FLINTKNAPPERS' EXCHANGE

AN EXCHANGE MEDIUM OF, BY, AND FOR LITHIC TECHNOLOGISTS

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The illustrations: both faces of one margin of a Solutrean laurel leaf #2 from Volgu, France, "Craftsman" illustrations are by Errett Callahan: others are submitted by the authors, as noted.

LETTERS & ANNOUNCEMENTS

Errett, I am writing you now just to tell you that I am well under way with my new text of the Livre de Beurre article for FE, and furthermore to react to your "invitation for comments" on page 1 in FE 3 (3) 1980:

— Do not continue with the interviews. Reason: After all, flintknapping is a technical-artistic craft and not a show business with "stars". Furthermore, there are not enough stars around anyway, so this feature will come to a "natural death" in not too long a time.

— The flint "Masterpiece" idea is great! But not on a two piece centerfold, but with a one page *master* drawing and/or photograph. But to multiply its value, this feature should have a high-level comment on the flintknapping aspect of the masterpiece presented. In other words, make the Denver series of Bob Patten with well chosen masterpieces.

The reason I warn against centerfolds of two pages is the bad profit-cost ratio: The centerfold as a nice picture or piece of art to put on the wall is not good enough because it is damaged through the fold and the haftings, which a full one page drawing is not. Furthermore, the information package is in the text and plenty good enough on a *good* one page drawing, and finally, centerfolds are a bothersome cost item in preparing and printing.

— You mention cost. I can only give you an emotional opinion: Even at double its price you would not lose one reader and FE would still be a bargain for the information it gives! This has nothing to do with the above mentioned centerfold, but with FE in general. It just is very good and valuable. If you want to improve FE, reduce the small talk and gossip 30% and increase true flintknapping articles 30%.

Anyway, after ten years of isolated flintknapping efforts by myself alone, and trying to decipher the too rare and too abstract and not transparent enough articles of the original pioneers (Barnes, Cheynier, Kidder, Coutier, Cabrol, Bordes and Tixier), FE is a pure pleasure, beautifully continuing the inspiring and open spirit one could see with Don Crabtree.

One last thing. Maybe it's typical old world. Don't make flint knapping too much a show business. Or if you have to do it, separate it from the real work. (I have great question marks when reading about the Little Lake weekend. Not because of normal shortcomings but because there is a danger that flintknappers become degraded to be public exhibits themselves. I know that also some aspects of Leire go the same dangerous way. I also know that the financing is part of the problem.) Because there is so little real progress when the public is around!

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My condolence to the family and friends of Don Crabtree. Who among us was not influenced by his work and ideas? His profound insights spawned a veritable revolution in archeology.

Many compliments to the staff of F.E. for a truly fine job putting the publication together. A special thanks to Errett for his interviews and drawings. He has done a superb job with them. I would like to see him continue with them. I do feel that he has ignored himself.

Due to time restrictions, the knap-in tentatively scheduled for the Middle Atlantic States Archeology Conference was shelved. John Cresson (who was trying to put together the above knap-in), myself and Mike Johnson have discussed a knap-in the second weekend of September at the Gulf Branch Nature Center which includes a log house, blacksmith's shop and the interpretive center.

This workshop will focus on the rhyolite industries of the Middle Atlantic States. Besides your antler billets and soft stone hammers, bring some hardwood billets. Ironwood box-wood, black locust and maple have been discussed, but if we knew it all we wouldn't need the workshop.

We will make every attempt to have on hand a good supply of the various grades of rhyolite, plenty of hammerstones and a fair supply of wood billets.

Anyone with a serious interest in the subject is invited to participate at whatever angle they're working on.

Sunday afternoon is reserved for whatever you like to do with stone as long as it's legal. The public will be invited for the afternoon to watch and ask questions.

For further information please contact me.

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COMMENT ON "A DISCUSSION OF FORCE BULB FORMATION AND LIPPED FLAKES"

J. B. Sollberger has successfully snared a topic that has been elusive to Flintknappers and Archeologists alike. This article [FE 4 (1):13-15] should be required reading for anyone interested in lithic theory or analysis. Persons attempting to classify and categorize flaking debris from archeological sites should pay special attention to the closing paragraph.

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ARTICLES

FLINTKNAPPING AND SILICOSIS

INTRODUCTION:

Could early man have been a victim of an industrial disease? I believe this to have been the case.

Flintknapping, an activity that dominated more than 99% of the archaeological record of human evolution, turns out to be potentially dangerous to the health of the flintknapper. The process, which involves the breaking of siliceous rocks, produces a fine dust. Repeated inhalation of the free silica particles (SiO_2) can lead to a pneumonic condition called silicosis or fibrosis. This problem has also been noted by workers in mining, sandblasting, stone carving, road construction and ceramics, where silica is a major cause of pneumonoconiosis or occupational lung disease (Agrecola 1557; Arlidge 1882; Collis 1915; Hunter 1978; Middleton 1930; Oliver 1902 and 1916; Ramazzini 1713; Severo 1980). Prolonged exposure to silica dust particles increases the chance of developing severe silicosis. When microscopic particles are inhaled they pass into the lungs by way of the trachea branching into the two main bronchi. The bronchi, in turn, branch into many tubes which continue to branch repeatedly until each finally terminates in an elongated saccule, the alveolar duct. Branching off this saccule are millions of tiny globular sacs or alveoli. The openings into these sacs are very small, about 5-10 microns. It is in the alveoli that gas exchange takes place with the blood. Our lungs contain approximately 750 million alveoli, which explains why the interior surface area of our lungs is more than fifty times that of the skin of our bodies.

Our bodies provide a defense of filters to protect our lungs. The hairs and sinuses of the nose catch the initial dust. The trachea and the larger branches of the bronchial tubes are covered with mucous cells and cilia which protect and clean the lungs of the finer particles. Mucous traps the particles while the beating of the cilia removes dust-laden mucous from the lungs.

Problems arise because silicates can break into very small particles, much smaller than 20 microns. These minute flakes enter the deepest part of the lungs, past the mucous and cilia cells in the bronchae and continue until they reach the alveoli, or air transfer sacs. Once these flakes become lodged in the alveoli, they cannot be removed by the lung's natural defense mechanism.

The condition becomes more and more serious as the alveoli fill up with razor sharp particles, although the effect is often not felt for many years (usually after 10 to 25 years according to Plunkett, 1976, and 20 to 30 years according to Berkow, 1977).

HOW SILICOSIS DEVELOPS:

Silicosis develops through three recognizable phases (Hunter, 1978; Middleton, 1930). In the beginning the most important symptom is a slight difficulty in breathing which becomes apparent after exertion, increasing in severity as the condition progresses. A cough may also develop, which is usually "dry", with little mucous. Generally, because of the gradualness of the process, individuals feel little immediate effect from the changes taking place in their lungs. Fibrous tissue develops around the dust ladened cells and forms small round nodules, several millimeters in diameter. These become a permanent part of the lung tissues and are visible by x-ray analysis.

Coughing and shortness of breath become noticeable in the next stage. Nodules increase in size and number, occasionally lumping together into conglomerates. Sounds can sometimes be heard in the lungs. A reduced chest expansion, high blood pressure and noticeable effects on working ability are also symptomatic.

During the final stage, the dehabilitating effects of the condition are accentuated nodular development, emphysema, and x-ray evidence of growing fibrous masses of tissue. These cause extensive incapacitation of the victim and may ultimately result in death.

In addition to the lacerating sharpness of the tiny flakes, a chemical reaction must take place for silicosis to occur (Hunter 1978; Kettle 1932). A soluble substance called silicic acid dissolves off the surface of the stone and polymerizes when it is neutralized by the body tissue. (In polymerization, molecules combine to form long chain compounds of a high molecular weight. This type of reaction is used to make polyethylene or common plastic.) During its creation, polysilicic acid poisons the surrounding tissues. The affected cells appear to be mummified and do not decompose as dead cells in the lungs normally do. What makes flint and quartz particles among the most dangerous of all mineral dusts is the extent to which they dissolve into the blood plasma and the low pH of the acid produced (Hunter 1978). The fibrosis is caused by a poorly understood reaction from the interaction of silica by-products with lung macrophages or defense cells (Cullen 1980). This can be illustrated by comparing flint dust to cement dust which is also high in silicic acid. The high alkaline pH of the limestone in the cement neutralizes the acid and renders it harmless before it reaches the blood plasma and

body tissues (Hunter 1978).

TYPES OF QUARTZ:

Some types of quartz dust are more dangerous to inhale than others (Cullen 1980; Stober 1966). There are three major types of silica deposits which constitute the majority of knappable stones: Amorphous, common quartz crystal and cristobalite. Cristobalite is a cubic crystal that forms at high temperatures and is less prevalent than amorphous and common quartz. A fourth type, tridymite, is rare and only encountered in minute traces.

The least dangerous, but by no means safe, is the amorphous type which is a quick cooling, crystal free variety. Glass, obsidian and opal are examples of amorphous quartz.

Common quartz and quartzite are examples of quartz crystal. Also included in this group are chalcedony, flint, jasper, and chert, all of which are microcrystalline and possess microscopic needle or fiber-like quartz crystals, often arranged in fan-like structures.

COMPOSITION OF FLINT:

Most flints are composed of 98% silica with 1% to 2% water and minute quantities of impurities which cause color variation. The water appears to be responsible for the exceptional tensile strength of the material (Shepherd 1972). The needle-like, microcrystals of quartz may vary in size and shape from the shorter, stouter type, like those in Irish gray flint, to the long slender crystals found in English black flint. Not all flints are common quartz. Amorphous quartz, cristobalite and tridymite may occur adventitiously also. In Danish flint, which is visually similar to English flint, common quartz was found to range between 4% and 100%. The remainder of its composition was made up of cristobalite, glassy quartz, or a mixture of the two (Shepherd 1972). Traces of tridymite were also found in several samples. Cristobalite has proven to be the most dangerous of the silica dust and workers exposed to cristobalite display a higher incidence of silicosis (Cullen 1980). Cristobalite may also be found in rhyolite, bentinite, obsidian crystal pockets, high fired ceramics, and basalt.

DIAGNOSIS OF SILICOSIS:

Silicosis is easy to diagnose in its early stages by x-ray and the individual can take appropriate steps to avoid the dehabilitating and irreversible effects of the advanced stages. An obvious step is to stop exposure to silica dust. Continued exposure will aggravate one's silicosis condition, but there is a difference of opinion as to what happens when a person with silicosis symptoms is no longer exposed to silica dust. In severe cases, it appears the disease does not arrest itself. However, evidence from several studies in England show that when people with early silicosis discontinue their exposure to silica dust, either the disease does not progress, or its development is retarded for a considerable number of years (Middleton 1930; Board of Trade 1945).

ADDITIONAL COMPLICATIONS:

Curiously, rheumatoid arthritis sufferers show a high rate of incidence of previous exposure to silica dust. This may be explained because silica-ladened white blood cells often re-enter the blood stream from the lungs and thereby transport particles to other lymphatic areas of the body (Cullen 1980). In 1885 Arnold found silica particles included in the liver, the spleen and bone marrow (Arnold 1885). Cuts from knapping may also leave slivers of stone in the body.

It also appears that smoking increases the danger of silicosis. Be it today, or in ancient times in the New World, nicotine paralyzes the cilia and prevents the natural cleansing of the bronchial tubes, which results in the bigger flakes being retained.

