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On the Early to Middle Archaic Occupation of Hudson-Meng: A Geoarchaeological and Lithic Study

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On the Early to Middle Archaic Occupation of Hudson-Meng:

A Geoarchaeological and Lithic Study

by

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Abstract

The goals of this research are to come to a greater understanding of site formation processes at the Hudson-Meng site, to gain a greater understanding of Early to Middle Archaic lifeways through the material record at Hudson-Meng, and to quantify the potential for error between observers in a lab setting, using the Hudson-Meng assemblage as a vehicle for discussion. Situated in Sioux County, Nebraska, the Hudson-Meng site (25SX115) has been a site of contention for decades. Hudson-Meng has been evaluated multiple times since its original excavation in 1968, with the primary research focus being on a large Paleoindian bone bed. However, an oft overlooked Component of Hudson-Meng is an Early to Middle Archaic phase, which has been noted by each of the major undertakings at the site. More recent excavations at the site, conducted by Dr. Mark Muñiz from St. Cloud State University from 2006 to 2014, have uncovered further evidence of Early to Middle Archaic occupation of the site. It is this assemblage of artifacts which is the specific focus of this research. This find is of considerable interest, as there is a relative absence of sites at this age in the Northwest Plains. By synthesizing the geoarchaeological context of the site and region with the material record from this Component, a greater understanding of Northwest Plains Archaic groups may be realized. Additionally, assessment of measurement errors between observers will provide more robust methodological frameworks by which artifacts can be analyzed. Based on the data, three distinct cultural Components are observed; these Components represent short term occupation of the site, as evidenced by the scarcity of artifacts and lack of exotic materials. Four of the six previously observed soil anomalies correspond to two of the cultural Components observed. These four are interpreted as cultural, with the remaining two features being interpreted as naturally occurring. Lastly, measurement errors among observers become much greater as the metric in question becomes more subjective; awareness of this should serve to encourage a greater degree of specificity in measurement constraint. This Component of Hudson-Meng is also notable as being the first documented appearance of thermally altered rock within an Early Archaic setting.

Acknowledgements

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Chapter I: Introduction/Problem Statement

In light of numerous attempts to determine the history of the Hudson-Meng Site (25SX115), many aspects of the site formation processes at work remain unanswered. Additionally, noted Early Archaic Components of the site (Agenbroad 1978; Muñiz 2007; Muñiz 2010; Todd and Rapson 1999) have received significantly less attention than the Paleoindian Components of the site. This lack of focus is viewed as problematic, given the small number of Early Archaic sites in the region. Furthermore, issues crucial to understand the material past can extend from the field to the lab. It has been noted that errors between and among observers can skew interpretation (Lyman and VanPool 2009); looking to the expression of these measurement errors as they relate to debitage will provide more robust methods moving forward. With all of these things in mind, I will be focusing this research on the Early Archaic occupation of the site, by working with lithic remains as well as pertinent geoarchaeological data. Looking to statistical concerns, understanding the quantification of errors as they relate to linear measurements on debitage will hopefully serve to mitigate such issues in the future, resulting in clearer results.

Situated in Sioux County, northwest Nebraska (Figure 1), the Hudson-Meng site sits in what is currently the Oglala National Grassland, on the north face of the Pine Ridge Escarpment. The primary features of the site are a ground spring flowing north from the Pine Ridge, and two geographic high points known as Round Top and Little Round Top. A map of the site and its immediate surroundings are available in Figure 2. A subject of debate for decades, different areas of Hudson-Meng have been excavated multiple times since the initial research took place in 1968, with the primary research focus being on a large Paleoindian bone bed. However, Early to Middle Archaic Components of the site (Agenbroad 1978; Muñiz 2007; Muñiz 2010; Todd and

Rapson 1999;) have been noted. Most recently, Muñiz noted an Early to Middle Archaic Component in the Paleo-Cultural Research Group Southeast Block of his excavation, in an area separate from the Southeast Block recorded by Todd and Rapson (1999). This find is of considerable interest because, with the exception of a small number of notable sites (Fosha 2001; Frison 1973; Niven and Hill 1998), there is a relative absence of Early Archaic sites in the Northwest Plains. The reason for this absence is commonly thought to be the result of larger climate changes; transitioning into the Altithermal period resulted in a sharp increase in aridity (Antevs 1953; Kay1998a ; Wright 1970), which would have made life on the Plains a difficult existence, with some authors going as far as to suggest a complete cultural absence during this time (Mulloy 1958). Despite these earlier claims, there have been multiple sites found since which run counter to this claim, such as Beaver Creek, Licking Bison, and Hawken (these and several others are referenced by Kornfeld and associates [2010]). As a result of this purported absence, information on Early Holocene human occupation of the region is a subject of interest, and the presence of an Early Holocene material record at the site allows for data-driven conclusions on these lifeways to be drawn.

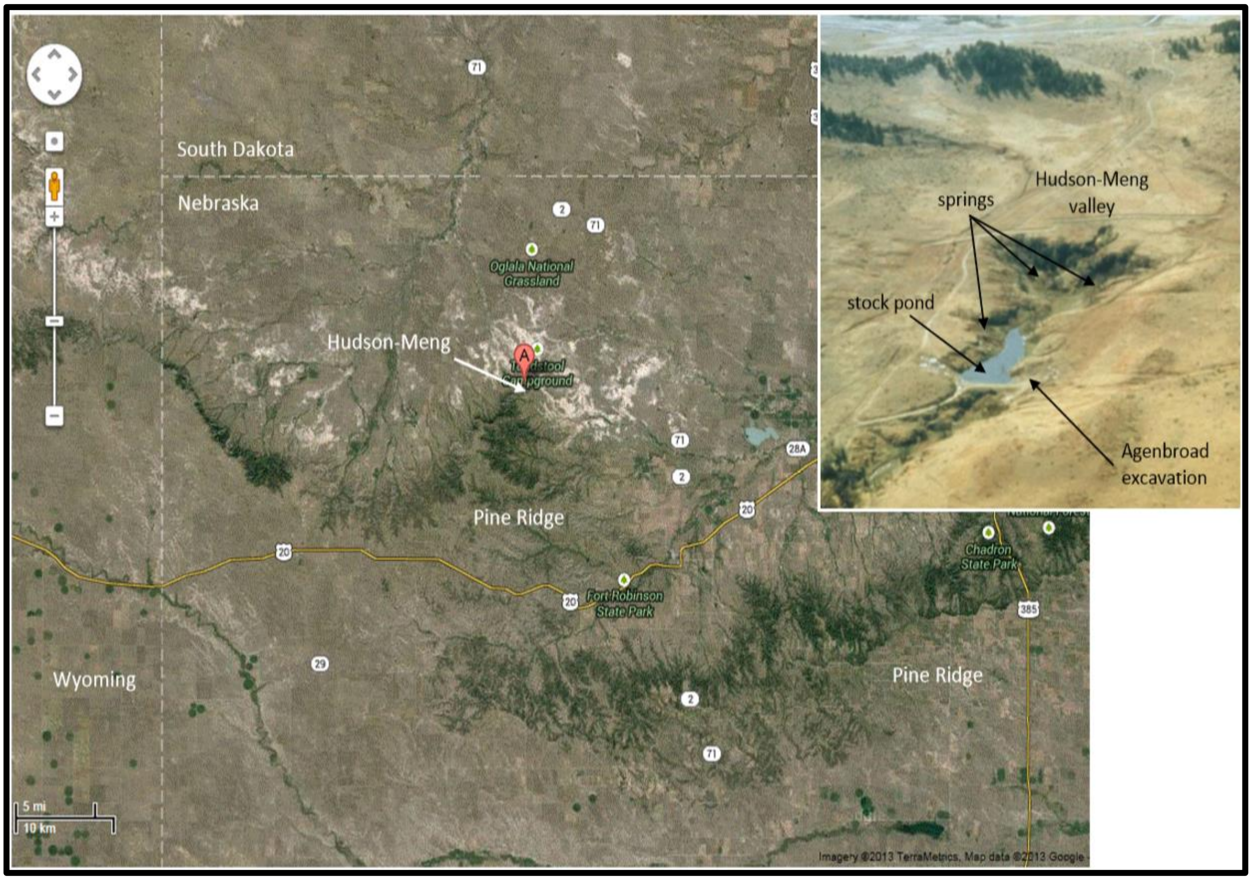

Figure 1: 25SX115 location (Muñiz et al. 2018, Credit: Google Earth).

Figure 2: The Hudson Meng Site, with the nearby Round Top (east) and Little Round Top (west) (Credit: Google Earth).

Furthermore, the nature of the geology of Hudson-Meng has been debated across several separate excavations of the site (Agenbroad 1978; Muñiz 2013; Todd and Rapson 1999). By analyzing the geologic data available, a better understanding of site formation processes and the environment at the time of the Early Archaic occupation can be addressed. Running parallel to this analysis is an assessment of potential laboratory errors in artifact measurement which may skew statistical evaluations of lithic collections. Understanding the cause and degree of these errors will lead to ways in which they may be avoided. By understanding how to mitigate these errors, the accuracy of post-measurement analyses can be increased.

Chapter II: Background/Literature Review

Regional Overview

Studies on the Northwest Plains are numerous; however, the majority of this work places a heavy focus on Paleoindian and Archaic groups (Kornfeld et al. 2010). The following work seeks to build upon current chronological data, and present a timeline of human occupation on the Northwest Plains. For the sake of this research, the Northwest Plains will be constrained to the western ends of Nebraska and South Dakota, extending northwest to the Rocky Mountains, which will also include vast areas of Montana and Wyoming. The Hudson-Meng site is treated as a part of the Northwest Plains in this instance. This is in light of its location north of the Pine Ridge Escarpment, which serves the northern terminus of the High Plains; to the north of the ridge is the Missouri Plateau region (Fenneman 1931:17). Dates presented in this section will all be reported in ^{14}C BP unless otherwise specified.

Before considering the Paleoindian Component of this area, it is worth mentioning that Kornfeld, Larson, and Frison (2010) argue that there are a number of sites in this part of the Plains which are compelling candidates for a pre-Clovis Component. Thanks to paleontological sites such as Bell Cave (Anderson 1968), a strong record of the fauna surrounding the Pleistocene-Holocene transition is present. While these sites themselves do not yield a cultural Component, they present baseline data against which faunal remains from other sites can be compared. Furthermore, Dr. Steven Holen (2006) has made what some believe to be a compelling case for non-lithic tools made from mammoth bone with a minimum age of 18,860 BP at the Lovewell site in Kansas and the La Sena site in Nebraska. While the results of Holen’s research have not yet been fully accepted, there is still merit in its evaluation.

Moving forward to Paleoindian studies, there is a great deal more information to work with. The Northwest Plains yields a multitude of different complexes and lithic variation. Looking specifically to Clovis studies, Kornfeld (1999) maps a very narrow Clovis corridor extending from Alberta down to New Mexico, with a number of well-known localities such as the Colby site in Wyoming (Frison and Todd 1986) and the Lange-Ferguson site in western South Dakota (Hannus 1990). These are relevant to understanding Clovis behaviors, as these are both mammoth kill sites, providing a direct link to Paleoindian peoples and megafauna hunting. Regarding the lithic record of the region, numerous projectile point varieties are present from the Early to the Late Paleoindian periods, with a variety of morphological differences throughout time. Looking to the Early Paleoindian period, the Clovis technocomplex is well-distributed in the Northwest Plains, with multiple separate groups having their technology as a common ground. Folsom points are some of the better-known examples of the technology of the time. Both of these feature a prominent flute up the midline of the point, and both are ubiquitous across the entirety of the Plains.

Transitioning to the Middle Paleoindian Period, there is a clear change in projectile point morphology, particularly when looking at the Agate Basin point, which dates to between 10,500 and 10,000 BP (Kornfeld et al. 2010). Moving away from a fluted base entirely, the Agate Basin point is a long and narrow point which tapers towards the base, though this is a gradual narrowing and not a proper basal stem. A more exaggerated example of this taper is found in the Hell Gap point, which is dated to 10,000 to 9500 BP. Named for the Hell Gap Site (Irwin-Williams et al. 1973) which has recently been designated a National Historic Landmark, this point forgoes a lanceolate shape in favor of heavier lateral shoulders. A full and proper stemmed point is seen in the Cody complex, whose dates range from 9900 to 8000 BP (Frison and Todd 1986; Knell and Muñiz 2013; Stanford 1999). This Late Paleoindian technocomplex is characterized by a straight stem and convergent parallel flaking, and includes such specific point types as Alberta, Scottsbluff, and Eden points.

Transitioning into the Archaic, which spans roughly 8000-1500 BP (Kornfeld et al. 2010) a much larger amount of information is able to be gained than is the case with Paleoindian studies. This information is weighted towards Middle (4500-3000 BP) and Late (3000-1500 BP) Archaic groups, which underscores the need for studies of Early (8000-4500 BP) Archaic Components such as that reported here from Hudson-Meng. The contrast between Paleoindian and Archaic populations in the Northwest Plains is best summarized by Bamforth (1997:15-16):

> …the division reflects a series of obvious differences in archaeological sites dated before and after roughly 8000 years ago, including a shift from lanceolate to side-notched projectile points, an increased abundance of grinding stones, an overall shift to exploitation of a wider range of fauna and often a decrease in the abundance of material present in a site.

It bears mention that for some time, it was argued that a possible reason for the scarcity of Early Archaic sites was due to a complete cultural hiatus (Benedict 1978; Mulloy 1958), while others, such as Reeves (1973) argue that errors in survey methods were the cause of this absence. While Archaic sites span a significant portion of the Northwest Plains, the earliest dates come from southwestern Wyoming and northwestern Colorado (Kornfeld et al. 2010:107) which, while they are a considerable distance from Hudson-Meng, still fit into the cultural chronology of the Northwest Plains. Information regarding the Early Archaic is slightly more dated than more recent inquiries into the Middle and Late phases of this tradition. Whereas projectile points throughout the Paleoindian period tend to generally transition from concave fluted basal sections towards straight stemmed points, projectile points in the Archaic are differentiated by the emergence of side notched stems. While some of the oldest Early Archaic points have yet to have a specific name or site type associated with them, being simply referred to as "early side-notched," Husted and Edgar (2002) have isolated and named two specific types, Pahaska Side-Notched and Blackwater Side-Notched. Further to the west, similar side notched points are found; these still hold a generally triangular shape with deep side notches and parallel flaking, though they are referred to as Bitterroot (Frison et al 1996:18; Holmer 1986:104) or Elko Side-notched (Holmer 1978). This lack of nomenclature is due to the fact that a prevalent stratigraphic profile has not been as easily observed at Early Archaic sites in the same way that complexes from other time periods have been located (Kornfeld et al 2010:109). Furthermore, it is noted that lacking a dated, stratigraphic context, it is possible to misidentify diagnostic Early Archaic Points as being Late Archaic (Frison et al. 1996:18). In the absence of several sites with absolutely dated diagnostic tools, a considerable amount of confusion can arise in clarifying the relationship between Early Archaic tool types. Until such stratified sites are located, lines of inquiry such as radiometric dating will establish sites as being Early Archaic in age. A notable exception to this is found in the material record at the Hawken site in Wyoming, located approximately 110 miles northwest of Hudson-Meng, near the town of Sundance.

The Hawken site, excavated in the mid-1970s, is a bison kill site which features an extinct variant of bison (Frison et al. 1976). While use of the arroyo is clearly displayed, no evidence of butchery, processing, or encampments were found. However, later research by Cunnar (1997) suggested evidence of butchery on long bones found at the site. Components of a similar age were found at the Rourke and Cordero Mine sites (both also located in Wyoming), which suggests some degree of mobility for subsistence purposes (Niven and Hill 1998). In addition to these Wyoming sites is the Licking Bison site, located approximately 190 miles north of Hudson-Meng, roughly three miles west of Buffalo, South Dakota (Fosha 2001). This site features several Early Side-notched points made from local materials, as well as a minimum of 11 bison. The point to focus on is that though data regarding this time period are rare, the evidence that is present strongly suggests a diversity of tools and subsistence strategies once thought unlikely (an opinion once held by Syms [1969,] for example). This is exemplified in a recent presentation at the 75th annual Plains Anthropological Conference (Garhart et al 2017), which focuses on Early Archaic activity at the Laddie Creek Site in the Bighorn Mountains of north central Wyoming. Working with use-wear analysis, the authors determined that a variety of lithic tools at the site were used to process a wide variety of materials such as woody plants, soft and hard woods, hide, and antler. These materials, when processed, would provide a variety of useful goods for the site occupants. This clearly shows that while the archaeological record skews towards artifacts with greater longevity (e.g., lithic and bone materials), a variety of materials were employed in the day to day life of Early Archaic groups.

While the information regarding the material record of Archaic peoples is certainly important, it is only one part of a much broader approach which must be taken. The geoarchaeology of the region is of substantial importance as well, as the geologic context will provide critical information regarding the environment of the region at the time of occupation. Since there are considerably fewer sites of this age than more recent Precontact groups, viewing the site through a geoarchaeological lens can provide further insight into the issues faced during the Middle Holocene. The varied and sometimes abrupt changes in paleoclimate have been well documented (Antevs 1953; Grimm et al 2011), and a number of geoarchaeological analyses have been undertaken at Hudson-Meng specifically (Agenbroad 1978; Kelly and Wohl 1994; Miller 1994; Muñiz 2013; Muñiz et al. 2018). This sharp variation in climate, often termed the "8.2ka event", is evidenced by large scale freshening of water sources, which would indicate glacial melt (Alley and Agustsdottir 2005; Dean et al. 2002). The 8.2ka event has been understood to have reaching implications for Precontact groups in the Plains, as suggested by Wedel (1953: 500-501), who posits, "…in an exceptionally wet year… much of the Kansas-Nebraska region may have a climate approaching that normally characteristic of Iowa and western Illinois. In a very dry year, the same localities may be little better than desert." He notes the potential for dramatic cycles of drought within the Central Plains that would lead to a difficult existence at the time. This drought cycle is addressed more recently by Clark and colleagues (2002), who utilize lake sediment cores from Kettle Lake in northwest North Dakota to address 100-130 year drought cycles. They observe that during periods of drought, grass productivity decreases while erosion levels increase, until there is more stable climate in the Late Holocene. These observations dovetail with Bettis III and Hajic (1995), who provide useful insight into the ways in which these drought cycles can affect site integrity during the Early Archaic. When dealing with surface Archaic sites on various landforms in the upper Midwest, the authors note that there is a bias towards sites on upland hillslope settings. By contrast, surface sites on colluvial aprons, alluvial fans, or flood plains are all but absent. They go on to contend that pulses of sediment (during the drought periods noted by Clark and associates above) tend to bury lower Archaic sites in drainage networks, which results in the disparity towards upland sites. This line of reasoning is further reinforced by Mandel (1995), who builds a case for Holocene erosion as a driving factor in the sparse nature of Archaic sites on the Central Plains. Working with data from 65 separate sites, Mandel (1995:38) observes that,

> Reduced vegetative cover, combined with infrequent but intense rainfalls during the warm, dry Altithermal favored erosion and net transport of sediment within small valleys. As mean annual precipitation increased during the late Holocene, vegetation recovered and erosion rates decreased, prompting sediment storage in small valleys.

Looking at the Northwest Plains more broadly Albanese (2000) provides a summary of the geoarchaeology of the region, by looking to the ways in which geoarchaeological inquiry on specific sites can be pieced together to provide a mosaic of understanding the pedogenesis of the region, much in the same way as Mandel above. He also spends great time in explaining the relationship between geology and archaeology, and its development within the Northwest Plains.

While there is clearly an extensive research base for this region, the most pertinent review for this thesis is found in field reports published by Dr. Mark Muñiz (2010, 2013), who led field excavations at Hudson-Meng from 2006 to 2014. Relevant stratigraphic information is cataloged, in addition to artifact provenience data, and this information is well synthesized by Muñiz and colleagues (2018), who recently undertook a geoarchaeological assessment of the various cultural occupations within Hudson-Meng. With the enormous amount of raw data available, there is sufficient information from which conclusions can be drawn. A more comprehensive review of Hudson-Meng excavations will be covered below.

Moving into the Middle Archaic, Frison (1998) provides a wealth of information surrounding the time period. The primary change which signifies the transition into the Middle Archaic (4500-3000 BP) is the appearance of the McKean complex, which was first identified by Mulloy (1954). An intricate relationship between McKean, Duncan, Hanna, and Mallory projectile point styles is another trait indicative of the artifacts of the Middle Archaic. Kornfeld et al (2010:114) offer several solutions to the lack of order inherent in Middle Archaic tool types:

> 1) some investigators have suggested that different variants in a single site might represent different bands coming together for special occasions, 2) both functional differences and differences in raw materials have been suggested as causes for the variants, and 3) variability in the projectile points might be due to different occupations of the same site that represent slight temporal differences, which we are as yet unable to detect in the stratigraphic record. Recent reinvestigations at the McKean site, as well as data from other sites, appear to be supporting the third model.

Regardless of the origin of these distinct variations, the differences between them are clear. The McKean lanceolate point moves away from the side notched points of the Hawken point and side notched points recovered from Medicine Creek Lodge, with its diagnostic attributes being a return to lanceolate shape, excurvate lateral edges, and a deeply concave base. There are several other notable points within the McKean complex, however, that do contain side and basal notches; the Duncan point has a straight stem and weak shoulders, and the Hanna point exhibits more pronounced notching due to an expanding, trapezoidal stem. Another main point in the complex is the Mallory point, which was first observed at the Signal Butte site in western Nebraska. The Mallory point is morphologically similar to the true McKean point, with the addition of deep, parallel side notches; it still maintains a concave base, which can occasionally bring with it a basal notch with a similar depth as the side notching (Forbis et al. 1965).

Looking to the climate of the area, a broader climatological transition from arid to mesic trends had occurred, generally resulting in increased vegetative cover by the time Middle Archaic populations began appearing. This is reflected in the archaeological record by a general increase in plant processing implements such as manos and metates (Frison 1965).

Turning to social structure of the Middle Archaic, Frison (1998:147) makes his observations clear:

> There is little, if any, evidence to suggest changes in the complexity of the societal structure of human groups during the 6500 years ago that Archaic cultures occupied the Northwestern and Northern Plains. The distribution of resources called for continual aggregation and fragmentation of the groups in response to the availability of food, so the band was the highest level of integration reached. There is no evidence to indicate the amalgamation of bands with any temporary authority to organize economic activities or meet the threat of outside aggression.

As was seen in the Early Archaic, bison kills were still a regular occurrence, though such activities would still be possible at the sub-band level, as contended above. Data regarding subsistence activities strongly suggest that even during the Early Archaic, there was a noticeable split between hunting and gathering activities. As was stated above, metates and other implements used for the grinding of seeds and grains, are documented with much increased frequency on Middle Archaic sites, with diagnostic varieties presenting themselves in the Middle and Late Archaic (Frison 1965). Despite this material record, there is no hard and fast number for the amount of time spent on hunting activities as opposed to gathering activities. In light of this absence, another subsistence activity presents itself at this time: longer term food storage. Plains Archaic sites have yielded features indicative of food caching (Kornfeld et al. 2010:362), which is a reasonable expectation when considering the amount of surplus generated during a bison kill event.

