Supplemental Information

Methods

Immunological Methods

Although beyond the scope of this paper, methodological details of CIEP are well-established in the scientific literature and have been used successfully on archaeological specimens for decades (Dorrill and Whitehead 1979; Gerlach et al. 1996; Jenkins et al. 2013; Kind and Cleevely 1969; Kooyman et al. 1992, 2001; Loy and Dixon 1998; Newman 1990; Newman et al. 1996; Seeman et al. 2008; Shanks et al. 2001, 2004; Yohe and Bamforth 2013). Renewed criticism of the method by Grayson and Meltzer (2015) cites the unpublished MA work of Vance (2011) wherein her experimental tools used on yucca and rabbit returned negative or incorrect results when they were sent to an undisclosed “commercial” lab for analysis. We cannot fully evaluate this issue due to a lack of detailed information, and are uncomfortable evaluating unpublished graduate student research, but we can offer a few comments. Vance states that she chose yucca and rabbit for her experiments because the commercial lab had antisera that indicated to her that testing could be done for these species. However, the plant antisera she lists do not include any taxa that are even in the same Family or Subfamily as yucca, hence the negative results were guaranteed and are as expected. This does not test the method. The lab also did obtain a positive result on the rabbit butchering tool on its final test. It has been demonstrated that CIEP works and that we basically understand why (Shanks et al. 2001). As has been indicated by researchers in the past, the only realistic manner in which to test the validity of CIEP is to do testing on known archaeological assemblages that have a certain result, such as the studies at Head-Smashed-In Buffalo Jump (Kooyman et al. 1992). These can be easily done as blind tests.

Antisera used in this analysis were obtained from commercial sources and, except where noted, are prepared specifically for use in forensic medicine. These antisera are solid phased absorbed, where necessary, to eliminate cross-reactivity. All antisera used are polyclonal, that is they recognize epitopes shared by closely related species. For example, anti-deer serum will elicit positive results with other members of the Cervid family such as moose, elk, and caribou. Immunological associations do not necessarily bear any relationship to the Linnaean classification scheme, although they usually do (Gaensslen 1983). Antisera have all been tested against related and non-related species by the manufacturers and have been shown to be specific for the taxa indicated. Table 1 (print version) shows the antisera used and the relationship of antisera used in CIEP to other members of each family.

Microwear Methods

Definitions of microwear traces following the Plisson-Kimball scheme, which is an extension of that developed by Keeley (1980), are found in Kimball (1989, 1994a, 1994b), Faulks et al. (2011), and Kimball et al. (1995, 1998). Identification of microtraces was made by reference to a collection of over 300 experiments. The majority of these experiments and the observed microtraces due to use, projection, hafting, accidental breakage, trampling, and chemical alteration are documented in detail elsewhere (Kimball 1989, 1994a, 1994b, 2009, 2012). Three of the nine types of hafting traces described in detail by Kimball (1989:93-95, 1994b:F4-F6) are observed in this analysis.

An Olympus BH metallurgical binocular microscope with incident-light (halogen lamp) featuring 50, 100, and 200 power magnifications was used in the analysis. Each archaeological specimen was digitally photographed and then cleaned before microscopic examination. The cleaning process was to soak each specimen in a detergent bath in an ultrasonic cleaner, followed by a bath of running room-temperature water. Intensive cleaning of each specimen (cf. Keeley 1980) was not utilized due to the weathered nature of the artifacts, and the consensus among European analysts (Juel Jensen 1988; van Gijn 1990; among others) that such baths of acids and bases can alter the microwear polishes as well as the surface of the flint. There is variable adherence to Keeley's original cleaning protocol among North American analysts as experiments have shown that the effect observed by the Europeans (Plisson and Mauger 1988) is not found at least in the case of Knox flint from east Tennessee (Coffey 1994). Admittedly, more experimentation is warranted to further resolve this methodological concern. Nevertheless, the vast majority of organic and inorganic surficial deposits (where present) were easily removed by the combination of detergent and ultrasonication.

