The Antler Foreshaft – The Original Shrink Wrapped Package

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Figure 1 – North Slope of Alaska

One evening during the summer of 2003 I was sitting in the white tent in Figure 1 with John and Tasha. The white tent was our kitchen and we were doing archaeological survey work for the BLM on the North Slope of Alaska. This was our first day at this location and I remember Tasha asking if we could build a fire on the gravel bar later in the evening. She strengthened her request by arguing that by building it on the gravel bar we would not contaminate any archaeological sites with new charcoal. John then said, "OK, what are we going to burn?" A silly little smile slowly crept on to Tasha's face. There was no wood there. The nearest sizeable wood was 50 miles to the south on the other side of the Brooks Mountain Range.

I offer Figure 1 and this story because I want to emphasize the fact that there is no wood on the North Slope of Alaska. It is above the latitude timber line. Yet, we were finding Paleoindian points that are called Mesa/Sluiceway. These are large points with lengths in excess of 100 millimeters (mm). So the obvious question is how were these large points hafted in this woodless environment? Images of Mesa and Sluiceway points can be see at my webpage "*Lithic Artifacts from North of the Arctic Circle*" (www.ele.net/arctic_artifacts/arctic_artifacts.htm).

Mesa/Sluiceway points are similar to the Agate Basin point in Figure 2, which is from the Texas Panhandle. In fact, the Mesa/Sluiceway points of Alaska, the Haskett/Agate Basin points of Canada and the lower 48 states, and the El Jobo points of South America, all have the same morphology. Originally constructed, before any damage and refurbishment, they have a convex, tapering base and a width-to-thickness ratio in the range of 3.2. These are all large thick-bodied points. So, even in a wooded environment, how might they have been hafted?

Figure 2
Resharpened
Agate Basin
length=84mm w/t=2.8

Antler and Bone Foreshafts

In the 1960s I was attending college and living at home with my parents. I remember one evening my father told me that he had been feeding the dog some table scraps that afternoon, and in the process, he noticed that the soft marrow portion of a beef rib was about the size of a Folsom point. He suggested that maybe Folsom points were hafted in a rib bone foreshaft. A number of years later he passed this idea on to Jim Judge, who then used it to explain the consistency in the basal width of Folsom points. Judge suggested that "… the fine retouch and grinding of the Folsom lateral edges was to permit the relatively easy insertion and extraction of the point base into the socket haft" (1973:176).

Figure 3 is a diagrammatic sketch of the socketed foreshaft configuration that my father and Judge were envisioning. I show this Figure because the words "foreshaft" and "socketed foreshaft" have several configurations in the archaeological literature. In this paper I am referring to the configuration in Figure 3 and only this configuration.

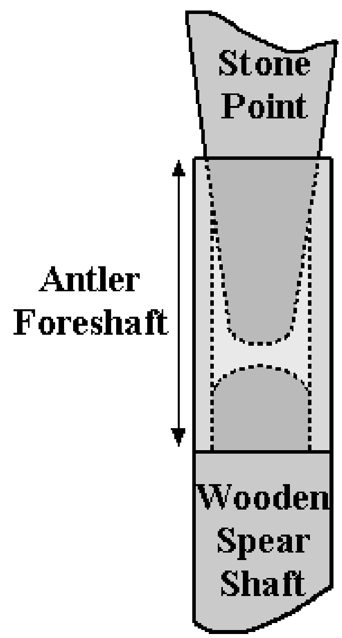


Figure 3
Socketed Foreshaft

I have always been attracted to this idea of a bone foreshaft . One could carry one wooden shaft and a number of extra foreshafts with hafted points. In a sense, it changes a thrusting spear or atlatl dart from a single shot into a six-shooter. Since the 1960s I have suspected that Folsom and other thin-bodied points were hafted in a rib bone. However, a rib bone has the wrong shape for the thick-bodied points. They required a bone with a rounder marrow center. Seeing a number of modern antler-hafted stone knifes in curio stores in the Western U.S., caused me to realize that antler shafts had the correct shape for the thick-bodied points. At the same time, I could not imagine how one could cut and shape antler with only stone tools. However, I assumed that the Paleoindian people knew how to use their tools and had a tremendous amount of patience.

In the early summer of 2009, Bob Patten (www.stonedagger.com) and I were discussing the subject of antler foreshafts. I said something to the effect that I strongly believed the Mesa/Sluiceway people were using caribou antler for their foreshafts, but I could not imagine how they could carve the stuff. Bob said that one could soften antler by soaking it in water. That was all I needed. A few quick Internet searches and sure enough, they claimed that one can soften antler and bone by soaking them in water. So I decided to do some experimental archaeology. The next section is a report on that work.