Carving soapstone may cause mesotheleoma (a cancerous lung disease) due to the asbestos fibers in the stone. While silicosis and cancer are found together, there is no proven evidence that silica is a carcinogen (Hunter 1978). In the last year or two, some evidence suggesting silica related cancer has been emerging (Cullen 1980).

Ironically, even black lung disease, common among coal miners, is attributed not so much to the coal itself, but to the silica dust present in the coal (Shottenfield 1980).

Tuberculosis often accompanies silicosis and the result is a devastating combination. Since it is the most frequently associated complication, tuberculosis plays an important role in silicosis history (Hunter 1978).

Capable of infecting other animals (cows, for example) as well as humans, the roots of tuberculosis have been traced back thousands of years in Africa, Asia, Europe, and North and South America. Examples of tubercular disease and deformation have been identified through autopsies of ancient mummies, deformed bones (Potts disease) and may be seen depicted in examples of prehistoric art work (Brothwell 1968; C. Wells 1966; Ritchie 1952). Silicosis has been identified in mummies from Egypt (Harris 1978) and Peru.

It is very difficult to differentiate between silicosis and tuberculosis by x-ray alone, and diagnosis should not be made unless additional tests are run. Even in autopsy, the two lung diseases tend to obscure one another, making diagnosis very difficult (Hunter 1978).

TABLE I

RELATIONSHIP OF DEATHS FROM TUBERCULOSIS TO QUARTZ CONTENT OF DUST*

OCCUPATION	QUARTZ CONTENT OF DUST	PERCENT DEATHS FROM PULMONARY TUBERCULOSIS
FLINTKNAPPERS (Brandon, Eng.)	100%	77.8%
GRINDERS (Sheffield, Eng.)	50% – 100%	49.7%
GRANITE-CUTTERS (Maine and NH)	30%	47.8%
POTTERS (Certain Processes Only)	28%	18.9%
COAL MINERS	—	9.8%

*After Collis

There is a direct relationship between the silica content of an industrial dust and workers' deaths from pulmonary tuberculosis. The 1913 study by Dr. E. Collis showed that over three quarters of the flintknappers at Brandon, England died

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of this problem. He was able to show that workers with silicosis are more prone to contracting tuberculosis and more susceptible to infections from other types of pathogens. Even relatively harmless dusts, when inhaled by a person with mild silicosis, may create a potentially serious pneumonoconiosis condition (Collis 1913). His research concluded that the more different a substance is from those of which the body is naturally composed, the more injurious it is to the body.

In light of this information, how can we flintknappers protect ourselves from these dangers?

THE DANGERS OF WORKING INDOORS:

In 1930, Middleton measured the atmospheric dust produced by two flintknappers working in a shed. His findings showed concentrations as high as 1,313 particles per cubic centimeter, with the majority of the flakes under 1 micron in size. Only 2% of these tiny flakes were over 2 microns. These minute particles easily enter the 20 micron alveolar sacs of the lungs, making silicosis complications from flintknapping understandable. Remembering that a micron is only one thousandth of a millimeter helps you visualize how small these flakes actually are. By definition, particles smaller than 1 micron cease to be called dust and are classified as fumes and those smaller than .3 of a micron are listed as smoke. Imagine the particle counts at a modern indoor knap-in. Errett Callahan spoke of seeing clouds of dust at the Flintknappers' Exchange 1979 Knap-in at Casper, Wyoming (E. Callahan 1980).

During the winter I maintain an indoor workshop in the basement of my house. Since the ventilation is poor, I now wear a respirator while working. The Mine Safety Appliances Company in Pittsburg, Pennsylvania makes a mask for dust and fumes that does the job. It is a COMFO 2, custom respirator with a filter cartridge for asbestos-containing dusts, fumes, and mists. While no filter gets everything, the filter meets Mine Safety and Health Administration (MSHA) and National Institute for Occupational Safety and Health (NIOSH) safety requirements. A mask with dual filter cartridges should cost about $20. The cartridges may be used until they become clogged with dust before changing, but care must be taken not to let the interior of the mask become contaminated with silica dust when it is not being used. To prevent this, I fasten plastic sandwich bags around the cartridges with rubber bands. Be sure to wear your mask while sweeping up debitage. When working indoors, remember it takes over a half an hour for suspended silica dust and fumes to settle (Middleton 1930).

An exhaust fan will also prove useful when working indoors. Clothes worn while knapping should be changed, or at least brushed off, after working to avoid tracking dust into living and sleeping areas. Another possibility would be some type of knapping apron to protect clothing from dust. Use of a particle ionizer will also reduce exposure to small particles (electrostatic precipitator).

WORKING OUTDOORS:

Unless a wind is present, I try to wear a mask while working outdoors, especially when the work is very dusty. When working without a mask, I try to sit so that the wind aids in dust removal. I also try consciously to time my breathing to avoid inhaling the clouds of dust I have just produced, whether from quarrying the stone or finishing a biface with pressure. Fine dust forms whenever the stone is broken. For example, I have found that my platform preparation technique of shearing/abrading tends to produce a lot of visible dust. This can easily be seen when viewed by a strong side light against a dark background. You will notice that while the tiny flakes

fall to the ground, a smoke-like powder floats upward, where it is easily inhaled. Because of this, when I work without a mask, I try to avoid inhaling whenever I see dust while abrading. I hold my breath or slowly exhale, blowing a fine stream of air across my platform. This helps to get the dust away from me so it can be dispersed and removed by air currents.

Incidently, most of the disposable dust masks for sale in hardware and paint stores provide only limited protection and are inadequate for filtering the suspended silica dust and fumes produced by knapping.

HISTORIC:

Silicosis is the oldest known occupational lung disease (Berkow 1977). Historically, the use of dust masks for flintknapping begins in Brandon, England, where gun-flint knappers wore sponges tied under their noses in an effort to prevent the devastating effects of Phthisis or "knappers rot" (Shepherd 1972). Historically the flintknappers of Brandon, England, still a knapping center, suffered a high mortality rate from silicosis, often with tubercular complications (Collis 1913, 1915). Working mostly in sheds, skilled knappers, who could make three thousand gun flints a day (Webb 1911), were not expected to live much more than forty years (Collis 1913 and 1915; Middleton 1930; Shepherd 1972). The Table (Table II) by Edgar Collis, Medical Inspector for Factories in England, shows the death rate for Brandon Flintknappers. We are most indebted to him for his research.

Notice that wives of flintknappers and others not engaged in the profession were not affected by silicosis and had normal life spans. Agrecola (1557) noted that wives of Carpathian miners had as many as seven husbands, due to the high mortality rate among the miners from silicosis.

In the "Minutes of Evidence", Collis describes in detail several of the flintknapping families. At the time the study was made, in one family of twenty-six persons (thirteen males and thirteen females), twelve of the males had been flintknappers and ten of them had died. This left two flintknappers and the one non-flintknapping male alive, while all thirteen of the women were still alive. In another family of six males, three became flintknappers. Two died leaving one flintknapper and three non-flintknappers alive. In a third family, two of the six males became flintknappers, and only one was still alive to join all four of the non-flintknapping males still living. Collis concluded by saying, "Despite the size of this small industry, there is an excessive mortality problem."

In modern Brandon, Mr. Fred Avery, the last of Brandon's flintknappers, said that in an effort to avoid silicosis, he tries to work in a well-ventilated room and limits his knapping to 1-1/2 hours per day. Avery said that because of the historic instances of silicosis and its recorded high mortality, parents in the town discouraged their children from learning to knap (Gould 1980).

In France, among the people of the town of Meusenes, the gun-flint industry produced results similar to those at Brandon, England. Chateauneuf said, "By a fate, which seems connected with all that concerns the art of war, this industry slays those who follow it; it kills them before their time; for them there is no old age." When asked the cause of so premature a mortality, doctors and officials gave the same reply -- pulmonary phthisis induced by prolonged inhalation of dust generated from working flints" (Collis 1915).

Industrialization is probably responsible for these problems among the gun flintknappers, for it is from the con-

TABLE II

COMPARING THE MORTALITY FROM PHTHISIS OF FLINTKNAPPERS
WITH THAT OF CERTAIN OTHER CLASSES*

CAUSE OF DEATH, STATED AS
PERCENTAGES FROM

	ALL CAUSES	PHTHISIS	RESPIRATORY OTHER THAN PHTHISIS	ALL OTHER CAUSES	TOTAL DEATHS	AVERAGE AGE	DEATH[1] RATE PHTHISIS
FLINT - KNAPPERS[2]	100.0	77.8	7.4	14.8	27	46	41.0
WIVES (2) AND WIDOWS (11) OF KNAPPERS	100.0	0.0	15.4	84.6	13	78	0.0
BRANDON RURAL[3] DISTRICT	100.0	6.5	11.7	81.8	63	––	0.8
ALL MALES[4] (ENGLAND AND WALES)	100.0	11.2	17.6	71.2	509,567	Median 56-57	1.6

1. Death rate from Phthisis per annum among 1,000 living.
2. Average number employed for 25 years estimated at 16.5.
3. The figures for this class supplied by Dr. A. Harris, M.O.H., Thetford, Norfolk, are for all ages, 1901-1910.
4. The figures for this class, calculated from the Supplement to the Sixty-Fifth Annual Report of the Registrar General for all males aged 15 upwards, 1900-1902.

The average age at death of the 21 flint knappers who died from phthisis was 42.3 years, which is rather higher than the median age at death — between 39 and 40 — of all males dying from phthisis. The immunity of wives and widows of flint workers (see Table II) is also found among the families and relations.

Conclusion — as far as this small industry is concerned, exposure to fine dust of pure silica causes an excess mortality from phthisis, not found in the neighborhood in which the industry is carried on, nor among workers' relatives who do not carry on the industry.

E. Collis, M.B. H.B.
MEDICAL INSPECTION
OF FACTORIES

*From the Royal Commission Report on Metalliferous Mines and Quarries, 1914, page 262 Appendix J.

tinued exposure to silica dust that most cases of silicosis occur. If this is so, one would expect that this early industrial disease extended back into the Paleolithic period (Brothwell 1968; Wells 1964; Brothwell and Higgs 1969). Archaeologically, it might be possible to identify it in burials by analysis of the silica content in the dirt in the chest cavity compared to the surrounding soil. Biopsies of lung tissue in mummies could provide valuable data (Harris 1978). By Neolithic times extensive flint mining operations were taking place in northern Europe, and flints were dug and worked by the ton (Bosch 1979). Much of this flint went into making axes, which were often pecked and ground smooth for completion. These processes, if done without water, would produce excessive quantities of dust. Also, if water had been used and then was permitted to dry in the work area, it would allow flint dust to become airborne.

Thomas Benson, who in 1713 invented a method for wet grinding flints, states in the patent that the process of dry grinding "proved very destructive to mankind insomuch that a person ever so healthful or strong, working in that business, cannot possibly survive over two years, occasioned by the dust sucked into his body by the air he breathes" (Royal Commission, Vol. 1, Pg. 134).

OTHER CAUSES OF SILICOSIS:

While industrialized production of stone implements took place in different societies, not all silica workers could be considered flintknappers. Great numbers of craftsmen were exposed to dust as they carved out monumental statues and other constructions. In 1869, Hugo Millers wrote, "The mason is almost always a silent man; the strain on his respiration is too great when he is actively employed to leave the necessary freedom to the organs of speech" (Royal Commission, Vol. I 1914).

