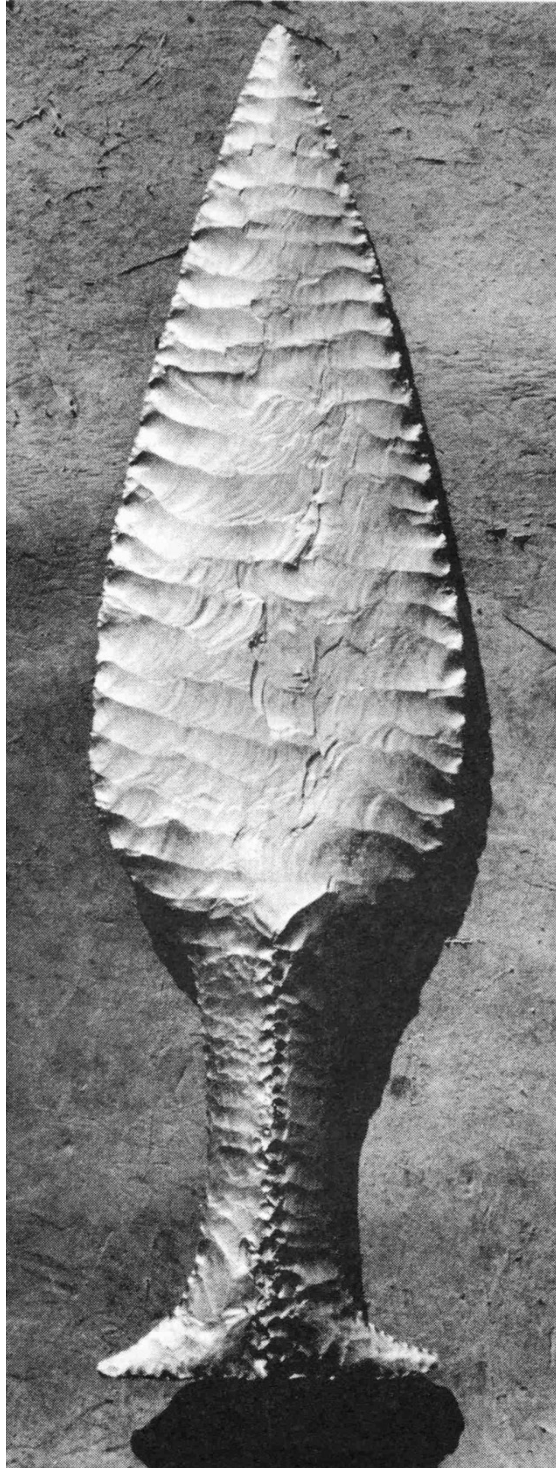

Fig.1.5 Type IV-E Danish dagger. Errett Callahan's replica of the famous Hindsgavl Dagger. Flint, 29.3 cm long. (Callahan 1999, reproduced with permission)