Experimental Archaeology

Experimenting for me has never been a set of sequential steps from beginning to end. It is more like working one's way through a maze, with a can of spray paint. The spray paint permits one to mark the dead-end routes that are discovered, so one does not attempt those routes again. I must admit that my writing process is done exactly the same way. Often I don't know what the end will be or how I will get there. I just start writing and trying things. That said, below I present my procedures and findings in an organized manner. However, the reader should know that they did not occur this way. The real process was spray-paint experimental archaeology.

Figure 4 – Antler Specimens Prior to Soaking in Water

Soaking Antler in Water

The three pieces of antler in Figure 4 were used for this soaking experiment. Specimens I and II are deer and Specimen III is caribou. The time between the shedding of the specimens and this experimental work is unknown, but it is suspected to be numerous years. The larger pieces from which Specimens I and II were cut were given to me by Bob Patten. Specimen III is from a shed that I collected from the North Slope of Alaska. All ends were cut with a metal hacksaw. One end on both Specimen I and II was a new cut made for this work. The other end on Specimen I and II, plus the three ends on Specimen III were old cuts made at a minimum of two or three years earlier. Finally, Specimen I had been painted with shellac sometime in the past, so only the new cut exposed the antler directly to the water in the beginning.

Figure 5 – Weighing a Submerged Specimen

The experiment began by weighing the specimens in air and then weighing them submerged in water. The submerged weights are always less than the weights in air because they are buoyed up by the weight of the water they displace (Archimedes'

Principle). Due to the marvels of the metric system, the weight in air (grams), less the submerged weight (grams), is equal to the volume of the specimen (cubic centimeters). Figure 5 depicts weighing a submerged specimen. The thread that holds the specimen inside the glass is attached to the bottom of the pan of the scale. The glass is normally filled with water, however I left the water out of the glass so the reader could better see the specimen.

The specimens were then submerged in water for approximately 160 hours (6.5 days). Periodically, I would remove and again weigh them in air and then submerged. Since these were old, dry antlers, I had expected an increase in their densities as they slowly absorbed water. This did in fact happen. See Figure 6. Specimen II apparently had the most porosity of the three since it had the largest increase in density. Yet, the relative positions of the three specimens, with regard to density, did not change during the 160 hours. Specimen II, the least dense, remained the least dense and Specimen III held its position as the most dense.

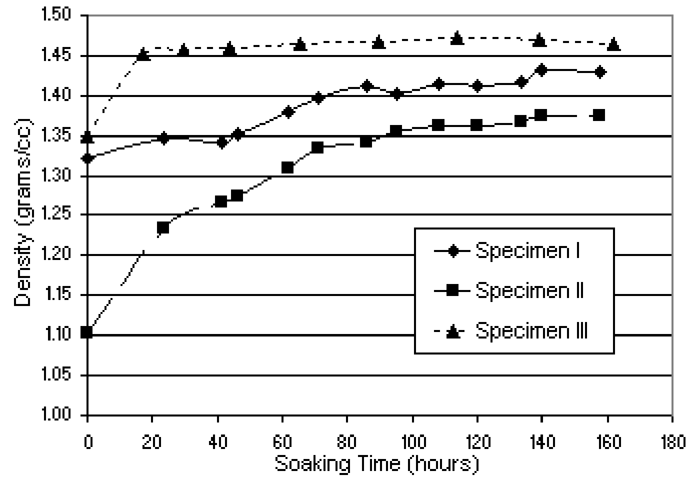


Figure 6 – Density Increase while Soaking in Water

What I didn't expect was for the volumes to increase. They all gained approximately 17% in volume during soaking. See Figure 7. This means that their diameters and lengths increased. As previously mentioned, Specimen I had been painted with shellac sometime prior to the soaking experiment. As it began to swell, the shellac started to peel off in small clear flakes. The soaking of Specimen III was done after I had already observed the volume increases in Specimens I and II. So, to verify these volume increases I measured the diameters of the three ends on Specimen III with a micrometer each time I weighed it during soaking. These three diameters demonstrated an average increase of 7.6%. These ends were not actually round, but assuming that they were, an increase in a circle's diameter by 7.6% will increase its area by 16.8%. Specimen III actually had a total volume increase of 18.6%. Assuming a cylindrical shape, with a cross-sectional area increase of 16.8%, the length would only have to increase by 10.7% to realize an 18.6% volume increase. Unfortunately, I didn't