Generally, an archaeological specimen was scanned at 100x to determine the existence of microtraces, with the areas exhibiting potential microtraces then inspected at 200x. Once traces that were interpreted to be the consequence of manufacture, use, hafting, or post-discard alteration were identified, the loci or the distribution of these locations were drawn onto the artifact photograph (Kimball 2013). See Table 3 in print version for codes on the class and number of microtraces for each tool.

Results

Microwear Analysis

Hafting traces (types 3,5,6 as defined by Kimball 1989:93-95,1994b:F4-F6) were observed on 17 (55 percent) of the 31 analyzable tools with the proximal portion present. A large database of flint or chert artifacts (n=2816) from 33 sites in eastern North America (Kimball

2009, 2010) reveals that hafting traces are expected on most projectile points (86 percent, n=465) and end scrapers (90 percent, n=136) that have been used. In a smaller sample of side scrapers (n=32), a slight majority (53 percent) exhibited microwear polishes due to hafting. By comparison, 48.5 percent of the used metavolcanic tools from the nearby Blackjack site were hafted (Kimball 2012). The lower than expected evidence of hafting traces suggests that the raw material and post-deposition alteration of the artifact surfaces have resulted in the loss of some microscopic wear traces. The contemporary traceological approach, following the French sense of the original term used by Semenov (see Plisson 1988), employs both low and high-power methods (Anderson et al. 1998, 2006; Beyriès and Rots 2008a, 2008b; Longo and Skakun 2008; van Gijn 2010; Rots 2010). This approach is used herein because of the medium-grain texture of the lithic raw materials used by the inhabitants of the Flamingo Bay site.

The fact that three fragmentary fluted projectile points exhibit microtraces due to use or hafting is of particular note. Two have been intentionally modified (Figures 5a and 5b in print version and Supplemental Figure 1) by snap-fracture or bipolarization (as indicated by a sheared cone of force) to provide steep angled working edges without additional retouch for hide-working[1]—i.e., end scrapers on fluted points (see Kimball 1996:163, 2013:41-43). Probable analogues include: a retouched end scraper edge on a manufacture (or maybe use) hinge fracture illustrated for Lindenmeier (Wilmsen and Roberts 1978:Fig. 148a); and a Clovis point at Williamson (McAvoy and McAvoy 2003:Fig. 6.31, Table 10.2) identified to have been used in hide scraping by microwear analysis. This creation of a secondary scraping working edge by intentional fracture has also been documented on a number of Archaic points in eastern North America (Kimball 2009, 2010).

The third fluted point fragment (#18) has been retouched very steeply to create a drill for antler boring (Figures 5c in print version and Supplemental Figure 1). The drill appears to have been broken in use at the proximal and distal ends creating a longitudinal split down the middle of biface. There are similar recycled Folsom points and many "manufacturing failures/splits" at Lindenmeier (Wilmsen and Roberts 1978:Figs. 102,103,149), as well as at least one Clovis point at Debert (MacDonald 1968:Plate IXB). Paleoindian drills are observed at Debert (MacDonald 1968:Plate X), and Vail (Gramly 1982:Plates 10f,14,19a,20e) in some frequency, but are not generally common in Paleoindian assemblages. This could be due to site function or the focus on game other than deer, elk or caribou, which would have provided the raw material for antler points as suggested by the study by Kimball (1994b). He observed a correlation of 0.979 for the relationship between antler points (n=900) and well-made bifacial drills (n=3210) for 18 Archaic components at twelve sites in the Mid-South (Eva, Carlson Annis, Indian Knoll, Chiggerville, Anderson, Penitentiary Branch, Koster, Modoc, Stanfield-Worley, Whitesburg Bridge, Russell Cave, and McLean). While the bone projectile point is a known component of Paleoamerican technology, (Waters et al. 2011), the regular evidence of antler polish on Clovis drills indicates the use of bored antler points as well.