Exposure to volcanic dust after eruption may also cause silicosis. The effects of exposure to high silica ash from Mt. St. Helens should become evident in the coming years (Severo 1980). Throughout time, volcanic eruptions covered different areas of the world with huge amounts of high silica ash. In some places the ash fall was so great that it buried whole cities, such as Pompeii or Thera, or caused entire populations to move, such as the Maya (Trotter 1977).

Silicosis also affected workers in the ceramic industry (Arlidge 1892; Oliver 1902 and 1906). Flint glazes, mixing dry clay and sweeping up the powdery residues are probably

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the most dangerous activities.

In PreColumbian Mexico and Central America and in the Middle East, large specialized knapping centers developed to serve the elaborate obsidian trade networks that traded blades, bifaces and ground stone objects. Through chemical-stone analysis it has been possible to trace how specialized craftsmen work daily in special quarry towns to make tools for people hundreds of miles away (Flannery 1976; Dixon 1968). In both these areas of the world, industrial stone knapping still exists today. For example, in the town of Teotehuecan, just north of Mexico City, craftsmen make percussion flaked spear points (projectiles) and carefully carved and polished obsidian objects. These are decorative rather than functional products, manufactured for the tourist market which has carried many of these items as far as Europe, Australia, and Asia (personal observation).

Stone tool making on a functional basis can be seen today in northwestern Turkey. Here professional flintknappers make direct percussion blades used in threshing sledges during the wheat harvest. A good knapper can manufacture almost 500 pounds of blades a day if the flint has been quarried beforehand. A village can produce about 500 tons a year. The blades are sold to merchants who distribute them throughout the country (Bordaz 1968).

Clearly, in these specialized occupations, workers are exposed to excessive quantities of silica dust and occupational lung disease could result. I am unaware of any medical study that has been done on the flintknappers of Turkey or the obsidian workers of present day Mexico, but these would be prime groups to investigate for signs of pneumonoconiosis.

Today, unfortunately, many of us find ourselves in a similar situation as we work daily making lithic artifactual replications and the like. Whether for scientific research, pleasure, or commercial production, we have become industrial craftsmen who subject ourselves to excessive amounts of silica dust and the inherent dangers.

The questionaire which follows is an attempt for all of us to find out more about ourselves and flintknapping. Once the data is compiled, the results will be made available in a future issue of *Flintknappers' Exchange*. The Brandon history need not repeat itself today. By increasing our understanding and awareness of these potential hazards, we should be able to take appropriate steps to protect ourselves against unnecessary pulmonary damage.

SUMMARY:

Silicosis is caused by the life-long exposure to and accumulation of free silica dust (SiO_2) in the lungs. Its degree of severity appears to be directly related to density, length of exposure, particle size and type of quartz. The effects are often not felt until many years after exposure. The best way to prevent silicosis is to minimize the inhalation of suspended silica dust. While knapping, this may be accomplished by working outdoors and by wearing a respirator mask. If you are an avid knapper, a respirator would be an important part of your tool kit. Even if you only wear your mask for the more dusty operations, every little bit helps. When working without a mask, try to time your breathing to avoid inhaling the dust. Changing or brushing off your clothes after knapping may also prove useful. Where possible, water should be used when grinding silicates.

It is strongly recommended that knapping not be done indoors or in poorly ventilated areas unless a respirator is worn.

The last few issues of *Flintknappers' Exchange* (Volumes 3:1 and 3:2) showed pictures of indoor flintworking with windows shut. In many ways this simulates a prehistoric mining operation, lots of dust and little ventilation, and may be considered very unhealthy and dangerous. Realizing that health problems can arise from flintknapping is only half the battle. We must each take responsibility for taking precautions and changing old habits, to protect our own lives and the lives of those whom we introduce to the art. By taking the necessary precautions, we will be able to continue knapping to a ripe old age, free from the fear of silicosis.

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FLINTKNAPPING QUESTIONNAIRE

NAME_____ DATE _____

ADDRESS _____

YEARS KNAPPING_____ HOW OFTEN? SELDOM_____ OCCASIONALLY_____ .OFTEN _____ DAILY_____

WORK LOCATION (GIVE APPROXIMATE PERCENT): INDOORS_____ % OUTDOORS_____ %

DURING THE LAST YEAR, WHAT WAS YOUR KNAPPING FREQUENCY? SELDOM _____

OCCASIONALLY_____ OFTEN_____ DAILY_____

HRS/DAY_____ , DAYS/MONTH_____ , MONTHS/YEAR_____

ACTIVITY FREQUENCY, NUMBER FROM 1 (MOST) TO 6 (LEAST): PERCUSSION: BILLET_____ ,

HAMMERSTONE (PLEASE TELL TYPE OF STONE)_____ ,

PRESSURE_____ , PECKING_____ , GRINDING_____ , OTHER (SPECIFY)_____

TYPES OF MATERIALS WORKED (GIVE % IF POSSIBLE) _____

_____

WHAT PRECAUTIONS DO YOU TAKE.	INDOORS	OUTDOORS
VENTILATION	_____	_____
FAN	_____	_____
FACEMASK	_____	_____
NONE	_____	_____
OTHER	_____	_____

IF OTHER, PLEASE DESCRIBE _____

DO YOU SMOKE? _____ IF SO: LIGHT_____ MEDIUM _____ HEAVY _____ DO YOU SMOKE

WHILE KNAPPING? _____ IF NO, WHY NOT_____

ARE YOU EXPOSED TO, OR DO YOU WORK AROUND OTHER TYPES OF DUST? _____ WHAT KINDS OF

DUST?_____ FOR HOW MANY YEARS? _____

HOW OFTEN? SELDOM_____ OCCASIONALLY _____ FREQUENTLY_____ DAILY_____

DO YOU HAVE ASTHMA _____ ALLERGIES (NAME)_____

OTHER RESPIRATORY CONDITION (NAME)_____ TUBERCULOSIS_____ HIGH

BLOOD PRESSURE_____ HEADACHES AFTER KNAPPING_____ ARTHRITIS_____

DO YOU EVER CUT YOURSELF WHILE KNAPPING? _____ WHERE _____

HOW OFTEN – WHEN FIRST LEARNING?_____ TODAY?_____

DO YOU EXPERIENCE ANY OF THE FOLLOWING SYMPTOMS:

SYMPTOM INTENSITY	NONE	SLIGHT	MODERATE	ACUTE	OTHER
FATIGUE	_____	_____	_____	_____	_____
SHORTNESS OF BREATH	_____	_____	_____	_____	_____
COUGH	_____	_____	_____	_____	_____
PAINS IN CHEST	_____	_____	_____	_____	_____
ARTHRITIS	_____	_____	_____	_____	_____
WHEEZING	_____	_____	_____	_____	_____
OTHER	_____	_____	_____	_____	_____

IF OTHER, PLEASE DESCRIBE_____

SYMPTOM OCCURRENCE	SELDOM	OCCASIONALLY	OFTEN	CONSTANT	OTHER
FATIGUE	_____	_____	_____	_____	_____
SHORTNESS OF BREATH	_____	_____	_____	_____	_____
COUGH	_____	_____	_____	_____	_____
PAINS IN CHEST	_____	_____	_____	_____	_____
ARTHRITIS	_____	_____	_____	_____	_____
WHEEZING	_____	_____	_____	_____	_____
OTHER	_____	_____	_____	_____	_____

IF OTHER, PLEASE DESCRIBE_____

SYMPTOM OCCURRENCE	A.M.	P.M.	AFTER KNAPPING	DURING EXERCISING	OTHER
FATIGUE	_____	_____	_____	_____	_____
SHORTNESS OF BREATH	_____	_____	_____	_____	_____
COUGH	_____	_____	_____	_____	_____
PAINS IN CHEST	_____	_____	_____	_____	_____
ARTHRITIS	_____	_____	_____	_____	_____
WHEEZING	_____	_____	_____	_____	_____
OTHER	_____	_____	_____	_____	_____

IF OTHER, PLEASE DESCRIBE_____

HAVE YOU EVER VISITED A DOCTOR ABOUT ANY OF THESE SYMPTOMS?_____

DO YOU CONSIDER FLINTKNAPPING TO BE INVOLVED IN THESE CONDITIONS?_____

DO YOU HAVE MEDICAL DATA CONCERNING THESE CONDITIONS? _____ X-RAYS _____

MAY WE USE YOUR NAME IN ASSOCIATION WITH THIS DATA?

DID YOU KNOW ANYTHING ABOUT THE DANGER OF SILICOSIS FROM FLINTKNAPPING BEFORE READING THIS ARTICLE? EXPLAIN: _____

PLEASE FILL OUT THIS QUESTIONNAIRE AND RETURN IT TO:

JEFFREY KALIN
FLINTKNAPPING QUESTIONNAIRE
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THE FIFTH TEXAS KNAP-IN

The fifth Texas knap-in was held on April 2 to 5, 1981, at the usual location at Lake Belton, near Temple, Texas. This event is nominally scheduled for three days, but several attendees come early, so in practice the knap-ins have been lasting four days. Amateur attendance included: J. B. Sollberger, L.W. Patterson, Bill Carroll, Troy Herndon, Carey Weber, Darrel O'Dell, Elmer Stacey, Bruce Ellis, Wayne Brown and Jim Shofner. Professional archeologists attending were Glen Goode (Texas Highway Dept.) and Phil Bandy (New World Research). The group continues to display good enthusiasm for this event.

Some of the activities at this knap-in included: atlatl striking platform geometry, Paleoindian flaking patterns, Folsom point fluting techniques, heat treating techniques, and central Texas archeological point types and flaking patterns. One of J.B. Sollberger's students, Troy Herndon, has been able to produce a number of good Folsom replicates, using the Sollberger lever technique, which is described in the Bulletin of the Texas Archeological Society 51:289-299, 1980.

Some of the activities at this knap-in included: atlatl throwing demonstrations and point breakage patterns by Carey Weber, projectile point manufacturing by everyone, quarrying of local flints, and examination and testing of regional flint types. Sollberger was able to make a very accurate replica to reproduce a plastic cast of an Agate Basin type point. He used a central Texas type flint, and some very fine workmanship was required.

The average flintknapping skills of the entire group continue to increase. Also, Texas knap-ins continue to aid attendees in the development of published articles on lithic technology and archeological research. Every year, members of this group publish articles that have been at least partially aided by ideas generated or more fully considered at these knap-ins. These events are now a demonstrated success in increasing knowledge of lithic technology and of aiding in research projects of the participants.

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A DIACHRONIC STUDY AND ECONOMIC ANALYSIS OF
MILLSTONES FROM THE ARGOLID, GREECE

Nearly 300 millstones from ten excavations in the Argolid, Korinthia and Attica are examined in this study. They date from the seventh millennium B.C. to the beginning of Byzantine times. Little previous research on Greek millstones exists, and this is the first quantitative study of unpublished millstones from this area. The millstones are classified according to their shapes, methods of manufacture, raw materials and uses. The raw materials are traced by thin section petrography to their geological sources which are investigated for evidence of ancient exploitation and quarrying. The data show that, with respect to raw materials, shapes, methods of manufacture and uses, millstones underwent major changes in the past. A basic conclusion of this thesis is that millstones are sensitive indicators of change. It is argued that these changes were the result of shifts in production, consumption and distribution strategies which can be explained by models of supply and demand based upon ethnographic analogies.