In the Central Plains, a more noticeable series of changes in lifeway occur in the Middle Archaic, which are best summarized by Kay (1998b:193): "…it is best conceived as a time of varied responses to a changing Holocene landscape, biota, and climate, on the one hand, and to equally dynamic hunting and gathering systems on the other." A trend of increased plant procurement continues for the Central Plains Archaic groups to the southeast of Hudson-Meng, as evidenced by the Munker's Creek phase. First identified at the William Young Site (Witty 1982), it is defined by distinct projectile points, axes, knives, and gouges. Several examples of the Munker's Creek knife in particular were found at the Coffey site in Pottawatomie County, Kansas (Schmits 1978). Through use-wear analysis, it was determined that the most likely use of these knives was plant procurement (Douglas 2015). The diversification of hunting strategies is also noted in the Central Plains. Schmits (1978) notes several non-bison faunal remains at Coffey such as fish, waterfowl, and non-bison mammals. To the northwest, Widga (2004) observes significant diversification of faunal remains at the Spring Creek site in central Nebraska.

Transitioning into Late Archaic/Late Middle Prehistoric sites in the Northwest Plains, information regarding artifacts with more than strict utilitarian value become more available (Kornfeld et al 2010:123-124). This transition is marked by the appearance of the Pelican Lake cultural horizon, which is identified by marked changes in point typology (Wettlaufer 1955). The Pelican Lake complex appears as early as 3000 BP and as late as 1500 BP, with the full age range being represented at Medicine Lodge Creek (Frison and Walker 2007). Its notable attributes are wide corner notches which form sharp, barbed shoulders. Another diagnostic point for the Late Plains Archaic is the Yonkee Point. Triangular in shape with a slightly expanding base, the Yonkee point is generally associated with the Powder River Basin (Frison 1968), though it is also seen to the east, along the Belle Fourche River in Wyoming (McKibben et al. 1988). Also appearing in the material record around the time of the Late Archaic are articles of clothing and cordage which have remained complete and intact, much more well-preserved than the traces and remnants of such materials seen earlier (Frison 1965). Daughtery Cave has an intact hide moccasin dating to the Late Archaic, and tailored clothing from 1200BP is found on human skeletal remains in Mummy Cave (Kornfeld et al. 2010). Intact atlatl weights, as well as the pieces of two atlatls were found in Daughtery Cave, with intricate carvings on the stones used for counterweights. There is also strong evidence for ritual activities during the Late Archaic period. The Ruby site in Wyoming (Frison 1971) contains a feature which is widely believed to hold religious significance, as there are a multitude of bison skulls arranged around one end of the structure, and nothing about the feature suggests association with animal processing. A similar arrangement of deer skulls at the Dead Indian Creek site (Frison 1991) suggests similar activity.

When looking to the Protohistoric, two interesting new trends appear in the archaeological record. First and foremost is the introduction of the horse, which is believed to have occurred during the early eighteenth century (Kornfeld et al. 2010). This expedited mobility, and is argued by Kornfeld and colleagues to be the most significant impact of the Protohistoric Period. The second major trend at this time is the appearance of metal tools. Kornfeld and colleagues (2010) make note of a burial excavated in the 1930's which contained a bow with several hafted arrows, whose points ranged from obsidian and chert to diagnostic European trade points and hammered iron points, believed to have been made by indigenous populations.

In summary, activities on the Northwest Plains are incredibly diverse, and represent a considerable variation in human behaviors over time. From large scale hunting of megafauna, to wide variation in tool manufacture, the variety of human activity in this region of the Great Plains represents a response to a constantly changing environment over time.

Past Excavations at Hudson-Meng

The Hudson-Meng site (25SX115) is located approximately 23 miles northwest of Crawford, Nebraska, and sits on the northern face of the Pine Ridge Escarpment at an elevation of roughly 4200 feet above sea level. The Pine Ridge is relevant in this instance as it serves as the northern terminus of the High Plains and the southern boundary of the Missouri River Short Grass Prairie (Agenbroad 1978). It occupies portions of Sections 17 and 18, Township 33 North, Range 53 West (Agenbroad 1978). The coordinates of the site as noted by Agenbroad are 42 degrees 44' 22" North and 103 degrees 36' 10" West.

According to Agenbroad's (1978) volume on Hudson-Meng, the site itself was first reported to him in 1967 by Bill Hudson and Albert Meng (for whom the site is named). Test excavations began in the fall of 1968 and continued during the falls of 1969 and 1970. It was not until the fall of 1971 that the basal portion of a Knife River Flint projectile point was located in direct association with the bone bed, establishing the Hudson-Meng Site as such. During formal excavation of the site, an arbitrary datum was designated at coordinate 0N, 0W, and a site grid was established in one-meter intervals. A backhoe was brought in to clear the majority of the overburden capping the site (including much of the Archaic-aged material), at which point site volunteers excavated with trowels. The manually removed overburden was processed through a quarter-inch screen until debitage was collected, at which point an eighth-inch screen was used to recover more debitage.

The research conducted by Agenbroad (1978) was extensive and thorough for the time. Over the course of the excavation, 21 Alberta-Cody projectile points in various stages of completion were recorded on site. In addition, the minimum number of individual bison noted on site was 474. These raw data in conjunction with geoarchaeological evidence, led Agenbroad to conclude that the Hudson-Meng site was a secondary processing site for hunted bison. He posited that the bison were forced off of an existing terrace located some 60 meters to the west of the site, and moved to their *in situ* location for processing. The argued ridge which the bison would have been forced from is represented by a layer of bedrock which has since been capped by aeolian deposition; Agenbroad argues that it would have been of sufficient height to serve as a jumping off point. He ultimately concludes that a) the bison at Hudson-Meng were killed en masse in an amount of time not exceeding one month, b) the *in situ* bison at the site were in their secondary processing location near a proposed jump, c) the frequency with which various elements of bison appeared in the archaeological record were the result of human action, butchery, and selection, and d) a system of preservation and storage of meat would have been necessary to justify such a large kill event.

While the majority of the early work at Hudson-Meng was addressed by Agenbroad, several authors contributed to supplemental appendices. Bruce Huckell (1978) looks to trends in the chipped stone debitage of Hudson-Meng, noting four major knapping loci, and observing a variety of local and exotic chipped stone, with nearly 3000 specimens present. From there, Wu and Jones (1978) go on to discuss the presence of nonmarine mollusk shells at Hudson-Meng. First observed during the 1972 season, extra care was taken to document any recovered mollusks in later years, and the authors eventually noted 11 different varieties of nonmarine gastropod, with one species of clam on site. Following this summary, Rhoda Owen Lewis (1978) looks to phytoliths on site, arguing that differential grasses within the valley the site occupies, and the surrounding upland indicate a micro-climate within the valley. She observes a higher concentration of Festucoid grasses in the valley (which favor humid environments), while Chloridoid short grasses were more readily represented in upland settings. Lastly, Young and Weedon (1978) look to the flora on the present site, and make comparisons to the flora during the Late Paleoindian period. The authors posit that the grasses on site are relatively consistent with the flora of the time of site occupation. By contrast, the trees that exist on the site currently (most notably Ponderosa Pine and riparian trees such as the Cottonwood) would likely have not been present at the time. While these contentions were thorough and well-founded at the time, they would not go unchallenged.

A reassessment of the Hudson-Meng site was conducted by Larry Todd and Dave Rapson (1999), who published a reevaluation of the original site interpretations some 20 years after the original findings. Taking issue with both the interpretation of the geologic context of the site as well as the bonebed itself, the authors utilized more recent methods to come to a greater understanding of site activity. Looking to the original interpretation of Hudson-Meng as a bison jump, Todd and Rapson utilize two deep trenches extending from the primary bonebed to conclusively show that the Alberta-Cody paleosol did not terminate at the western bedrock as Agenbroad argued. Todd and Rapson's trenches show that the paleosol sits above the purported jump site, providing a gentle slope rather than a sharp cliff at the time of occupation. Looking to the lithics associated with the bonebed as well as the faunal remains themselves, the authors see further issues with the site, which they view through both geological and taphonomic lenses.

The lithic analysis of the site was criticized on two fronts: context within deposition, and representation. Looking to context, Todd and Rapson (1999) argue that the Alberta points on the site were located 'above' the bonebed rather than 'within.' This is noteworthy, for if the site occupants were present for the express purpose of hunting and processing, the recovered points would be in more direct association with the faunal remains, rather than sitting above the remains with a sediment buffer between them. Looking to representation, there are a further two arguments. The first is that Todd and Rapson noted Archaic age artifacts, as well as an out of context Agate Basin point. If this were a single event as argued by Agenbroad (1978), the question of why the Alberta-Cody Component is sandwiched between older and younger cultural deposits must be addressed. Additionally, looking to representation, Todd and Rapson contend that there are far too few diagnostic points when considering the minimum number of bison present. They cite a number of other bison kill sites of similar age and argue that it would be projected to have 150-175 projectile points present on the site, rather than the 21 which were recovered.

Having addressed the lithic concerns with the site, Todd and Rapson (1999) move on to address taphonomic issues. They discuss their approach to taphonomy, which considers the bonebed as a 'mosaic' as opposed to the bonebed as an 'artifact.' By considering a number of taphonomic processes beyond human activity, different conclusions and interpretations of the Hudson-Meng bonebed present themselves. An argument in support of this, which was heavily disputed between the authors involves the completeness of several skulls on site. Todd and Rapson observe several bison skulls missing their caps, which they argue represent differential erosion as a result of partial burial of the skulls. This is argued in direct opposition to Agenbroad's (1978) argument that these incomplete elements were the direct result of human action, specifically butchery. Ultimately, Todd and Rapson (1999:493-494) advise caution when referring to Hudson-Meng as a 'kill site' based on their interpretations, and suggest alternative explanations for the bonebed, including an inescapable brush fire or a lightning strike. They go on to contend that "human activity was not the only, and probably not even the primary, factor for the patterns documented archaeologically at the site" (Todd and Rapson 1999:497).

Given the relative incompatibility of these two site interpretations, the United States Forest Service (USFS) determined that further excavation of the site would lend itself to a greater understanding of the site. With this in mind, the USFS reached out to Stan Ahler and Mark Mitchell of the Paleo-Cultural Research Group (PCRG) to conduct excavation further from the original blocks by Agenbroad (1978) and Todd and Rapson (1999). Following a successful first field season in 2005, research continued under the leadership of Mark P. Muñiz of St. Cloud State University. The initial research goals as outlined by Muñiz (2007:1) were to excavate further from the previous excavations to determine what, if any, cultural horizons are present at the periphery, and to determine the site formation processes related to the bonebed, which would inform longer term research goals. The original grid placed by Agenbroad was arbitrarily designated N1000 E1000, with elevation made in reference to the main site datum in the USFS facility which houses the bone bed. This elevation was designated 100.000 meters. From there, Todd and Rapson designated Master Level 1 began at an elevation of 102.100 m. Any areas at higher elevations than these were above the master level and thus designated as "AML", with level numbers increasing with an increase in elevation. Levels excavated by SCSU during all seasons were arbitrary five-centimeter levels, with a level being split into "a" and "b" Components in the case of a stratum change. The first year of excavation by Muñiz focused on two sections of the site: the Enclosure Trench on the south of the site, and the aptly-named PCRG Southeast Block (named as such to distinguish it from the Todd and Rapson Southeast

Block), located some 50 meters from the facility surrounding the original bonebed excavation. It bears repeating that the PCRG Southeast Block excavated by Muñiz is distinct from the Southeast Block excavated by Todd and Rapson. Excavation of these areas resulted in further cultural Components being identified around the periphery of the site. In the Enclosure Trench, three stratified cultural horizons were identified, with a Late Paleoindian Eden Point found *in situ*.

This diagnostic find informed further work, with the scope of the 2007 season dramatically expanding upon the previous years' work (Muñiz 2008). The primary goals of the 2007 season were to expand upon the two new cultural horizons identified in the previous season: the aforementioned Eden Component as well as an unaffiliated Late Paleoindian Component. In addition to continuing excavation in the 2006 areas, several new excavation areas were opened up: the North Block, a further investigation into an area adjacent to previous work by Todd and Rapson, and what is referred to in the technical reports as the FAND Trench. This trench was excavated over the course of three days, with the focus being on exposing a complete geologic profile of a large terrace remnant on the south end of the site.

The 2007 season yielded three primary results: increased public outreach, recovery of a notched bone artifact, and a greater understanding of the site stratigraphy (Muñiz 2008). One of the critical goals of the 2007 season was on increased public outreach efforts. Through the efforts of both avocational and professional volunteers, a total of 128 person days of volunteer effort went into the site excavations. This is a significant increase from the 59 person days volunteered in 2006. Turning to the second outcome, a notched bone artifact was located in the western half of the Enclosure Trench, in the Eden cultural horizon. This opened up new lines of enquiry into the sorts of activities taking place on site. The third outcome of the 2007 field season was that the stratified sequence containing the majority of the site covers a much larger area to the north and south of the portions of the site excavated to this point. This opens new areas of the site for further excavation in the future, in an attempt to find further evidence of Paleoindian site occupation.

The 2008 field excavation at Hudson-Meng was the last in a cycle of three years' work, with the following year being dedicated to researching and processing the results of previous excavations (Muñiz 2010). Public outreach efforts were even more noteworthy in the 2008 field season, with 259 person days of volunteer work contributed to the field season, which is more than twice the time volunteered the previous year. The primary focus of the 2008 research was stated in the conclusion of Muñiz's (2008) report on the 2007 excavations: continued focus on the PCRG Southeast Block and Enclosure Trench, geoarchaeological enquiries into the FAND Trench, and further excavation near Todd and Rapson's (1999) units inside the Visitor Center. Several noteworthy results came after this last season in the cycle. In the Eden Component of the site, shaped tools including an end scraper and a retouched blade were recovered. Their proximity to the projectile point recovered in 2006 and notched bone in 2007 suggests hide processing as a potential site activity. Furthermore, artifacts in this Component tested for protein residue returned positive results for rat and horse antiserum, which could be indicative of diversification of hunting practices. The second major result of the 2008 session was "the documentation of three small, lithic artifacts, and a potential bone tool situated stratigraphically at the base of, or just below, the main bison bonebed deposit" (Muñiz 2010:3). The third result of the 2008 field season was the recovery of multiple artifacts from the PCRG Southeast Block, which at the time were believed to range from the Late Paleoindian period to the Early Archaic period, based on stratigraphic position. However, we now know that these artifacts date to the Early and Middle Archaic and comprise the sample upon which much of this thesis is focused. Unfortunately, cultural association for these artifacts remains unestablished in the absence of diagnostic artifacts. The fourth major result of the season was the completion of a full stratigraphic profile of the FAND Trench and Enclosure Trench. These profiles allow for correlation between the rest of the site, providing better context for the artifacts within. The final major result of the season was the recovery of "important three-dimensional data… for a newly recognized Late Paleoindian or Early Archaic Component" (Muñiz 2010:4). These data will allow for better correlation of the later occupation with the main bonebed Component. It is the third result in Muñiz's 2010 report which is considered the most important for this undertaking, though more relevant information comes in the final year of analysis into the Southeast Block.

> Following a break in 2009 to focus on processing the Hudson-Meng sample backlog, the PCRG Southeast Block was reopened in 2010, with three test units being excavated further. These were U75-9, U75-12, and U75-13 (Figure 3). Unit U75-9 was excavated from AML-12 to AML-9 (102.700-102.500 m). Unit U75-12 was excavated from level AML-14 to AML-11 (102.776-102.500 m). Lastly, Unit U75-13 was excavated from level AML-13 to AML-9 (102.800-102.600 m). Multiple lithic artifacts were recovered during this season, the most notable of which is artifact U75-12-48, a utilized blade (Figure 4). Numerous other artifacts were recovered from the Early Archaic horizon discovered during the 2008 season. In addition to the many artifacts, several sandstone cobbles were observed at various depths in the units, which aids in geoarchaeological analysis of deposition at the PCRG Southeast Block. The significance of these geological and archaeological data are the focus of the following research questions.

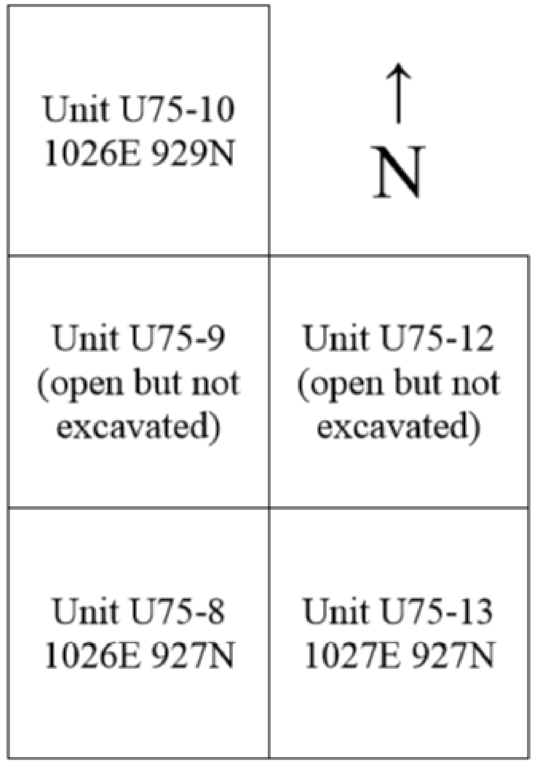

Figure 3: Layout of the PCRG Southeast Block (Muñiz 2010).

Figure 4: Artifact U75-12-48.

Chapter III: Research Questions

There are a multitude of research questions that can be addressed when considering the various Components at the Hudson-Meng site. For this research, I will be focusing my efforts on the Early to Middle Archaic Components through three primary research questions:

1. What can the geologic data from Hudson-Meng tell us regarding site formation processes during the Early to Middle Archaic periods?

Over the many decades that excavation at Hudson-Meng has taken place, interpretations surrounding the geoarchaeology of the Paleoindian occupations at the site have been a subject of debate. As was stated above, one of the primary points of contention is the means by which the bison were killed. While Agenbroad (1978) contended that a cliff was present on site (as evidenced by what he believed was a termination of a Late Paleoindian paleosol at bedrock), Todd and Rapson (1999) reject this interpretation. They argue that if the cause of the bison death were anthropogenic, it would be through the use of an arroyo trap, rather than a jump. Mark Muñiz (2007, 2008, 2010, 2013, et al. 2018) looks to the broader geologic context of the site, which is captured in his FAND trench and several other stratigraphic exposures across the site. The profile of the FAND trench is reflected in Figure 5, and the final results of his study are currently pending publication. In the interests of clarity, I will be working with the data collected by Muñiz to turn the focus to the Archaic occupation of the site as it fits within the broader depositional context of Hudson-Meng. There are two underlying issues this question seeks to resolve: first, how does the PCRG Southeast Block fit into the broader site stratigraphy? Second, how many occupations are represented in the PCRG Southeast Block? There are several avenues by which the geoarchaeology of the site can result in much greater understanding about Early to

Middle Holocene lifeways. Waters (1992:11) clearly states the importance of geoarchaeological inquiry:

> Site formation has become a major research focus of archaeology in the past few decades as archaeological research has been redirected toward understanding prehistoric human behavior… Before archaeologists can infer meaningful interpretations of human behavior from this existing context, they must know how [the site] was created.

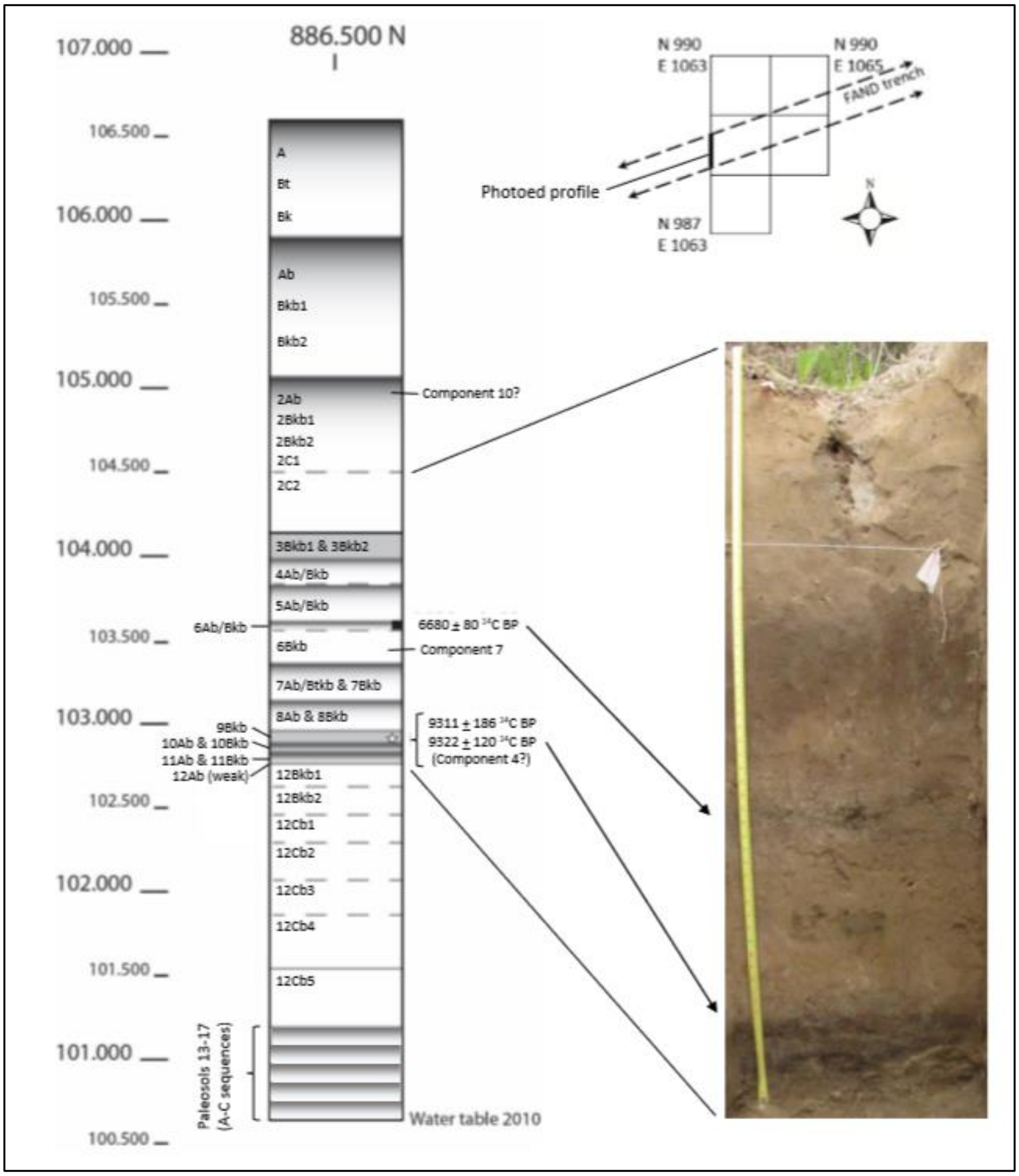

Figure 5: Profile of the FAND trench excavated during St. Cloud State University site investigations (Muñiz et al. 2018).

By understanding the ways in which natural forces shape and impact the site, we can have a better knowledge of human behavior in the Early to Middle Archaic Component of Hudson-Meng. These interpretations will make it possible to understand periods of stability, aggradation and degradation, which can more strictly define the Early Holocene cultural Component in a temporal and geologic context. These data come in a variety of forms such as soil descriptions, photographs of profile walls which illustrate the depositional environment, information regarding the size and location of notable features, three radiocarbon dates taken from the PCRG Southeast Block at the site, and the spatial location and depositional context for the 61 lithic artifacts recovered from the deposits.