The large bifacial knife identified with bison residue (see #35 in Figures 3-4 and 6a in print version) exhibited use-wear traces indicating a cutting action, but surface weathering precluded specific identification of the contact material. It is clearly a finished tool commonly found in Clovis (e.g., MacDonald 1968; McAvoy and McAvoy 1997, 2003) and Early Archaic assemblages (Chapman 1975, 1977, 1978, 1979; Coe 1964; Daniel 1998; Gramly 1982; Kimball 1994b, 1996, 2009, 2010) and was most likely used in heavy butchery activities. The presence of bison residue on the tool is consistent with this interpretation.

Convex side scrapers produced on regularized blanks, such as the five complete ones (#s 1, 2, 21, 27, and 34 in Figure 3 in print version) and one fragment (#14 in Figures 3-4 and 6g in print version) included in the sample, are commonly observed in Clovis and Hardaway assemblages (Coe 1964; MacDonald 1968; Gramly 1982; McAvoy 1992; McAvoy and McAvoy 2003; among others). Side scrapers #1 and #2 conform to Side Scraper, Type I defined at Hardaway (Coe 1964:77; Daniel 1998:84). The complete scrapers exhibit very precise retouch that created a regular and slightly convex working edge along the entire length of one lateral edge.

The three large side scrapers (Figure 5g-i in print version) were hafted and used to scrape relatively fresh hide—probably in very intense defleshing (Supplemental Figures 2-3). Such defleshing tools are documented in the ethnoarchaeological and traceological research (e.g., Beyriès 2008; Beyriès and Rots 2008a, 2008b) with contemporary stone tool-users in Siberia, Ethiopia, and British Columbia. These side scrapers were probably used like a draw-knife, at least in terms of the relation of the working edge and haft (both parallel to the long axis) to the hide (perpendicular). In addition, Side Scraper #2 (Supplemental Figure 3) was laid on an anvil and intentionally snapped at the mid-point of the lateral left edge to make the width of the scraper fit the haft. Additionally, Side Scraper #34 (Supplemental Figure 2) exhibited grinding on the edge opposite the working edge to accommodate the haft. By contrast, two smaller side scrapers (#s 14, 21 in Figures 3-4 in print version) were used in bone working—to plane and point and to saw, respectively. The proximal end of side scraper #14 (Figure 6g in print version) (positive for turkey residue) appears to have been backed to facilitate hafting before use to cut or saw bone.

Eleven end scrapers (Table 2 in print version) in the sample conform to End Scraper Types I, II, and III of Coe (1964:73-76). Five of these specimens (#s 5, 8, 15, 17, 26) exhibit small notches along one or both lateral edges that likely facilitated hafting, given the absence of microwear traces within the notches (Kimball 2013). The texture of the Allendale Chert and surface weathering, however, makes this observation less than certain. For example, the notches on double end scrapers 8 (Figures 3 and 6d in print version) and 26 (Figure 3 in print version) appear to have been created to facilitate hafting or re-hafting. Eight of the eleven end scrapers exhibited hafting traces, but this should be considered a minimum given the condition of the lithic raw material. Five end scrapers were inferred to have been used to scrape fresh hides, and four were used to scrape hides in relatively drier states (Table 2 in print version) (see Kimball 2013). As argued elsewhere (Keeley 1982; Kimball 1994b, 1996; Loebel 2013), the relative abundance of fresh versus dry hide-working at forager sites is important in the determination of site function: hunting camp versus base camp, respectively. Two double end scrapers (8 and 22 in Figures 3, 6d, and 6f in print version) were identified with microtraces and residues indicative of fresh and dry hide scraping and residues of Galliformes (grouse, quail, or other gallinaceous fowl) and deer, respectively (Table 2; Figure 4 in print version).

