Exploring the Interpretive Potential of Clovis Waste Flakes

Submitted by Nancy V. Littlefield,

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I certify that all material in this dissertation which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

(signed)

Abstract

This research examines the technology behind Clovis biface production from Clovis manufacturing areas at the Gault Site, Texas, (41BL323), with specific focus on flake striking platform preparation traits. Lithic analysts agree that platform bearing flakes retain clues into knapping technologies (Andrefsky 2005:86). Clovis experts agree that Clovis knappers invested effort before removing flakes by preparing platforms (Bradley, *et al.* 2010:66; Morrow 1995) for exerting control during biface manufacture, including mastering control of overshot flaking (Bradley 2010:466). Evidence shows that Clovis knappers were highly skilled in their craft and preferred high quality raw materials to manufacture their tools and frequently produced overshot flakes. While basic manufacturing traits are present, Clovis represents a complex bifacial reduction technology (Bradley, *et al.* 2010:64). The data here elucidates differences in the application of reduction techniques used by Clovis. These data reveal no set pattern in the application of platform preparation traits used by Clovis knappers, but identified trends in the use of preparing platforms in flake types and phases that highlight Clovis biface reduction sequences, which may have followed a systematic 'template.' Therefore, a consistent approach may have been used to produce Clovis bifaces, but individual platform preparation traits were not. In addition to this study, a supplemental study was conducted concerning the intentionality of Clovis overshot flaking. This separate study revealed these flakes regularly exhibit the removal of stacks, hinges, deep flake scars and other error traits. As such, overshot flakes were a technique that served a dual purpose of removing errors while simultaneously thinning the biface. This research has contributed to a greater understanding of Clovis biface technology reduction processes and flake removal techniques used at the Gault Site.

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This dissertation is dedicated

to the memory of

Merle Samuel Gardner

Chapter 1 – Clovis Culture and Clovis Technology

Clovis- An Early Paleoindian Fluted Point Culture

Clovis is an early North American Paleoindian flaked stone tool culture that dates roughly to a time range of 13,250 to 12,800 cal yr B.P. (Waters and Stafford 2007). Clovis is a prolifically documented culture that is primarily characterized by large, well-made, fluted lanceolate-shaped spear points (Bonnichsen and Turnmire 1991; 2005:1-26; Bradley 1991:369; Bradley, *et al.* 2010:56-106; Collins 1999a:46; Meltzer 1993:293-310; 2004:123-161; 2009:64; Smallwood 2012; Waters *et al.* 2011a).

The Clovis fluted spear point is the defining feature of Clovis culture and usually dominates most research studies related to Clovis habitation and kill-sites (Boldurian and Cotter 1999, Frison and Todd 1986:136; Speer 2014). Extensive data are available on Clovis points (Anderson, *et al.* 2010; Meltzer 1986:27) including variation and morphology (Sholts, *et al.* 2012), and regional distribution patterns (Hamilton, *et al.* 2013; Smallwood 2012).

However, with the exception of some Clovis caches, (Bamforth 2014:39; Collins, *et al.* 2007:101-123; Frison and Bradley 1999; Jennings 2013; Waters and Jennings 2015), many Clovis points can be problematic in that they are rarely recovered in a pristine state. These are often incomplete or broken (Bradley, *et al.* 2010:56; Ferring 2001:130; Smallwood 2012), reworked to exhaustion, or severely damaged (Fig.1) (Bradley, *et al.* 2010:56,102-04).

Figure 1— Lost or discarded Clovis spear points from the Gault Site, Texas, (41BL323): (a) & (c) have severe thermal damage; (b) is a Clovis basal fragment; (d) & (e) have unretouched minor damage; (f)-(i) depict various states of heavy reworking. (Used with permission from the Gault School of Archaeological Research (GSAR), photos by Sergio Ayala)

The Clovis tool kit has expanded considerably beyond the iconic fluted point (Collins 2002; Ferring 2001:130; Haynes 1982:393) with the discovery of macroblades at Blackwater Draw (Green 1963) as well as bone and ivory technology (Bradley *et al.* 2010:114; Haynes 1993:219-236; Huckell 2007:110). Artistic expressions (Fig. 2) of Clovis culture have also been conveyed as delicately scored patterns on limestone pebbles and chert flake fragments (Collins 2002:37, 39; Haynes and Warnica 2012:6; Lemke, *et al.* 2015; Wernecke and Collins 2012:120-121).

Figure 2 – An engraved limestone from the Gault Site, Texas, (41BL323) (UT-4801-6) (Photo by M. Samuel Gardner, used with permission from the GSAR)

Clovis Sites

Clovis sites have been found throughout North America and comprise a vast geographic expanse that includes portions of Canada and the lower contiguous United States, as well as portions of northern and central South America (Stanford and Bradley 2012:31). In the early 1930s, the discovery of a large fluted point near the town of Clovis, New Mexico (Howard 1935a; 1935b; Wormington 1957), led to similar (Clovis) point discoveries in what is known as the Southern High Plains region; a prominent geographic component of the Great Plains (Bradley 1991:369; Holliday 1997:150-51).