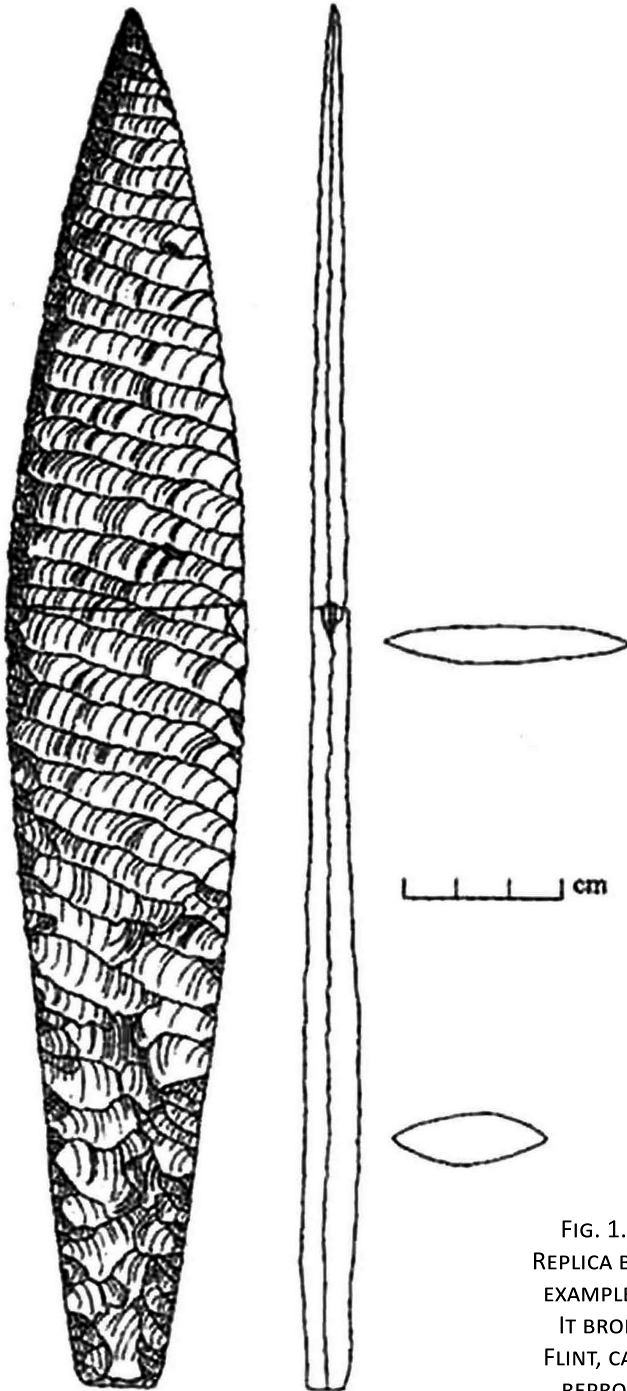

Fig. 1.6 Type IC Danish dagger. Replica by Greg Nunn. An excellent example of edge-to-edge flaking. It broke during final retouch. Flint, ca 26 cm long. (Nunn 2006, reproduced with permission.)

FIG. 1.7 REPLICAS OF NEOLITHIC SQUARE SECTION AXES OF DENMARK BY THORBJORN PETERSEN (COURTESY OF ERRETT CALLAHAN. PHOTO BY JACK CRESSON).

Knapping has been observed among aboriginal tribes in Australia (Tindale 1985, Hayden 1979) and New Guinea (Blackwood 1950, White 1967). Use of traditional knapping in New Guinea has also been observed very recently (Schick and Toth 1993, Hampton 1999). Flaked stone axes were made, utilizing the flake biproducts for miscellaneous other tasks for which they happened to be suitable.

Recent uses of modern glass as tools have been reported for many parts of the world, including Australia, Africa, the U.S., Greece, France and Great Britain. Use of teeth in edge chipping of obsidian blades has been observed in Africa.

Some Specialized Knapping Traditions

Three specialized knapping industries – which may be viewed as traditions – are noted here. The youngest of these is the production of flint blocks for liners in ceramic industry. Gunflint manufacture as an industry is some 400 years old. The production of flint inserts for threshing sledges dates back thousands of years, to Roman and earlier times.

Gunflints

Gunflints are thought to have been used first in the 15th century. Leonardo da Vinci illustrates a flintlock mechanism in his *Codex Atlanticus,* dated 1490 (Shepherd 1972). With inventions of new flintlock mechanisms, use of gunflints became more significant from the early 17th century on, peaking during the Napoleonic Wars. The British army abandoned the use of flintlock rifles around 1850.

The need of gunflints in flintlock arms brought to life a new flintknapping industry. The most extensive gunflint manufacture was in England and France, with manufacturing centers also elsewhere.

Production of gunflints in England involved three specialists. A "cracker" would "quarter" or break a nodule with a large metal hammer to get a flat platform, and remove preliminary flakes and blades to prepare the cores. A "flaker", the most skilled craftsman, would use a small metal hammer to produce blades – the larger ones about 15 cm X 2.5 cm. An expert knapper could produce 5000 to 7000 blades a day. Finally, a "knacker", later called a "knapper", would break and trim the blades into segments for use as gunflints. For this task, one family in the 19th century is reported to have used a specially tempered cast steel file for a hammer and a square rod of soft iron, covered with leather, set in a wood block at an angle (Shepherd 1972). From good blades, an expert "knacker" produced some 300 gunflints in an hour. Finally, gunflints were sorted and then counted, sometimes at the rate of 20 000 an hour!

In England, the tradition still survives as a part-time occupation to produce gunflints for antique arms and hunters using flintlock rifles. The last gunflint knapper at Brandon, Fred Avery, died in 1996. In France, the tradition lasted at least until 1920. More recently, the son of Fred Avery has taken up knapping for gunflints.