Two formal gravers included in the sample (#s 6 and 11) exhibit hafting traces and were used to work bone albeit in different actions. Graver #6 (Figures 3 and 6h in print version) was used extensively along all four edges, primarily to plane bone. Given the presence of hafting traces, it must have been rehafted several times. Graver #11 (Figure 6i in print version) is a very small tool, also hafted, and used to grave (or shallowly groove) bone using the finely retouched, lateral right and distal end (which was probably straighter before a small notch was retouched into it). This small notch exhibits polish indicating that the tool was used to point or smooth a cylindrical piece of bone (Kimball 2013).

By comparison, microwear analysis of 54 such typological "gravers" from Williamson and four Paleoindian through Late Archaic sites in Pennsylvania (Kimball 2010) were observed to have been used on a variety of contact materials: 13 bone; nine bone/antler; one antler; 10 wood; seven fresh hide; one dry hide; two meat cutting; eight indeterminate; and three unused. Other microwear analyses show different, multi-task patterns for graver function. Boast (1983) determined that a sample of 90 Folsom gravers was primarily used in butchery activities. Using a low-power approach assisted with experimentation, Tomenchuk and Storck (1997) argued that Paleoindian “compass” gravers were used as a specialized tool to manufacture decorative items. Marvin Kay analyzed 33 gravers from five Western Paleoindian sites and found them to have been used to bore, slot, and pierce, but it is unclear what materials were being worked (Davis and Kay 1999).

Of the three blade-like flakes included in the sample (#s 16, 24, 28 in Table 2 in print version), one (#16: Figure 6b in print version) is inferred to have been hafted and used in fresh hide cleaning work, while #24 (Figure 6c in print version) is inferred to have been hafted and used in butchery activities. The last blade-like flake fragment (#28) was indeterminate for use-wear.

Regarding temporally diagnostic Early Archaic tools, one heavily reworked Taylor Point and one likely Early Archaic point fragment (#s 29, 30 in Figures 3-4 in print version)—both positive for turkey residue—have microtraces consistent with wood whittling (Figure 5d in print version) and butchery (Figure 5e in print version), respectively. Wood whittling microtraces and animal residue on the same tool should not be surprising. Rather than being interpreted as an example of discordance between the microwear and immunological analyses, these results most likely represent the multifunctional use of formal bifaces with animal residues derived from secondary use or as a result of animal-derived mastics applied during hafting.

Hafting traces discerned through microwear suggest large unifaces at Flamingo Bay were hafted in draw-knife fashion for intensive defleshing and hide scraping (e.g., Beyriès and Rots 2008b). Hafting microtraces are prevalent and are consistent with bone or antler haft elements. These activities are behaviorally and spatially consistent with butchery and hide processing of large mammals such as bison and deer. Use-wear evidence for hafting highlights the fact that further work is needed to determine if some residues represent those from haft adhesives (i.e., mastics) rather than from butchery activities (Seeman et al. 2008).

Microwear evidence for intentional snap-fracture of exhausted fluted points and reuse as un-retouched, steep angle, end scrapers provides behavioral information unobtainable through normal visual inspection of tool edges. The use of snap-fracture suggests that Clovis inhabitants of the Upper Coastal Plain of South Carolina were maximizing raw material use while away from sources of high-quality toolstone, through reuse and recycling of exhausted hafted bifaces—including those made on exotic raw materials.

Supplemental Notes

[1]Microwear polishes due to working hide in fresh and dry conditions are differentiated following Kimball 1989. Fresh hide polish is fluid, grainy. The microtrace follows the microtopography but the higher elevations are modified, which gives a grainy/greasy-matte coalescence. Most concentrated at projections on the edge. Dry hide polish is soft and grainy. There is significant edge rounding and modification of the microtopography, which is most extensive at the edge. In addition, there are observable differences due to the *extent* (fresh hide – invasive; dry hide – moderate); *texture* (fresh hide – weak to average; dry hide – dense); *brightness* (fresh hide – greasy-matte; dry hide – matte); and type of *striation* (fresh hide - short, wide, and deep in the polish; dry hide - long, wide, and deep, which are numerous).