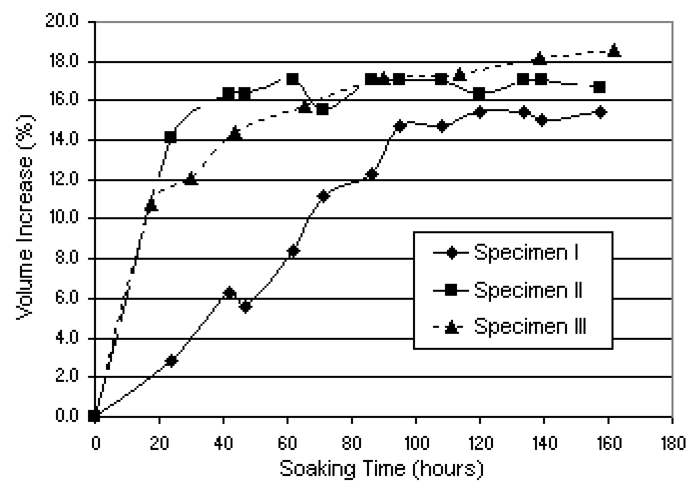


Figure 7 – Volume Increase while Soaking in Water

take length measurements of Specimen III during the experiment. But, this experiment totally convinced me that the volume of a piece of dry antler will increase if soaked in water.

Specimen I was the only one of the three that was not later modified after soaking in the water. It was set aside to air dry. This was done because after the first two days of soaking, the specimens' water began to turn brown and murky. The specimens were then separated into individual soaking containers, all with fresh water, to determine which specimen(s) was causing the murky water. Time soon proved that each specimen's individual water was getting murky. It was obvious the water was dissolving something from the specimens. So, Specimen I was allowed to dry to see if it would return to its original volume and density. After 818 hours (34 days) it had returned to its original weight in air of 18.9 grams, but its submerged weight was 4.9 grams or 0.3 grams heavier than prior to soaking. This meant the volume of the specimen had decreased by 2% and the density had increased by 2%.

The above reduction in the volume of Specimen I, with no change in mass, is difficult to explain. I know that the water was dissolving something from the specimens because the water was getting murky. So, I must assume that some mass was dissolved, and that it was very small, because I could not detect it. My balance scale only reads to the nearest tenth of a gram. On the other hand, an increase in the submersed weight of 0.3 grams is very detectable. Therefore, the volume of Specimen I was actually reduced by the soaking and drying process. Somehow this process altered the structure of the antler and caused it to become denser.

Modifying Antler with Stone Tools

"*Shaping unsoftened antler with flint tools is very difficult and particularly ineffective.*"

(Osipowicz 2007:9)

The above citation expresses my sentiment of many years. This is the reason that the ends of the three specimens in Figure 4 were cut with a hacksaw. Yet, cutting antler with stone tools would have been one of the basic modifications that was performed if antler was utilized. Therefore, cutting was one of the experiments I attempted after soaking the antler in water for 160 hours.

I selected Specimen III for the cutting experiment. It was the longest and I was going to only hold it in my hands. The smaller specimens would have been much more difficult to hold. My knapping skills are less than elementary, so the purposeful creation of a tool was out of the question. I found my tools in a bucket of knapping debris at Bob Patten's knap-in. I tried a number of different flakes, smashed a few more to created different cutting edges, and finally found one that worked great. In fact, it did about 95% of the cutting of Specimen III. Unfortunately, I didn't photograph it, but it was equivalent to a burin tip as seen in Figure 8. In different words, the tool needs to have a small screwdriver-like tip that doesn't increase in thickness with distance from the tip. I tried acute edge flakes, but the increasing thickness soon jammed the flake at the edges of the cut and the cutting stopped. Just like excavating, one needs the walls of the cut to be straight. A tapering or "V" shaped cut just doesn't work.

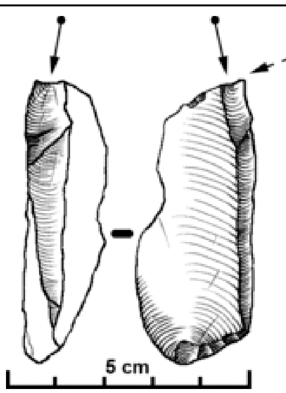


Figure 8 -- Burin
Image from Wikipedia Commons

Figure 9 – Incised Specimen III, Before and After Breaking w/ Hands

Figure 9 is the results of my cutting efforts after 2.75 hours. The specimen was photographed intact (top left and right), and then I broke it with my hands (bottom left). During the 2.75 hours, I tried different chips and chunks, but as mentioned above, the burin-like tip did the vast amount of work. Very little effort was required to break it.