In mid-1800s just before the Crimean War, 36 knappers at Brandon shipped 11 million gunflints in one year to Turkey alone. Brandon gunflints were still used by Abyssinians against Mussolini in 1935, and at least until the 1960's in West Africa because of a prohibition on firearms except flintlocks (Shepherd 1972).

The productivity at Brandon can be appreciated from the following (Forrest 1983):

- During 1880 – 1885, one shop produced over 23 million gunflints.
- In 1813, the quota ranges placed on individuals were from 60 000 to 156 000 per month.
- About the same time during the Napoleonic Wars, 14 Brandon masters were called upon to produce 1,500,000 musket flints a month in a national emergency.

A 75 year old knapper recalled in 1950 that his apprenticeship started at the age of eight. Many knappers died at an early age of lung disease due to inhaling silica dust (Kalin 1981).

In 1983, I visited the pub Flintknappers Arms in Brandon. It used to belong to a gunflint knappers family. There was a workshop with a shed and a vast amount of knapping debris in its backyard. Several exhausted blade cores (Fig. 1.8) were seen along

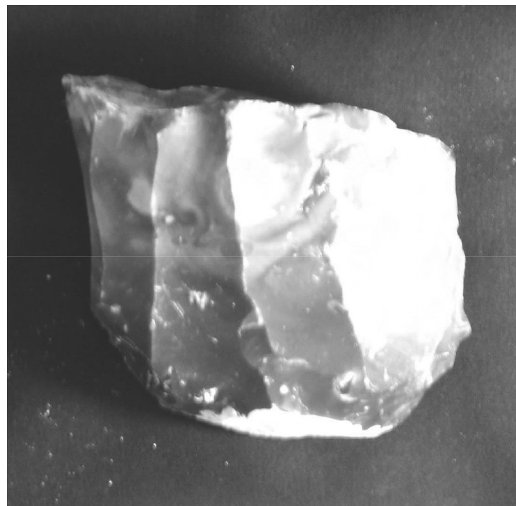

FIG. 1.8 AN EXHAUSTED BLADE CORE ON THE GUNFLINT KNAPPERS WORK FLOOR AT BRANDON.