2. What can the Early and Middle Archaic lithic assemblage from Hudson-Meng tell us about adaptive strategies on the Western Plains during the Early Holocene?

The fundamental question must be asked to understand site function: what are the occupants doing at this site? It has been argued that lithic tools and debitage "represent the most abundant form of artifacts found on prehistoric sites" (Andrefsky 2005:1). With this in mind, we can look to the lithic assemblage at Hudson-Meng to provide an understanding of the technological and production strategies employed by occupants of the site at the time. By analyzing and sourcing the raw materials found on the site, it is possible to gain insight regarding group mobility. Knowing the approximate sources of raw materials can either tell us how far occupants of the site were willing to travel for said materials, or it can provide ideas as to a distance and direction from whence site occupants arrived. These various lines of enquiry can ultimately lead to a picture of the types of activities occurring at the Archaic occupation of Hudson Meng, as adaptive strategies can be reflected in the material record. For instance, a resource procurement strategy which focuses on gathering rather than hunting activity could be indicated by the presence of artifacts such as plant processing tools, while a hunting camp would likely see a greater number of projectile points. Ultimately, the inferred site function will inform the adaptive strategies present.

By analyzing the types of cores present on the site, a much greater understanding of site activity can be inferred. A skilled flintknapper's objective may be production of usable tools ranging from formally shaped diagnostics to expedient flake tools, which can be reflected in the core type. By looking to the core morphology and flake scars on the core as a measure of variability, the objective of each core can be better understood (Andrefsky 2005). A unidirectional core would be more pragmatic for flake tool production (regardless of whether the objective is an expedient tool or one which requires more labor). By contrast, a multidirectional core may allow for early-stage use as a chopping implement, while further refinement can lead to more specialized tools. Additionally, methods of core measurement can be used in tandem with refit studies (Hofman and Enloe 1991) or Minimum Analytical Nodule Analysis (Larson and Kornfeld 1997) to understand mobility, site function, site formation processes, and technological organization to a further degree.

3. To what extent can variations in debitage measurement skew results between observers?

It has been previously noted that variations in measurement of artifacts can occur when multiple individuals are taking measurements on a collection, as well as when single observers assess and reassess collections (Lyman and VanPool 2009). Lyman and VanPool observe that errors regarding ratio level data often stem from the clarification of processes of measurement.

The clarity issues seen by Lyman and VanPool may potentially be mitigated by the use of methods which provide metadata on ratio level measurement. This notion has been addressed in a recent presentation at the 74th Plains Anthropological Society meeting (Shelton 2016), using an Artec Spyder (a piece of emergent hardware capable of producing highly accurate three-dimensional renders of physical objects) as a vehicle for discussion. Using a collection of debitage from the St. Cloud State archaeology lab, it was shown that this technology could be used to mitigate observer (precision-based) error and methodological (accuracy-based) errors. While these new technologies may serve to offset such errors, the financial investment may be too great for many institutions, though it can be presumed that such technologies will become more accessible over time. However, this issue of variation between observers still remains; while Lyman and VanPool addressed many types of artifacts in their analysis, a review of lithic debitage was not present. Seeking to fill this gap, I will be employing several methods to quantify precision and accuracy-based measurement of the Early to Middle Archaic debitage of Hudson-Meng. Ignorance of this issue presents problems; if for example, a researcher wishes to apply statistical analysis to a large assemblage, aggregation of errors could potentially skew their results. This would raise issues such as potentially significant outcomes being lost, or insignificant outcomes being mistaken as meritorious. By increasing the scientific rigor behind metric analysis, more certain analytical conclusions can be found.

Chapter IV: Methodology

Geoarchaeological Data

Waters (1992) notes two of the primary goals of geoarchaeological study are to place sites in a temporal context through geologic principles, and to understand the natural processes of site formation. The latter of these goals is achievable through understanding the cultural and natural transformations that a site undergoes. Elsewhere, Muñiz and colleagues (2018) have identified at least one Early-Middle Archaic cultural zone, but noted there could be multiple occupations present within it. The first goal for this study is to determinate how many cultural Components are present in the early Holocene PCRG Southeast Block deposits. Another very important goal is to recognize the depositional context for any cultural Components by associating the artifacts with deposits which may indicate aeolian, alluvial, or colluvial forces at play. Finally, the site formation processes and cultural Components will be situated in time using C-14 and AMS dates from the PCRG Southeast Block.

The geoarchaeological concepts to be addressed will build off of one another using the full stratigraphic profile and soil descriptions from the PCRG Southeast Block, as well as relevant data from the full stratigraphic profile of the FAND Trench (which in this case include the texture, color, structure, consistency and features of the soil, in addition to boundaries and reactions in the soil) in tandem with the observed depositional structures such as bedding, potential welded soils, and morphological evidence of paleo-channels. All strata referenced in this section will be referred to using the system established by Muñiz et al. (2018). These profiles will be utilized in tandem with the three-dimensional position data of the artifacts, to identify artifact concentrations as well as the potential for pedoturbation. I utilized these position data to establish a backplot, wherein all point-plotted objects within the PCRG Southeast Block (including artifacts and secondarily deposited cobbles) are graphically represented in their original locations in the block. This backplot is useful for two reasons: first, having a visual representation will make clear patterns that would not be observable by strictly looking at the raw data. Second, this positional data can be compared against the original field illustrations of the soil profiles as mapped during field sessions, to see correlations between artifacts, cobbles, and soil strata. By using the above data in conjunction with the three C-14 dates taken from the PCRG Southeast Block, it will be possible to have a greater understanding of the timing for the cultural and natural transformations occurring at the site. Furthermore, using the FAND trench data, it will be possible to correlate the data in the PCRG Southeast Block with other areas of the site. By having a temporal context, the Early Holocene deposit can be understood as it fits into the broader context of the Pine Ridge Escarpment and surrounding area. However, both the geoarchaeological and lithic artifact lines of enquiry will carry less impact if the artifact observations are suspect; looking to understand and mitigate such concerns is the focus of my third research question.

Lithic Artifacts

I worked with the 61 lithic artifacts from the PCRG Southeast Block, recording metric data such as length, width, thickness, and weight in grams. These data are useful for aggregate analysis, as “differences and similarities in the populations [of lithic artifacts] can be used to make interpretations about each population” (Andrefsky 2005:132). However, while the relatively small number of artifacts will allow for quick collection of data, it must be stated that a smaller sample size will prohibit certain types of statistical claims and observations which would be possible with greater numbers. In addition to these physical measurements, categorical information such as flake type (e.g., primary flakes with greater than 50 percent dorsal cortex, secondary flakes with 1-50 percent dorsal cortex, tertiary flakes void of cortex, etc.), raw material, and core (e.g., unidirectional or multidirectional) and tool types (e.g., projectile point, scraper, drill) were noted. Andrefsky (2005) explains the merits of typological analysis of debitage at length, which proves useful in understanding site behavior for a number of reasons. By classifying flakes as either primary, secondary, or tertiary, conclusions regarding site activity can be reached; a significant abundance of one flake category can suggest particular activities at a site. For instance, a higher quantity of primary flakes would suggest that initial core shaping took place at a given location, while a higher quantity of tertiary flakes would imply that more late-stage tool shaping or maintenance took place on-site. While this sort of analysis is relatively common in the research base, Andrefsky makes it clear that it is not void of issues (2005:115):

> …two major problems with the triple cortex approach are 1) lack of an available replicable procedure to partition varying expressions of cortex, and 2) under-standardized proportions of cortex that define each of the three types. The first leads to unreliable data with regard to actual cortex amount on the dorsal surface of flakes. The second may produce a substantial incomparability between studies, where primary flakes in one study would be called secondary flakes in another, or tertiary flakes in a third.

Regarding flakes and other debitage, we can make inferences regarding site activity by looking to traits such as direction and number of flake scars on the dorsal surface of the flakes. Looking to the number and direction of flake scars enables flakes in the assemblage to be situated in the context of reduction trajectories (Odell 2004), which can further inform the varieties of tool manufacture taking place. Dividing flakes into meaningful categories by sorting by traits such as cortex, flake scars, and retouch provides substantive data from which to interpret human behavior. A further venue of analysis that provides substantial data is the characteristics of platforms on the flakes in the assemblage. Besides simply noting presence or absence, Andrefsky (2005:89-98) notes that “variability in striking platforms has been used to determine type of hammer used, type of objective piece being modified, stage of tool production, and size of detached pieces.” With the merits of platform analysis made clear, Andrefsky offers a number of metrics to observe such as platform angle and facet count, platform width and thickness, and platform type. Citing the work of Gilreath, Andrefsky (2005) notes that the amount of platform preparation increases as flakes progress from the original raw nodule to the finished project. Additionally, it has been observed (Andrefsky 2005) that it is possible to distinguish between biface manufacture and core reduction. Since it can be seen that platforms can provide valuable information on material production, it should follow that there is clear importance in noting these features.

When considering cores specifically, site activity can be inferred from the types of cores observed; these can be differentiated by looking to traits such as flake scar directions, patterns, and reduction sequences. Andrefsky (2005) broadly divides cores into unidirectional or multidirectional, and notes many subcategories such as Levallois blade cores and Alaskan microblade cores. Noting that the variation in cores is representative of the end goal, Andrefsky notes that the features on a core will be markedly different depending on the objective. If the core itself is treated as an objective, it may be bifacially worked into a formal tool. By contrast, if the flakes being removed are the objective (e.g., expedient flake tools), a core may take a radically different form. By differentiating between core types and noting any correlation between cores present and the associated debitage, more observations regarding site function can be made.

In addition to noted attributes on the debitage and cores, we can use Minimum Analytical Nodule Analysis (MANA) (Larson and Kornfeld 1997) in conjunction with data on nearby raw material outcroppings. The benefit of MANA is found in situations where similar raw materials are to be compared against one another in order to ascertain which flakes and tools may have been produced from individual nodules (i.e., cores), even if a direct refit is absent. By looking to factors beyond color and general rock composition (e.g., chert, chalcedony, obsidian, etc.) such as evidence of heat treating, patina, streaks and bands, and specific inclusions, it can be noted that materials may come from the same "analytical nodule", even if a direct refit is not observed. This type of analysis is useful when considering observations on mobility and material procurement for two reasons. First, by comparing the material varieties present on site with nearby material sources and quarries, a degree of mobility can be ascertained. Second, by noting Minimum Analytical Nodules, it is possible to augment other observations of site activity, since an abundance of a particular material type could suggest some degree of workshopping on-site, bringing completed tools onto the site that were manufactured elsewhere, and/or the production of tools on site which were then taken off site. That being said, while lithic analysis may yield considerable insight regarding site activity, geoarchaeological data serves to provide greater context for such observations.

Variation between Observers

To address the concern over empirical error of data collection made between different lithic analysts, multiple statistical methods will be employed. To conduct this part of the study, I have solicited the aid of four peers in the Department of Anthropology, St. Cloud State University. While all of these recorders have familiarity with the Hudson-Meng lithics, I have attempted to represent a variety of backgrounds in the selection of subjects. Of the four recorders (not including myself), two of the students are undergraduates while the other two are graduate students. Of the undergraduate students, one of them has a stronger background in biological anthropology, while the other has a background in historical archaeology. Of the two graduate students, one has focused their research on historical archaeology, while the other is focusing on lithics in pre-contact archaeology. Each of these recorders worked with the 54 pieces of lithic debitage, and did not analyze the five pieces of fire-cracked rock or the two cores found on-site. Five points of metric data were taken on each of the artifacts cataloged: maximum length (that is, the longest unbroken line segment on an artifact), maximum width (a measurement taken relative to the maximum length, rotated 90 degrees), oriented length (measured from the striking platform to the termination of the flake) oriented width (taken by measuring 90 degrees offset from the oriented length), and thickness (taken by measuring the cross section of a given artifact relative to its lengths and thicknesses). In addition to the four recorders, I have included my own measurements of the same data, to increase the total number of data points. All 1,350 separate measurements were taken with the same pair of Mitutoyo digital calipers, which have a resolution of .01 millimeters, and an accuracy of ± 0.02 millimeters. By working with and illuminating measurement errors on equipment with such precision measurements, variation in these kinds of data can be presumed to be considerably worse if any future dataset is measured with a less precise piece of equipment. After all of the data were collected, multiple statistical analyses were applied to the data in order to describe and quantify variability and error. In addition to basic information such as the average measurement values and standard deviations, I calculated the Coefficient of Variation (CV), which describes the amount of variability (e.g., standard deviation) relative to the mean, for all measurements. The equation for CV is as follows:

$$CV = \left(\frac{\sigma}{\mu}\right) * 100$$

Where σ is the standard deviation for the population, and μ is the mean of all members of the population. Following this, the **Technical Error of Measurement** was calculated for the population. This is a measure of difference between observers, and is expressed using the initial units of measurement (e.g., millimeters or grams). While Lyman and VanPool (2009) used a calculation suitable for two observers, the larger number herein requires a modified calculation for TEM (Sicotte et al. 2010), expressed as follows:

$$\sqrt{\frac{\sum_1^N \left[\left(\sum_1^K M(n)^2 \right) - \frac{\left(\sum_1^K M(n) \right)^2}{K} \right]}{N(K-1)}}$$

Where *K* is the number of observers (in this case, five), *M (n)* is the measurement value, and *N* is the population size. With this value, it is possible to calculate the **Relative Technical Error of Measurement (%TEM)**, which expresses the magnitude of error and is reported as a percentage of the average size of the dimension under study. The %TEM is expressed as follows:

$$\%TEM = \left(\frac{TEM}{\mu}\right) * 100$$

With μ again being the mean of the population. These served to quantify the difference in measurements made by the five researchers.

Chapter V: Results

Over a period of several weeks, I was able to collect all necessary data to adequately answer my first two research questions. Additionally, with the help of Christiana Peach, Benjamin Shriar, Caleb Frauendienst, and Elizabeth Pawelk, I was provided with multiple sets of metric data for the PCRG Southeast Block debitage. Using their measurements in tandem with my own provided sufficient data to answer my third research question. The results of these data collection efforts are presented below.

Geoarchaeological Data

In order to understand the broader trends occurring at Hudson-Meng the following lines of information were considered. In addition to focus on the time of site occupation, Muñiz and colleagues (2018) address the broader trends which led to the environments observed during occupation. For considerations at the site level, multiple works which resulted from multiple field seasons were considered (Muñiz 2007, 2008, 2010, 2013; Muñiz et al. 2018). The results of these publications were synthesized to provide broader stratigraphic information with regards to the PCRG Southeast Block. The soil profile of the PCRG Southeast Block is seen below (Figure 6). The soil descriptions for the PCRG Southeast Block, from the ground surface to the base of the excavations, were taken from a combination of the 2010 stratigraphic profiles and the work of Muñiz and colleagues (2018). They are as follows:

Table 1: Soil profiles in the PCRG Southeast Block.

Stratum	Color	Texture	Structure	Consistence	Boundary
Modern A	Very dark grayish brown (10YR 3/2)	Sandy clay loam	Spheroidal Crumb	Slightly hard	Abrupt wavy
Ab	Brown (10YR 4/3)	Sandy clay loam	Subangular blocky	Slightly hard	Gradual smooth
Bb	Very dark grayish brown (10YR 3/2)	Loamy sand	Subangular blocky, very weak	Soft	Gradual smooth
2BtkB	Grayish brown (10YR 5/2)	Loam	Subangular blocky, very weak	Soft	Gradual smooth
2Cb	Grayish brown (10YR 5/2)	Loam	Subangular blocky, very weak	Soft	Clear, wavy
3Ab	Grayish brown (10YR 5/2)	Sandy clay loam	Subangular blocky, very weak	Soft	Gradual smooth
3Btkb	Grayish brown (10YR 5/2)	Sandy clay loam	Subangular blocky, very weak	Soft	Abrupt smooth
4Ab	Grayish brown (10YR 5/2)	Sandy clay loam	Spherical granular	Slightly hard	Clear, smooth
4Bkb1	Grayish brown (10YR 5/2)	Sandy clay loam	Subangular blocky	Slightly hard	Clear, smooth
4Bkb2	Weak red (2.5YR 5/2)	Sandy clay loam	Subangular blocky	Slightly hard	Gradual irregular
5Ab	Weak red (2.5YR 5/2)	Sandy loam	Subangular blocky	Slightly hard	Clear irregular
5Bk/Btkb	Weak red (2.5YR 5/2)	Sandy loam	Subangular blocky	Slightly hard	Clear irregular
6Ab	Weak red (2.5YR 5/2)	Sandy loam	Subangular blocky	Slightly hard	Abrupt irregular
6Bb1	Very dark grayish brown (10YR 3/2)	Sandy clay loam	Subangular blocky, very weak	Soft	Abrupt wavy
6Bb2	Brown (10YR 4/3)	Sandy loam	Subangular blocky, weak	Soft	Abrupt wavy
6Cb1	Brown (10YR 4/3)	Sandy loam	Subangular blocky, weak	Soft	N/A
6Cb2	Brown (10YR 4/3)	Loamy sand	Subangular blocky, weak	Soft	N/A

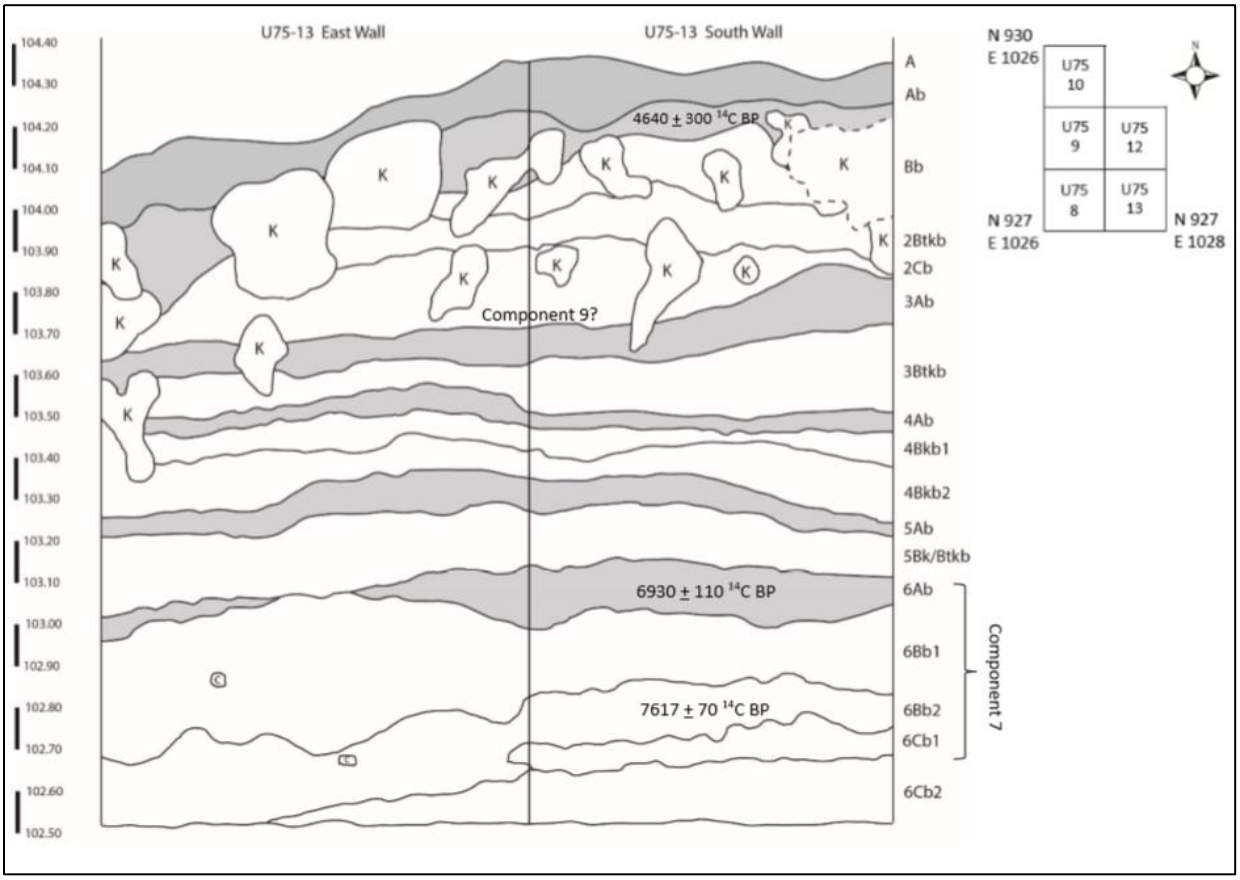

Figure 6: Soil profile of the PCRG Southeast Block (K=krotovina, C=cobble)
(Muñiz et al. 2018).

While there are multiple buried soils noted in this profile, the focus will be placed on stratum Ab, and strata 5Ab through 6Cb2, which are the strata where the majority of the lithic materials to be discussed were recovered. Stratum 6Ab, when measured along the southern wall of the excavation block, first appears at approximately 103.130 m elevation, and fully transitions into stratum 6Bb1 at an elevation of 102.700 m. This is also the stratum from which a radiocarbon date of 7617 ± 35 BP was acquired from a burned bone fragment. In an elevation range of 102.700–102.800 m, a second radiocarbon date of 6930 ± 55 BP was recovered, corresponding to stratum 6A. The third and final radiocarbon date of 4640 ± 150 BP from the PCRG Southeast Block was recovered from a range of 103.850–103.910 m. This third date comes from stratum 1Ab. Regarding potential features, there are three noteworthy circular soil stains in the PCRG Southeast Block. Two of these are in unit U75-9 at an elevation of 103.000 (AML19), while the other stain is found in units U75-8 and at depths of 102.685. The stain in unit U75-8 is approximately 3.5 centimeters in diameter, the two stains in U75-9 are approximately 14 and 18 centimeters in diameter, and the stain in unit U75-8 is approximately 5 centimeters in diameter. There are also 136 non-knapped cobbles located in the lower levels of the PCRG Southeast Block, which have weights ranging from 4 to 364 grams. The plotted cobbles range in elevation from 103.200 m to 102.546 m, with the majority of these coming from a range of 102.900 m to 102.600 m. Working with the northing and elevation from the original site reports, I was able to build a graphic representation of all point plotted cobbles, fire cracked rock, and pieces of lithic debitage into a backplot (Figure 7) which runs north to south and encompasses units U75-8, U75-9, U75-12, and U-75 13. Unit U75-10 is omitted, as no cobbles or debitage were recorded *in situ* during excavation. Additionally, the three larger soil anomalies have had their full extent inserted into the backplot as a transparent shape.

The PCRG Southeast Block has three distinct artifact-bearing horizons, which correspond to cultural components as described by Muñiz and colleagues (2018): the first of these, which will be referred to as Cultural Component 7a, appears at the southern end of unit U75-13 and ranges in elevation from 103.054 to 102.869 m. This horizon gradually decreases in elevation moving northward, and terminates at a range of 102.740 to 102.621 m at the northern half of units U75-9 and U75-12 (Figure 8). The second horizon (Cultural Component 7b) appears at 103.078 m elevation in the northern end of unit U75-13, and terminates at 103.014 m in the northern end of unit U75-12. Cultural Component 7b is also the cultural layer where four pieces of fire-cracked rock were located. There is a third group of three artifacts (Cultural Component 9) in unit U75-12 at an elevation range of 103.800-103.665 m; all three artifacts are in the northern third of unit U75-12.