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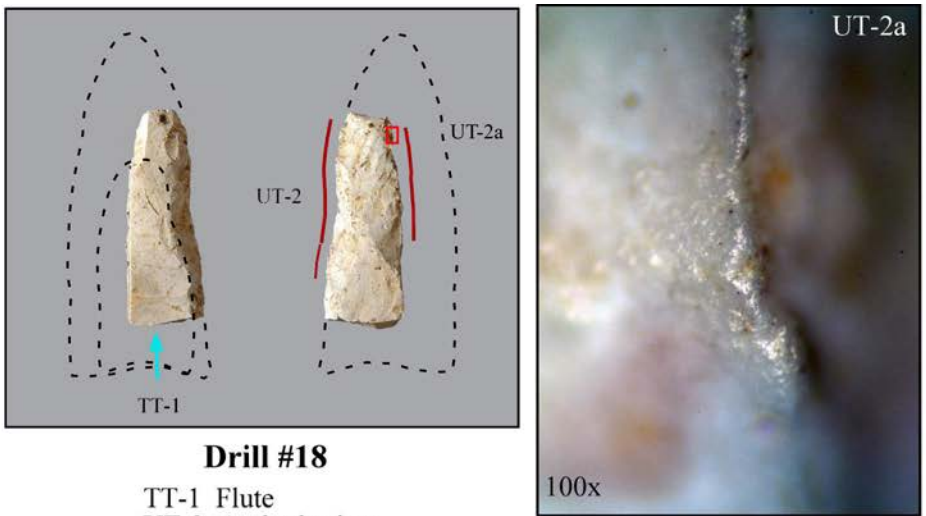
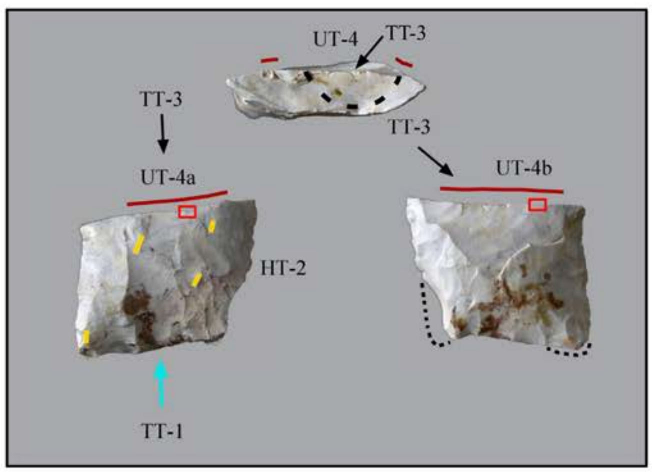


Drill #18

TT-1 Flute
UT-2 Antler boring



Clovis Point #4

TT-1 Fluting
HT-2 Hafting Traces
TT-3 Intentional Fractures (bipolar)
UT-4 Dry Hide Scraping