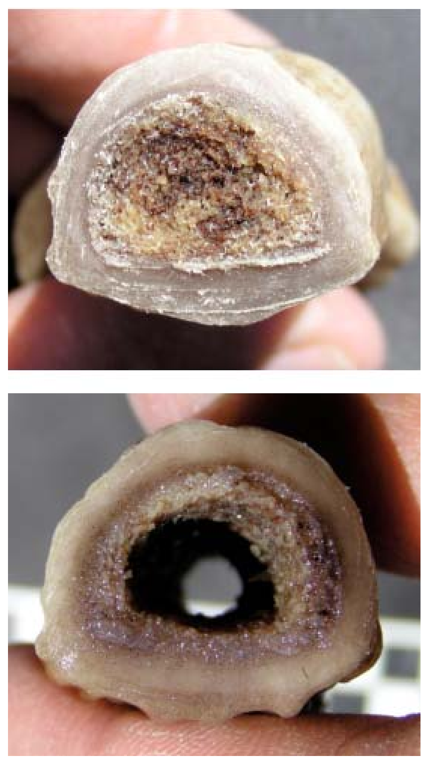


Figure 10
Center Hollowing Experiment

The easy follow-up experiment I performed was to hollow out the center of the antler. I chose to work on the smaller cut half of Specimen III (Figure 9) immediately after it was cut. The top image in Figure 10 is looking directly into the stone-cut end prior to hollowing out the center. The bottom image is the same end after it was hollowed out, which took only 15 minutes. The tool I used was a small metal screwdriver. This of course is not a stone tool, but I wouldn't have used one anyway. I would have used a splinter of a long bone, but none was available at the time. The center of the antler is so soft, because of the high porosity, that the screwdriver was not an over-qualified proxy. There is no doubt in my mind that a bone splinter would have done an equivalent job in the same amount of time.

Reducing the antler wall thickness by shaving or scraping was the third experiment. Figure 11 shows the before and after results of the shaving process. The unshaven piece on the left came from the larger piece of Specimen III (Figure 9) after the cutting experiment. I elected to cut this larger piece down to size with a hacksaw because it was quicker than stone tools. Therefore, the before and after piece, in Figure 11, has a hacksaw cut end on the top, and a stone tool cut end on the bottom. I then hollowed it out with a screwdriver as in the previous experiment.

Figure 11
Before and After Saving Process

There was no way I could shave the piece by holding it in my hands because it was too small. So, I used a single forked antler that was like a three-legged stool. With this shed I could firmly pin the piece to the table in a somewhat upright position with my left hand. I then scraped the piece with a stone tool that I held in my right hand. See Figure 12.