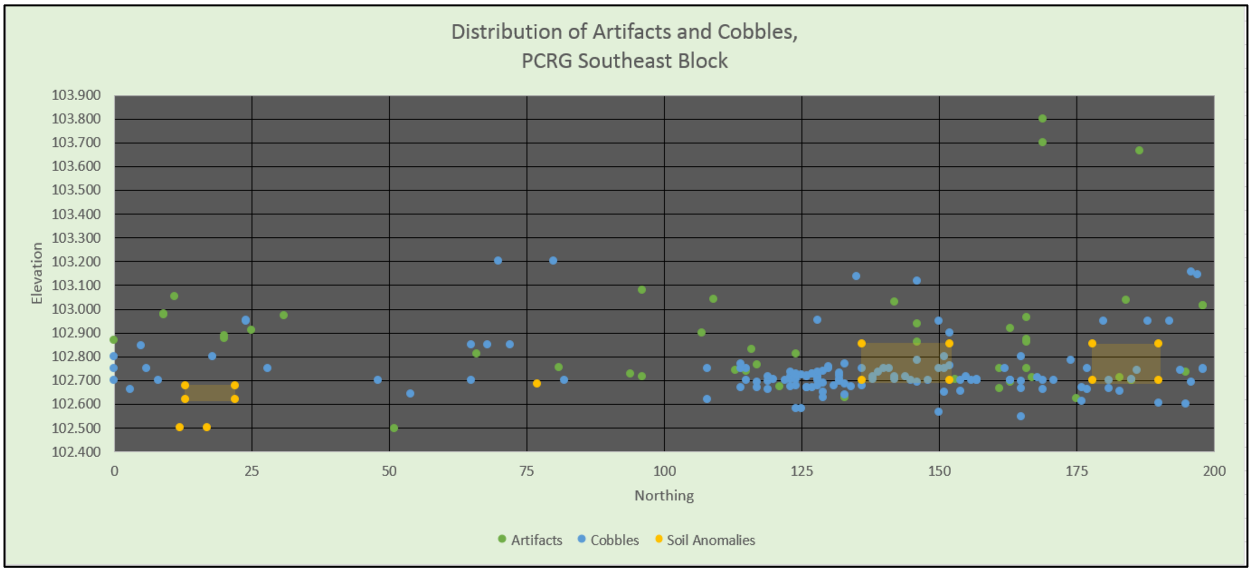

Figure 7: Distribution of artifacts and cobbles within the PCRG Southeast Block.

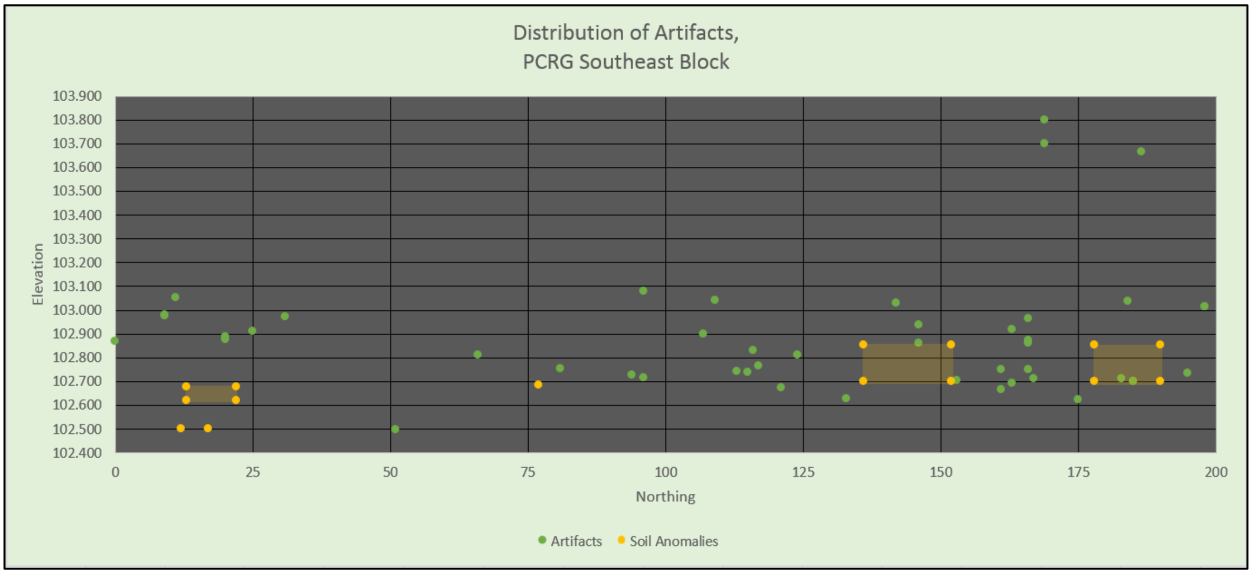

Figure 8: Distribution of artifacts within the PCRG Southeast Block.

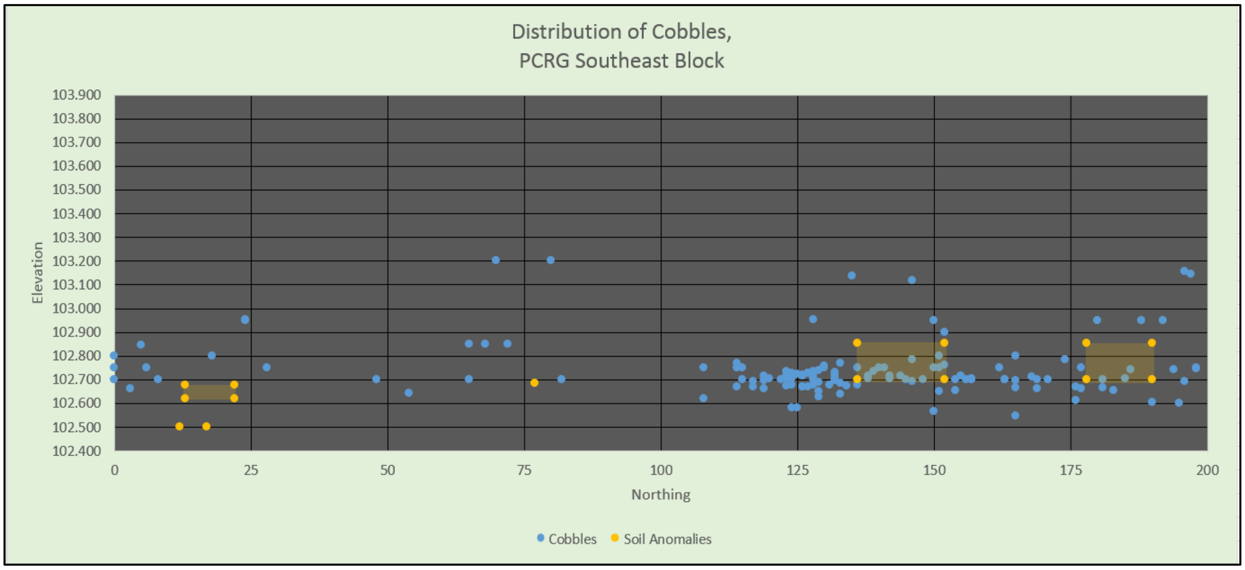

Figure 9: Distribution of cobbles within the PCRG Southeast Block.

In addition to the artifacts plotted here, 136 cobbles were recorded as well. While the artifact horizons tend to decrease in elevation trending north, there is a relatively flat horizontal distribution of cobbles, though they occupy a wider vertical distance, from 102.850 to 102.500 m. In general, the southern two units, U75-8 and U75-13 have a much more diffuse distribution of cobbles, while units U75-9 and U75-12 are more tightly grouped. As is the case with the artifacts, there are some outliers in the cobble groups as well, with outliers being noted as high as 103.200 m in the southern two units. The distribution of artifacts and cobbles are each seen in their own separate back plot (Figures 8 and 9), as well as in the aforementioned combined display (Figure 7). While there is some degree of co-occurrence between the debitage and cobbles, each has sections where there is a clear distinction between them. In all three of these plots, six soil anomalies are mapped in. In three of these instances, the anomalies were large enough that top and bottom elevations were taken across several levels. In two of the three larger soil anomalies, as well as one of the smaller anomalies, there is a correlation with the two artifact horizons. The remaining two smaller soil anomalies first appear approximately 50 centimeters below artifact-bearing horizons in their test units, while the remaining large anomaly appears 35 centimeters below artifact bearing horizons. The two small anomalies at the base of U75-8 are also far below the horizons which contain cobbles. They first appear 35 centimeters below the deepest cobbles in units U75-8 and U75-13. The larger anomaly at the southern end of the block is first noted at the same elevation as three of the deepest cobbles at the southern end of the southern two units. Interpretations of these artifact distributions will follow in the discussion.

Lithic Artifacts

A comprehensive list of the following data are available in Appendix A-1. Of the 61 lithic artifacts from the Early Archaic Component of Hudson-Meng, 54 artifacts are chipped stone debitage, 5 artifacts are fire-cracked rock, and 2 artifacts are cores. The five pieces of fire-cracked rock are noteworthy, as they represent the only instance of thermally altered rock in an absolutely dated Early Archaic site. The nearby Licking Bison (Fosha 2001) and Hawken (Frison et al. 1976) sites contain no fire cracked rock whatsoever, and the only instance of FCR at the Medicine Lodge Creek is found in a Paleoindian phase of the site (Frison and Walker, 2007). All five pieces of FCR are composed of a quartzite of indeterminate origin. Of the five pieces of fire-cracked rock, four of them were plotted *in situ*, all of which correspond to the contact between the 5Ab and the 5Btkb horizon. All five pieces of fire cracked rock are cobble sized, with maximum dimensions ranging from 13 to 37 cm; average maximum dimension is 24.2 cm.

Looking to the two cores and the 54 pieces of debitage, it is worth noting that every artifact in this assemblage comes from local sources. Many artifacts are from material in the White River Group formation, which is local to Oglala National Forest, while many other artifacts are made from various cherts and chalcedonies, all of which source to an Eocene-age cobble field near Pete Smith Hill, a local landmark which is situated approximately nine and a half miles east-northeast of Hudson-Meng. These materials were confirmed against comparative collections in the St. Cloud State University archaeology lab, and the South Dakota Archaeological Research Center. A representative sample of the raw material classes found in the PCRG Southeast Block is seen in Figure 10.

Figure 10: Selected artifacts from the PCRG Southeast Block showing material classes.

The two cores are multi-directional, with one of them being made of White River Group chert and the other being made of Plate Chalcedony, from the Pete Smith Hill locality. The WRGS core is the larger of the two, with a maximum dimension of 8 cm, and a weight of 304 grams. This core is relatively round in shape, there are approximately twenty attempts at flake removal, and seams of non-silicified material running throughout the core. Considerable portions of its cortex are still present and intact, suggesting this attempt was abandoned following observation of inclusions which would make knapping difficult. The latter core is bidirectional, and is considerably smaller than the former, with a maximum dimension of 5.9 cm and weighing a mere 32 grams. The second core only has five negative flake scars, though they encompass the majority of the core surface.

Of the 54 pieces of debitage, 9 have been identified as shatter; this is due to a combination of factors, the most notable of which is the inability to distinguish dorsal and ventral surfaces. Of the remaining 45 artifacts, a mere 3 artifacts meet Andrefsky's (2005) definition of a primary flake (greater than 50 percent dorsal cortex), 9 artifacts fall into the secondary flake category (that is, notable dorsal cortex which covers fewer than 50 percent of the dorsal surface. The remaining 32 tertiary flakes lack any cortex whatsoever. Looking to the completeness of the artifacts, only 15 flakes are unbroken in any way, with notable platforms and clear terminations. Of the remaining 30 artifacts, 4 are proximal flakes which have a platform but lack termination, 14 are distal flakes which have a clear termination but are broken in such a way that the platform is missing, while the remaining 12 medial flakes have neither a clear platform nor a clear termination, though dorsal and ventral surfaces are notable. Additionally, consistent with Hofman and Enloe (1991), an attempt was made at refitting the debitage in this collection; there were no direct refits observed. Of the 19 flakes which have platforms, 11 platforms are flat while the remaining eight are faceted, with an average facet count of 3.125. The metric attributes of the debitage recovered is noted in the following section. A particularly noteworthy artifact in the assemblage is specimen U75-12-48, a prismatic blade made from Plate Chalcedony

(Figure 3). It is a very long, thin flake with evidence of edge retouch, and likely saw regular use as a cutting implement. Whether this blade was used for cutting hide, muscle, floral materials, or something else could easily be determined by further research reminiscent of Douglas (2015).

Quantification of Variation between Observers

As was stated above, this aspect of research serves to expand on Lyman and VanPool (2009) by looking at inter-observer error as it applies to debitage. The measurements taken by the four experimental observers is shown in Tables 4 through 7. My own measurements were used in this analysis as well; refer back to Appendix A-1 for those data. After all four observers had collected their data, average values, variances, and standard deviations were taken on each of the 270 data points (five separate metrics for each of the 54 artifacts), as well as Variance, TEM, %TEM, CV, and error ranges at a 95 percent confidence interval (see Appendix A-2 through A-14).

The participant statistics were run in three batches: the first of these (Table 2) shows the average mean, variance, standard deviation, standard error, error range (at a 95 percent confidence interval), coefficient of variation, technical error of measurement, and relative technical error of measurement, for all artifacts measured by all five participants. Table 3 shows this same list, focusing only on the artifacts located in the aforementioned Cultural Component 7a, while Table 4 shows the same list focusing on Cultural Component 7b. Cultural Component 9 was not separated into its own dataset, as an *n* of three artifacts is too small for meaningful conclusions.

The most notable of the comparisons among observers is the coefficient of variation and the relative technical error of measurement. In these instances, the percentage of variation increases as the measurement becomes more subjective. Oriented lengths and widths are highly variable, with 12-15 percent variation between the observers. By contrast, objective measurements such as maximum length and maximum width are more consistent, with a 4 percent and 8 percent variation respectively. In terms of error and variation, thickness of artifacts sits between maximum and oriented measurements. It is likely that the coefficient of variation is higher than the maximum values as a result of difficulty on the part of the observers in determining the thickest part of a flake cross-section. However, the coefficient of variation is likely lower than the oriented values due to a much lower variance; this is to say, with a population which is much less varied, the potential for error is naturally lower.

In addition to the analyses relating to linear measurements by multiple observers, three chi-square analyses were conducted, which attempted to determine if a statistically significant difference existed between attributes of the Cultural Component 7a and Cultural Component 7b debitage. The first of these compared the presence and amount of primary, secondary, and tertiary flakes in each Component, the second analysis looked to the number of flakes with platforms versus the number of flakes without platforms, and the third compared the ratios of flat versus faceted platforms in each Component. The comparison of flake types (Table 5) yielded a $\chi 2$ value of 8.4676 ($df = 2$, $p = 0.014$, Cramer's V = 0.51), the analysis of presence or absence of platforms (Table 6) returned a $\chi 2$ value of 0.007 ($df = 1$, $p = 0.930$, Cramer's V = 0.015), and the comparison of platform types (Table 7) returned a $\chi 2$ value of 0.626 ($df = 1$, $p = 0.429$, Cramer's V = 0.230). Simply put, it can be stated with 98% confidence that the difference in flake types between components 7a and 7b is not due to the vagaries of sampling. By contrast, the p values of 0.930 and 0.429 seen in the second and third tests make it clear that the difference in the presence or absence of platforms, as well as the difference in platform types between the two components is statistically insignificant.

However, data which is unable to reject a null hypothesis remains as valid data and can still carry implications regarding similarities and differences between the two components. While the highly significant difference between flakes in different reduction stages lends credence to the idea that these components represent genuinely separate occupations of the site, the similarity of platform presence and type suggests a similarity in flake reduction and production technique.

Table 2: Average measurements for total population.

Average measurements	Max Length	Oriented Length	Max Width	Oriented Width	Thickness
Mean	17.431	16.039	11.887	11.746	3.337
Variance	0.664	5.363	2.236	5.399	0.125
Std Dev	0.604	1.797	0.991	1.816	0.268
Std Err	0.121	0.359	0.198	0.363	0.054
Err Rng @95% CI	0.335	0.998	0.550	1.008	0.149
CV	4.368	12.614	8.332	15.672	8.608
TEM	0.604	1.797	0.991	1.816	0.268
%TEM	4.368	12.614	8.332	15.672	8.608

Table 3: Average measurements for Cultural Component 7a.

Component 7a	Max Length	Oriented Length	Max Width	Oriented Width	Thickness
Mean	19.349	18.077	12.624	12.354	3.855
Variance	0.429	3.863	3.332	5.241	0.197
Std Dev	0.521	1.595	1.173	1.843	0.350
Std Err	0.104	0.319	0.235	0.369	0.070
Err Rng @95% CI	0.289	0.886	0.651	1.023	0.194
CV	3.080	10.759	8.337	15.881	9.869
TEM	0.521	1.595	1.173	1.843	0.350
%TEM	3.046	10.842	8.410	15.924	10.007

Table 4: Average measurements for Cultural Component 7b.

Component 7b	Max Length	Oriented Length	Max Width	Oriented Width	Thickness
Mean	21.393	18.972	14.869	15.255	4.062
Variance	0.294	13.636	1.203	10.564	0.09
Std Dev	0.489	2.812	0.804	2.531	0.246
Std Err	0.098	0.562	0.161	0.506	0.049
Err Rng @95% CI	0.272	1.561	0.446	1.405	0.136
CV	3.087	14.731	6.019	15.345	6.262
TEM	0.489	2.812	0.804	2.531	0.246
%TEM	3.087	14.731	6.019	15.345	6.262

Table 5: Flake types by Component.

	Primary	Secondary	Tertiary	Total
Component 7a	1	1	18	20
Component 7b	1	6	6	13
Total	2	7	24	33

Table 6: Presence of platform by Component.

	Platform	No Platform	Total
Component 7a	8	12	20
Component 7b	5	8	13
Total	13	20	33

Table 7: Platform type by Component.

	Flat Platform	Faceted Platform	Total
Component 7a	5	3	8
Component 7b	2	3	5
Total	7	6	13

Chapter VI: Discussion

The results of this data collection will lend itself towards insight into the behaviors of the Early–Middle Archaic occupants of Hudson-Meng. Looking to the lithic artifacts from the PCRG Southeast Block, it is unfortunate that no diagnostic artifacts were associated with the Components in question; with that said, the debitage recorded can still provide information on site behaviors. Looking to the activity of the Archaic occupants of the site, it is worth considering the pressures of the local environment in tandem with the material record observed at the site. Agenbroad (1978) contends that following the Late Paleoindian occupation of the site, the climate underwent a transition from a mesic environment to a more arid setting, which is reflected in phytolith analysis of grasses on site (Lewis 1978), and through gastropod analyses of the site (Muñiz et al. 2018). However, despite frequent periods of aridity throughout the site's history (Muñiz and colleagues note alternating periods of arid and mesic environments in both the FAND Trench [2018:44] and the Enclosure trench [2018:49]), the spring on the site probably flowed perennially. Running opposite to this are data from Muñiz and colleagues' discussion of the Hudson-Meng Enclosure Trench. When moving into strata 5 and 6 in the Enclosure Trench, it was noted that this was a period of increased aridity. If the environment of the site trended towards an increase in aridity while the springs were still flowing, there is a clear motive for site occupants to be present. This is further reinforced by the high vantage point of the nearby Round Top and Little Round Top hills, which provide a strategic vantage point for hunting. This use of advantageous nearby landforms was likely seen at Licking Bison, where the nearby Saddle Butte would have provided similar advantages (Fosha 2001). Licking Bison is also near Rush Creek, which would have provided a water source for the site occupants. Utilization of nearby water sources can also be seen in all occupations at the Medicine Lodge Creek site, which is situated immediately adjacent to the confluence of the Medicine Lodge Creek and North Fork Creek (Frison and Walker 2007:11). Both of these sites, as well as the Hawken Site (Frison et al. 1976) have established hunting activity, evidenced by multiple projectile points associated with Early Plains Archaic groups. These lines of evidence, as well as any faunal remains, are noticeably absent from the Hudson-Meng Early Archaic components; whether or not further excavation would yield these data cannot be determined at this time.

Looking to the materials found in the PCRG Southeast Block, it is noteworthy that all pieces debitage and cores on-site were from relatively local sources. This was confirmed by comparing the PCRG Southeast Block assemblage to collections at St. Cloud State University and the South Dakota Archaeological Research Center. The material classes represented on the site (which include WRGS cherts, silicified Fall River quartzite, and plate chalcedony) are in abundant supply at the nearby Pete Smith Hill Locality. Figure 11 shows the distance between Hudson-Meng and Pete Smith Hill, which is approximately 9.5 miles. This relatively short distance would easily be traversed in a day’s time, with ample time for initial reduction taking place away from Hudson-Meng itself. This is consistent with the low number of primary flakes found on site, as most early stage reduction and shaping could occur at a nearby quarry. This reliance on local sources is contrasted sharply by the lithic record of the Alberta-Cody occupation of the site as noted by Bruce Huckell (1978), who focuses on the debitage of the original excavations conducted by Agenbroad. He notes four loci with an abundance of exotic material, with Knife River Flint being the most represented by number. Knife River Flint is a high-quality material, whose source is located some 300 miles (straight-line distance) from

Hudson-Meng in western North Dakota (Root 1997). Of the 2,726 pieces of debitage recorded in Huckell's analysis, 1,184 were made from Knife River Flint. Additionally, seven of the 20 projectile points originally recovered are made of Knife River Flint as well. It has been previously noted that KRF has been traded across far distances (Clark 1984; Clayton et al. 1970; Hall 2005), including Hudson-Meng (Agenbroad 1978). This trade distribution, when compared against the exclusively local materials found in the PCRG Southeast Block, suggests a decline in trade and/or mobility during the Archaic period. The same trend is observed in other Early Archaic period sites such as Hawken (Frison et al. 1976) and Licking Bison (Fosha 2001); both of these sites' lithic artifacts were made up of entirely local sources. This trend is seen in later phases of the Archaic; Reher (1985) observed a paucity of exotic materials at the McKean site when compared to local materials such as Morrison Chalcedony and Hogback Quartzite, which would have been abundantly available in the nearby Black Hills of Wyoming and South Dakota.