The shapes of millstones underwent many changes. Grinding slabs and handstones of varying dimensions and proportions were used in the Neolithic, the Bronze Age and the Classical periods. They became increasingly standardized and specialized in form and use. In the Greco-Roman period, new commercial-scale millstones, including reciprocal and rotary varieties, were introduced. Raw materials show a similar pattern of change, with andesite replacing sandstone and becoming the principal material for millstones by the Classical period. The methods of manufacturing millstones went through an upheaval in Classical times when the technology of extractive quarrying was introduced. Thereafter, millstone production became an increasingly specialized and capital intensive industry.

Analysis of the demand for millstones shows an increasing inelasticity through time. Down to the Roman period, consumers show less and less willingness to substitute other materials or types of millstones for the products of andesite quarries in the Aegean Islands. Economic studies of a modern millstone industry in Greece, olive oil producers in the Argolid and of ancient agricultural practices point to a connection between shifts in millstone attributes and commercial uses of millstones. Changes in the characteristics of millstones mirror changes in the "market" for manufactured commodities or goods. When such markets are available, millstones are considered by their users as capital investments necessary for the production of the goods and commodities to be exchanged.

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BOOK REVIEW

Heat-Altered Cherts of the Lower Illinois Valley. John W. Rick. Northwestern Archeological Program, Prehistoric Records No. 2 (1978). 73 pp. 22 illustrations, 13 tables, appendix, paper or cloth covers. Order from Publications Office, Northwestern Archeological Program, 2006 Sheridan Road, Evanston, Illinois 60201.

While there is a significant amount of literature on the thermal alteration of siliceous minerals, only the publications by Purdy (1974), Purdy and Brooks (1971), and the publication being reviewed here offer detailed technical studies on this subject. Rick's work is a significant addition to the literature on heat treating of siliceous minerals, in this case some chert types from Illinois. His studies confirm much of the work by Purdy and Brooks, and also present some new methodology on measurements of surface luster and fracture strength.

This report is organized in a manner that is convenient for reading and for further reference use. Illustrations and tabular data are well done. After a brief introduction, there is a section that describes the details of chert sampling and the heat treating methods used. This is followed by a discussion of changes in color and luster caused by heat treating. A method is presented for the measurement of the degree of surface luster. As also reported by others, heat treating here resulted in varying degrees of change in color and luster, depending on the specific specimens used.

One section of this report examines the physical changes in cherts caused by thermal alteration, including weight loss and fracture strength changes. Tests described here by use of x-ray diffraction, and observations made with a scanning electron microscope, tend to confirm Purdy and Brooks' (1971) previous conclusions on the nature of physical alteration of siliceous minerals caused by heat treating. This indicates that heat treating causes intercrystalline materials to fuse, cementing cryptocrystalline grains together and eliminating microvoids. This results in fracture planes being able to take a more direct path through crystals instead of around them. The more regular fracture plane results in higher luster on fracture scars and decreased fracture strength.

More attention should be given to the variability in fracture strength of siliceous minerals in future research. This report notes the high variability in fracture strength that can be obtained even for a single material type. Some of this variability can be attributed to lack of uniformity in a material. However, most scientists working with brittle, elastic materials note that the surface conditions of individual specimens can have significant effects on the fracture strength. Surface imperfections are a major factor in the fracture strength of an individual specimen, and must be accounted for in explaining fracture strength variability. Some interesting references on this subject have been given to the reviewer by Edwin K. Beauchamp of Sandia Laboratories, including Langitan and Lawn (1969) and Marion (1979).

A discussion is given on the improved knapping properties of cherts after heat treating. The observation that longer flakes are easier to make with heat treated materials is consistent with results given by others, such as Flenniken and Garrison (1975) and Patterson (1979). In this and other studies, much of the improvement in knapping properties of siliceous minerals remains the subjective judgment of the individual knapper.

The edge angles of replicate pairs of projectile points were

used here to compare manufacturing results from materials before and after heat treating. However, the reviewer feels that final edge angles are more of a function of the skill and techniques of the individual knapper, rather than a function of physical changes made by heat treating. Measurements of the thickness to width ratios of bifaces would have been more appropriate to demonstrate improvements in bifacial thinning made possible after heat treating, such as noted by Callahan (1979).

The results given in this publication are limited by the relatively high heat treating temperatures used. Most experiments were done at 400 degrees C (752F) or higher. The reviewer (Patterson 1978) has observed that many siliceous materials can be effectively heat treated at temperatures as low as 260 degrees C (500F), with noticeable improvements in knapping properties, even when color and luster changes are minimal. It is felt that Indians, lacking precise temperature control, would have used the lowest effective heat treating temperature more often than a higher temperature range, to avoid high temperature damage to materials, and because lower temperatures are easier to obtain. Only a few tests were made in this report using a relatively low temperature range of between 230 and 290 degrees C, to observe color and luster changes, without examining corresponding improvements in knapping properties.

The bibliography given in this publication covers references on heat treating and related subjects to 1977.

In summary, this report represents a good contribution to information on the technology of heat treatment of siliceous materials. It is hoped that the reader will realize that there are inherent limitations to reports on this subject, because of the limited types of raw materials and test methods used in any given report.

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DANISH DAGGER A-10198

This issue's featured illustration is a rendering of a Type I Neolithic Danish dagger. It is one of literally hundreds of equally beautiful daggers which I found stored in boxes in the basement collections of the National Museum of Denmark in Copenhagen. Many of these specimens are surface finds from around the turn of the century and thus contain little provenience data (cf Müller 1902). More recent finds are carefully documented (Lomborg 1973).

I suspect that most American knappers haven't the foggiest notion of just how extensive, massive, and magnificent some of these Old World masterpieces are. Usually works such as these are omitted from textbooks in favor of "artwork". (See the Egyptian dagger in Aldred 1965:35, for an example. The carved bone handle gets all the credit. This dagger is also depicted in Waldorf 1979:2).

The Type I dagger depicted -- which I would consider a national treasure -- is the most perfectly controlled artifact I have ever held in my hands. Nevertheless, it was but one of innumerable daggers of such excellence that it was with great difficulty that I isolated one from the others for illustration. I finally chose this one because of the regularity with which the ribbon flakes were peeled from the right-hand margin of each face -- like so many perfect microblade scars. Other daggers were flaked from both margins. (Several basic approaches to flake scar patterning may be seen. These may each relate to separate workshops or "schools of thought". See below.)

Danish daggers are grouped into six basic types. All fall within a relatively short period of 300 years between 1800 and 1500 BC. All are Late Neolithic except Type VI, which is Early Bronze Age (and later than 1500 BC). The Type I daggers are of approximately the same thickness from end to end. The two basic sub-types, or styles, are called Jutland (parallel pressure flaked - shown here) and Zealand (fine percussion). This pressure-percussion division may be traced throughout the basic types (except Type VI).

The Type II daggers have a greatly thickened handle. The Type III daggers have what has been called a zig-zag "seam" usually running down the top and bottom center of the handle (as well as the sides of the handle), making that part

cm in

1 — 1
2
3 — 2
4
5
6 — 3
7
8
9
10 — 4
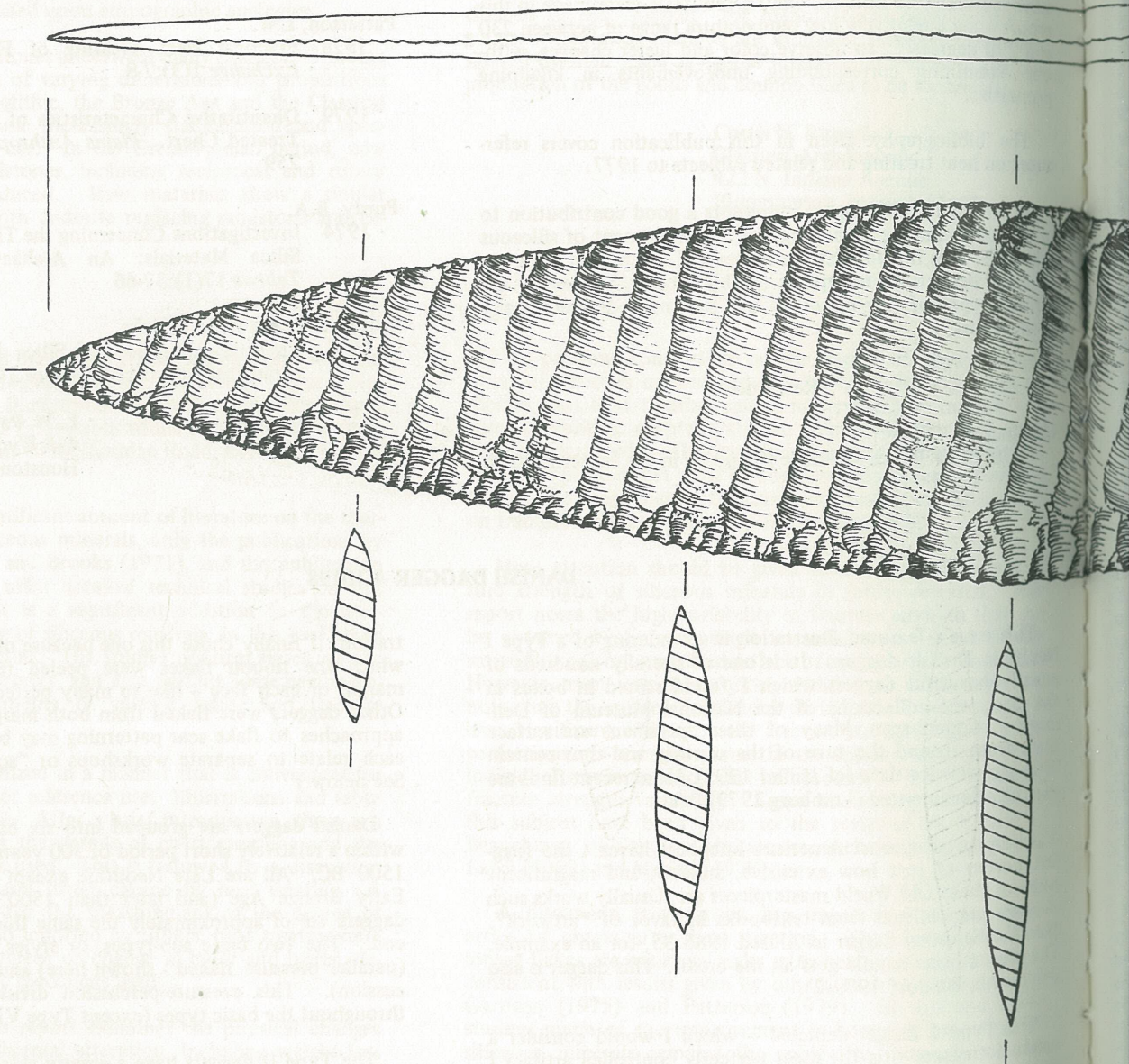
Type 1c
Jutland style