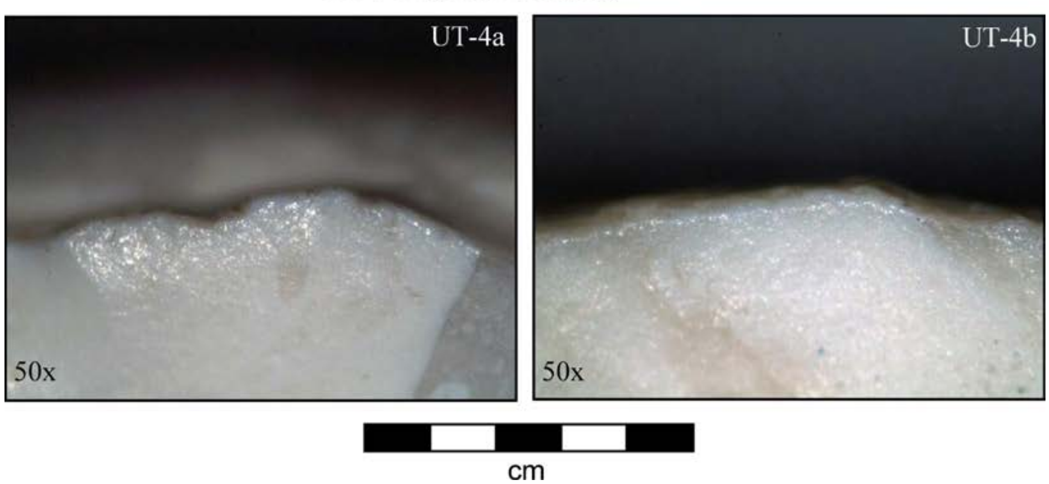


Figure 1. Allendale Chert drill #18 made on a fluted (TT-1) point fragment and Allendale Chert Clovis Point base #4. The proximal and extreme distal portions of the drill are broken (probably in use), and the tool was used to bore antler (UT-2);. The point was fluted (TT-1), hafted (HT-2), and then had been bipolarized (TT-3) which created a perpendicular working edge that was used to scrape dry hide (UT-4). The maximum dimensions of the microphotographs are approximately 1472 microns (50x) and 753 microns (100x).

GT-1 Edge grinding
HT-2 Hafting traces - striated
UT-3 Fresh hide scraping (heavier toward proximal end)

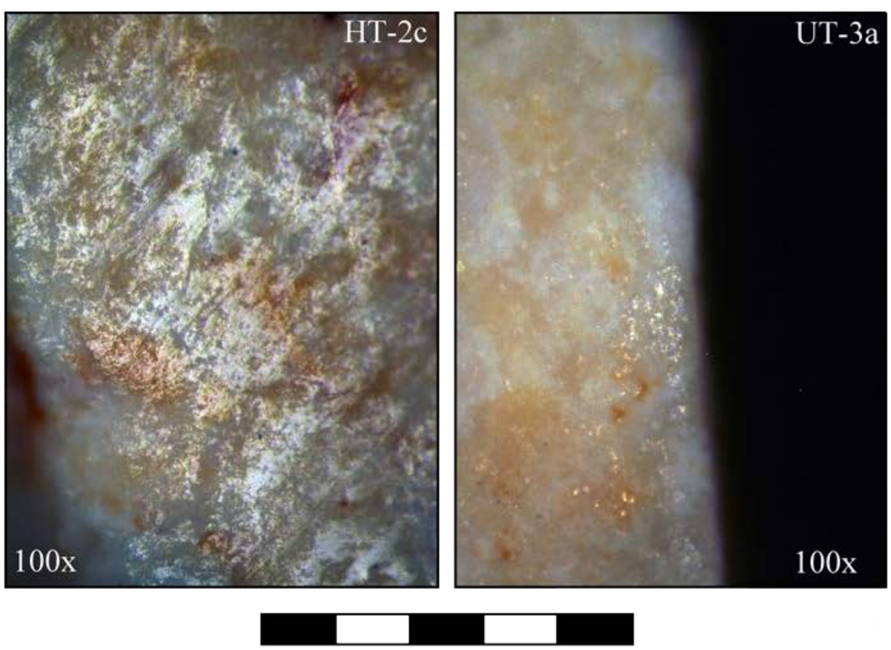


Figure 2. Allendale Chert side scraper #34 was used in fresh hide scraping (UT-3). The lateral edge opposite the working edge was ground to faciliate hafting (GT-1) and exhibits a striated Type-2 hafting traces (HT-2) concentrated along the prominent dorsal ridge.

Figure 3. Allendale Chert side scraper #2 was used to scrape hide in a fresh condition (UT-3). Hafting evidence includes an intentional fracture along the lateral edge opposite the working edge (TT-1) to better fit the tool in a handle and hafting traces (HT-2); and Allendale Chert side scraper #1 used hafted (HT-1) to scrape fresh hide (UT-2).