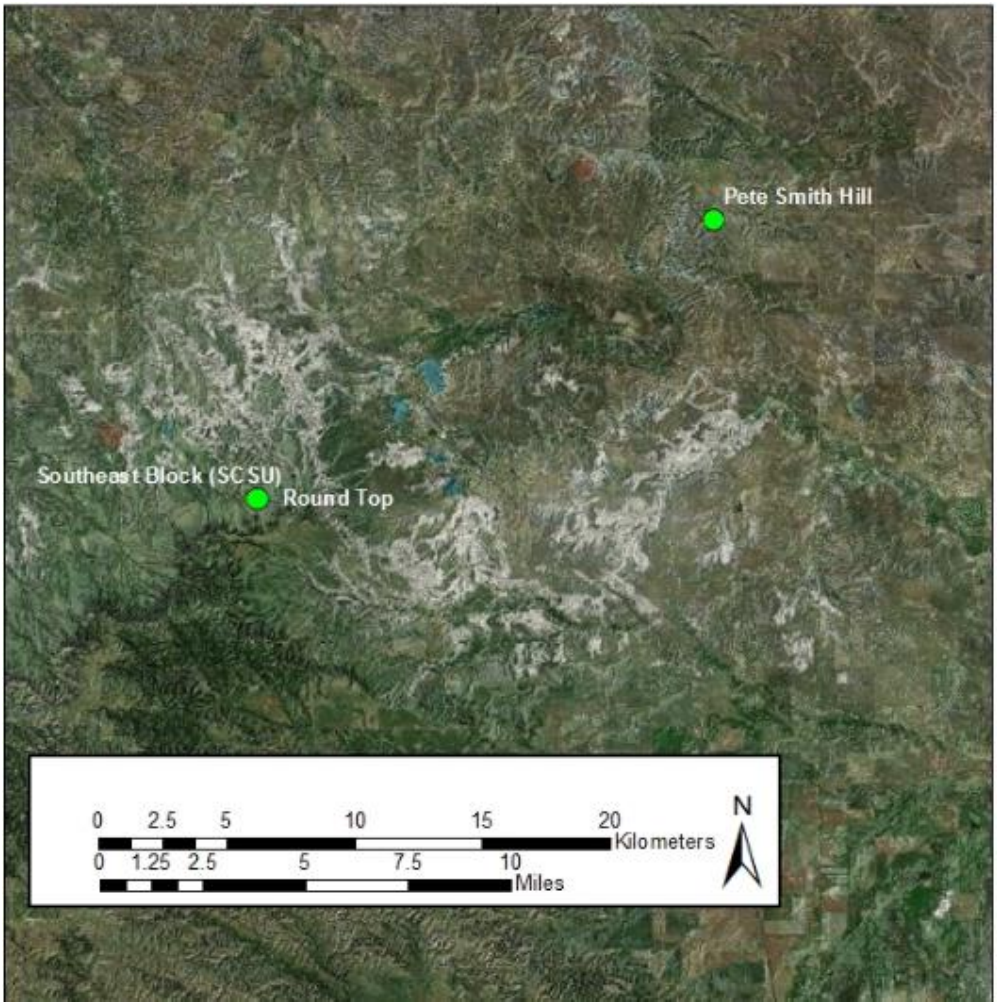

Figure 11: Approximate distance between Hudson-Meng and material sources at the Pete Smith Hill Locality (Credit: Google Earth).

When considering the lithic assemblage in the PCRG Southeast Block, it must be addressed in terms of its separate Components (Cultural Components 7a, 7b, and 9, defined by Muñiz and colleagues [2018]). When looking to the above Tables 3 and 4, the average measurements of Components 7a and 7b bear a certain similarity. The difference in average values of maximum and oriented lengths between the two Components are 2.04cm and 0.90cm (10 and 5 percent), respectively. Maximum and oriented widths are more varied, with differences of 2.24cm and 2.90cm (15 and 20 percent) respectively. Thickness is the second most similar attribute between the two Components, with a 0.21cm (6 percent) difference between Components. As was stated in the results, Cultural Component 9 does not have a sufficient number of artifacts for a meaningful independent assessment.

When compared against the high number of secondary and tertiary flakes, there are a relatively low number of early stage primary flakes (representing 5% of Component 7a and 7% of Component 7b). This low number of early stage flakes affords two possible interpretations of primary site function. These interpretations are bolstered when considered alongside analysis of the 19 flakes which have platforms present (through all stages of reduction). The first of these relies on the idea that a flat platform is indicative of flake production, which would lend credence to the site functioning as a processing area. If the soil staining features (to be discussed below) are interpreted as posts for hide processing, a ready supply of expedient flakes would be helpful for initial butchery, with more specialized scrapers to aid in hide processing efforts. By contrast, an abundance of flakes with faceted platforms would imply bifacial flaking, which would suggest formal tool production as a site activity. As there is not a significant difference in the number of flakes with flat or faceted platforms ($p = 0.429$) between Components 7a and 7b, it is possible that final tool shaping took place on site, with expedient flakes being prepared for processing of resources. However, the total lack of bifacially worked tools such as projectile points or scrapers for both components should be considered a point against workshopping or hunting as the primary function. If workshopping, hunting, or post-hunt processing were the primary activity at the site, it would be expected that some nonzero quantity of bifacially worked tools or preforms would be present for at least one of the components. Generally, the sparse nature of the material record suggests at least two short-term occupations (7a and 7b), with the

Archaic site occupants making intermittent visits to the spring, possibly for acquisition of floral or faunal resources, then traveling elsewhere after sufficient supplies had been procured. Plant acquisition is seen elsewhere in the Archaic as well, most notably at the Coffey Site (Schmits 1978), where Douglas (2015) argues that the Munker's Creek knives found on site were specialized tools for the cutting of big bluestem grass. Using experimental reproduction and microwear analysis, she makes a compelling argument in favor of grass cutting tools. While no such work has been conducted on the PCRG Southeast Block assemblage, such analysis would further solidify any arguments in favor of or against plant processing in components 7a and 7b. A compelling starting point for this research would be artifact U75-12-48 (Figure 3), a well made utilized blade from the PCRG Southeast Block.

The issue of relating the lithic materials on site to the geoarchaeological concerns is another task altogether. The lithic artifacts discussed above must be properly situated in a geologic context, which the aforementioned backplots will help with (Figures 7 through 9). This presents a somewhat difficult task, as Muñiz and colleagues (2018) note that the strata present in the PCRG Southeast Block are not present at all locations throughout the site. In light of this, there are data which can help understand the environment at the time. First, the large band of colluvium in stratum 6Cb2 (Muñiz et al 2018:14) indicates a significant depositional event. This, taken in tandem with the environmental data from the FAND Trench Cultural Component 7 suggesting increased aridity during the time of the PCRG Southeast Block Cultural Component 7a's occupation suggest a somewhat unstable land surface marked by at times intense erosion (Muñiz et al 2018:12). This erosion would help explain the lack PCRG of Southeast Block strata elsewhere on site. Looking to the artifacts, two components (Component 7a and 7b) are present in the lower levels of the PCRG Southeast Block units, with the small Cultural Component 9 serving as a third grouping. The cluster of artifacts in the upper levels of unit U75-9 sits in the 1Ab horizon, which was dated at 4640 ± 150 radiocarbon years before present. While this is a relatively late date compared to the lower AMS dates, it is within Kornfeld and colleagues (2010) range for the Middle Archaic. Looking to Components 7a and 7b in the lower levels of the block, the higher of these (Component 7b) mostly occupies units U75-9 and U75-12, and is consistent with the contact of the 5Ab and 5Btkb horizons. The location of artifacts at this contact is considerably important, as it further reinforces occupation of the site during a time of aridity. Development of an A horizon is indicative of surface stability, which would be caused by a denser root mat. The increased vegetative cover which would yield this mat would have developed in response to a more mesic environment. By their presence at the contact between stratum 5Ab and 5Btkb, it is most likely that site activity represented by Component 7b took place before this transition back into a mesic environment. While there is a notable artifact lens here, there are a handful of artifacts which sit firmly between this horizon and the lower level artifact lens. This is likely the result of bioturbation, as several krotovinas and root casts were present in the PCRG Southeast Block units. The lower Component (7a) sits below Component 7b in the northern two units, while it is roughly at the same elevation to the south. However, it should be noted that the second artifact lens follows the contact between the 6Ab stratum and the 6Bb1. All of these strata decrease in elevation moving northward, generally following the paleotopography of the landform. As is the case with Cultural Component 7b, the diffuse nature of the artifacts implies pedoturbation, likely through burrowing insects and rodents. Arguments that these artifacts are in a secondary or redeposited context can be ruled out due to the presence of associated cultural features.

Over the course of the 2005-2010 field seasons in the PCRG Southeast Block, six soil stain features were recorded. Three of these are viable as cultural features; however, three stains in unit U75-13, are most likely naturally occurring. This is probable for multiple factors; first, two of these stains were first noted at an elevation of 102.500 m, a full 50 centimeters below stratum 6Ab, the lowest buried soil in the block. Additionally, these two stains were observed within 10 centimeters of one another, and both are approximately 2.5 centimeters in diameter. Working from the assumption that these stains are post molds, it seems highly unlikely that two posts of such a small diameter would be driven so far into the ground below the stable surface at the time, that they would be placed so close together, and that there was no evidence of their presence prior to that point. What seems to be a more likely explanation is that these two stains are insect burrows. Figure 12 shows the two stains in question adjacent to a bone fragment, while Figure 13 shows the floor of unit N80-13, a unit in the Enclosure Trench elsewhere on the site. Unit N80-13 has several examples of insect burrows on the floor which bear a striking similarity to the stains from the PCRG Southeast Block. The third soil anomaly in the southern end of the block is also likely to be naturally occurring. It first appears at an elevation of 102.675 m which, while not as deep as the two smaller stains, is still greater than 30 cm deeper than the cultural horizons in the south of the block. When looking to other soil staining in the block, there is a sharp contrast between darker sediments which likely infilled, and the lighter soil matrix. This sharp contrast is not seen in the large southern soil anomaly, suggesting that slower infill (possibly from a collapsed rodent burrow) is a more likely culprit. With that said, the remaining three soil stains are most likely cultural in nature.

Figure 12: Base of AML 9 in unit U75-13 with two dark soil anomalies interpreted as insect burrows (Muñiz 2010).

Figure 13: Staining from insect burrows in unit N80-13, in the Enclosure Trench (Muñiz 2010).

Two stains in unit U75-9 were observed during the 2008 season (Figure 14), while the remaining stain in unit U75-8 (Figure 15), was observed during the 2010 site excavations. All of these stains are mapped in all three backplot figures (7 through 9), and all four of these were pedestaled and bisected. All four stains have clear sharp boundaries, and their elevations correspond to Archaic Components 7a and 7b. While the specific application of these posts cannot be conclusively determined, possible interpretations of the function of these posts include reinforcement for temporary lodging (though there is no clear pattern to the features), or for processing of hides or other materials.

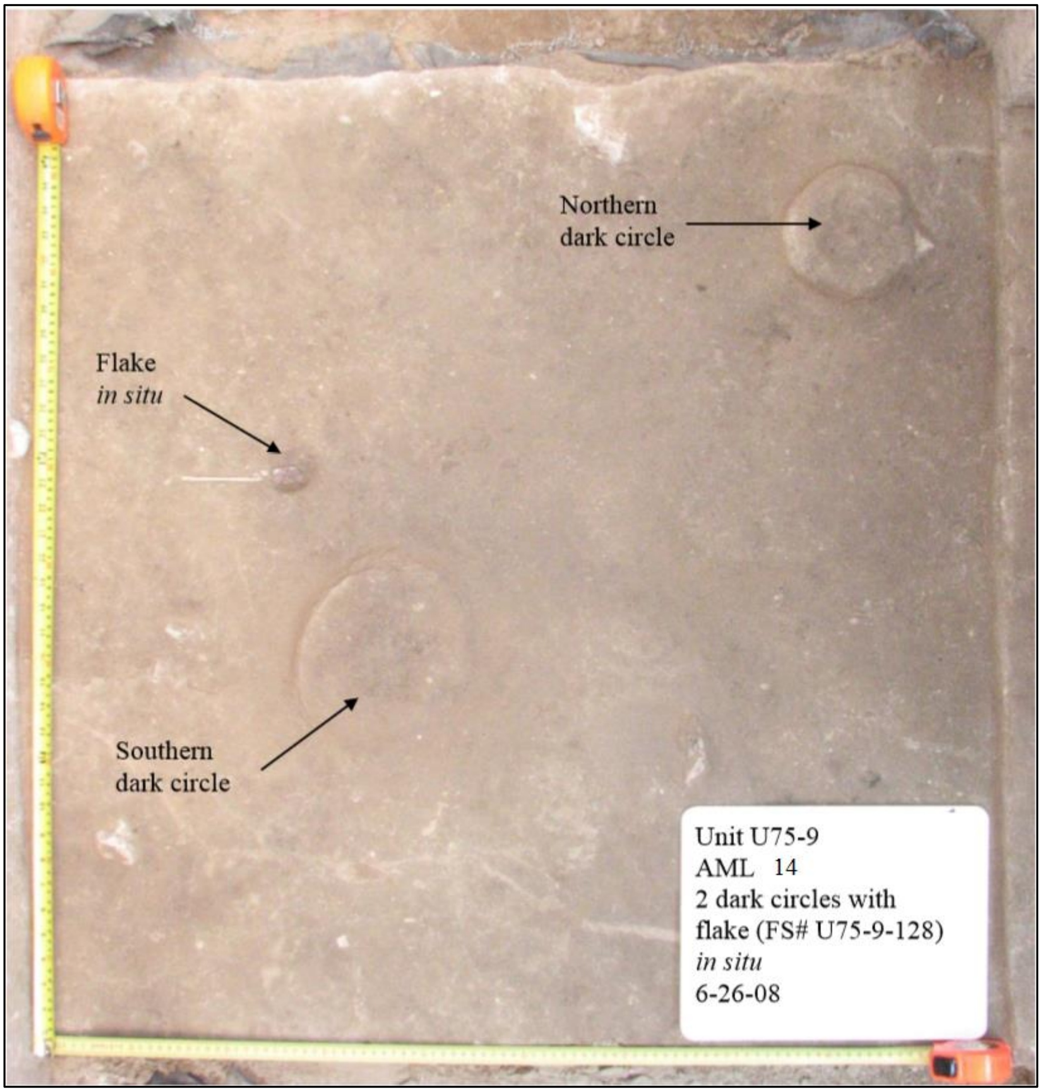

Figure 14: Two dark soil anomalies identified during the 2008 field season (Muñiz 2010).

Figure 15: Bisected soil anomaly in unit U75-8, level AML 13. Note strong outline (Muñiz 2010).

Turning to the implications surrounding inter-observer variability, there are a number of points to address which can shed light on issues of measurement error. For all measures of within-population difference (CV, %TEM) the same pattern emerges: the order of least difference to most difference is consistently Maximum Length, Thickness, Maximum Width, Oriented Length, and Oriented Width. The reasoning behind this is somewhat intuitive, given that maximum length is a simpler measure to take than the rest. It requires little to no technical knowledge of flake production to measure the longest distance between two points on a given artifact. In the cases of both maximum and oriented width, the variance is higher than the variance of their respective lengths. This too, is somewhat intuitive, as measurements of width are taken with respect to length; thus, if oriented length is in error, then width will likely be as well. Of all five metric attributes recorded by the five observers, thickness of the artifacts has the smallest variance. This is likely explained by a much smaller range of measurements compared to the other four metrics. By contrast, oriented length and width requires a greater degree of experience with debitage to record, so it would stand to reason that a non-specialist would have a more difficult task ahead of them. Furthermore, as both measures of width are taken with respect to length, it follows that the variance is higher in these cases. However, the degree of error is somewhat alarming; on average, measures of maximum width are off from the mean by 12.6 percent, and measures of oriented width are an even greater 15.6 percent. While it is true that such large margins of error should be avoided for their own sake, the need for greater rigor in methodology is best exemplified when looking to analyses of large populations or samples therein. In the case of oriented dimensions above, if a potential null hypothesis were something such as “are differences in flake size representative of different occupation groups?” margins of error this high could easily return type I error, where batch analyses may be interpreted to be significant when this is not the case. Equally as bad would be if such error resulted in a scenario where significantly different populations or samples were not determined to be such, due to the types of errors presented here.

Furthermore, these errors approach a best-case scenario from a methodological standpoint; while observer measures were taken with incredibly accurate equipment, companies and institutions whose funding can only allow for lower quality instruments will see greater errors than these. If it is the case that observer measurements can be off by nearly 1/6th of the desired outcome, an increased rigor in data collection is clearly necessary to reduce the likelihood of such egregious errors. This is particularly true when considering that large scale data collection is often ‘student work’; menial tasks of a given magnitude are often delegated to those with less experience in an attempt to hone their skills. While this is obviously a good way to accomplish two tasks at once, it presents a clear dilemma if the data collected is suspect. It is shown above that as the degree of subjectivity in measurements increases, the potential for inter-observer errors increases as well. The best way to offset this potential error is to reduce the subjectivity. By providing clear direction and oversight, these errors may be lessened, and if they are not, the issues which follow will quickly compound on themselves.

Chapter VII: Conclusions

Given the relatively small number of Early Archaic sites in the Northwest Plains, the importance of thorough research into the sites that are known is paramount. Additionally, while Archaic Components have been previously noted at Hudson-Meng (Agenbroad 1978, Muñiz 2010), there has yet to be a significant undertaking on this assemblage. With this work, a clearer picture of the Early Archaic occupation of Hudson-Meng presents itself through geoarchaeological and lithic foci. Additionally, with the help of colleagues at St. Cloud State University, statistically valuable data has been generated with respect to measurement variation in a lab setting. By knowing the cause and extent of these errors, their mitigation is more possible.

In summary, there are likely three occupations represented in the PCRG Southeast Block, one small representation (Cultural Component 9) in stratum 1Ab of the block, with two horizons in the lower levels which correspond with the 5Ab/5Btkb (Cultural Component 7b) and 6Ab (Cultural Component 7a) strata. Both of these strata have features directly associated with them, and roughly correspond with radiocarbon dates of 6930 ± 55 BP and 7617 ± 35 BP respectively. A possible interpretation of site activity could be the acquisition of plant resources, but this cannot be conclusively demonstrated without further analysis of the debitage. The somewhat sparse lithic record supports an ephemeral occupation, with local materials being quarried nearby, while further shaping and expedient flake production for potential resource procurement took place on site. Additionally, it has been shown that measurement of such debitage carries a risk of great statistical error between and among observers, and that removing subjectivity from measurement is likely an effective means to combat risk of such errors.

There are several directions in which this direction can be continued. First and foremost, similar research as above could be applied to other archaeological sites in the Plains with similarly aged Components. While there has been a general overview regarding the geoarchaeology of the PCRG Southeast Block, much more intensive analysis remains to be conducted, such as geochemical analyses and more intense study of the strata themselves. Lithic materials could also be further studied in areas such as potential use-wear or residue analysis. Lastly, while there are ways in which measurement error between observers can be mitigated, this study deals exclusively with chipped stone debitage. Lyman and VanPool (2009) address the potential for inter-observer error when dealing with ram skulls and bifaces; while their study uses more measurements and artifact classes, they do not address debitage. Repeating this study with a different lithic assemblage, or expanding into attributes not discussed here (such as platform angle or facet count) would add further data to support lab analysis.

Following the publication of Dr. Agenbroad's volume on Hudson-Meng in 1978, Dr. Dennis Stanford (1981) submitted a review of the book to *Plains Anthropologist.* After summarizing the volume, Dr. Stanford provides a brief account of the strengths and weaknesses of the work. His review concludes as follows: "…The data is presented so that the student of Paleo-Indian archaeology can assess and use it for comparative research for decades to come" (Stanford 1981:140-141). This statement has certainly shown itself to be true, though the temporal focus may be different in this instance. Over forty years after Dr. Agenbroad's original publication, Hudson-Meng continues to be a proving ground for many archaeologists, and it has continued to spark discourse and dialogue on the primary function of the site over time. It is hoped that further research undertaken at Hudson-Meng will look to the multiple occupations of the site, and that it may continue to shape our understandings of past lifeways for another 40 years and onward.

References Cited

Agenbroad, Larry D.
1978 *The Hudson-Meng Site: An Alberta Bison Kill in the Nebraska High Plains*. The Caxton Printers, Caldwell, Idaho.

Albanese, John
2000 Resume of Geoarchaeological Research on the Northwestern Plains. In *Geoarchaeology in the Great Plains,* edited by Rolfe Mandel, pp. 199-249. University of Oklahoma Press, Norman.

Alley, Richard B. and Anna Maria Agustsdottir
2005 The 8k event: Causes and consequences of a major Holocene abrupt climate change. *Quaternary Science Reviews.* 24:1123-1149.

Anderson, Elaine
1968 Fauna of the Little Box Elder Cave, Converse County, Wyoming. The Carnivora. *University of Colorado Studies, Series in Earth Sciences*. 6:1-59.

Andrefsky, William
2005 *Lithics: Macroscopic Approaches to Analysis*. 2nd ed. Cambridge University Press, New York.

Antevs, Ernst
1953 Geochronology of the Deglacial and Neothermal Ages. *The Journal of Geology*. 61(3): 195-230.

Bamforth, Douglas
1997 Adaptive Change on the Great Plains at the Paleoindian/Archaic Transition. In *Changing Perspectives of the Archaic on the Northwest Plains and Rocky Mountains,* edited by Mary Lou Larson and Julie E. Francis, pp. 14-56. University of South Dakota Press, Vermillion, South Dakota.

Benedict, J. B.,
1978 Getting away from it all; A study of man, mountains, and the two-drought Altithermal. *Southwestern Lore*. 451-12.

Bettis III, E. Arthur, and Edwin R. Hajic
1995 Landscape development and the location of evidence of Archaic cultures in the Upper Midwest. In *Archaeological Geology of the Archaic Period in North America*, edited by E. Arthur Bettis III, pp. 87-113. Geological Society of America, Boulder.

Clark, Frances
1984 Knife River Flint and Interregional Exchange. *Midcontinental Journal of Archaeology*. 9(2):173-198.

Clark, J. S., E. C. Grimm, J. J. Donovan, S. C. Fritz, D. R. Engstrom, J. E. Almendinger
2002 Drought Cycles and Landscape Responses to Past Aridity on Prairies of the Northern Great Plains, USA. *Ecology*. 83(3):595-601.

Clayton, Lee, W. B. Bickley, and W. J. Stone
1970 Knife River Flint. *Plains Anthropologist.* 15(50):282-290.

Cunnar, Christiane M.
1997 The Hawken Site: Taphonomy of the Long Bone Assemblage from an Early Plains Archaic Kill in Northeastern Wyoming. Master's Thesis, Department of Anthropology, University of Wyoming, Laramie.

Dean, Walter E., Richard M. Forester, J. Platt Bradbury
2002 Early Holocene change in atmospheric circulation in the Northern Great Plains; an upstream view of the 8.2ka cold event. *Quaternary Science Reviews*. 21:1736-1775.

Douglas, Allison K.
2015 The Cutting Edge of Subsistence Diversification: Use-Wear Analysis of a Specialized Lithic Plant Processing Technology at a Middle Archaic Central Plains Site. Master's Thesis, Department of Anthropology, The University of Kansas, Lawrence.

Fenneman, Nevin M.
1931 *Physiography of the Western United States*. 1st ed. McGraw Hill, London.

Forbis, Richard G., William Duncan Strong, and Maurice E. Kirkby
1965 Signal Butte and MacHaffie: Two stratified Sites on the Northern Great Plains. Manuscript on file, Department of Anthropology, University of Wyoming, Laramie.

Fosha, Michael
2001 The Licking Bison Site (39HN570) an Early Archaic Bison Kill in South Dakota. *Newsletter of the South Dakota Archaeological Society.* 31(3,4):1-6.

Frison, George
1965 Spring Creek Cave, Wyoming. *American Antiquity*. 31(1):81-94.
1968 Site 48SH312: An Early Middle Period bison kill in the Powder River Basin of Wyoming. *Plains Anthropologist* 13(39):31-39.
1971 The buffalo pound in Northwestern Plains prehistory: Site 48CA302, Wyoming. *American Antiquity* 36(1):77-91.