The Clovis type-site of Blackwater Draw in New Mexico and similar sites, *e.g.* the Dent Site in Colorado, the Lubbock Lake Site, Texas (Johnson 1987) and the Miami Site also in Texas, are all located in and around the Southern High Plains (Fig. 3) (Collins 1998a:85; 2007:74). The Southern High Plains remained the focus of Paleoindian research early on (Hester, J. 1972; Holliday 1997:1-20) and in later decades for supplemental studies (Boldurian and Cotter 1999; Haynes and Warnica 2012:1-9; Holliday, *et al.* 1994:234-244).

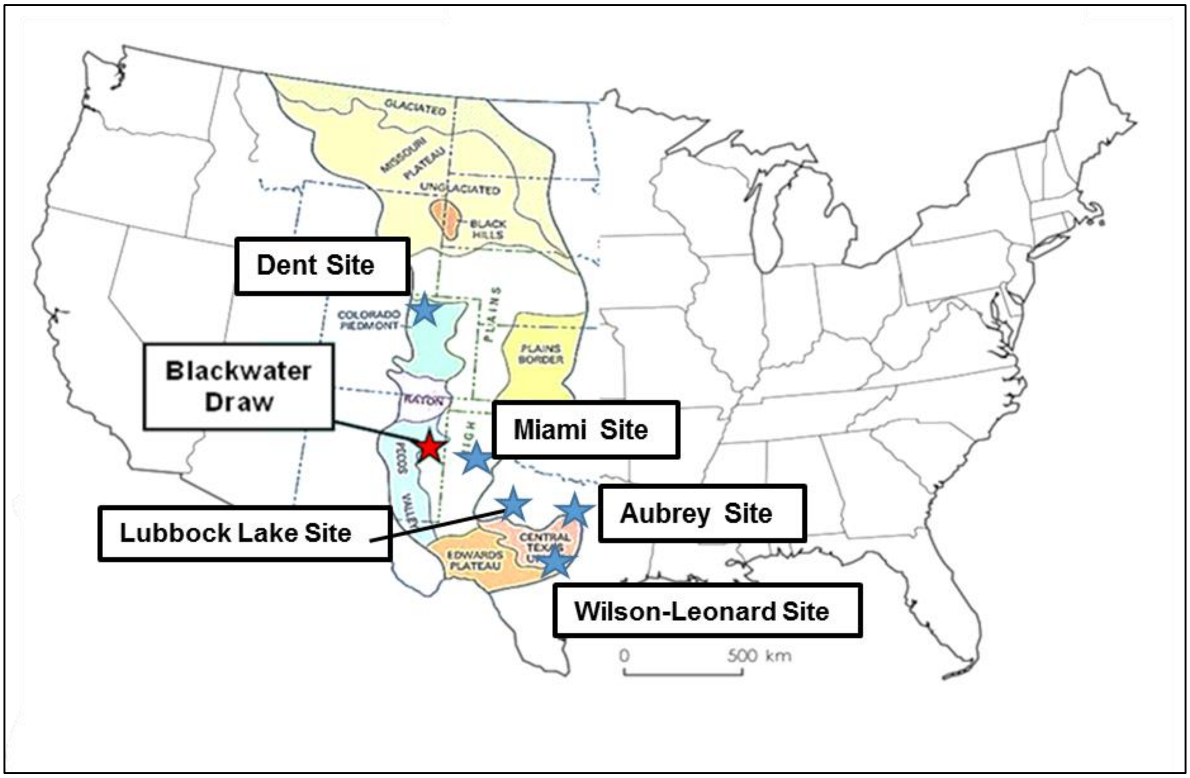

Figure 3-- United States map with highlighted overlay of the Great Plains province and section (Trimble 1980) and depicts primary Clovis sites in and around the Southern High Plains region (Collins 1998a:85; 2007:74) (Color overlay of Great Plains is modified from Trimble 1980. Used with permission from the U.S. Geological Survey, Dept. of the Interior U.S.G.S., U.S. Geological Survey).

The early discovery of Clovis sites in the Southern High Plains were often associated with extinct proboscidea remains and emergent evidence led many scholars to mischaracterize (Saunders and Daeschler 1994:1) Clovis hunting culture as nomadic super predators (Adovasio and Page 2002:124; Grayson and Meltzer 2002:313-359; Mithen 2003:213). By the mid-1960s, an hypothesis of "Clovis overkill" (Martin 1967) was advanced to explain the extinction of large Pleistocene mammals, and argued their demise was not caused by dramatic environmental or climatic changes. Instead it was proposed that Clovis hunters wiped out not only the North American species of mammoth *(M. columbi)*, but also the majority of large Pleistocene carnivores and herbivores (Collins 2002:31-4; Haynes 1982). One of the flaws with the 'overkill' hypothesis questions why only some species died and others survived (Grayson and Meltzer 2003:586). Clovis hunters may have been part of the problem, but the idea of human overkill on such a massive scale was eventually found to be overstated based on evidence to the contrary (Alford 1974; Grayson and Meltzer 2003:589; Frison 1986:114).