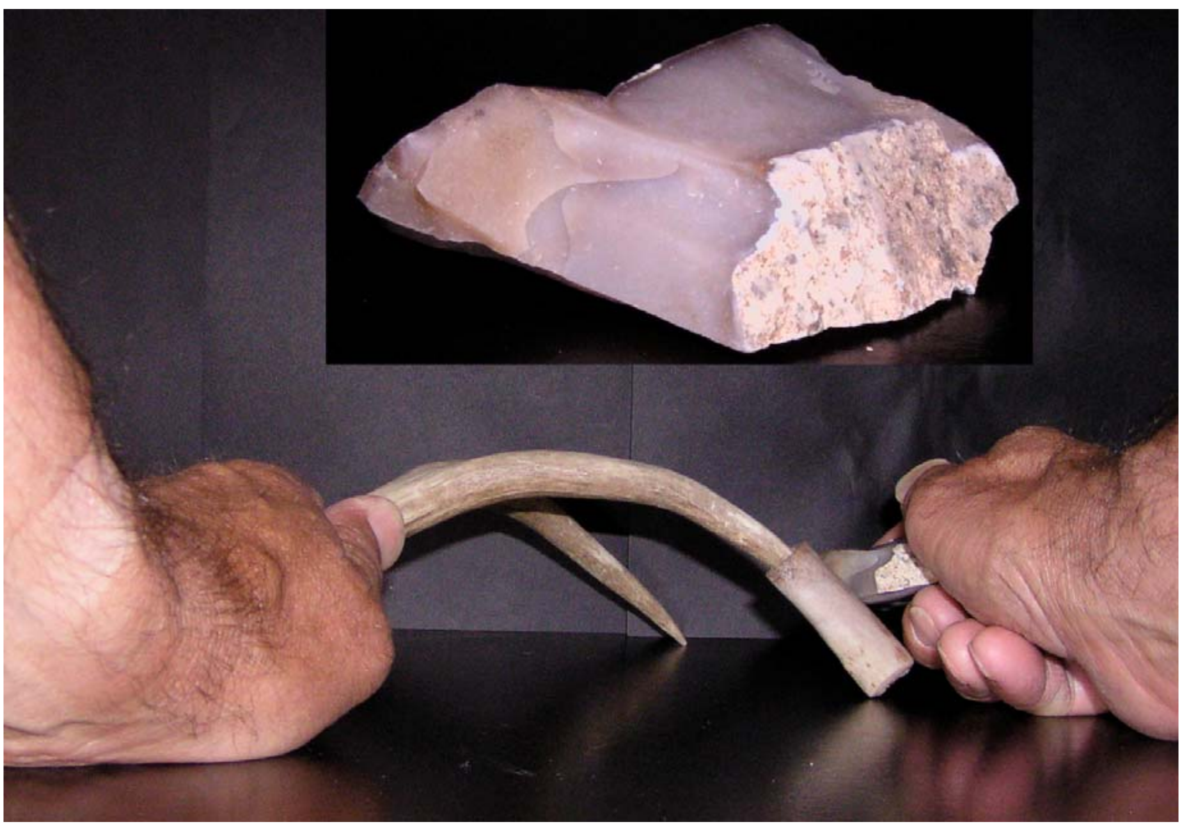


Figure 12 – Shaving the Cut Specimen III

The only stone tool I used was selected from a bunch of debris I created. The actual scraping edge was straight, sharp to the touch, and had an angle of 87 degrees. See the inset in the upper-center of Figure 12. It was the kind of edge one gets by hitting a thin biface or flake in the center of one face, which is often called a radial break. After the shaving process was terminated, the tool showed no visual damage. However, under a 10 power magnifying glass, use wear was apparent.

Figure 13 better shows the results of the shaving process. These two pieces fitted end to end were one piece before I hacksawed them into two, to begin this experiment. The average reduction was 2.4 mm on all edges, or about 5 mm reduction in diameter. The elapsed time for the shaving process was about two hours, which I actually did over several days in five to 10 minutes sessions, returning the antler to water between the sessions. I could have continued this shaving process a bit further, but elected not to.

Figure 13
Reduction from the Shaving Process

In summary to this section, the soaking of antler in water for 6.5 days greatly improved its workability. The tasks of cutting, hollowing, and shaving were not difficult, but would have been impossible for me if the antler had been dry.

Hafting the Projectile in the Foreshaft

I conducted two hafting experiments. The first one raised several unanticipated questions, so the second experiment was a follow up in an attempt to answer those questions.

For the first experiment I selected Specimen II from Figure 4 to be the foreshaft. See Figure 14. The obsidian point was a dumpy thing I made years ago in a knapping class in graduate school. After Specimen II had soaked in water for 160 hours, I noticed that the marrow (center) was extremely soft. So, I just tried pushing the point's base into the marrow without attempting to hollow it out. It penetrated a few millimeters and left a permanent indention. So I used a flake to cut out some of the marrow in the indented area. The marrow cut like it was styrofoam. Then I pushed the point further into the antler. I continued this process of pushing the point in and then digging the impression deeper with a flake until I was able to insert the point an average of 17 mm. The entire process took only about 15 minutes.

Figure 14 – 1st Hafting Experiment-Specimen II

The end view of Specimen II in Figure 14 (upper center) depicts the slot, which received the point. It is lenticular in cross-section similar to the point. When the point was inserted into the slot, the foreshaft contacted the faces of the point as well as the edges. This is important because for the next 166 hours (7 days) the foreshaft with inserted point was allowed to dry. If the reader recalls, all three Specimens increased in volume after soaking in water. See Figure 7. So I was expecting Specimen II to shrink and tighten around the point as it dried. If it did, then it would require some force to pull the point from the foreshaft. So after 166 hours of drying, I conducted an experiment to measure that force. Basically, I tied a bucket with weights to the foreshaft and then lifted the bucket by the point. See Figure 15. I started with just the bucket and then proceeded to add weight in ½ pound increments. When I got to 13 pounds, the point pulled out of the foreshaft. With only 17 mm of the point inserted into the foreshaft the point/foreshaft connection stayed together at 12.5 pounds. The soaked antler foreshaft, when allowed to dry, had shrink-wrapped the base of the point, creating an very tight connection.

Figure 15
Measuring Separation Force
between Point and Foreshaft

One of the problems associated with socketed foreshafts is the ledge at the junction of the foreshaft and the point. Again, see Figure 14 (right). I have been told by more than one person that this ledge is very detrimental to penetration of the prey. One solution to this ledge (gap), as suggested by Bob Patten, is to wrap (caulk) this area with rawhide or any string like material. See Figure 16. However, a better solution is to reduce the ledge as much as possible before hafting a point. This can be done by first selecting the foreshaft from an antler that has the same cross-section shape as the point. Then shave the walls of the foreshaft to as thin as possible. This was the birth of the experiment on shaving the foreshaft. See Figures 11–13.