1973 *The Wardell Buffalo Trap 48SU301: Communal Procurement in the Upper Green River Basin, Wyoming.* Anthropological Papers of the Museum of Anthropology No. 48. University of Michigan, Ann Arbor.

1988 Paleoindian subsistence and settlement during post-Clovis times on the Northwestern Plains, the adjacent mountain ranges, and intermontane basins. In *Indians Before Columbus: Ice-Age Origins,* edited by Ronald C. Carlisle, pp. 83-106. Department of Anthropology, University of Pittsburgh, Pittsburgh.

1991 *Prehistoric Hunters of the High Plains*. 2nd edition Academic Press, San Diego, California.

1998 The Northwestern and Northern Plains Archaic. In *Archaeology on The Great Plains*, edited by W. Raymond Wood, pp. 140-172 University Press of Kansas, Lawrence, Kansas.

Frison, George, and Lawrence C. Todd

1986 *The Colby Mammoth Site: Taphonomy and Archaelogy of a Clovis Kill in Northern Wyoming.* University of New Mexico Press, Albuquerque, New Mexico.

Frison, George, and Danny N. Walker (editors)

2007 *Medicine Lodge Creek Site.* Clovis Press, Avondale, Colorado.

Frison, George, Michael Wilson, and Diane J. Wilson

1976 Fossil Bison and Artifacts from an Early Altithermal Arroyo Trap in Wyoming. *American Antiquity*. 41(1):28-57.

Frison, George, David Schwab, L. Adrien Hannus, Peter inham, David Walter, and Robert C. Mainfort

1996 Archaeology of the Northwestern Plains. In *Archaeological and Bioarchaeological Resources of the Northern Plains*, edited by George Frison and Robert Mainfort, pp. 8-41. Arkansas Archaeological Society, Fayetteville, Arkansas.

Garhart, Zach, Mary Lou Larson, and Marcel Kornfeld

2017 Early Plains Archaic: A Micro Look at Laddie Creek. Paper presented at the 75th annual Plains Anthropology Conference, Bismarck, North Dakota.

Grimm, Eric C., Joseph J. Donovan, and Kendrick J. Brown

2011 A high resolution record of climate variability and landscape response from Kettle Lake, Northern Great Plains, North America. *Quaternary Science Reviews*. 30:2626-2650.

Hall, Matthew G.

2005 A Knife River Flint Clovis Point from St. Charles, Missouri. *Central States Archaeological Journal*. 52(2):114.

Hannus, L. Adrian

1990 Mammoth hunting in the New World. In *Hunters of the Recent Past,* edited by L. B. Davis and B. O. K. Reeves, pp. 47-67. Unwin-Hyman, London.

Hofman, Jack and J. G. Enloe

1991 *Piecing Together the Past: Applications of Refitting Studies in Archaeology.* British Archaeological Reports, International Series 578, Oxford.

Holen, Steven

2006 Taphonomy of two last glacial maximum mammoth sites in the central Great Plains of North America: A preliminary report on La Sena and Lovewell. *Quaternary International.* 142-143:30-43.

Holmer, Richard N.

1978 *A Mathematical Typology for Archaic Projectile Points of the Eastern Great Basin.* Ph.D. dissertation. University of Utah. University Microfilms, Ann Arbor.

1986 Projectile Points of the Intermountain West. In *Anthropology of the Desert West, Essays in Honor of Jesse D. Jennings*, Edited by Carol J. Condie and Don D. Fowler, pp. 89-116. University of Utah Press, Salt Lake City, Utah.

Huckell, Bruce

1978 Hudson Meng Chipped Stone. In *The Hudson-Meng Site: An Alberta Bison Kill in the Nebraska High Plains*. The Caxton Printers, Caldwell, Idaho.

Husted, Wilfred M., and Robert Edgar

2002 *The Archaeology of Mummy Cave, Wyoming.* United States Department of the Interior National Park Service, Midwest Archaeological Center, Lincoln, Nebraska.

Irwin-Williams, Cynthia, Henry T. Irwin, George Agogino, and C. Vance Haynes.

1973 Hell Gap: Paleo-Indian occupation on the High Plains. *Plains Anthropologist* 18(59): 40-53.

Kay, Marvin

1998a The Great Plains Setting. In *Archaeology on The Great Plains*, edited by W. Raymond Wood, pp. 140-172 University Press of Kansas, Lawrence, Kansas.

1998b The Central and Southern Plains Archaic. In *Archaeology on The Great Plains*, edited by W. Raymond Wood, pp. 140-172 University Press of Kansas, Lawrence, Kansas.

Kelly, Eugene F. and Ellen Wohl

1994 Integration of Palynological, Pedological, and Geomorphological analyses: Paleoenvironmental significance at the Hudson-Meng Site, Sioux County Nebraska. In *Hudson-Meng Bison Bonebed and Oglala National Grasslands 1993 Archaeological Research Design and Field Work Summary.*

Knell, Edward J. and Mark P. Muñiz
2013 *Paleoindian Lifeways of the Cody Complex*. University of Utah Press, Salt Lake City, Utah.

Kornfeld, Marcel
1999 Clovis in the Rockies: How High Do They Get. Paper presented at Clovis and Beyond, Santa Fe, New Mexico.

Kornfeld, Marcel, Mary Lou Larson, and George Frison
2010 *Prehistoric Hunter-Gatherers on the High Plains and Rockies*, 3rd edition, Left Coast Press, Walnut Creek, California.

Larson, Mary Lou and Marcel Kornfeld
1997 Chipped Stone Nodules: Theory, Method, and Examples *Lithic Technology* 22(1): 4-18.

Lewis, Rhoda O.
1978 Use of Opal Phytoliths on Paleo-Environmental Reconstruction at the Hudson-Meng Site. In *The Hudson-Meng Site: An Alberta Bison Kill in the Nebraska High Plains*. The Caxton Printers, Caldwell, Idaho.

Lyman, R. Lee and Todd VanPool
2009 Metric Data in Archaeology: A study of Intra-Analyst and Inter-Analyst Variation. *American Antiquity* 74(3):485-504.

Mandel, Rolfe D.
1995 Geomorphic controls of the archaic record in the Central Plains of the United States. In *Archaeological Geology of the Archaic Period in North America*, edited by E. Arthur Bettis, III. Geological Society of America Special Paper 297. Geological Society of 2007America, Boulder, Colorado.

McKibben, Anne, Kevin D. Black, Ronald J. Rood, Margaret A. Van Ness, and Michael D. Metcalf
1988 *Archaeological Excavations at 48CA1391, Campbell County, Wyoming.* Prepared by Metcalf Archaeological Consultants, Inc., for Cordero Mining Company and John Albanese. Report on file at the Wyoming SHPO Cultural Records Office, Laramie.

Miller, James C.
1994 Geology of the Hudson-Meng Site (25SX115) Sioux County, Nebraska. In *Hudson-Meng Bison Bonebed and Oglala National Grasslands 1993 Archaeological Research Design and Field Work Summary.*

Mulloy, William
1954 The McKean Site in North-eastern Wyoming. *Southwestern Journal of Anthropology*. 10:432-460.
1958 *A Preliminary Historical Outline for the Northwestern Plains*. University of Wyoming Publications 22(1): 1-235.

Muñiz, Mark P.
2010 Results of 2008 Archaeological investigations at the Hudson-Meng site (25SX115), Sioux County, Nebraska. Submitted to Heritage Resources Program, Nebraska National Forest.
2013 New Observations on the Geochronology and Depositional History of the Hudson-Meng Site. Presented at the 71st annual Plains Anthropology Conference, Loveland, CO.

Muñiz, Mark P., Justin Olsen, Diana Barg, Mikhail S. Blinnikov
2018 Geoarchaeology of the Hudson-Meng site (25SX115), Sioux County Nebraska, USA, An interdisciplinary study of chronology, paleoenvironments, and site formation processes at an early Holocene bison kill site. Manuscript on file, St. Cloud State University, St. Cloud, Minnesota.

Niven, Laura, and Matthew Glenn Hill
1998 Season of Bison Mortality at Three Plains Archaic Kill Sites in Wyoming. *Plains Anthropologist*. 43(163):5-26.

Odell, George
2004 *Lithic Analysis*. Plenum Publishers, New York, New York.

Reeves, Brian
1973 The Concept of an Altithermal Cultural Hiatus in Northern Plains Prehistory. *American Anthropologist* 75(5):1221-1253.

Reher, Charles A.
1985 Patterns of Lithic Source Utilization at the McKean Site (48CK7). In *McKean/Middle Plains Archaic: Current Research*. Edited by Marcel Kornfeld and Lawrence C. Todd, pp. 95-104. Wyoming Recreation Commission, Laramie, Wyoming.

Root, Matthew J.
1997 Production for Exchange at the Knife River Flint Quarries, North Dakota. *Lithic Technology* 22(1):33-50.

Schmits, Larry J.
1978 The Coffey Site: Environment and Cultural Adaptation at a Prairie Plains Archaic Site. *Midcontinental Journal of Archaeology*. 3(1): pp. 69-185.

Shelton, Jeff
2016 Stone Flakes and Laser Guns: Preliminary Morphometric Analysis of Early Archaic Lithics at the Hudson-Meng Site (25SX115). Paper presented at the 74th annual Anthropology Conference, Lincoln, NE.

Sicotte, Maryline, Marielle Ledoux, Maria-Victoria Zunzunegui, Soulemayne Ag Aboubacrine, Vinh-Kim Nguyen
2010 Reliability of anthropometric measures in a longitudinal cohort of patients initiating ART in West Africa. *BMS Medical Research Methodology* 10(102).

Stanford, Dennis
1981 Reviewed Work: The Hudson-Meng Site: An Alberta Bison Kill in the Nebraska High Plains. *Plains Anthropologist.* 26(94):339-341.

Syms, L.
1969 The McKean Complex as a horizon marker in Manitoba and the northern Great Plains. Master's Thesis, Winnipeg, University of Manitoba.

Todd, L. C., and Rapson, D. J.
1999 Formational Analysis of Bison Bonebeds and Interpretation of Paleoindian Subsistence. In *Le Bison: Gibier et Moyen de Subsistence des Hommes du Paléolithique aux Paléoindiens des Grandes Plaines*, edited by J. Brugal, F. David, F., J. G. Enloe, and J. Jaubert, pp. 479-499. Éditions APDCA, Antibes, France.

Waters, Michael
1992 Principles of Geoarchaeology: A North American Perspective. University of Arizona Press, Tucson, Arizona.

Wedel, Waldo R.
1953 Some Aspects of Human Ecology in the Central Plains. Paper presented at the for American Archaeology and Central States Anthropological Society, Urbana, Illinois, May 8, 1953.

Wettlaufer, Boyd
1955 *The Mortlach Site in the Besant Valley of Central Saskatchewan.* Saskatchewan Department of Natural Resources, Anthropological Series No. 1. Regina.

Widga, Christopher C.
2004 Early Archaic Subsistence in the Central Plains: The Spring Creek (25FT31) Fauna. *Plains Anthropologist.* 49(189):25-58.

Witty, Thomas A. Jr.
1982 The Slough Creek, Two Dog, and William Young Sites, Council Grove Lake, Kansas *Kansas State Historical Society, Topeka, Anthropological Series* (10).

Wright, H. E. Jr.
1970 Vegetational History of the Great Plains. In *Pleistocene and Recent Environments of the Central Great Plains,* edited by W. Dort, Jr., and J.K. Jones, Jr., pp. 157-172

Wu, S. K. and Charles Jones
1978 Molluscs from the Hudson-Meng Site. In *The Hudson-Meng Kill Site: An Alberta Bison Kill in the Nebraska High Plains,* edited by Larry D. Agenbroad, pp. 193-210, The Caxton Printers, Caldwell, Idaho

Young, Lawrence W. and Ronald R. Weedon
1978 Vegetation and Flora of the Hudson-Meng Bison Kill. In *The Hudson-Meng Kill Site: An Alberta Bison Kill in the Nebraska High Plains,* edited by Larry D. Agenbroad, pp. 217-225, The Caxton Printers, Caldwell, Idaho

Appendix A: Lithic Catalog

A-1: My own recording of metric data of Hudson-Meng debitage

FS #	Max Length (mm)	Oriented Length (mm)	Max Width (mm)	Oriented Width (mm)	Thickness (mm)
U75-12-22	8.58	6.88	6.15	6.41	2.15
U75-12-24	29.69	13.66	14.11	29.68	4.63
U75-12-27	27.13	16.77	17.22	24.21	3.99
U75-12-35	31.71	21.86	23.87	29.59	9.74
U75-12-37	8.43	7.86	7.98	8.40	1.94
U75-12-39	21.99	20.23	16.66	16.23	4.31
U75-12-44	14.07	14.07	13.75	13.75	2.06
U75-12-45	29.66	29.56	16.24	16.46	3.15
U75-12-47	17.83	15.58	15.14	17.68	3.76
U75-12-48	35.53	35.53	7.38	7.38	2.77
U75-12-50	15.43	9.30	12.08	14.27	4.82
U75-12-51	8.91	8.91	6.57	6.57	1.66
U75-12-52	39.31	39.31	21.17	21.17	8.59
U75-12-60	26.86	26.28	18.20	20.02	6.65
U75-12-61	29.47	17.77	17.77	29.47	8.88
U75-13-22	12.87	10.41	10.15	12.87	2.61
U75-13-25	12.47	12.47	10.66	10.66	3.48
U75-13-30	17.01	17.01	15.30	15.30	4.59
U75-13-32	21.62	13.86	12.86	18.54	4.03
U75-13-38	9.45	5.32	5.56	9.45	2.45
U75-13-39	14.05	13.71	11.87	11.87	3.00
U75-13-42-1	16.72	14.92	12.04	11.98	3.65
U75-13-42-2	14.47	14.47	7.10	7.10	2.79
U75-13-42-3	6.01	6.01	5.36	5.36	0.88
U75-13-43	17.10	16.11	11.60	10.22	2.62
U75-13-44	11.27	11.27	7.48	7.48	2.17
U75-13-45-2	11.87	11.87	11.87	11.87	2.79
U75-13-45-3	8.73	8.73	4.53	4.53	1.12
U75-13-45-4	11.00	11.00	5.00	4.00	1.00
U75-13-46	16.20	16.20	9.60	9.60	1.60
U75-8-1	16.60	15.87	12.88	12.39	1.75
U75-8-2	22.68	15.66	13.94	20.16	7.68
U75-8-3	17.23	14.72	12.95	14.95	3.72
U75-9-104	28.25	22.94	22.47	27.45	2.90

U75-9-114	12.00	8.80	9.37	10.39	1.75
U75-9-117	13.29	8.40	7.88	13.07	2.19
U75-9-118	29.59	29.50	18.14	17.85	7.76
U75-9-119	18.65	11.97	12.06	18.52	2.69
U75-9-122	11.02	10.64	10.06	10.51	5.09
U75-9-123-2	14.55	12.00	11.82	11.24	1.84
U75-9-123-3	12.60	9.60	11.20	12.02	2.54
U75-9-123-4	14.10	6.56	6.94	14.08	3.47
U75-9-123-5	10.21	7.26	9.28	9.35	1.22
U75-9-126	14.68	6.71	6.72	14.62	3.53
U75-9-128	31.60	29.81	26.90	18.13	5.92
U75-9-129	14.97	10.23	10.16	15.07	2.38
U75-9-133	8.55	6.59	7.11	5.78	1.05
U75-9-134	13.49	8.95	8.99	13.43	2.28
U75-9-136	39.69	36.22	33.52	27.82	10.54
U75-9-137	18.09	10.19	10.51	15.58	3.65
U75-9-138	14.15	10.05	10.00	14.08	3.45
U75-9-139	16.58	12.56	11.68	14.32	2.33
U75-9-162	11.89	8.86	10.63	11.26	1.60
U75-9-166	13.51	12.04	12.59	10.22	1.85

A-2: further descriptive information of site debitage

FS #	%Cortex	Proximal (0=no 1=yes)	Medial (0=no 1=yes)	Distal (0=no 1=yes)	Complete (0=no 1=yes)
U75-12-22	0	0	0	0	0
U75-12-24	0	0	0	1	0
U75-12-27	50	0	0	1	0
U75-12-35	85	0	0	1	0
U75-12-37	0	0	1	0	0
U75-12-39	45	0	0	0	1
U75-12-44	0	0	0	0	0
U75-12-45	0	0	0	0	1
U75-12-47	0	1	0	0	0
U75-12-48	0	0	0	0	1
U75-12-50	0	0	0	1	0
U75-12-51	0	0	1	0	0
U75-12-52	0	0	0	0	0
U75-12-60	0	0	0	0	1
U75-12-61	0	0	0	1	0

U75-13-22	0	0	1	0	0
U75-13-25	20	0	0	0	0
U75-13-30	0	0	0	0	1
U75-13-32	0	0	1	0	0
U75-13-38	0	0	0	1	0
U75-13-39	0	0	0	1	0
U75-13-42-1	0	1	0	0	0
U75-13-42-2	0	0	0	0	0
U75-13-42-3	0	0	0	0	0
U75-13-43	0	0	0	0	1
U75-13-44	0	0	0	0	0
U75-13-45-2	0	0	1	0	0
U75-13-45-3	0	0	0	0	0
U75-13-45-4	0	0	1	0	0
U75-13-46	0	0	0	0	1
U75-8-1	0	0	1	0	0
U75-8-2	0	0	1	0	0
U75-8-3	20	0	0	0	1
U75-9-104	15	1	0	0	0
U75-9-114	10	0	0	1	0
U75-9-117	10	0	1	0	0
U75-9-118	25	0	0	0	1
U75-9-119	0	0	0	1	0
U75-9-122	30	0	0	1	0
U75-9-123-2	25	0	0	0	1
U75-9-123-3	0	0	0	1	0
U75-9-123-4	0	0	0	0	1
U75-9-123-5	0	0	1	0	0
U75-9-126	0	0	1	0	0
U75-9-128	0	0	0	0	1
U75-9-129	0	0	1	0	0
U75-9-133	0	0	0	0	0
U75-9-134	0	0	0	1	0
U75-9-136	75	1	0	0	0
U75-9-137	0	0	0	1	0
U75-9-138	5	0	0	1	0
U75-9-139	0	0	0	0	1
U75-9-162	0	0	0	0	1
U75-9-166	0	0	0	0	1

A-3: Further debitage descriptive information

FS #	Platform (0=Absent 1=Present)	Flat Platform? (0=no 1=yes)	Faceted platform? (0=no 1=yes)	No. of Dorsal Flake Scars	No. of facets
U75-12-22	0	0	0	2	0
U75-12-24	0	0	0	4	0
U75-12-27	0	0	0	2	0
U75-12-35	0	0	0	0	0
U75-12-37	0	0	0	2	0
U75-12-39	1	0	1	4	3
U75-12-44	0	0	0	7	0
U75-12-45	1	1	0	9	0
U75-12-47	1	0	1	4	3
U75-12-48	1	0	1	13	3
U75-12-50	0	0	0	3	0
U75-12-51	0	0	0	2	0
U75-12-52	0	0	0	7	0
U75-12-60	1	1	0	6	0
U75-12-61	0	0	0	3	0
U75-13-22	0	0	0	3	0
U75-13-25	0	0	0	3	0
U75-13-30	1	1	0	12	0
U75-13-32	0	0	0	2	0
U75-13-38	0	0	0	2	0
U75-13-39	0	0	0	8	0
U75-13-42-1	1	0	1	1	4
U75-13-42-2	0	0	0	3	0
U75-13-42-3	0	0	0	1	0
U75-13-43	1	1	0	4	0
U75-13-44	0	0	0	5	0
U75-13-45-2	0	0	0	3	0
U75-13-45-3	0	0	0	2	0
U75-13-45-4	0	0	0	1	0
U75-13-46	1	1	0	6	0
U75-8-1	0	0	0	5	0
U75-8-2	0	0	0	8	0
U75-8-3	1	1	0	7	0
U75-9-104	1	0	1	7	2
U75-9-114	0	0	0	2	0

U75-9-117	0	0	0	1	0
U75-9-118	1	0	1	4	4
U75-9-119	0	0	0	4	0
U75-9-122	0	0	0	3	0
U75-9-123-2	1	1	0	1	0
U75-9-123-3	0	0	0	2	0
U75-9-123-4	1	1	0	2	0
U75-9-123-5	0	0	0	3	0
U75-9-126	0	0	0	7	0
U75-9-128	1	1	0	3	0
U75-9-129	0	0	0	4	0
U75-9-133	0	0	0	2	0
U75-9-134	0	0	0	3	0
U75-9-136	1	0	1	2	3
U75-9-137	0	0	0	4	0
U75-9-138	0	0	0	9	0
U75-9-139	1	0	1	7	3
U75-9-162	1	1	0	2	0
U75-9-166	1	1	0	5	0

A-4: First experimental group

Ex1 FS #	Max Length (mm)	Oriented Length (mm)	Max Width (mm)	Oriented Width (mm)	Thickness (mm)
U75-12-22	8.66	8.66	5.02	5.02	2.17
U75-12-24	29.24	29.24	14.45	14.45	4.37
U75-12-27	26.43	26.43	17.16	17.16	4.24
U75-12-35	31.81	31.81	23.98	23.98	9.75
U75-12-37	8.40	8.40	8.08	8.08	1.95
U75-12-39	21.64	21.64	16.45	16.45	4.24
U75-12-44	12.56	12.56	12.09	12.09	2.06
U75-12-45	29.54	29.54	16.39	16.39	3.86
U75-12-47	17.78	17.78	16.25	16.25	3.77
U75-12-48	35.44	35.44	7.42	7.42	3.13
U75-12-50	14.21	14.21	9.29	9.29	3.90
U75-12-51	8.62	8.62	6.77	6.77	1.29
U75-12-52	38.78	38.78	19.15	19.15	8.70
U75-12-60	26.86	26.86	18.30	18.30	5.45
U75-12-61	29.45	29.45	17.09	17.09	8.27