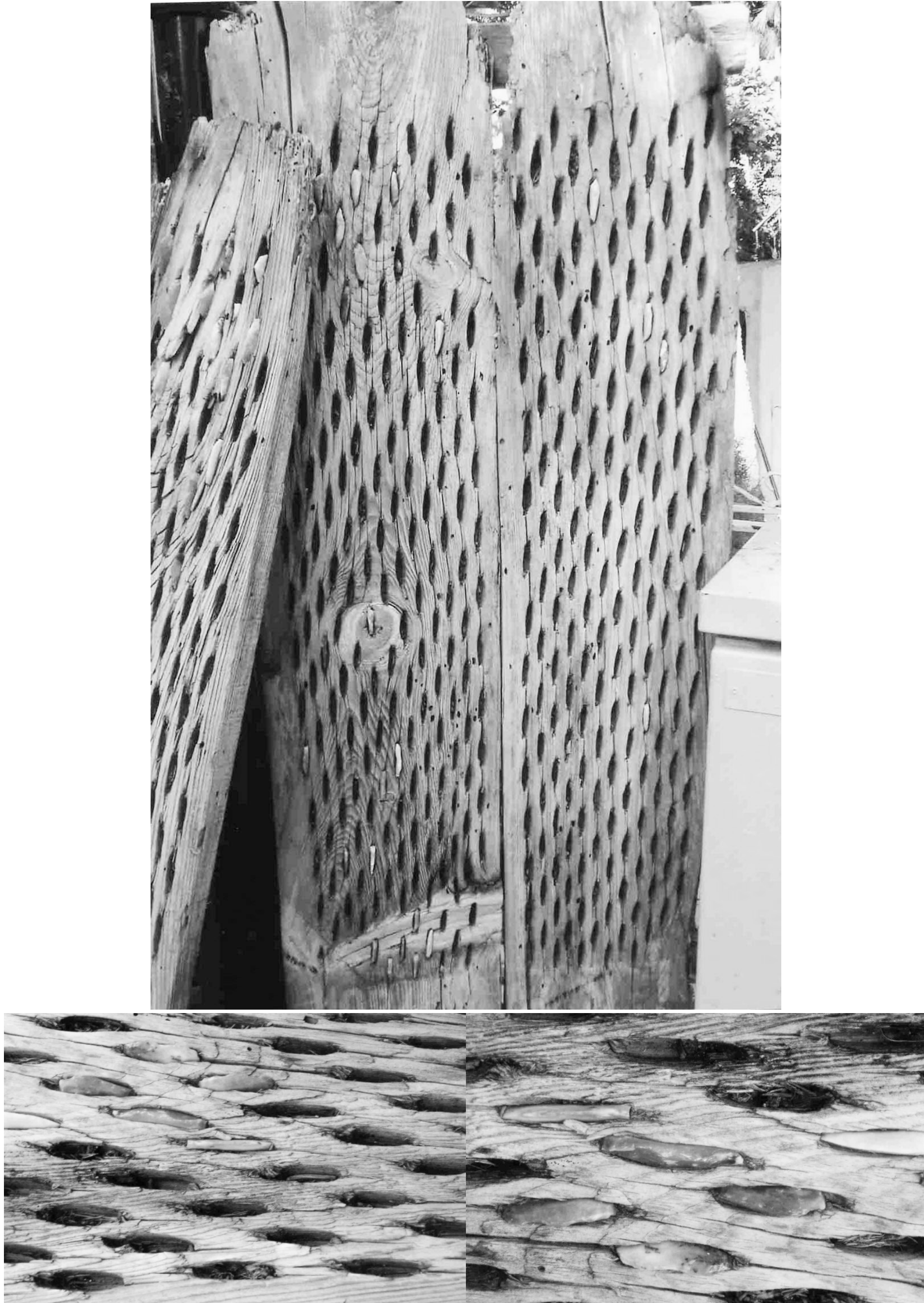

Fig. 1.9 Threshing sledges in Turkey. The one at the right, as well as the partly seen sloping one at the left, has two wide blanks. The lower two photos show the details of the flint blade inserts. These were in a "coffee shop" in the tourist section of Antalya.

with a number of proximal and distal blade sections as well as a few blades, all unsuitable for gunflints.

Threshing Sledges

Bordaz (1969) and others (Gebel 1980, Weiner 1980, Whittaker 1996, Whittaker et al. 2009) have reported on a recent or contemporary flintknapping industry in Turkey associated with threshing sledges.The sledges are usually made of two or three blanks side by side with flint inserted on their underside (Fig.1.9). They are used after a harvest to separate the grain and to chop up the stalks to facilitate winnowing. Professional knappers use soft steel hammers near the mines to produce the flint blades and flakes that are then transported to a village to be trimmed and retouched with metal hammers into forms suitable for inserting in a sledge. One knapper reported producing 4000 blades a day. Such threshing sledges were still made in Turkey in 2000.

A threshing sledge industry of recent times was widespread in the Mediterranean region. It has been reported most extensively for Cyprus, where it disappeared about 50 years ago as a viable occupation. Threshing sledges are still used extensively in Morocco. Many threshing platforms can be seen today in Southeast Morocco.

In recent years, threshing sledges have appeared for sale in antique stores in Paris and the U.S. The use of threshing sledges with flint inserts is an old tradition. A threshing sledge was known as a tribulum to Romans. They are also referred to in the Bible (Whittaker 2008: 5).

Ceramic Industry

Until the beginning of the 20th century, there was a knapping industry in Eben-Emaël, Belgium, for producing flint blocks for liners in steel drums used mostly in the porcelain industry (Fig. 1.10). The description here is based on Slotta (1980) and Callahan (1985).

The drums were used as mills for pulverizing the kaolin for making porcelain, or for other milling. The liners served to prevent discoloration of the kaolin by contact with the metal. The drums were cylindrical, with either flat or cupped ends.

Large flint nodules were "chopped" into sections by a sledge hammer, and little flaking was then used to dress the blocks with a smaller steel hammer having a very hard tungsten steel insert. It is quite remarkable how the production was optimized to use a minimum effort to yield finished blocks of almost identical shapes and sizes, mostly with rectangular or trapezoidal cross sections. One knapper at Eben-Emaël estimated working a ton of flint daily.

In the "chopping" of the nodules as well as the flaking to dress the blocks, the fractures had wedging initiations (also known as "split cones" or "shearing fractures") characteristic with a very hard percussor or flaker. Similar fracture initiations are encountered in the production of flint blocks for buildings.