Figure 16
Caulking the Gap

Next, I started fitting other projectiles from the Baker Collection into the Specimen II foreshaft. To my surprise, many fit quite well. So, it occurred to me that this dry foreshaft could be reused with other points after the first point was broken. However, there had to be a way to remove the broken base from the shrink-wrapped foreshaft. The obvious answer to this question was the foreshaft had to be hollowed out prior to shrink wrapping the first point. If this was done, there would be no problem in tapping out the broken base from the other end of the foreshaft with a punch-like tool. Then another point with similar dimensions could be jammed into the dry foreshaft. It wouldn't have to be shrink wrapped as the first point was, because a sufficiently tight connection could be achieved by just jamming a tapered base point of similar size into the foreshaft.

The second hafting experiment was done with a hollowed-out foreshaft. I wanted to see if the separation force between point and foreshaft was as great as Specimen II (1st hafting experiment). I suspected that it would not be because only the edges and not the faces of the point would be touching the foreshaft as it shrank around the point. The slot in Specimen II was created with the point. In this second hafting experiment I would hollow-out the foreshaft before inserting the point.

Figure 17
2nd Hafting Experiment
Specimen III

By now the reader knows that the second hafting experiment has already been partially discussed in the previous antler modification section. The piece that was cut from Specimen III (Figure 4), hollowed out (Figure 10), and then shaved (Figures 12-13) was the foreshaft. The point (Figure 17) was a plastic cast of a Haskett point from Idaho that I purchased from Lithic Casting Lab (www.lithiccastinglab.com). It was inserted in the foreshaft 24 mm and the pair set aside to dry. After 522 hours (22 days), the force required to separate this foreshaft from the point was 17 pounds.

Table 1 compares the two hafting experiments. Unfortunately, like so many experiments, more than one variable was changed between the two experiments. In this case the insertion depth, contact area, and hours of drying were all changed, so it is impossible to say why the separation forces are different between the two foreshafts. On the positive side, in each case the forces were more than adequate to hold a point in the foreshaft during any kind of service the hafted point would experience.

Table 1 -- Hafting Metrics

Experiment	Separation Force (lbs)	Insertion Depth (mm)	Contact Area	Hours Drying	Force (lbs) per mm of Insertion	Force (lbs) per Hour of Drying
1st	13	17	Edges & Faces	166	0.76	0.078
2nd	17	24	Edges	522	0.71	0.033

Discussion

The archaeological literature and the Internet has an abundance of stuff that falls under the title of antler, bone, or ivory foreshafts. However, Judge's dissertation (1973:76) is the only place I know where a socketed foreshaft, similar to Figure 3 and the two I created, is discussed. And, Judge was only writing hypothetically. The nearest artifact from the archaeological record is an early Archaic antler foreshaft found in an Indiana peat bog (Stanford 1996). The proximal end was socketed, but the distal end was a clothespin connection, which would have required tying the point in the foreshaft. That said, although there is no direct evidence for one like in Figure 3, I believe there is some indirect evidence. But, before I discuss this, I want to bring to the surface an assumption about stone projectiles.

Many people hold an implicit assumption that the stone projectile or arrowhead was the most important part of the apparatus that we know as a spear, dart, or arrow. The source of this assumption probably comes from its artful appearance and the fact that we don't find the other organic parts. Yet, the stone projectile is the quickest and easiest part of the total apparatus to make. The wooden shaft probably takes the most time and effort, and the foreshaft is next in line of time consumption or importance. That said, I do not believe that the stone projectile was hafted in a manner to protect it. Instead, it was hafted in a manner that would most effectively penetrate the prey on the first attempt, and there was little thought given to it after that first attempt.