U75-13-22	13.01	13.01	10.52	10.52	2.50
U75-13-25	11.61	11.61	11.37	11.37	3.29
U75-13-30	15.74	15.74	15.16	15.16	4.52
U75-13-32	21.59	21.59	12.84	12.84	4.02
U75-13-38	9.26	9.26	5.13	5.13	2.17
U75-13-39	13.63	9.92	9.92	13.63	2.97
U75-13-42-1	16.52	16.52	12.28	12.28	3.66
U75-13-42-2	14.14	14.14	7.14	7.14	2.42
U75-13-42-3	5.93	5.93	5.90	5.90	0.86
U75-13-43	16.57	16.57	9.25	9.25	2.55
U75-13-44	11.14	11.14	6.36	6.36	2.16
U75-13-45-2	11.78	11.78	11.56	11.56	2.77
U75-13-45-3	8.73	8.73	4.96	4.96	1.17
U75-13-45-4	7.00	7.00	5.00	5.00	1.00
U75-13-46	15.93	15.93	8.03	8.03	2.10
U75-8-1	16.53	16.53	12.38	12.38	1.76
U75-8-2	21.35	21.35	12.41	12.41	7.62
U75-8-3	16.94	16.94	12.42	12.42	3.40
U75-9-104	27.79	27.79	22.09	22.09	3.49
U75-9-114	10.25	10.25	8.84	8.84	1.67
U75-9-117	12.90	12.90	8.61	8.61	2.19
U75-9-118	29.52	29.52	18.07	18.07	6.92
U75-9-119	18.31	13.98	13.98	18.31	2.68
U75-9-122	10.61	10.61	10.42	10.41	4.48
U75-9-123-1	13.01	13.01	10.06	10.06	1.98
U75-9-123-2	11.89	11.89	9.73	9.73	2.73
U75-9-123-3	13.99	13.99	6.73	6.73	2.82
U75-9-123-4	9.15	9.15	7.27	7.27	1.25
U75-9-126	14.62	14.62	6.06	6.06	3.46
U75-9-128	29.75	29.75	18.01	18.01	5.78
U75-9-129	15.03	15.03	10.23	10.23	2.51
U75-9-133	6.61	6.61	5.93	5.93	1.04
U75-9-134	13.54	13.54	8.96	8.96	2.30
U75-9-136	36.30	36.30	27.79	27.79	9.96
U75-9-137	16.38	16.38	10.56	10.56	2.89
U75-9-138	14.14	11.95	11.95	14.14	3.43
U75-9-139	15.65	15.65	11.67	11.67	2.36
U75-9-162	10.94	10.94	9.34	9.34	1.79
U75-9-166	12.52	12.52	10.25	10.25	1.86

A-5: Second experimental group

Ex2 FS#	Max Length (mm)	Oriented Length (mm)	Max Width (mm)	Oriented Width (mm)	Thickness (mm)
U75-12-22	8.46	8.58	6.08	6.05	2.15
U75-12-24	29.53	29.65	14.12	14.40	4.53
U75-12-27	27.21	27.22	16.91	17.41	4.32
U75-12-35	31.87	31.67	23.88	23.93	9.59
U75-12-37	10.04	10.11	7.89	8.38	1.95
U75-12-39	21.48	21.83	16.29	16.20	4.29
U75-12-44	14.19	14.19	12.95	13.75	2.06
U75-12-45	29.63	29.66	16.12	16.19	3.79
U75-12-47	17.79	17.84	15.58	15.45	3.41
U75-12-48	35.47	35.58	7.70	7.18	3.50
U75-12-50	14.13	15.47	9.22	9.13	3.89
U75-12-51	8.56	8.82	6.79	6.64	1.34
U75-12-52	38.90	38.89	19.26	21.71	8.60
U75-12-60	26.99	26.97	17.94	17.62	5.68
U75-12-61	29.47	29.34	17.30	17.25	8.81
U75-13-22	12.58	13.48	10.32	10.07	2.58
U75-13-25	11.60	12.54	10.61	10.32	3.19
U75-13-30	17.02	16.86	15.37	16.62	4.51
U75-13-32	21.40	21.64	11.82	13.18	4.02
U75-13-38	9.40	9.45	5.27	5.33	1.92
U75-13-39	13.95	12.94	10.23	10.23	2.97
U75-13-42-1	16.19	16.69	11.27	12.25	3.54
U75-13-42-2	14.45	14.54	7.04	6.57	2.41
U75-13-42-3	5.98	6.53	5.09	5.11	0.75
U75-13-43	16.97	16.86	9.38	9.31	2.54
U75-13-44	11.23	11.23	6.36	6.62	2.15
U75-13-45-2	13.26	13.33	11.29	11.08	2.76
U75-13-45-3	8.43	8.22	4.96	5.01	1.09
U75-13-45-4	7.76	7.59	5.62	5.52	1.27
U75-13-46	16.13	16.18	8.05	7.93	2.09
U75-8-1	16.49	16.53	12.38	12.32	1.77
U75-8-2	22.60	22.59	12.42	12.17	7.66
U75-8-3	17.23	17.24	12.42	12.44	3.42
U75-9-104	27.48	28.29	21.29	22.85	3.54
U75-9-114	11.95	12.03	8.98	9.37	1.67

U75-9-117	13.28	13.58	7.90	8.04	2.18
U75-9-118	29.45	29.53	17.83	19.36	6.93
U75-9-119	18.51	18.65	12.03	12.29	2.76
U75-9-122	10.60	11.07	10.52	9.97	4.47
U75-9-123-1	14.47	14.63	11.84	12.11	1.95
U75-9-123-2	12.47	12.7	11.37	11.32	2.5
U75-9-123-3	14.13	14.13	6.83	6.71	2.82
U75-9-123-4	10.19	10.28	7.24	6.56	1.21
U75-9-126	14.61	14.73	6.62	6.67	3.48
U75-9-128	29.76	29.93	18.20	18.26	5.79
U75-9-129	14.91	15.02	10.19	10.15	2.36
U75-9-133	8.42	8.65	5.83	5.41	1.04
U75-9-134	13.51	13.50	9.58	9.04	2.29
U75-9-136	36.65	36.66	27.77	28.20	10.57
U75-9-137	17.86	18.02	10.26	9.97	2.28
U75-9-138	14.16	14.21	10.05	10.03	3.44
U75-9-139	16.16	16.56	11.55	11.91	2.39
U75-9-162	11.37	11.41	9.03	8.95	1.76
U75-9-166	13.31	13.63	10.22	10.26	1.95

A-6: Third experimental group

Ex3 FS#	Max Length (mm)	Oriented Length (mm)	Maximum Width (mm)	Oriented Width (mm)	Thickness (mm)
U75-12-22	8.20	6.35	6.70	6.17	2.70
U75-12-24	28.45	29.61	14.37	15.82	3.81
U75-12-27	25.77	22.35	16.47	18.13	3.85
U75-12-35	31.84	23.82	23.97	21.32	9.54
U75-12-37	10.01	8.30	9.99	7.71	1.83
U75-12-39	21.67	19.82	16.49	14.87	4.10
U75-12-44	14.06	10.48	13.62	12.05	2.00
U75-12-45	29.57	28.91	29.52	15.06	2.88
U75-12-47	17.52	16.70	15.32	14.73	3.00
U75-12-48	35.62	35.47	7.47	6.32	2.78
U75-12-50	14.02	11.86	9.78	8.99	3.33
U75-12-51	9.51	8.70	7.03	6.66	1.26
U75-12-52	38.61	38.66	16.28	12.94	8.45
U75-12-60	26.67	27.18	17.89	15.79	4.67
U75-12-61	29.34	24.70	17.25	15.00	7.27

U75-13-22	13.39	12.44	10.11	9.24	1.43
U75-13-25	12.39	11.10	11.20	10.14	3.15
U75-13-30	16.91	15.32	16.51	14.12	4.71
U75-13-32	21.48	18.67	12.42	13.72	3.90
U75-13-38	9.36	7.83	5.49	5.03	1.94
U75-13-39	13.85	12.98	10.28	6.60	2.93
U75-13-42-1	16.50	13.77	11.40	10.45	3.36
U75-13-42-2	14.41	11.17	6.43	5.18	2.00
U75-13-42-3	5.41	5.22	5.07	4.98	0.82
U75-13-43	17.02	13.54	9.16	7.89	2.15
U75-13-44	11.15	9.24	5.70	5.15	2.06
U75-13-45-2	13.21	11.43	11.20	8.02	2.71
U75-13-45-3	8.63	6.03	5.09	3.39	1.02
U75-13-45-4	7.00	6.00	6.00	4.00	1.00
U75-13-46	16.11	14.16	10.61	8.11	1.52
U75-8-1	15.57	12.92	12.08	10.98	1.52
U75-8-2	22.59	19.16	16.67	12.20	7.28
U75-8-3	16.93	14.89	12.30	10.34	3.14
U75-9-104	29.02	27.34	28.46	19.83	2.96
U75-9-114	11.97	10.47	9.29	8.71	1.63
U75-9-117	13.47	13.13	9.00	7.96	2.08
U75-9-118	29.43	27.81	19.29	17.55	6.28
U75-9-119	18.59	17.03	12.35	11.98	2.52
U75-9-122	11.51	9.80	10.16	9.96	4.36
U75-9-123-1	14.54	9.96	12.05	9.29	1.25
U75-9-123-2	12.37	11.18	11.24	9.74	2.46
U75-9-123-3	13.84	9.67	6.71	5.95	2.77
U75-9-123-4	10.11	8.67	9.46	6.47	1.16
U75-9-126	14.72	14.49	6.70	6.65	3.40
U75-9-128	30.93	28.92	27.34	17.88	5.76
U75-9-129	14.96	13.15	12.73	9.66	2.35
U75-9-133	8.47	6.83	6.94	5.33	0.96
U75-9-134	13.36	11.82	9.31	8.28	2.14
U75-9-136	39.63	36.35	33.21	26.55	8.53
U75-9-137	17.92	14.33	10.74	9.24	2.55
U75-9-138	13.98	13.16	9.99	9.14	3.45
U75-9-139	16.27	14.24	11.45	9.56	2.28
U75-9-162	11.77	11.02	10.56	8.89	1.74
U75-9-166	13.49	11.85	11.59	8.65	1.65

A-7: Fourth experimental group

Ex4 FS#	Max Length (mm)	Oriented Length (mm)	Max Width (mm)	Oriented Width (mm)	Thickness (mm)
U75-12-22	8.47	6.35	5.41	5.63	2.20
U75-12-24	29.20	15.30	15.71	13.16	4.71
U75-12-27	27.20	17.03	16.18	16.37	3.63
U75-12-35	31.32	21.50	23.70	17.38	9.17
U75-12-37	8.26	8.19	8.10	7.60	1.91
U75-12-39	21.00	20.10	16.05	15.74	4.05
U75-12-44	13.60	13.60	13.40	13.30	2.05
U75-12-45	29.09	28.50	16.90	15.80	2.60
U75-12-47	16.35	15.85	15.70	14.40	2.97
U75-12-48	34.45	34.45	7.15	7.15	2.74
U75-12-50	13.94	12.90	8.60	8.50	3.50
U75-12-51	7.82	7.68	6.80	6.80	1.21
U75-12-52	38.58	38.90	14.56	13.80	8.67
U75-12-60	26.30	24.40	16.64	14.78	4.41
U75-12-61	28.90	20.80	16.88	16.90	7.44
U75-13-032	12.70	12.60	10.20	9.10	1.24
U75-13-22	12.27	10.44	10.90	9.30	3.25
U75-13-25	17.00	15.30	14.10	14.10	4.95
U75-13-30	21.67	20.96	11.96	13.01	3.80
U75-13-38	9.31	8.06	4.83	4.45	2.11
U75-13-39	13.10	13.00	10.50	10.30	3.33
U75-13-42-1	16.40	14.57	10.50	11.60	3.21
U75-13-42-2	14.21	14.00	6.15	6.05	1.90
U75-13-42-3	6.00	5.90	5.20	5.00	0.80
U75-13-43	16.63	13.22	8.70	8.50	2.42
U75-13-44	10.17	9.71	4.93	4.87	2.05
U75-13-45-2	11.22	10.80	11.20	10.79	2.73
U75-13-45-3	7.20	6.53	4.31	4.20	0.90
U75-13-45-4	6.00	5.00	4.00	4.00	1.00
U75-13-46	14.90	14.80	8.25	7.80	1.34
U75-8-1	15.10	14.80	14.20	11.60	1.34
U75-8-2	18.64	16.75	11.90	11.40	6.56
U75-8-3	16.70	13.90	11.80	9.40	3.36
U75-9-104	27.57	26.14	22.10	18.69	2.50
U75-9-114	11.15	9.85	8.06	7.03	1.70

U75-9-117	13.25	9.27	8.07	6.67	1.92
U75-9-118	29.00	28.90	17.26	16.80	6.31
U75-9-119	17.50	16.60	12.05	10.82	2.62
U75-9-122	10.80	9.60	10.02	7.86	4.06
U75-9-123-1	11.44	11.20	11.00	9.20	1.55
U75-9-123-2	12.38	10.58	11.33	9.40	2.54
U75-9-123-3	6.60	6.50	13.90	13.70	2.66
U75-9-123-4	9.90	7.80	8.80	8.70	0.80
U75-9-126	14.30	13.80	5.46	3.57	3.33
U75-9-128	29.60	27.20	17.20	16.20	3.80
U75-9-129	14.30	12.90	9.57	8.90	2.19
U75-9-133	8.70	6.55	8.05	5.60	0.92
U75-9-134	13.29	11.31	8.81	8.48	2.24
U75-9-136	37.38	36.44	29.78	26.40	9.30
U75-9-137	18.00	11.20	9.71	9.43	2.92
U75-9-138	13.20	12.07	9.30	9.82	3.36
U75-9-139	14.12	13.00	12.00	12.80	2.01
U75-9-162	13.06	12.70	10.24	8.83	1.62
U75-9-166	11.20	11.10	9.70	8.96	2.01

A-8: Average measurement of all five observers

Average FS #	**Max Length (mm)**	**Oriented Length (mm)**	**Max Width (mm)**	**Oriented Width (mm)**	**Thickness (mm)**
U75-12-22	8.47	7.36	5.87	5.86	2.27
U75-12-24	29.22	23.49	14.55	17.50	4.41
U75-12-27	26.75	21.96	16.79	18.66	4.01
U75-12-35	31.71	26.13	23.88	23.24	9.56
U75-12-37	9.03	8.57	8.41	8.03	1.92
U75-12-39	21.56	20.72	16.39	15.90	4.20
U75-12-44	13.70	12.98	13.16	12.99	2.05
U75-12-45	29.50	29.23	19.03	15.98	3.26
U75-12-47	17.45	16.75	15.60	15.70	3.38
U75-12-48	35.30	35.29	7.42	7.09	2.98
U75-12-50	14.35	12.75	9.79	10.04	3.89
U75-12-51	8.68	8.55	6.79	6.69	1.35
U75-12-52	38.84	38.91	18.08	17.75	8.60
U75-12-60	26.74	26.34	17.79	17.30	5.37
U75-12-61	29.33	24.41	17.26	19.14	8.13

U75-13-22	12.91	12.39	10.26	10.36	2.07
U75-13-25	12.07	11.63	10.95	10.36	3.27
U75-13-30	16.74	16.05	15.29	15.06	4.66
U75-13-32	21.55	19.34	12.38	14.26	3.95
U75-13-38	9.36	7.98	5.26	5.88	2.12
U75-13-39	13.72	12.51	10.56	10.53	3.04
U75-13-42-1	16.47	15.29	11.50	11.71	3.48
U75-13-42-2	14.34	13.66	6.77	6.41	2.30
U75-13-42-3	5.87	5.92	5.32	5.27	0.82
U75-13-43	16.86	15.26	9.62	9.03	2.46
U75-13-44	10.99	10.52	6.17	6.10	2.12
U75-13-45-2	12.27	11.84	11.42	10.66	2.75
U75-13-45-3	8.34	7.65	4.77	4.42	1.06
U75-13-45-4	7.75	7.32	5.12	4.50	1.05
U75-13-46	15.85	15.45	8.91	8.29	1.73
U75-8-1	16.06	15.33	12.78	11.93	1.63
U75-8-2	21.57	19.10	13.47	13.67	7.36
U75-8-3	17.01	15.54	12.38	11.91	3.41
U75-9-104	28.02	26.50	23.28	22.18	3.08
U75-9-114	11.46	10.28	8.91	8.87	1.68
U75-9-117	13.24	11.46	8.29	8.87	2.11
U75-9-118	29.40	29.05	18.12	17.93	6.84
U75-9-119	18.31	15.65	12.49	14.38	2.65
U75-9-122	10.91	10.34	10.24	9.74	4.49
U75-9-123-1	13.60	12.16	11.35	10.38	1.71
U75-9-123-2	12.34	11.19	10.97	10.44	2.55
U75-9-123-3	12.53	10.17	8.22	9.43	2.91
U75-9-123-4	9.91	8.63	8.41	7.67	1.13
U75-9-126	14.59	12.87	6.31	7.51	3.44
U75-9-128	30.33	29.12	21.53	17.70	5.41
U75-9-129	14.83	13.27	10.58	10.80	2.36
U75-9-133	8.15	7.05	6.77	5.61	1.00
U75-9-134	13.44	11.82	9.13	9.64	2.25
U75-9-136	37.93	36.39	30.41	27.35	9.78
U75-9-137	17.65	14.02	10.36	10.96	2.86
U75-9-138	13.93	12.29	10.26	11.44	3.43
U75-9-139	15.76	14.40	11.67	12.05	2.27
U75-9-162	11.81	10.99	9.96	9.45	1.70
U75-9-166	12.81	12.23	10.87	9.67	1.86

A-9: Standard Deviations of all five observers

StDev FS #	Max Length (mm)	Oriented Length (mm)	Max Width (mm)	Oriented Width (mm)	Thickness (mm)
U75-12-22	0.174011	1.16714609	0.660583	0.54615	0.239018828
U75-12-24	0.477148	8.2487496	0.664545	6.872461	0.358608422
U75-12-27	0.636647	4.97598232	0.450189	3.167804	0.282542032
U75-12-35	0.226164	5.1951872	0.112472	4.454554	0.2355207
U75-12-37	0.912453	0.88344213	0.888352	0.370513	0.0507937
U75-12-39	0.361704	0.93713926	0.230261	0.630056	0.116490343
U75-12-44	0.673817	1.53809948	0.67199	0.858033	0.02607681
U75-12-45	0.232959	0.50624105	5.869385	0.574761	0.555184654
U75-12-47	0.62923	1.05242577	0.425112	1.314941	0.390474071
U75-12-48	0.481217	0.47489999	0.197053	0.446542	0.329590655
U75-12-50	0.614679	2.35834052	1.344909	2.385242	0.57677552
U75-12-51	0.612234	0.4966689	0.163156	0.095237	0.178521707
U75-12-52	0.295178	0.24488773	2.632286	4.125425	0.09679876
U75-12-60	0.269128	1.13358723	0.667668	2.069498	0.887761229
U75-12-61	0.244193	5.16991973	0.329803	5.84467	0.751684774
U75-13-22	0.314245	1.176805	0.165378	1.520839	0.677325623
U75-13-25	0.428158	0.89876026	0.332069	0.755592	0.128140548
U75-13-30	0.558507	0.83203365	0.855552	1.037593	0.182701943
U75-13-32	0.109864	3.2960628	0.483115	2.416365	0.101390335
U75-13-38	0.074364	1.65103907	0.293564	2.023443	0.214406157
U75-13-39	0.377862	1.48273396	0.761019	2.597755	0.164012195
U75-13-42-1	0.19308	1.26871195	0.700514	0.756485	0.19501282
U75-13-42-2	0.150599	1.41213668	0.452405	0.818089	0.359346629
U75-13-42-3	0.256768	0.46655118	0.34195	0.383275	0.051185936
U75-13-43	0.240977	1.74058898	1.137198	0.883646	0.185553227
U75-13-44	0.462731	0.96766213	0.941637	1.079088	0.058051701
U75-13-45-2	0.917371	0.93197103	0.289707	1.535979	0.031937439
U75-13-45-3	0.651137	1.27832703	0.333092	0.663528	0.104642248
U75-13-45-4	1.920292	2.28267825	0.759526	0.714199	0.120747671
U75-13-46	0.542522	0.9236233	1.152788	0.739209	0.346265794
U75-8-1	0.68174	1.5215617	0.842069	0.627997	0.191755052
U75-8-2	1.729644	2.94118514	1.946271	3.649366	0.476025209
U75-8-3	0.225898	1.46922429	0.409536	2.153346	0.207171427
U75-9-104	0.632432	2.14342016	2.926477	3.388675	0.43671501
U75-9-114	0.766799	1.16991453	0.521603	1.221933	0.044497191

U75-9-117	0.207774	2.42469173	0.493731	2.452784	0.116918775
U75-9-118	0.231236	0.74395564	0.740858	0.934361	0.603199801
U75-9-119	0.47172	2.65226884	0.841089	3.721093	0.08988882
U75-9-122	0.377584	0.61945944	0.222441	1.081374	0.374926659
U75-9-123-1	1.374471	1.77557033	0.827273	1.266432	0.310048383
U75-9-123-2	0.269017	1.19063009	0.698735	1.156123	0.103826779
U75-9-123-3	3.318037	3.77574496	3.175417	4.082099	0.320889389
U75-9-123-4	0.443306	1.1790123	1.081665	1.295704	0.186198818
U75-9-126	0.166072	3.46254964	0.548015	4.172029	0.077136243
U75-9-128	0.889815	1.14624168	5.119111	0.848074	0.902219485
U75-9-129	0.301546	1.97185953	1.234253	2.443864	0.113885908
U75-9-133	0.867381	0.90326076	0.918161	0.2499	0.058480766
U75-9-134	0.107564	1.88929352	0.310564	2.143693	0.065574385
U75-9-136	1.626761	0.16876018	2.817043	0.818456	0.869913789
U75-9-137	0.715192	3.32742092	0.399787	2.635513	0.515043687
U75-9-138	0.412529	1.55119954	0.995274	2.457747	0.037815341
U75-9-139	0.973925	1.70288579	0.207244	1.737777	0.153068612
U75-9-162	0.79387	1.38209262	0.730856	1.029092	0.086139422
U75-9-166	0.984698	0.9356121	1.18876	0.795531	0.136674797

A-10: Variance of all five observers

Vari FS #	Max Length	Oriented Length	Max Width	Oriented Width	Thickness
U75-12-22	0.03028	1.36223	0.43637	0.29828	0.05713
U75-12-24	0.22767	68.04187	0.44162	47.23072	0.1286
U75-12-27	0.40532	24.7604	0.20267	10.03498	0.07983
U75-12-35	0.05115	26.98997	0.01265	19.84305	0.05547
U75-12-37	0.83257	0.78047	0.78917	0.13728	0.00258
U75-12-39	0.13083	0.87823	0.05302	0.39697	0.01357
U75-12-44	0.45403	2.36575	0.45157	0.73622	0.00068
U75-12-45	0.05427	0.25628	34.44968	0.33035	0.30823
U75-12-47	0.39593	1.1076	0.18072	1.72907	0.15247
U75-12-48	0.23157	0.22553	0.03883	0.1994	0.10863
U75-12-50	0.37783	5.56177	1.80878	5.68938	0.33267
U75-12-51	0.37483	0.24668	0.02662	0.00907	0.03187
U75-12-52	0.08713	0.05997	6.92893	17.01913	0.00937
U75-12-60	0.07243	1.28502	0.44578	4.28282	0.78812