Jutland style
Late Neolithic
(1800 BC)
Mottled dark
gray flint
with pale spots
Lithic grade 3.0
34.86 x 5.87 x .79cm
Edge-angle range:
tip to grinding 35°±5°
grinding to base 60°±10°
Flake orientation 77°±2°
Unit A10198
National Museum of
Denmark, Copenhagen
Rum 324, Scab 2c, Hylde I
Surface find
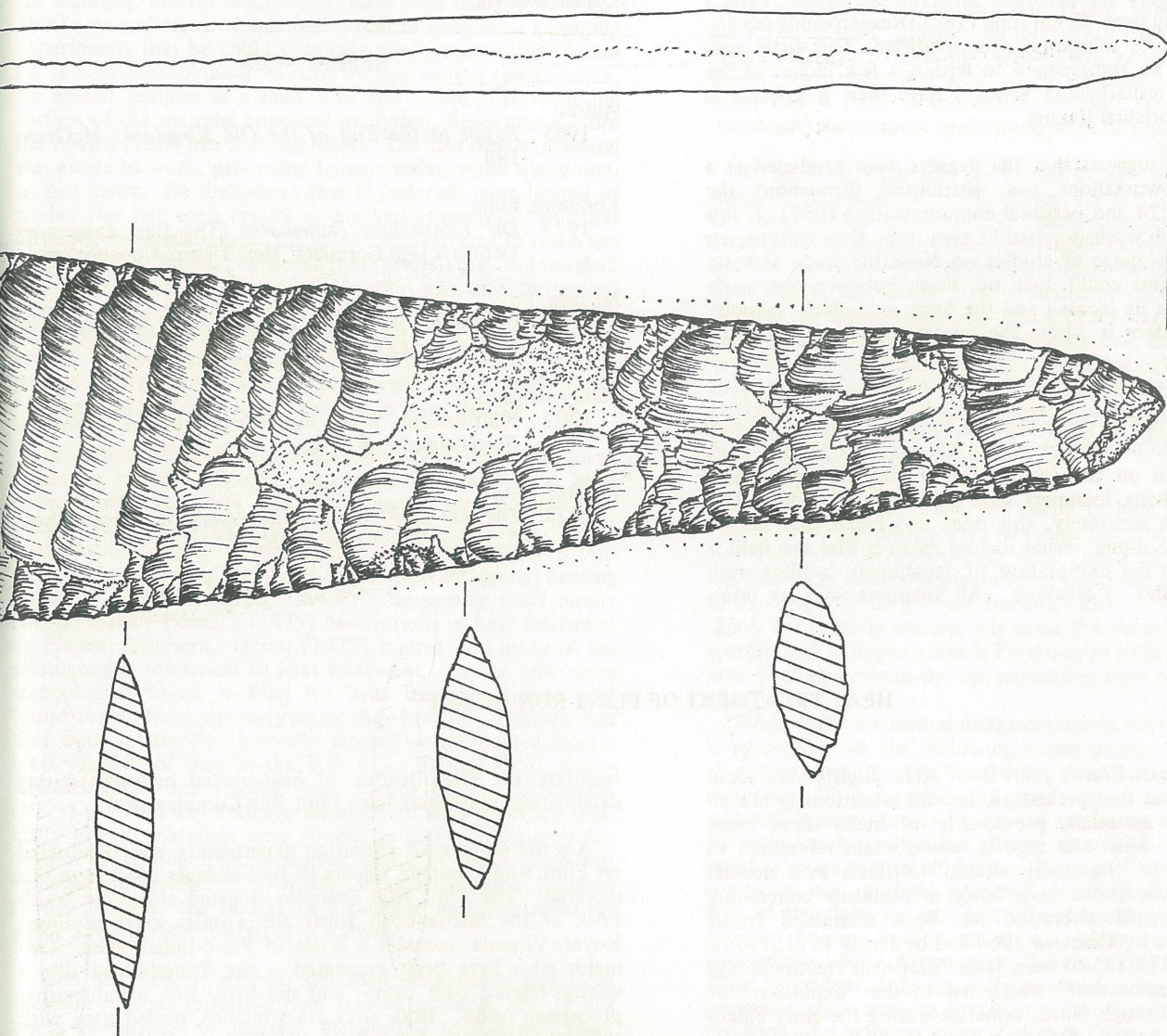
of the dagger a quadriface (four faces) and not a biface (two faces). Type IV daggers have both median seam and basal flare. The Hindsgavl dagger (pronounced "Hinsgowl") is of this type (cf Waldorf 1979:2, where it is depicted just over half scale). The Hindsgavl is the most famous of the Danish daggers and the only one most American knappers ever see depicted. It is given a prominent position in the Danish National Museum; it is undoubtedly Denmark's finest treasure -- the pinnacle of flintworking achievement anywhere.

The Type V dagger has basal flare but no median seam. The Type VI, Bronze Age, dagger has neither seam nor flare, as Type II, but has a distinctive bronze-dagger-like blade shape. The fine pressure flaking seen on some of the above types is not seen here. These daggers are widest just above the handle, as are Types IV and V, whereas the Types I-III are generally more narrow and widest at the mid-point. There are numerous other flaking details to be noted, but this is not the time and place for a detailed discussion.

Danish daggers are generally large in size, some Type I specimens being over 45 cm long (18"). Resharpening occurs, but the handle is seldom if ever modified. The distal end, however, may be resharpened to within a few inches of the handle. The resharpening which I have seen is inferior in quality to the original flaking.

Bo Madsen suggests that the daggers were produced at a few selected workshops and distributed throughout the country (1980:24 and personal communication 1979). If this is so, and if each workshop had its own style, then with proper analysis, a new range of studies on Neolithic trade and distribution patterns could open up. First, however, the workshop sites must be located and the basic reduction "schools" be analyzed. Here is where the modern flintknapper comes in.

Input is needed at every level to arrive at an understanding of the range of techniques which will produce the kinds of flake scars seen on the various Danish daggers. Although I know of no living knappers who are replicating the better Danish daggers accurately, this does not mean that we are incapable of so doing. What it does mean is that the field is wide open for the exploration of techniques, holding positions, and modes of working. All knappers who are inter-

ested are urged to put their heads and hands together and see what they can come up with in this regard. Bear in mind that what we need are ideas, not necessarily masterpieces. (Experiments may be done on small bifaces to work out sequences of manufacture; experiments on square-section handles could easily be done on small blocks of flint.)

In an effort to facilitate such research, I am offering this illustration of Danish dagger No. A-10198. Incidentally, the International Flintworking Seminar at Lejre, Denmark, which will be held in early August 1981, will concentrate on the Danish Neolithic Period. Dagger replication will be a key research target.

I would like to thank the Archaeology Department of the National Museum of Denmark for allowing me to draw this specimen and for putting up with my many visits to their collections in 1979. This drawing is one of a series of drawings made in conjunction with a proposed illustrated book on Danish daggers.

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Errett Callahan

HEAT TREATMENT OF FLINT RUN JASPER

Within the past fifteen years most archeologists have come to the realization that prehistoric Indians intentionally heated siliceous lithic materials, presumably to make them more easily worked. Most site reports now contain references to "heat-treated" or "thermally altered" artifacts as a normal course of action, and a large body of literature concerning intentional thermal alteration has been assembled (most notably, articles by Crabtree 1964 and by Purdy 1971, 1974). Bonnichsen (1977:185-6) even feels "that heat treatment was the catalytic innovation" which led to the 'explosion' of fluted points through North America during the early Paleo-Indian (Clovis) period. One item emphasized by most reports is that specific lithic sources are "altered" in different ways and at different temperatures (see Patterson 1978) and that the raw material used at a particular site should be tested before conclusions are made concerning "heat-treatment." With this in mind, testing was conducted to set up a usable guide, consisting of flakes of both heated and unheated jasper, to

facilitate the identification of heat-treated materials during cataloguing of artifacts from Flint Run Complex sites.

A series of thermal alteration experiments was conducted on Flint Run Complex jaspers to find changes specific to this material. The Flint Run Complex, located along the South Fork of the Shenandoah River, seven miles south of Front Royal, Virginia, includes a series of Paleo-Indian sites. Two major sites have been excavated -- the Thunderbird site, a quarry related base camp; and the Fifty site, a butchering/processing camp. Both sites are stratified, buried sites, with cultural continuity from Paleo-Indian through Early Archaic (see Gardner 1974). The vast majority of artifacts are made from locally available jaspers, quarried from sites along Flint Run, directly across the South Fork from the Thunderbird site. (The quarry sites, unfortunately, are not stratified, although one quarry reduction site -- the Lockhart site - is stratified, but lacks diagnostic artifacts from levels below

Early Archaic.) A large number of artifacts from all sites had shown what appeared to be results of thermal alteration -- color change from yellow to red, and a glassy texture. Through experimentation we hoped to more specifically describe the changes that occurred to establish guidelines for cataloguing artifacts from Flint Run sites. Both "controlled' (i.e., in a kitchen oven) and "uncontrolled" (i.e., under a camp fire) experiments were conducted. Within the framework of this report the term "heat-treatment" will refer only to rock intentionally heated, presumably to improve its flaking characteristics. The general term "thermally-altered" is a better one when dealing with artifacts, in that it merely notes that the stone has been altered by elevated temperature without requiring a decision on whether this alteration was accidental or intentional.

LITERATURE REVIEW

The first published account of heat treatment of silica materials was Don Crabtree's (Crabtree and Butler 1964), although Callahan (pers. com.) notes that some flintknappers, for example, Marvin McCormick, have been using it since the 1930's or earlier. Crabtree had noted in early flint knapping experiments that he could duplicate the "greasy luster" found on certain archeological remains by heating the raw material. He heated samples in a sand bath and found that while the surface of the material appeared unaltered, flakes struck from the heated pieces had a greasy luster. The heat treated material was easier to work, producing longer, wider, more easily controlled flakes. He discovered that if materials were heated or cooled too fast they crazed or cracked extensively, and that different materials require different temperatures to reach the proper luster. Finally, he noted that "spalls, cores and roughed out blanks that are comparatively thin can be heat treated more successfully than thick chunks or nodules" (1964:2). His succinct article presents, in three pages, all the information crucial to the heat treatment of siliceous minerals. All the studies that follow it serve only to verify and quantify Crabtree, and explain the physical process in more detail.

In response to Crabtree's article, intentional heat treatment began to be taken more seriously, and research into both ethnographic literature and archeological site reports produced examples of thermal alteration. One frequently cited ethnographic report is Man's (1883), which described Andaman Island women (who did all the flint knapping) heating "quartz" before knapping. Another frequently cited report is John Wesley Powell's (1875) descriptions of heat treatment by Plateau Shoshoni. Hester (1972) summarized many of the ethnographic references to heat treatment. At the same time archeologists began looking for heat treated artifacts, and found them seemingly everywhere they looked. Artifacts that that were apparently thermally altered were reported from a great number of sites in the U.S. (e.g., Fitting 1966, Irwin-Williams 1966) and Europe (e.g., Bordes 1969). Mandeville (1973) provides an extensive summary of sites at which thermally altered materials were found, as well as a lengthy discussion of ethnographic examples, many of which were not included in Hester's (1972) article. In an early article, Shippee (1963) reported the finding of a possible heat treatment pit at the Spillway Site (14Po12) in Kansas.

With the process of heat treatment established and large numbers of sites reporting heat treated artifacts, the 1970's saw a florescence of research attempting to discover what, exactly, occurred during heat treatment. The most detailed scientific investigation into thermal alteration is Purdy's, done originally as research for her dissertation, but summarized in two articles (Purdy and Brooks 1971; Purdy 1974). Purdy disproved the popular notion that flint was worked by heating and then dripping water on the heated rock to cause spalls to be released (Purdy 1974; see also Mandeville 1973).