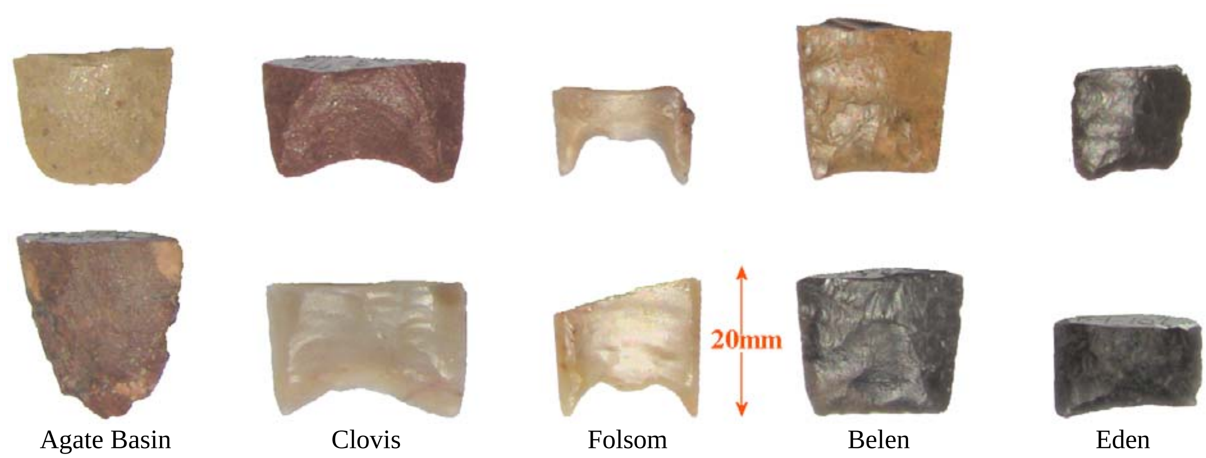


Figure 18 – Proximal End Fragments of Paleoindain Points

In 2002 Amick (180) suggested Folsom points were only hafted to a depth of 20mm based on the lengths of the proximal fragments in the archaeological record. See Figure 18. This is a logical suggestion because, assuming no flaws in the stone, the point will break at the location of maximum bending stress, which is at the tip of the haft when a bending load is applied. This concept was further supported by Hunzicker's experimental work with Folsom point hafting. Hunzicker fired replicated atlatls, tipped with foreshafts and Folsom points, into beef rib cages. He used five different foreshaft designs, yet each was designed to cover (protect) 2/3 of the point. Of the 73 shots that caused damage to the replicated Folsom points, "only 15 of 73 (21%)

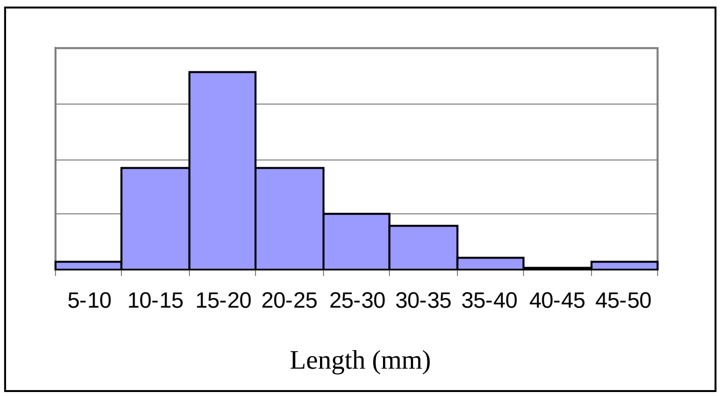
shots resulted in damage below the protection of the haft" (Hunzicker 2008:301). Since I had hafted my own two creations less than 1/3 of the length of the points, I became curious about the hafting depth of the other Paleoindian points. I decided to investigate the lengths of the proximal fragments of Folsom and other Paleoindian point types in the archaeological record.

The proximal fragment data I used came from two sources. All but 22 Agate Basin fragments came from the Baker Collection. Since there were only 11 Agate Basin fragments in that collection, and it is a type identical to the Mesa/Sluiceway points, I supplemented that type with data from the Agate Basin Site (Frison and Stanford 1982). From both sources I only selected whole fragments with bending breaks. Split fragments, or those with impact fractures, were not used. Additionally, from the Agate Basin Site, I selected only the proximal fragments that were **not** refits to other fragments in the collection, because I did not want any that might have been broken after discard. Table 2 shows the basic statistics for the ten point types I used. A single factor analysis of variance (ANOVA) indicates that the lengths of the fragments of the various point types are not significantly different from each other (P-value = 0.35). In different words, they all appear to be from the same population. If one assumes that most do not break below the tip of the haft, then all these point types were hafted less than an inch (25.4mm) from the base. Figure 19 is a frequency distribution of the lengths treating the 192 fragments as one population.