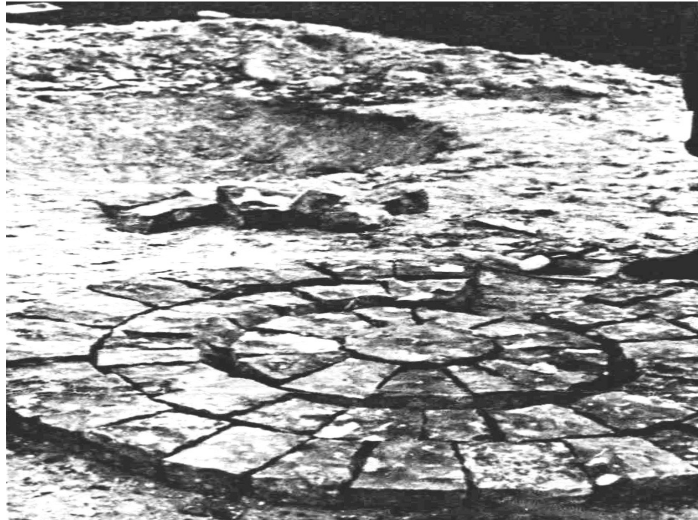

Fig. 1.10 Knapped blocks at Eben-Emaël for porcelain industry. Squared blocks for end of the mill. (Callahan 1985. Reproduced with permission.)

The flint liner blocks in Eben-Emaël have been produced for a number of countries in Europe, as well as Africa and the U.S. It was reported in 2000 that the Eben-Emaël industry would close very shortly, because ceramic materials were replacing the flint as liners. At that time, there were similar industries still operating in the former Yugoslavia and China.

Modern Knapping and Recent Explosion Of Interest

A slow revival of flintknapping began with experimentation going back to the 19th century (Lewis Johnson 1978). In the 3rd quarter of the last century, especially since the 1960's in the U.S., there was a significant resurgence in the craft of flintknapping. The last quarter of the century saw an explosive expansion in the practice of knapping. It is too early to assess its impact, but it may very well be drastic, with positive as well as negative implications for archeology (Whittaker and Stafford 1999, Whittaker 2004).

"Modern knapping" is used here for all contemporary and recent knapping in industrialized societies. It is removed from the context of traditional lifeways, subsistence activities and value systems of a pre-industrial society. In that sense, all modern knapping is non-traditional with respect to the societies in which it is practiced. However, I will use the terms "traditional" and "non-traditional" in quite a different sense subsequently.

Why is knapping practiced today? For many reasons, including the following (Whittaker 2004: 136-146): for understanding how prehistoric tools were or could have been made; as a source of income by the production of "replicas" (and occasionally forgeries) or other artifacts not resembling any prehistoric ones; as a hobby for just the pleasure of practicing the craft, with its technical and esthetic aspects, as part of "living archeology" experience; for survival in nature interests; for the purpose and satisfaction of re-creating and practicing "primitive technology", meaning pre-industrial technology. The above

reasons are often overlapping for particular individuals. As Bruce Bradley, after some 40 years of experience aptly put it, "I do it for fun, art and science."

Until recently, most modern knapping has been experimentation to understand prehistoric stone tools and lithic industries. Some experiments have involved replication of only the end product, or attempted replication of the whole process of tool manufacture with the intermediate stages and by-products or only some aspects of the manufacturing process. The first scientist to give a public flintknapping demonstration was Sir John Evans in 1868 (Lewis Johnson 1978). He had observed the Brandon knappers, read ethnographic descriptions on knapping, and experimented personally. A number of scholars as well as others, mostly in England, experimented with knapping in the last quarter of the 19th century, with forgeries already a problem.

For 19th century knapping, reference must be made to the tragic tale of Edward Simpson, better known as Flint Jack, born in 1815. He was an extremely talented flintknapper with great curiosity about flint fracture and ancient implements - how they were made. He also considered good craftsmanship in flint an art, and took pride in some of his fine work ending up at the British Museum (without being identified as such). Flint Jack gave demonstrations to distinguished societies and scholars. He loved flintknapping above everything else, and refused to pursue a more comfortable occupation. Homeless and to avoid starvation, he stole and was jailed. Flint Jack's talents were appreciated by only a handful of scholars. But even they viewed him as a curiosity, oblivious to the potential scientific significance of his work. Flint Jack's tragedy, it seems, was being born ahead of his time (Blacking 1953).