She found that the critical temperature for heating Florida cherts was about 400°C, with the interval between 350-400°C of greatest importance. Rock must be heated slowly from 350-400°C and slowly cooled to prevent spalling and explosion. This temperature was considerably lower than the 1400-1700°C necessary to melt the silica cryptocrystals in chert (Purdy 1974:43) and higher than the 240-260°C necessary to change the oxidation state of the iron impurities, which produces the color change typical of some heat treated materials. Purdy hypothesizes that the change occurring in the rock is that the mineral "impurities (or combinations of impurities) contained in Florida cherts are serving as fluxes (substances promoting fusion) to fuse a thin surface of the cryptocrystals" (Purdy 1974:45-6). The impurities melt at the critical temperature, then recrystallize to bond the cryptocrystals in such a way that fracture occurs across the crystals instead of around them, causing the vitreous luster of the heat treated rocks. This helps to explain why different materials have different critical temperatures -- they are dependent on the melting points of the impurities rather than the silica material itself. Purdy also found that slowly heated and cooled rock had a higher compressive strength, but a lower tensile strength. This would explain why heat treated material flakes more easily and with greater frequency of feather terminations -- force is transmitted further through the rock, which also shears more easily along lines of stress.

M. D. Mandeville has performed extensive tests into heat treatment (Mandeville 1973; Mandeville and Flenniken 1974) and summarized work by C.J. Phagin, David Cole, Mike Gilman, D.C. Anderson, Dave Leach and Larry Lee Nelson, as well as his own. He utilized a greater variety of materials than Purdy, and notes that: "Different cherts respond differently to heat treatment; fine grained varieties show the desired changes at a lower temperature than do coarse grained varieties and are also subject to thermal shock at lower temperatures" (Mandeville 1973:191). Mandeville and Flenniken (1974) also conducted in-the-field experiments -- in January, with an air temperature of −16°F. My own field experiments were based largely on this discussion.

Other studies of heat treatment include Sollberger and Hester (1973), working with Arkansas novaculite; and Collins and Fenwick (1974) working with Kentucky cherts. There has also been some discussion as to why only the tips of some artifacts appear to be heat treated. McCary (1975:57) feels this is for esthetic reasons -- it turns the tip red in color -- but a more logical explanation is Patterson's (1975). He feels that heat treating weakens the tip, permitting finer pressure flaking.

While there are several disagreements in the literature, there is agreement on the following major points. One, thermal alteration does improve the flaking characteristics of siliceous materials, although, as Callahan (pers. com.) notes, this altered material is also more easily broken or damaged. My own experience has been that the altered material works better, but requires more care in working -- flakes go further, but if platforms are not carefully prepared, or if the direction and extent of the flake are not properly planned, it is very easy to get step fracture and/or end shock. Heat treatment appears particularly useful for pressure flaking. Two, thermal alteration is evident only on surfaces struck after heating -- the original surface remains much as before heating -- usually in the form of a vitreous luster. Callahan (pers. com.) notes that the vitreous luster that Purdy reports only appears when a relatively high grade material is heated. Lower grade material, such as granular jasper, will improve in flaking characteristics, but the flakes do not exhibit the vitreous luster. While heating improves the workability of a rock, it cannot alter low-grade material into a fine, glassy state. In this case the flakes do not exhibit the luster of heated, higher-grade materials. Three,

color change may occur when the rock is heated, but the change occurs at a lower temperature and, therefore, does not necessarily indicate thermal alteration. Observable change in color appears linked to presence of iron impurities in the materials (especially in jasper) and color change may or may not appear in heated stone. When color change does occur, it is greatest at or near a surface, with little or no internal color change. Four different kinds of siliceous minerals appear to have different critical temperatures above which the characteristics of the material are altered and below which they are unaltered. Five, rocks must reach this critical temperature through a slow heating process, and then be cooled slowly, or else they will fracture and/or craze.

In terms of how and when the raw materials are heated, it appears that the most efficient form of heat treatment is to heat large flakes or primarily thinned bifaces in fire pits. Crabtree (Crabtree and Butler 1964) notes that the maximum effect on the stone is achieved from heating thin pieces, not large chunks. He also notes the lack of heat treated debris near quarry sites, but its presence in camps near the quarries (1964:3). Powell states that rocks were first reduced from "larger masses of the rock" (1875:27-8). What this appears to indicate is that blocks of material were reduced enough to be easily carried, either as large spalls or as bifaces, to the campsite, heated, and then further reduced. Klippel adds support for this with evidence from Graham Cave. He reports: "More than 80 per cent of the thin bifaces are treated whereas over 75 per cent of the thick bifaces, crude bifaces and cores are not" (1971:44). Evidence that heating was conducted in a pit comes primarily from ethnographic analogy, but one such pit has been excavated (Shippee 1963). While Powell (1875) gives evidence for heat treatment above ground, underneath a fire, the concept of slow heating is the same. In this case it appears that insulation is built up above ground level instead of being contained in a pit.

EXPERIMENTATION AND RESULTS

A series of experiments was conducted to test the effects of thermal alteration on Flint Run jaspers. The one major field experiment was part of a course in lithic technology, taught by Errett Callahan at Catholic University in the Fall of 1976. Originally I planned to follow the methodology of Mandeville and Flenniken (1974) with a heat-treatment pit, but the ground was too deeply frozen to permit easy excavation with native tools. A shallow (10 cm) pit was dug, lithic material was placed within a pile of insulation (7 cm of ash) and covered with 13 cm of damp moss (similar to what Powell (1875) observed for the Plateau Shoshoni). A variety of jasper from the Flint Run quarries was included, ranging in quality from excellent to poor, and a variety of sizes was used, ranging from large bifaces, through large flakes, to small flakes, at various distances from the fire (deep within the ash layer, on top of the ash layer, within the moss layer, on top of the moss, and, after the fire was started, within the fire itself). Many of the results from this experiment have since been observed in more controlled (i.e., kitchen oven) experiments with Flint Run jaspers.

A variety of results came from the heat-treatment experiments, most of which replicate those experiments already described earlier. The main goal of the experiments was to provide reference artifacts to aid in cataloguing materials from Flint Run sites, and this was achieved. It appears that distance from the fire played an important role in heat-treatment -- artifacts too near the fire heated too fast and exploded or crazed. Small flakes either just below the fire or within it exploded rapidly, and noisily, with the characteristic potlids covering the remaining surfaces. A larger piece exploded, and attempts to flake the remaining fragments produced no con-

trolled results -- the pieces shattered. All these pieces were uniformly red in color throughout -- even in the center of the larger, fractured piece.

Properly heat treated jasper produced the predicted results -- red color appeared only on the surface; upon flaking, the quality of the heated material was better than the untreated control sample. For several samples the change in the interior of heat-treated jasper was only visible upon comparing the heat-treated to the original rock. The interior showed no apparent color change. While the quality improved markedly, if the original texture was grainy, the texture of the heat-treated rock was not even so glassy (vitreous) as fine-grained, unheated rock. Pre-existing fracture or bedding planes continued to determine flake properties, even if heat-treated. With no adhering reddened areas from the original surface, it is highly likely that flakes from these grainy textured rocks would be catalogued as unheated.

DISCUSSION

For cataloguing thermally altered material I have used three terms: thermally altered, heat treated, and burned. I now define these. (1) Burned: uniformly red in color, with potlidding and/or heat fracture; subsequent flaking produced uncontrolled fracture. (2) Heat treated: intentionally thermally altered to improve flaking quality of the stone; exterior red in color (for Flint Run jasper), interior unaltered in color, but with a finer texture than originally (up to a vitreous luster in better quality stone). (3) Thermally altered: any stone that appears to have been changed by exposure to high temperature. Burned artifacts would include stone for which heat treatment was unsuccessfully tried and flakes that were accidentally heated rapidly -- for example, after falling into a campfire. I doubt that Indians would have the consistency of success of modern laboratory experimenters, who can control temperature in ovens -- there must have been some failure. This failure should produce a number of small flakes, either left in a pit or scattered where the fire had been built. There is difficulty in cataloguing some heat-treated artifacts; unless some of the reddened surface remains or unless the texture is extremely glassy, it can be difficult to differentiate unheated from heat treated material. In any event, unless these two terms are clearly applicable, I prefer the use of "thermally altered," in that it does not necessitate a decision as to the motive of the Indian. While this may appear a form of "copout," I feel caution should be used in assuming too much about lithic remains.

The results from these experiments have been applied to cataloguing artifacts from the Flint Run sites, with some interesting results. A large percentage of artifacts from the Thunderbird site show some degree of thermal alteration -- a point which might support Bonnichsen's hypothesis. As analysis continues we will be able to produce computer maps of excavated floors, showing areas of concentrations of thermally altered and burned artifacts. Large concentrations of burned jasper flakes might indicate the presence of a campfire, with the flakes being burned as an accidental result.

I would also like to add to the growing discussion concerning stages in stone tool manufacture (especially bifacial tools). Callahan has discussed in his M.A. thesis a number of stages for manufacture of fluted points. Patten (Pers. com.) feels that this concept is overblown. It may be, however, that thermal alteration played a part in a staging strategy. As has been noted, the effects of thermal alteration are greatest on thinned bifaces and most useful for pressure flaking. It seems possible that jasper was reduced to a certain point (or stage), and then heat treated. Following heat treatment the material would be sufficiently altered to require different flaking tech-

niques -- for example, greater use of pressure rather than percussion. In this line, last year's (1978) excavations at the Thunderbird site produced two interesting chipping clusters. A moderate sized chipping cluster was excavated (Fea No. 102) that showed a large number of very large flakes, presumably hard hammer percussion flakes (two hammerstones were found in direct association, including a very large greenstone hammerstone with a great deal of damage). Less than five percent of the flakes showed any sign of thermal alteration. From a similar level of another square (both levels are approximately late Paleo-Indian/Early Archaic) another chipping cluster (Fea No. 101) was excavated. This cluster was very small in area, and produced a large number of small, presumably pressure, flakes. Over ninety percent of the flakes indicated thermal alteration of some kind. I see the possibility of three functional stages, based on research to this point. One, quarried jasper is reduced to portable size; cortex is largely removed; lower grade jaspers are discarded. The partly reduced cores are carried to the Thunderbird site. Two, these cores are further reduced by hammerstone and billet percussion. Large flakes are struck from the cores and these flakes as well as the cores are reduced. Three, reduced bifaces are heat treated prior to pressure flaking that produces the finished tool. I should note that this strategy applies only to bifacial tools -- flake tools show none of the staging requirements, or thermal alteration. This is by no means the final word on this, and I would appreciate any discussion.

This paper has served to summarize earlier studies about lithic thermal alteration, and present some findings from experiments and excavations at the Flint Run Complex sites. In keeping with the tenets of experimental archeology, I feel flint knapping should be conducted on the particular raw material occurring at sites being excavated and this experimentation compared to the excavated results. Flint Run jaspers were heated and flaked, and the results are being used to guide further cataloguing and analysis.