U75-12-61	0.05963	26.72807	0.10877	34.16017	0.56503
U75-13-22	0.09875	1.38487	0.02735	2.31295	0.45877
U75-13-25	0.183319	0.80777	0.11027	0.57092	0.01642
U75-13-30	0.31193	0.69228	0.73197	1.0766	0.03338
U75-13-32	0.01207	10.86403	0.2334	5.83882	0.01028
U75-13-38	0.00553	2.72593	0.08618	4.09432	0.04597
U75-13-39	0.14278	2.1985	0.57915	6.74833	0.0269
U75-13-42-1	0.03728	1.60963	0.49072	0.57227	0.03803
U75-13-42-2	0.02268	1.99413	0.20467	0.66927	0.12913
U75-13-42-3	0.06593	0.21767	0.11693	0.1469	0.00262
U75-13-43	0.05807	3.02965	1.29322	0.78083	0.03443
U75-13-44	0.21412	0.93637	0.88668	1.16443	0.00337
U75-13-45-2	0.84157	0.86857	0.08393	2.35923	0.00102
U75-13-45-3	0.42398	1.63412	0.11095	0.44027	0.01095
U75-13-45-4	3.68752	5.21062	0.57688	0.51008	0.01458
U75-13-46	0.29433	0.85308	1.32892	0.54643	0.1199
U75-8-1	0.46477	2.31515	0.70908	0.39438	0.03677
U75-8-2	2.99167	8.65057	3.78797	13.31787	0.2266
U75-8-3	0.05103	2.15862	0.16772	4.6369	0.04292
U75-9-104	0.39997	4.59425	8.56427	11.48312	0.19072
U75-9-114	0.58798	1.3687	0.27207	1.49312	0.00198
U75-9-117	0.04317	5.87913	0.24377	6.01615	0.01367
U75-9-118	0.05347	0.55347	0.54887	0.87303	0.36385
U75-9-119	0.22252	7.03453	0.70743	13.84653	0.00808
U75-9-122	0.14257	0.38373	0.04948	1.16937	0.14057
U75-9-123-1	1.88917	3.15265	0.68438	1.60385	0.09613
U75-9-123-2	0.07237	1.4176	0.48823	1.33662	0.01078
U75-9-123-3	11.00937	14.25625	10.08327	16.66353	0.10297
U75-9-123-4	0.19652	1.39007	1.17	1.67885	0.03467
U75-9-126	0.02758	11.98925	0.30032	17.40583	0.00595
U75-9-128	0.79177	1.31387	26.2053	0.71923	0.814
U75-9-129	0.09093	3.88823	1.52338	5.97247	0.01297
U75-9-133	0.75235	0.81588	0.84302	0.06245	0.00342
U75-9-134	0.01157	3.56943	0.09645	4.59542	0.0043
U75-9-136	2.64635	0.02848	7.93573	0.66987	0.75675
U75-9-137	0.5115	11.07173	0.15983	6.94593	0.26527
U75-9-138	0.17018	2.40622	0.99057	6.04052	0.00143
U75-9-139	0.94853	2.89982	0.04295	3.01987	0.02343
U75-9-162	0.63023	1.91018	0.53415	1.05903	0.00742
U75-9-166	0.96963	0.87537	1.41315	0.63287	0.01868

A-11: Coefficient of variation of all five observers

CV FS #	Max Length (mm)	Oriented Length (mm)	Max Width (mm)	Oriented Width (mm)	Thickness (mm)
U75-12-22	0.035956	0.210159	0.27	0.109794	0.047803766
U75-12-24	0.099806	1.64438	1.336	1.381024	0.071721684
U75-12-27	0.127695	0.853401	0.939	0.644871	0.056508406
U75-12-35	0.041545	0.837602	0.715	0.890535	0.04710414
U75-12-37	0.186437	0.044127	0.215	0.063413	0.01015874
U75-12-39	0.075374	0.405177	0.455	0.128402	0.023298069
U75-12-44	0.134763	0.292456	0.158	0.149589	0.005215362
U75-12-45	0.04751	1.160609	1.432	0.113838	0.111036931
U75-12-47	0.127253	0.194676	0.213	0.261998	0.078094814
U75-12-48	2.533277	3.121599	3.072	2.530283	0.065918131
U75-12-50	0.153913	0.445966	0.457	0.475404	0.115355104
U75-12-51	0.122021	0.189578	0.161	0.01997	0.035704341
U75-12-52	0.058934	1.539416	1.956	0.731397	0.019359752
U75-12-60	0.052904	0.79536	0.836	0.417333	0.177552246
U75-12-61	0.046325	1.02317	1.095	1.168133	0.150336955
U75-13-22	0.067007	0.271929	0.211	0.302602	0.135465125
U75-13-25	0.074955	0.177265	0.075	0.152608	0.02562811
U75-13-30	0.108504	0.155707	0.232	0.128701	0.036540389
U75-13-32	0.014629	0.786544	0.798	0.526945	0.020278067
U75-13-38	0.016888	0.352185	0.376	0.405536	0.042881231
U75-13-39	0.095631	0.351265	0.331	0.519551	0.032802439
U75-13-42-1	0.027041	0.313256	0.437	0.141525	0.039002564
U75-13-42-2	0.03431	0.669551	0.698	0.173381	0.071869326
U75-13-42-3	0.079443	0.086355	0.083	0.077092	0.010237187
U75-13-43	0.046618	0.579315	0.69	0.177929	0.037110645
U75-13-44	0.092546	0.376597	0.494	0.210697	0.01161034
U75-13-45-2	0.187325	0.09101	0.171	0.310595	0.006387488
U75-13-45-3	0.130195	0.333279	0.338	0.130533	0.02092845
U75-13-45-4	0.384324	0.481085	0.285	0.150051	0.024149534
U75-13-46	0.10986	0.677372	0.661	0.145254	0.069253159
U75-8-1	0.137656	0.365183	0.361	0.127543	0.03835101
U75-8-2	0.345633	0.69838	0.876	0.725069	0.095205042
U75-8-3	0.045682	0.327525	0.443	0.430427	0.041434285
U75-9-104	0.111657	0.475149	0.634	0.676722	0.087343002
U75-9-114	0.156038	0.135103	0.293	0.238801	0.008899438

U75-9-117	0.05195	0.495337	0.446	0.493079	0.023383755
U75-9-118	0.047678	0.867378	1.017	0.098833	0.12063996
U75-9-119	0.098041	0.47209	0.551	0.751858	0.017977764
U75-9-122	0.067637	0.095169	0.05	0.227382	0.074985332
U75-9-123-1	0.280266	0.228957	0.329	0.235362	0.062009677
U75-9-123-2	0.062504	0.173963	0.195	0.233158	0.020765356
U75-9-123-3	0.663607	0.650413	0.791	0.812477	0.064177878
U75-9-123-4	0.091793	0.209043	0.218	0.23613	0.037239764
U75-9-126	0.035721	0.836329	0.756	0.834923	0.015427249
U75-9-128	0.173121	0.976462	1.161	0.167694	0.180443897
U75-9-129	0.06246	0.417642	0.45	0.488252	0.014877276
U75-9-133	0.178211	0.112591	0.196	0.047214	0.011696153
U75-9-134	0.021194	0.390398	0.403	0.4239	0.013114877
U75-9-136	0.32496	0.727121	0.692	0.144849	0.173982758
U75-9-137	0.146071	0.563856	0.674	0.522294	0.103008737
U75-9-138	0.084031	0.274497	0.397	0.490978	0.007563068
U75-9-139	0.206042	0.297117	0.401	0.350505	0.030613722
U75-9-162	0.157712	0.322427	0.147	0.203975	0.017227884
U75-9-166	0.206954	0.17713	0.305	0.157652	0.027334959

A-12: Technical Error of Measurement among all five observers

TEM FS #	Max Length (mm)	Oriented Length (mm)	Max Width (mm)	Oriented Width (mm)	Thickness (mm)
U75-12-22	0.174011	1.1671461	0.660583	0.5461502	0.239018828
U75-12-24	0.477148	8.2487496	0.664545	6.872461	0.358608422
U75-12-27	0.636647	4.9759823	0.450189	3.1678037	0.282542032
U75-12-35	0.226164	5.1951872	0.112472	4.4545538	0.2355207
U75-12-37	0.912453	0.8834421	0.888352	0.3705132	0.0507937
U75-12-39	0.361704	0.9371393	0.230261	0.6300556	0.116490343
U75-12-44	0.673817	1.5380995	0.67199	0.8580326	0.02607681
U75-12-45	0.232959	0.506241	5.869385	0.5747608	0.555184654
U75-12-47	0.62923	1.0524258	0.425112	1.3149411	0.390474071
U75-12-48	0.481217	0.4749	0.197053	0.4465423	0.329590655
U75-12-50	0.614679	2.3583405	1.344909	2.3852421	0.57677552
U75-12-51	0.612234	0.4966689	0.163156	0.0952365	0.178521707
U75-12-52	0.295178	0.2448877	2.632286	4.1254248	0.09679876
U75-12-60	0.269128	1.1335872	0.667668	2.0694975	0.887761229
U75-12-61	0.244193	5.1699197	0.329803	5.8446702	0.751684774

U75-13-22	0.314245	1.176805	0.165378	1.5208386	0.677325623
U75-13-25	0.428158	0.8987603	0.332069	0.7555925	0.128140548
U75-13-30	0.558507	0.8320337	0.855552	1.0375934	0.182701943
U75-13-32	0.109864	3.2960628	0.483115	2.416365	0.101390335
U75-13-38	0.074364	1.6510391	0.293564	2.0234426	0.214406157
U75-13-39	0.377862	1.482734	0.761019	2.5977548	0.164012195
U75-13-42-1	0.19308	1.2687119	0.700514	0.7564853	0.19501282
U75-13-42-2	0.150599	1.4121367	0.452405	0.8180892	0.359346629
U75-13-42-3	0.256768	0.4665512	0.34195	0.3832754	0.051185936
U75-13-43	0.240977	1.740589	1.137198	0.8836459	0.185553227
U75-13-44	0.462731	0.9676621	0.941637	1.0790876	0.058051701
U75-13-45-2	0.917371	0.931971	0.289707	1.5359785	0.031937439
U75-13-45-3	0.651137	1.278327	0.333092	0.6635284	0.104642248
U75-13-45-4	1.920292	2.2826783	0.759526	0.7141989	0.120747671
U75-13-46	0.542522	0.9236233	1.152788	0.739209	0.346265794
U75-8-1	0.68174	1.5215617	0.842069	0.6279968	0.191755052
U75-8-2	1.729644	2.9411851	1.946271	3.6493657	0.476025209
U75-8-3	0.225898	1.4692243	0.409536	2.1533462	0.207171427
U75-9-104	0.632432	2.1434202	2.926477	3.3886753	0.43671501
U75-9-114	0.766799	1.1699145	0.521603	1.2219329	0.044497191
U75-9-117	0.207774	2.4246917	0.493731	2.4527841	0.116918775
U75-9-118	0.231236	0.7439556	0.740858	0.9343607	0.603199801
U75-9-119	0.47172	2.6522688	0.841089	3.7210926	0.08988882
U75-9-122	0.377584	0.6194594	0.222441	1.0813741	0.374926659
U75-9-123-1	1.374471	1.7755703	0.827273	1.266432	0.310048383
U75-9-123-2	0.269017	1.1906301	0.698735	1.1561228	0.103826779
U75-9-123-3	3.318037	3.775745	3.175417	4.0820987	0.320889389
U75-9-123-4	0.443306	1.1790123	1.081665	1.2957044	0.186198818
U75-9-126	0.166072	3.4625496	0.548015	4.1720295	0.077136243
U75-9-128	0.889815	1.1462417	5.119111	0.8480743	0.902219485
U75-9-129	0.301546	1.9718595	1.234253	2.4438637	0.113885908
U75-9-133	0.867381	0.9032608	0.918161	0.2499	0.058480766
U75-9-134	0.107564	1.8892935	0.310564	2.1436931	0.065574385
U75-9-136	1.626761	0.1687602	2.817043	0.8184559	0.869913789
U75-9-137	0.715192	3.3274209	0.399787	2.6355132	0.515043687
U75-9-138	0.412529	1.5511995	0.995274	2.4577469	0.037815341
U75-9-139	0.973925	1.7028858	0.207244	1.7377773	0.153068612
U75-9-162	0.79387	1.3820926	0.730856	1.0290918	0.086139422
U75-9-166	0.984698	0.9356121	1.18876	0.7955313	0.136674797

A-13: Relative Technical Error of Measurement among all five observers

%TEM FS #	Max Length	Oriented Length	Max Width	Oriented Width	Thickness
U75-12-22	2.05348	15.84935	11.24971	9.32633	10.51094
U75-12-24	1.63284	35.11302	4.56669	39.26672	8.13171
U75-12-27	2.38017	22.65930	2.68161	16.98008	7.05297
U75-12-35	0.71323	19.88056	0.47099	19.16762	2.46412
U75-12-37	10.10692	10.30614	10.56556	4.61181	2.65103
U75-12-39	1.67798	4.52200	1.40506	3.96311	2.77490
U75-12-44	4.91981	11.84976	5.10553	6.60635	1.27453
U75-12-45	0.78975	1.73169	30.83632	3.59675	17.05113
U75-12-47	3.60507	6.28314	2.72542	8.37435	11.54566
U75-12-48	1.36314	1.34555	2.65427	6.29820	11.04526
U75-12-50	4.28467	18.49969	13.73197	23.76686	14.83476
U75-12-51	7.05013	5.81171	2.40218	1.42399	13.20427
U75-12-52	0.76006	0.62940	14.55588	23.23659	1.12531
U75-12-60	1.00661	4.30400	3.75221	11.96103	16.52571
U75-12-61	0.83268	21.17778	1.91102	30.53323	9.24127
U75-13-22	2.43412	9.49956	1.61187	14.67991	32.68946
U75-13-25	3.54811	7.72662	3.03315	7.29477	3.91628
U75-13-30	3.33716	5.18530	5.59624	6.88973	3.92401
U75-13-32	0.50976	17.03920	3.90238	16.94743	2.56425
U75-13-38	0.79483	20.67935	5.58532	34.42400	10.12305
U75-13-39	2.75490	11.85239	7.20662	24.67941	5.39514
U75-13-42-1	1.17260	8.29549	6.09249	6.45906	5.59738
U75-13-42-2	1.05049	10.33472	6.68052	12.76669	15.59664
U75-13-42-3	4.37723	7.88360	6.42281	7.27278	6.22700
U75-13-43	1.42945	11.40622	11.82365	9.78134	7.55510
U75-13-44	4.20971	9.20006	15.27144	17.70157	2.74087
U75-13-45-2	7.47776	7.87005	2.53595	14.40340	1.16052
U75-13-45-3	7.80366	16.71453	6.98305	15.01875	9.87191
U75-13-45-4	24.77156	31.19265	14.82292	15.85699	11.45614
U75-13-46	3.42199	5.97660	12.94104	8.91258	20.01536
U75-8-1	4.24549	9.92539	6.58690	5.26225	11.77857
U75-8-2	8.01801	15.39726	14.45108	26.70007	6.46773
U75-8-3	1.32834	9.45568	3.30858	18.08015	6.07897
U75-9-104	2.25691	8.08838	12.56970	15.27669	14.18827
U75-9-114	6.68875	11.38049	5.85545	13.77913	2.64235
U75-9-117	1.56953	21.16526	5.95430	27.65258	5.53593

U75-9-118	0.78657	2.56077	4.08907	5.21232	8.81871
U75-9-119	2.57602	16.95174	6.73194	25.86966	3.38692
U75-9-122	3.46154	5.98859	2.17312	11.10012	8.34654
U75-9-123-2	10.10492	14.60173	7.28618	12.20069	18.08917
U75-9-123-3	2.17969	10.64013	6.36718	11.07185	4.06526
U75-9-123-4	26.47652	37.12630	38.62097	43.27007	11.03471
U75-9-123-5	4.47241	13.65862	12.86166	16.89315	16.50699
U75-9-126	1.13857	26.90404	8.68211	55.52342	2.24233
U75-9-128	2.93397	3.93600	23.77664	4.79246	16.67689
U75-9-129	2.03280	14.86401	11.67032	22.62418	4.82977
U75-9-133	10.64271	12.81948	13.55820	4.45455	5.83640
U75-9-134	0.80045	15.97846	3.40158	22.24209	2.91442
U75-9-136	4.28885	0.46370	9.26232	2.99231	8.89482
U75-9-137	4.05208	23.72662	3.86044	24.05543	18.02112
U75-9-138	2.96229	12.62369	9.70242	21.48005	1.10378
U75-9-139	6.18130	11.82395	1.77587	14.41900	6.73125
U75-9-162	6.72429	12.58049	7.33791	10.88525	5.06107
U75-9-166	7.68935	7.65139	10.93615	8.22850	7.33234

A-14: Error Ranges on observer data (*d.f.* = 4, C.I. = 95 percent)

ErrRng FS #	Max Length (mm)	Oriented Length (mm)	Max Width (mm)	Oriented Width (mm)	Thickness (mm)
U75-12-22	0.099813	0.583401	0.748341	0.304789	0.132703
U75-12-24	0.277061	4.564798	3.708083	3.833723	0.199099
U75-12-27	0.354481	2.36904	2.607015	1.790163	0.156867
U75-12-35	0.115329	2.325183	1.984843	2.472124	0.130761
U75-12-37	0.517549	0.122497	0.597149	0.176034	0.028201
U75-12-39	0.209237	1.124773	1.264337	0.356445	0.064675
U75-12-44	0.374103	0.811859	0.439854	0.415258	0.014478
U75-12-45	0.131888	3.221851	3.975388	0.316016	0.308239
U75-12-47	0.353253	0.540421	0.59218	0.727306	0.216791
U75-12-48	7.032377	8.66556	8.528885	7.024066	0.182989
U75-12-50	0.427262	1.238003	1.268633	1.319722	0.320226
U75-12-51	0.338731	0.52627	0.448109	0.055437	0.099115
U75-12-52	0.1636	4.27342	5.42914	2.030357	0.053743
U75-12-60	0.146861	2.207918	2.321701	1.158518	0.492885
U75-12-61	0.128598	2.84032	3.040252	3.242737	0.417335
U75-13-22	0.186013	0.754874	0.586694	0.840023	0.376051

U75-13-25	0.208074	0.492087	0.206979	0.42364	0.071144
U75-13-30	0.301208	0.432244	0.643678	0.357275	0.101436
U75-13-32	0.040609	2.183445	2.214286	1.4628	0.056292
U75-13-38	0.046881	0.977664	1.042604	1.125767	0.119038
U75-13-39	0.26547	0.97511	0.91785	1.442273	0.09106
U75-13-42-1	0.075065	0.869598	1.212717	0.392872	0.108271
U75-13-42-2	0.095246	1.858672	1.937579	0.481304	0.199509
U75-13-42-3	0.220534	0.239722	0.229735	0.214008	0.028418
U75-13-43	0.12941	1.608179	1.916174	0.493931	0.103019
U75-13-44	0.256908	1.045433	1.371518	0.584895	0.03223
U75-13-45-2	0.520015	0.252643	0.473752	0.862211	0.017732
U75-13-45-3	0.361422	0.925184	0.937085	0.362359	0.058097
U75-13-45-4	1.066883	1.335493	0.789775	0.416541	0.067039
U75-13-46	0.304971	1.880385	1.834672	0.403226	0.192247
U75-8-1	0.382133	1.013749	1.002021	0.354059	0.106462
U75-8-2	0.959477	1.938703	2.431505	2.012791	0.264289
U75-8-3	0.126812	0.90921	1.22848	1.194865	0.115022
U75-9-104	0.309959	1.319014	1.761153	1.878579	0.242464
U75-9-114	0.433163	0.375046	0.812789	0.662912	0.024705
U75-9-117	0.144213	1.375056	1.238752	1.368787	0.064913
U75-9-118	0.132354	2.407842	2.824461	0.274361	0.334897
U75-9-119	0.272161	1.310523	1.530797	2.087158	0.049906
U75-9-122	0.187761	0.26419	0.138377	0.631214	0.208159
U75-9-123-1	0.778019	0.635584	0.913443	0.653364	0.172139
U75-9-123-2	0.173512	0.482922	0.540581	0.647247	0.057645
U75-9-123-3	1.842174	1.805547	2.19711	2.255436	0.178158
U75-9-123-4	0.254818	0.580302	0.604314	0.655496	0.103378
U75-9-126	0.099162	2.32165	2.09942	2.317748	0.042826
U75-9-128	0.480583	2.71066	3.222295	0.465518	0.500912
U75-9-129	0.173388	1.159374	1.249891	1.355388	0.041299
U75-9-133	0.494714	0.312553	0.545327	0.131067	0.032469
U75-9-134	0.058835	1.083746	1.12003	1.176746	0.036407
U75-9-136	0.902088	2.018488	1.920643	0.402101	0.482976
U75-9-137	0.405494	1.565263	1.870211	1.449889	0.285952
U75-9-138	0.23327	0.762005	1.102257	1.362954	0.020995
U75-9-139	0.571972	0.824798	1.112725	0.973003	0.084984
U75-9-162	0.43781	0.895057	0.408429	0.566236	0.047825
U75-9-166	0.574505	0.491714	0.845386	0.437641	0.075882

Appendix B: Radiocarbon Details

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Accelerator Mass Spectrometry Result

This result for the sample submitted is for the exclusive use of the submitter.
All liability whatsoever to any third party is excluded.

NZA	**37642**
R	32761/5
Job No	106584
Measured	23-Sep-11
TW No	2656
Issued	04-Oct-11

Sample ID FS#U75-9-160
Description Bison spp. burned bone fragment
Fraction Dated cremated bone
Submitter Mark Muniz Department of sociology and anthropology

*** Radiocarbon Age** **7617 ± 35 BP** $\delta^{13}C$ = -21.7 ‰

**** Per cent modern =** 38.46 ± 0.16 $\delta^{14}C$ = -612.8 ± 1.6 ‰ $\Delta^{14}C$ = -615.4 ± 1.6 ‰

* Reported age is the conventional radiocarbon age before present (BP)
** Per cent modern means absolute per cent modern relative to the NBS oxalic acid standard (HOxI) corrected for decay since 1950.
Age, $\Delta^{14}C$, $\delta^{14}C$ and absolute per cent modern are as defined by Stuiver Polach, Radiocarbon 19:355-363 (1977)

Sample Treatment Details
Sample consisted of small chip of white bone with gray patch on one side. Submitted wrapped in toilet paper. Examination under the microscope showed bone is white and a little shiny. Dark gray patch extends into the fragment of bone. One edge had a slight red discoloration: scraped away with scalpel. Scraped all surfaces of fragment to clean. Use all for dating.
Cremated bone treatment: Na hypochlorite and acetic acid cleaning, HCl etch, followed by CO_2 evolution with phosphoric acid.

Stored none

Comments

The reported errors comprise statistical errors in sample and standard determinations, combined in quadrature with a system error component based on the analysis of an ongoing series of measurements on an oxalic acid standard.
For the present result the system error component is conservatively estimated as 0% (= ± 0 radiocarbon years).

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RAFTER RADIOCARBON LABORATORY

R32761/5

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RADIOCARBON CALIBRATION REPORT

NZA 37642 CONVENTIONAL RADIOCARBON AGE 7617 ± 35 years BP

Atmospheric data from Reimer et al (2009);
PJ Reimer, MGL Baillie, E Bard, A Bayliss, JW Beck, PG Blackwell,
C Bronk Ramsey, CE Buck, GS Burr, RL Edwards, M Friedrich, PM Grootes,
TP Guilderson, I Hajdas, TJ Heaton, AG Hogg, KA Hughen, KF Kaiser, B Kromer,
FG McCormac, SW Manning, RW Reimer, DA Richards, JR Southon, S Talamo,
CSM Turney, J van der Plicht, CE Weyhenmeyer (2009) Radiocarbon 51:1111-1150.

CALIBRATED AGE in terms of confidence intervals (Smoothing parameter: 0, Offset: 0)

68% confidence interval is 6475 BC to 6436 BC 8424 BP to 8385 BP (67.6% of area)

95% confidence interval is 6561 BC to 6547 BC 8510 BP to 8496 BP (1.9% of area)
plus 6526 BC to 6416 BC 8475 BP to 8365 BP (93.1% of area)