Reference is made in Lewis Johnson (1978) to many knappers in the last quarter of the 19th and the first half of the 20th century. From the U.S., the names Havlor Skavlem (Pond 1930) and W. Holmes Ellis (1944) stand out. The former primarily because of Pond's extensive reporting, and the latter because of his landmark experimentation on a great variety of knapping techniques.

One must, of course, recall the knapping of L.S.B. Leakey and François Bordes. Because of their great fame as scholars, they also created much world-wide interest in knapping. The first films of flintknapping were made of Leakey and L. Coutier of France.

As discussed in Lewis Johnson (1978), a great impetus to flintknapping experimentation came by the archaeologist Earl Swanson "discovering" Don Crabtree, both of Idaho. Born in 1912, Crabtree had been knapping since the age of 7, but had never published. This led to the establishment of the Flintworking School sponsored by the National Science Foundation, to the 1964 Les Eyzies Conference, to numerous publications and films by Crabtree (1967a, 1967b, 1968, 1972), and the establishment of the *Newsletter of Lithic Technology*, later *Lithic Technology*. The Les Eyzies Conference brought a number of archaeologists together with the three most renowned knappers of the world: Don Crabtree and the archaeologists François Bordes and Jacques Tixier (Tixier 2012). The conference not only led to greater international communication and cooperation on knapping but, more importantly, to communication between archaeologists and non-archeologist knappers.

Among the contemporary French knappers is the master knapper and archeologist Jacques Pelegrin. The best students of Don Crabtree are the archeologists and master knappers Jeffrey Flenniken and Bruce Bradley. It can be said there are three knapping “traditions” in the U.S.: the Idaho tradition of Don Crabtree (1912-1980), the Virginia tradition of Errett Callahan, and the Texas tradition of J. B. Sollberger (1914-1995). By now, the influence of these traditions has spread across the U.S. and internationally (Whittaker 2004). Sollberger was a master knapper in Dallas, Texas. He had a lasting influence, mostly through personal contacts, but also publications (Whittaker 1994). Among the master knappers was the late Gene Titmus of Idaho.

The work of the master knapper Errett Callahan of Virginia has had the greatest impact on international communication among knappers and archeologists interested in knapping. He is an archeologist, artist, expert on survival skills, and has experimented on “just about everything” related to archeology or “primitive” lifeways, including ceramics, bows and arrows, and housing. He started the *Flintknapper’s Exchange* and has conducted “living archeology” as well as flintknapping schools. He is the founder and, until 1996, was the president of the Society of Primitive Technology. Callahan is not only a scholar, but has also earned his living through flintknapping. Some of his commercial products represent a level of craftsmanship in flintworking never achieved in prehistory.

Among the professional knappers in the U.S. is D.C. Waldorf of Branson, Missouri. He has taught numerous flintworking schools, published perhaps the best beginner’s guide, *The Art of Flintknapping*, and edits *Chips* for communication among knappers. Among other accomplished professional knappers are Chris Miller of Ohio, Jim Redfearn and Tim Dillard, both of Missouri, and Dan Theus of Texas.

Since 1970’s, a great many “knap-ins” or workshops on flintknapping and “primitive technology” for anyone interested have been organized in the U.S., and some also in Europe. The number of such knap-ins has greatly increased in the past 25 years and is still growing. In other words, we still seem to be in the middle of an explosion of interest in the craft of knapping. The number of knappers in the U.S. has increased perhaps by a factor of 50 to 100 in the last 30 years. This has brought much talent to the craft, and may become increasingly more significant for information and potential experimentation, if utilized by archaeologists. However, it also has its negative aspects. For one, the sources of raw material are being depleted. In 1996, about 20, 000 kg of flint from Brandon were imported by one enterprising individual, and about 23,000 kg from Belize by another. Comparable quantities of mookite (a.k.a. mook jasper) have been imported from Australia. Great numbers of knappers procuring flint have become a nuisance to landowners.

The scarcity of raw material has led commercial knappers to sawing a nodule to slabs, and then flaking it into a finished product. Especially the commercial aspects have stimulated increasing use of the so-called “copper boppers” for expediting their work. It conserves antler that is becoming scarce as well. Making stone tools from slabs with the so-called “copper-bopper” is not flintknapping in the traditional sense, but it does conserve raw material. A “copper bopper”, incidentally, is really a lead plug with a thin copper shell casing.