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PROBLEMS AND SOLUTIONS

THE ANALYSIS OF STRIKING PLATFORM GEOMETRY

L. W. Patterson

INTRODUCTION

The striking platform angle is an attribute often mentioned in lithic analysis and archeological reports. However, like many attributes in lithic technology, this variable is often simply tabulated without any further discussion of its importance. Also, not all analysts use the same geometric definition of angles related to striking platform orientation. The use of lithic attributes in archeological studies is of little value unless terms are clearly defined and consistent. The tabulation of lithic attributes has value in basic data presentation, but is of most value only when accompanied by a discussion of the significance of each attribute.

This article discusses both the definitions and the significance of various angles that can be measured in relation to the striking platform orientation, especially in reference to residual striking platforms on lithic flakes.

STRIKING PLATFORM ANGLE

Lithic flakes are detached in a controlled manner by the application of force to a surface of a core called the striking platform. The angle between the striking platform surface and the adjacent core face is the striking platform angle, as shown in Figure 1. On a flake, the striking platform angle is the angle between the residual striking platform and the dorsal surface.

The striking platform angle is one of the key variables used in obtaining controlled flaking. This angle must be acute (less than 90 degrees) to consistently do controlled flaking. An occasional example may be found where the striking platform angle is a few degrees over 90, but these examples are not usually statistically significant. If the striking platform angle is obtuse, it is not geometrically possible to apply force in a manner to obtain an outward force element to start and maintain a tensile force fracture plane. A blow on a core with an obtuse striking platform angle may produce a fracture, but it will not be under controlled flaking conditions, where a desired fracture plane is obtained.

By choosing a striking platform angle on a core, or by preparing the desired angle, the flintknapper can control the length of the flake detached. More acute striking platform angles normally give shorter flakes and less acute striking platform angles normally give longer flakes. As the striking platform angle approaches 90 degrees, force application is directed more into the core mass, with greater force application required to detach flakes, and there is a greater tendency to obtain abrupt fracture terminations, instead of the usually desired feathered flake end. It should be understood that there are also other key variables in controlled flaking, such as: core geometry, force application direction, amount of force applied, and the type of force application tool. These key variables can be used effectively only if the rotation and deflection of the core are controlled.

Striking platform angles of less than 90 degrees on lithic flakes are one indication of controlled flaking by man. Natural forces and random mechanical forces such as gravel crushing can produce flakes, but will simulate the attributes of controlled flaking by man only when striking platform angles are less than 90 degrees. Both man-made and naturally fractured stone collections can have specimens with apparent obtuse striking platform angles, but this is due to incorrect identification of true striking angles, or incorrect measurement of striking platform angles.

During biface manufacture, striking platform angles will be varied by edge beveling to control the production of various desired flake lengths. In some types of lithic manufacturing, such as prismatic blade manufacture, the striking platform angle will be held fairly constant to obtain a consistent type of product flakes. In lithic analysis, the striking platform angle should be regarded as one of the controlled variables used in the manufacturing process, and as such is one of the possible attributes that can be used to reconstruct the manufacturing process.

FLAKE DETACHMENT ANGLE

The flake detachment angle measured on a flake is defined here as the angle between the residual striking platform and the fracture plane, which is the ventral surface, as shown in Figure 1. In controlled flaking, this angle is obtuse, although the *initial* fracture plane may be at 90 degrees to the striking platform on lipped flakes. When a prominent force bulb occurs on the ventral face of a flake, the flake detachment angle is difficult to define with any degree of precision.

It should be noted that the flake detachment angle is a dependent product variable, with fracture plane control achieved by the use of other independent variables. The usefulness of this variable in lithic analysis is somewhat limited because it is a dependent variable and is often difficult to measure accurately.
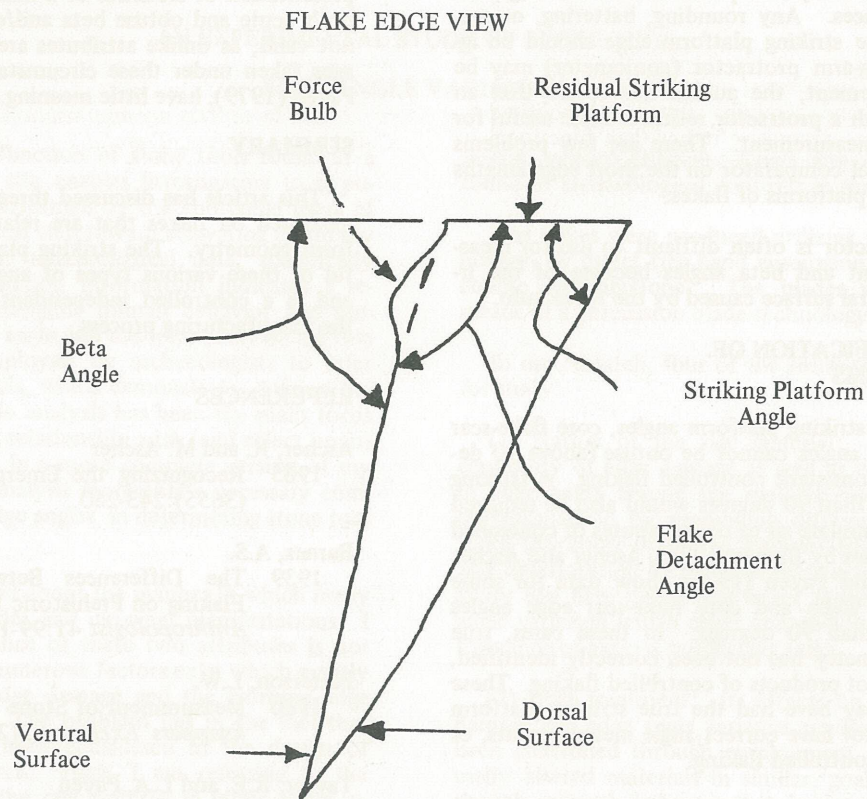
BETA ANGLE

Some lithic analysts have published data on an angle related to the striking platform orientation on a flake which Wilmsen (1970:14) refers to as the beta angle. This is the angle from the plane of the striking platform down to the fracture plane, which is the ventral surface, as shown in Figure 1. In controlled flaking, this angle is acute, and fairly parallel to the striking platform angle at the initial point. The beta angle may be 90 degrees for the *initial* fracture plane on lipped flakes, but it will not be obtuse in controlled flaking. This angle is often difficult to measure accurately for the same reasons that the flake detachment angle is often difficult to measure.

As with the flake detachment angle, the beta angle is also a dependent product variable, and is more descriptive of manufacturing results than of the manufacturing process itself. Barnes (1939) used the striking platform angle on stone tools *after* flake detachment as an indication of man-made flaking, when this angle was consistently acute. Barnes' flake-scar edge angle is equivalent to the beta angle on flakes. Consistently acute beta angles would be an indication of controlled flaking, in the same manner as consistently acute

FLAKE EDGE VIEW

Force Bulb

Residual Striking Platform

Beta Angle

Striking Platform Angle

Flake Detachment Angle

Ventral Surface

Dorsal Surface

CORE SIDE VIEW

Striking Platform

Force Application

Striking Platform Angle
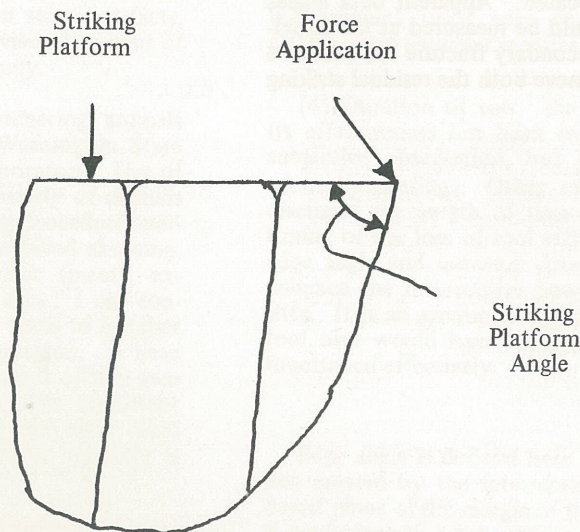
striking platform angles. In the determination of whether or not flakes are man-made, studies should not be confined to a single attribute, however.

STRIKING PLATFORM ANGLE MEASUREMENT

Problems in the measurement of edge angles in general have been previously discussed by the author (Patterson 1980). The striking platform angle is usually easier to measure than other types of edge angles, in that the striking platform angle is normally formed by fairly flat planes of the striking platform and dorsal surfaces. Any rounding, battering, or secondary fracture of the striking platform edge should be ignored. While a swing-arm protractor (goniometer) may be used for this measurement, the author has found that an optical comparator with a protractor reticle is more useful for this specific type of measurement. There are few problems with focusing an optical comparator on the short edge lengths of the residual striking platforms of flakes.

A swing-arm protractor is often difficult to use for measuring flake detachment and beta angles because of the irregularities on the ventral surface caused by the force bulb.

INCORRECT IDENTIFICATION OF
STRIKING PLATFORMS

As outlined above, striking platform angles, core flake-scar edge angles, and beta angles cannot be obtuse (above 90 degrees) when there is consistent controlled flaking. A striking platform angle of less than 90 degrees would also be required for natural forces to simulate all of the attributes of controlled flaking by man. Studies by Barnes (1939), Ascher and Ascher (1965), and Taylor and Payen (1979) show data for some specimens with beta angle and core flake-scar edge angles significantly greater than 90 degrees. In these cases, true striking platform geometry has not been correctly identified, or the specimens are not products of controlled flaking. These types of specimens may have had the true striking platform surfaces missing, did not have correct angle measurements, or were not products of controlled flaking.

One example of incorrect identification of a striking platform surface would be where the force application point is apparent by an existing bulb of force on the ventral face of a flake, but the apparent striking platform and beta angles are obtuse. This generally means that the true residual striking platform has been removed by a secondary fracture. Another case where incorrect identification of the striking platform surface could occur is where the bulb of force is missing but the direction of ventral face ripple lines indicates where the proximal end of the flake is located. Apparent beta angles and striking platform angles could be measured at the proximal end of the flake, but here secondary fracture has occurred far enough down the flake to remove both the residual striking

platform and the bulb of force, or the specimen is not the product of controlled flaking.

Because of popular beliefs promoted by impressions of past studies, the conclusion given here should be emphasized, as follows: *Intact examples of controlled flaking must have striking platform and beta angles of less than 90 degrees.* Specimens that are stated to have striking platform and beta angles significantly greater than 90 degrees probably have incorrect identifications of true striking platform surfaces. The presentation of statistics of a mixture of flakes stated to have both acute and obtuse beta and/or striking platform angles is not valid, as unlike attributes are being used together. Averages taken under these circumstances, such as by Taylor and Payen (1979), have little meaning.

SUMMARY

This article has discussed three types of angles that can be measured on flakes that are related to residual striking platform geometry. The striking platform angle is the most useful of these various types of angles. It is easiest to measure and is a controlled independent variable directly related to the manufacturing process.

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FROM THE LITHICS LAB

The WSU Lithics Lab is under the direction of Dr. Jeffrey Flenniken.

AN EXPERIMENTAL STUDY OF STONE TOOL
EDGE ANGLE VARIANCE[1]

Determining probable function of stone tools found at a prehistoric archaeological site enables investigators to hypothesize on the activities performed by the aboriginal users of those tools. This is a critical step toward answering culturally significant questions from archaeological data, specifically lithic artifacts. Tool function information indicates a relationship between the intangible human behavior and tangible stone artifacts. Edge angle and use-wear analyses are two techniques commonly employed by archaeologists to infer the function of stone tools, which demonstrates human behavior. Though edge angle analysis has been the main focus of the present research, its relationship with (and effect upon) use-wear is to be discussed in a more complete version of my work. I believe use-wear analysis represents a necessary complement to the study of edge angles in determining stone tool function.