Table 2
Proximal Fragment Length
Statistics by Projectile Types

Point Type	N	Average mm	St. Dev. mm
Agate Basin	33	22.7	9.7
Belen	40	20.2	6.0
Clovis	16	21.5	5.4
Eden	39	18.8	7.5
Firstview	5	20.4	10.8
Folsom	34	20.9	6.2
Hell Gap	2	28.0	13.1
Midland	8	18.2	6.0
Plainview	10	21.1	5.1
Scottsbluff	5	25.4	14.6
Total	**192**		

Figure 19
Proximal Fragments Lengths
all Projectile Types (N=192)



This similarity in lengths of the proximal fragments of the various point types is suggestive of a common hafting configuration. This was a total surprise for me as I have always believed that the different point types had different hafting configurations. At the extreme, who could imagine that a Folsom could be hafted in the same manner as an Agate Basin point. Or, maybe they were not and the proximal fragment lengths are similar for a different reason. On the other hand, the configuration in Figure 3 would accommodate both types if the correct antler shape was selected.

When one considers Paleoindian points in aggregate, there is another common characteristic they all have. If the reader will again look at the Agate Basin point in Figure 2, the two red arrows point to ink marks that my grandfather placed there many years ago. These ink marks indicate the termination of the lateral edge grinding. The edges are abraded smooth from the marks to the base and around the base itself. This lateral edge grinding is a trait of all Paleoindian points and some stemmed Archaic ones. For example, all the proximal fragments in Figure 18 are ground. My father taught me that the purpose of lateral edge grinding was to reduce the chances of cutting the sinew that was used to tie the point to the shaft. This theory goes back to at least the 1930s (Renaud 1934:3), and today it thrives on the Internet. Yet, like the antler foreshaft in Figure 3, there is no direct evidence for this protecting-the-sinew theory.

Let's return to what Judge wrote in 1973 about the Folsom point. "… The fine retouch and **grinding** of the Folsom lateral edges was to permit the relatively easy insertion and extraction of the point base into the socket haft" (176). In my opinion, this is exactly correct. Lateral edge grinding would remove any high spots on the edges of the point and permit it to be inserted further into the foreshaft, and therefore create more contact between the point's edges and the foreshaft. Also, if the high spots were not ground down they would create stress concentrations in the hafted point that would lead to a weakened hafted point. Lateral edge grinding would greatly improve the hafting process if socketed foreshafts were used.

Conclusions

The literature reports that antler and bone can be softened by soaking them in water (MacGregor 1985, Osipowicz 2007). So, I began this short journey in experimental archaeology to determine if it was feasible for **me** to make a foreshaft from antler or bone. I decided to work with antler since I had the material, and I assumed the results would also apply to bone. In retrospect, I have been attracted to the idea of a bone foreshaft since the 1960s, so in a sense this was just an extension of my thinking and research over the last 40+ years.

I found that soaking antler in water for seven days made it pliable enough for me to cut, scrape, and hollow it out with the simplest of stone tools. Actually, the soft center makes the antler a more ideal form for a foreshaft (Figure 3) than wood. I discovered that the antler swelled when soaked and shrunk when allow to dry. As a result, an antler foreshaft would shrink tight around a point if it was inserted into the foreshaft when it was wet and then allowed to dry. No additional masking or lashing was necessary to tightly secure the point. I also discovered that any point with a tapered base can be hafted in this manner because it is not necessary for the faces of the point to be in contact with the foreshaft. The point is only supported by the edges. So, this hafting method works equally well for thick-bodied points (e.g. Agate Basin) and thin-bodied points (e.g. Folsom).

Finally, the archaeological record indicates that two traits are common to all Paleoindian points. These are short hafting lengths and lateral edge grinding. These two traits are suggestive of socketed hafting, which may have been the preferred method for all point types throughout the Paleoindian Period.

References

Amick, Daniel. S.
2002 Manufacturing Variation in Folsom Points and Fluted Preforms. In *Folsom Technology and Lifeways*, edited by J. E. Clark and M. B. Collins, Lithic Technology, Special Publication No. 4, pp. 159-187.

Frison, George C. and Dennis J. Stanford
1982 *The Agate Basin Site.* Academic Press, New York.

Hunzicker, David A.
2008 Folsom Projectile Technology: An Experiment in Design, Effectiveness, and Efficiency. *Plains Anthropologist* 53:291-311.

Judge, W. James
1973 *Paleoindian Occupation of the Central Rio Grande Valley in New Mexico*. University of New Mexico Press, Albuquerque.

MacGregor, Arthur
1985 *Bone Antler Ivory & Horn: The Technology of Skeletal Materials Since the Roman Period.* University of Toronto Press, Toronto.

Osipowicz, Grzegorz
2007 Bone and Antler—Softening techniques in prehistory of the North Eastern part of the Polish Lowlands in the light of experimental archaeology and micro trace analysis. *EuroREA* 4:1-22.

Stanford, Dennis J.
1996 Foreshaft Sockets as Possible Clovis Hafting Devices. *Current Research in the Pleistocene* 13:44-46.