What will the future see? On the one hand, experimentation and the practice of knapping may be expected to continue (or decline) along the more conventional paths, but at a more skilled level and perhaps with greater use of industrial tools and materials for learning and experimentation. On the other hand, we are witnessing the growth of a "modern knapping tradition" in flintworking with metal and other non-traditional tools. For archeology, its relevance may be akin to that of the manufacture of gunflints or blades for threshing sleds. Several opposing categories have been used for modern knapping – such as academic vs. non-academic and commercial vs. non-commercial knapping.

Knapping Studies

Lucy Lewis Johnson (1978) provides a survey on flintknapping studies from 1838 to 1976.

Archaeological Record

Evidence on prehistoric knapping comes from the archaeological record. This does not mean that information or supporting evidence of some kind cannot come from other sources.

Ethnography

Ethnography can suggest possible hypotheses. The probability of the hypothesis being correct depends on a number of factors, including the similarities in context.

Knapping Experiments

Knapping experiments can also suggest possible hypotheses for prehistoric studies. In one sense, they are less useful because of the great contextual differences. On the other hand, they are more useful because the experimenter can change the focus and objectives of his study at will. Knapping experiments and ethnographic observations can point to questions of interest and to some relevant data that may not have been thought of by studying the archaeological data alone.

Lewis Johnson (1978) provides valuable references to research by Bordes, Bradley, Callahan, Crabtree, Ellis, Newcomer, Sollberger, Tixier and others. Recent and past experimental work includes that of Clark, Flenniken, Kelterborn, Titmus (Hirth et al. 2006) and others (Apel and Knutsson 2006, Ellis 1944).

Living Archaeology

To overcome the limits posed by the context of knapping experiments, experiments in "living archaeology" and survival were conducted by Errett Callahan in the 1970's.

Experiments in "living archaeology" can provide information to archeologists that other sources can not. They can pose questions and point to relevant data that may not be apparent otherwise. "Living archaeology" has also been used in a very different sense (Gould 1971 and 1980) to refer to ethnoarchaeology or ethnography.

Mechanics, Fracture Mechanics and Fractography

While "living archaeology" takes knapping experiments to broader contexts for the purpose of representing more relevant situations, application of mechanics, fracture mechanics and fractography as science does the opposite. With the former, the number of variables increases, their relationships become more complex, and the meaning of experimental control becomes more fuzzy. The opposite is true for application of mechanics to flintworking. Mechanics is a relatively "hard" science. Theories and their empirical bases change with time in all sciences, but less so in the "harder" and more mature sciences. In other words, establishing relationships in mechanics, if useful, could provide a firmer basis.

Flintknapping is not a mechanical process. Some of its elements however are. To make use of mechanics in flintknapping, the key is to recognize what these elements are and what the field of mechanics can do. For this, interdisciplinary communication is important. The application of mechanics can pose questions and point to relevant data not apparent otherwise. It is possible to apply the body of knowledge already available in mechanics to improve our understanding of flaking, and to perform controlled testing for particular purposes.

Contemporary Crafts

Observations from contemporary crafts and industrial practices can occasionally provide clues to knapping. While observing a mason pointing a masonry chimney with a steel chisel and hammer, he occasionally hit his knuckles. Yet he would not use a longer chisel, he said, because he would then need to use a heavier hammer. In the past, bricks were split by first chiseling a groove all around, for the crack to run flat across. In the rejuvenation of prehistoric obsidian cores, a section of the core by its platform was sometimes removed by first pecking around the core (Trachman 1999). Experiments by Gene Titmus confirmed the feasibility of doing this (Trachman and Titmus 2003).

Fire has been used in quarrying and breaking up larger blocks or boulders of rock in contemporary and prehistoric societies (Cresson 2005, personal communication) as well as recently in New Guinea (Hampton 1999).

During a flintknapping demonstration I was tapping an obsidian nodule to check for cracks., A lady in the audience said that she also does that – tapping a loaf of bread in the oven to see if it is ready. A roofer may also tap a piece of slate to check for cracks. In the first half of the last century, welds were sometimes checked by tapping with a hammer and listening with a stethoscope. When asked about the significance of sounds in knapping, Gene Titmus said, "I don't think I could knap if I couldn't hear."