However, I am concerned about the manner in which many researchers study edge angles and use-wear manifestations. I feel that the full significance of these two attributes is not adequately understood. Numerous factors exist which greatly affect the formation of edge damage and the working edge angle of the tool margin. The problem lies in the fact that these factors have rarely been considered in the design of stone tool function research. Here, I am referring to the following: (1) nature of the raw material in terms of its inherent properties; (2) effects of heat treatment on the stone; (3) changes in edge angle which occur with extended use, (and closely related to the last factor); (4) evidence of intentional tool resharpening and subsequent reuse; (5) depositional history of the material under study (that is, noting exposure to agents that can create unintentional damage); and (6) effects of the material being worked on the formation of edge damage. The present research is evaluating the role most of these factors, or variants of them, play in the formation of an edge angle and secondarily edge damage on stone artifacts. The utility of edge angle analysis is being reviewed in light of the observations made in this experimental study.

My experimental program involved butchering animals using unmodified flakes and blades at the Washington State University Veterinary School Diagnostic Laboratory. Use of the facilities afforded me access to a wide variety of animals in terms of species and sizes. The butchering procedures performed during the experimental program involved skinning, disarticulating limbs, slicing up muscle tissue (meat), extracting tendons (sinew), and other minor tasks. I am confident about my skill in manipulating stone tools to butcher animals, given the time spent in experimentation. I have butchered animals at the Diagnostic Lab on and off for two years. Other experimentors fail to discuss this important variable, that is, their own skill in performing the task. Skill in performing experimental procedures correctly certainly is a critical part of any experiment.

The raw materials chosen for use in the experiments were chert from northcentral Oregon and obsidian from Glass Buttes, central Oregon. Chert and obsidian are commonly found in archaeological contexts in the western United States.

The flakes were produced utilizing a biface reduction technology, by direct free-hand percussion with a small limestone cobble hammerstone. The blades were manufactured by means of a percussion blade technology.

In my research, four of the above factors have been chosen for study:

(1) Nature of the raw material: differences in the susceptibility of edge damage as well as the effects of differences in edge angle among the material used are noted. This is operationalized by employing different materials for similar tasks (duration of use is known) to note differential wear and deterioration of the tool margin for instance. The present study can help define the exact ranges of use-wear and edge angle variation which chert and obsidian exhibit from the performance of various butchering tasks.

(2) Heat treatment: its effects on the formation of edge damage and edge angle variance are described. This factor has been controlled through employment of both raw and thermally altered materials in similar, goal-oriented tasks. Even though research indicates that heat treatment has significant effects on the tensile strength and "flakeability" of stone, the pertinent literature lacks studies which correlate this factor with edge damage and edge angle manifestations.

(3) Changes in edge angle and use-wear during tool use: measurements of the edge angle, microscopic examination and microphotography of the working margins of artifacts have documented changes throughout the use life of an experimental implement. I paid close attention to the effect of tool re-sharpening upon edge angle and, to a lesser extent, its effects upon use-wear manifestations.

(4) Duration of use: the length of time a tool maintains its effectiveness has been recorded. Loss of efficiency is a subjective observation, but one that can be easily noticed when butchering. Other experimental studies have rarely discussed the length of time a tool was used. I feel that the timing of the loss of tool efficiency should be correlated with edge angle and use-wear data. Such information can greatly enhance the interpretive power of lithics from archaeological sites. It is an assumption of this study that a prehistoric stone tool user would have been concerned with how long a tool functioned effectively.

Edge angle is defined here as the measurable figure or outline created by the intersection of the ventral plane and the dorsal plane at the margin of the stone specimen. This measure is equivalent to what other researchers have called the "spine plane angle."

I am still in the early stages of the analysis of my experimental tool collection. Therefore, only a few more apparent and important trends will be discussed at this time. My research suggests that the utility of edge angle analysis must be questioned. We should re-evaluate much of the work previously conducted in this area. They include such important publications as S.A. Semenov's 1964 classic treatise, *Prehistoric Technology,* and Edwin Wilmsen's 1970 study, *Lithic Analysis and Cultural Inference;* both are frequently cited in the literature on edge angles.

Changes in edge angle resulting from tool resharpening (pressure flaking with an antler tine along one face) has been highly variable. My sample of obsidian tools averaged a change of slightly over 5° per episode. The range was from an increase of 14° to a decrease of 4°; only two tools decreased. My sample of chert tools averaged a change of over 4°. The range of variation is no change up to 11° increase. I found in my butchering work that resharpening did not significantly alter tool effectiveness. Given the amount of change resulting from tool resharpening, the functional significance of tool edge angle figures from an archaeological context can be problematical. They either represent the initial working angle, a maximum usable angle, or somewhere in between.

At this point in the analysis of my experimental tools, there appears to be no apparent link between length of use time and edge angle. A number of other factors must also be considered, the most impostant one (probably) being the tasks for which the tool had been used. For example, when disarticulating limbs, bones will inevitably be contacted. Bone, being a relatively hard substance, tends to wear tool margins down at an accelerated rate. Certain animals have tougher hides, thicker tendons, more fat, etc., all of which hasten loss of tool efficiency.

Concomitantly, a strong case for the relationship between edge angle and tool efficiency cannot be made. A number of other variables confuse the issue, such as suitability of the raw material for the task, shape of the working margin, tasks for which the tool will be used, etc. As an example, I found during my butchering experiments that a stone tool too dull or otherwise unsuitable for one task, may be serviceable in performing other tasks. I have also noted that tools of 45° or 50° angle can perform as efficiently as more acute angled ones. Such a finding indicates that precision in edge angle measurements may not be necessary.

These few conclusions indicate that edge angle data alone should not be employed to suggest stone tool function; additional information (e.g., use-wear analysis) must complement it. The relationship between various functional categories and certain edge angle ranges, as has been proposed by Semenov and Wilmsen, must at least be amended. More experimental work which incorporates the factors outlined above seems warranted.

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[1]Paper presented at the 46th annual meeting of the Society for American Archaeology, San Diego, May 2, 1981.

FLINTKNAPPING QUESTIONNAIRE

NAME_____ DATE _____

ADDRESS _____

YEARS KNAPPING_____ HOW OFTEN? SELDOM_____ OCCASIONALLY_____ OFTEN _____ DAILY_____

WORK LOCATION (GIVE APPROXIMATE PERCENT): INDOORS_____ % OUTDOORS_____%

DURING THE LAST YEAR, WHAT WAS YOUR KNAPPING FREQUENCY? SELDOM _____

OCCASIONALLY_____ OFTEN_____ DAILY_____

HRS/DAY_____ , DAYS/MONTH_____; MONTHS/YEAR_____

ACTIVITY FREQUENCY, NUMBER FROM 1 (MOST) TO 6 (LEAST): PERCUSSION: BILLET_____,

HAMMERSTONE (PLEASE TELL TYPE OF STONE)_____,

PRESSURE_____, PECKING_____, GRINDING_____, OTHER (SPECIFY)_____.

TYPES OF MATERIALS WORKED (GIVE % IF POSSIBLE) _____
_____
_____

WHAT PRECAUTIONS DO YOU TAKE:	INDOORS	OUTDOORS
VENTILATION	_____	_____
FAN	_____	_____
FACEMASK	_____	_____
NONE	_____	_____
OTHER	_____	_____

IF OTHER, PLEASE DESCRIBE _____

DO YOU SMOKE? _____ IF SO: LIGHT_____ MEDIUM_____ HEAVY_____ DO YOU SMOKE

WHILE KNAPPING? _____ IF NO, WHY NOT_____

ARE YOU EXPOSED TO, OR DO YOU WORK AROUND OTHER TYPES OF DUST? _____ WHAT KINDS OF

DUST?_____ FOR HOW MANY YEARS?_____

HOW OFTEN? SELDOM_____ OCCASIONALLY_____ FREQUENTLY_____ DAILY_____

DO YOU HAVE ASTHMA _____ ALLERGIES (NAME)_____

OTHER RESPIRATORY CONDITION (NAME)_____ TUBERCULOSIS_____ HIGH

BLOOD PRESSURE_____ HEADACHES AFTER KNAPPING_____ ARTHRITIS_____

DO YOU EVER CUT YOURSELF WHILE KNAPPING? _____ WHERE _____

HOW OFTEN – WHEN FIRST LEARNING?_____ TODAY? _____

DO YOU EXPERIENCE ANY OF THE FOLLOWING SYMPTOMS:

SYMPTOM INTENSITY	NONE	SLIGHT	MODERATE	ACUTE	OTHER
FATIGUE	_____	_____	_____	_____	_____
SHORTNESS OF BREATH	_____	_____	_____	_____	_____
COUGH	_____	_____	_____	_____	_____
PAINS IN CHEST	_____	_____	_____	_____	_____
ARTHRITIS	_____	_____	_____	_____	_____
WHEEZING	_____	_____	_____	_____	_____
OTHER	_____	_____	_____	_____	_____

IF OTHER, PLEASE DESCRIBE _____

SYMPTOM OCCURRENCE	SELDOM	OCCASIANALLY	OFTEN	CONSTANT	OTHER
FATIGUE	_____	_____	_____	_____	_____
SHORTNESS OF BREATH	_____	_____	_____	_____	_____
COUGH	_____	_____	_____	_____	_____
PAINS IN CHEST	_____	_____	_____	_____	_____
ARTHRITIS	_____	_____	_____	_____	_____
WHEEZING	_____	_____	_____	_____	_____
OTHER	_____	_____	_____	_____	_____

IF OTHER, PLEASE DESCRIBE _____

SYMPTOM OCCURRENCE	A.M.	P.M.	AFTER KNAPPING	DURING EXERCISING	OTHER
FATIGUE	_____	_____	_____	_____	_____
S.HORTNESS OF BREATH	_____	_____	_____	_____	_____
COUGH	_____	_____	_____	_____	_____
PAINS IN CHEST	_____	_____	_____	_____	_____
ARTHRITIS	_____	_____	_____	_____	_____
WHEEZING	_____	_____	_____	_____	_____
OTHER	_____	_____	_____	_____	_____

IF OTHER, PLEASE DESCRIBE _____

HAVE YOU EVER VISITED A DOCTOR ABOUT ANY OF THESE SYMPTOMS? _____

DO YOU CONSIDER FLINTKNAPPING TO BE INVOLVED IN THESE CONDITIONS? _____

DO YOU HAVE MEDICAL DATA CONCERNING THESE CONDITIONS? _____ X-RAYS _____

MAY WE USE YOUR NAME IN ASSOCIATION WITH THIS DATA?

DID YOU KNOW ANYTHING ABOUT THE DANGER OF SILICOSIS FROM FLINTKNAPPING BEFORE READING THIS ARTICLE? EXPLAIN: _____

PLEASE FILL OUT THIS QUESTIONNAIRE AND RETURN IT TO:

JEFFREY KALIN
FLINTKNAPPING QUESTIONNAIRE
30 EAST AVENUE
NORWALK, CONNECTICUT 06851