Many Paleoindian sites have been discovered in the Southern High Plains region, which extends into the Central Texas region and the Edwards Plateau (Holliday 1997:149-150). Central Texas Paleoindian sites have been found to occur in deep sedimentary environments such as floodplains and valley fills (Pertulla 2004:34; Driese, *et al.* 2012). Floodplains are ideal environments for preserving archaeological sites in relative stasis (Goldberg and MacPhail 2006; Mandel, *et al.* 2001:183).

One of the oldest Clovis sites in North America that dates to around 11,550 cal yr BP is the Aubrey Clovis Site in North Texas (*see above* Fig. 3). Construction crews digging an outlet for a local reservoir exposed the site. Archaeologists discovered well-preserved concentrations of Clovis-age artifacts buried seven to nine meters below the floodplain of the Elm Fork of the Trinity River Drainage Basin (Ferring 2001). Closer to Austin, Texas, construction work in the area exposed the Wilson-Leonard Site (*see above* Fig. 3). Archaeologists recorded multiple components, including Paleoindian deposits, which were buried under six-meters of valley fill (Collins 1998a:26-32).

This section briefly highlights the historical significance of the earliest discoveries of Clovis sites in and around the Southern High Plains region as well as the vital role of geosciences in Paleoindian research around the Edwards Plateau region in Central Texas.

The Clovis Phenomenon

Since its discovery in the 1930's, the origins of Clovis culture and their technology remain unknown. The archaeological evidence reveals a seemingly concurrent emergence of Clovis points across North America (Goebel, *et al.* 2008:1499; Morrow and Morrow 1999). Likewise, recent dating of Clovis sites, (Waters and Stafford 2007) seems to support the widespread nature of Clovis as being a relatively quick dispersion throughout North America (Madsen 2004a:1).

The term "Clovis-first" refers to the model developed as a single event of humans entering the continent from Asia who then quickly populated the interior of North America (Bonnichsen and Turnmire 2005:3). While humans did eventually migrate across Beringia, Clovis was likely not the first to arrive in the Americas (Collins, *et al.* 2013:521-539; Waters and Stafford 2007; 2013:541-560). The model became outdated as sites much older than Clovis were being exposed in the 1970s and 1980s (Adovasio and Page 2002; Dillehay 1997). Furthermore, the geneses of a post-Last Glacial Maximum (or late-entry model) of humans entering North America is deeply rooted in American history, being traced as far back as the late sixteenth-century (Meltzer 2009:64) during post-contact explorations by Europeans in the Americas (Mithen 2003:211).

In 2007, radiocarbon (^{14}C) Clovis era dates were reevaluated of Clovis dating records from well-documented Clovis sites (Waters and Stafford 2007). Waters and Stafford (2007) re-tested available organic matter using high-precision accelerator mass spectrometry (AMS). Their adjustments shortened the existing

Clovis dates from 11,500 to 10,900 ^{14}C yr BP, to a revised time span of 11,050 to 10,800 ^{14}C yr BP (or 13,000 to 12,800 cal yr BP based on Calpal-online.de (2014)). However, in 2013, Waters and Stafford (2013:541) presented an altered range of 13,000 to 12,600 cal yr BP without clear validation.

Obtaining accurate dates from established Clovis sites has been impaired by deficient preservation and/or lack of organic matter and is a common problem amongst many Paleolithic and Paleoindian sites (Collins 2002). The dates reported by Waters and Stafford in 2007 were challenged as being problematic (Haynes, *et al.*, 2007) in that the data were insufficient to support the wide dispersal of Clovis technology, even though Waters and Stafford (2007:1124) contend that such a feat could have been achieved in as little as 200 years or less.

In addition to dating issues, there are problems correlating Clovis dates to migration theories (Haynes 1964; Stanford and Bradley 2012:45). At best, the timing of the earliest human migrations into North America is unclear and seem to coincide with unpredictable glacial cycles, meltwater, and climate change (Stanford 1991:1-14). It is known that rapid changes to environments and climates were well underway in North America by 16,500 cal yr BP (Reimer, *et al.* 2009:1122). According to Mithen (2003), between 16,000 and 12,000 (cal yr BP), the North American ice sheets had advanced at least four times (Mithen 2003:239), and at one point reached as far south as the state of Iowa (Gwynne 1942:200-208).

However, around 13,000 cal yr BP, erratic glacial melt was interrupted by the onset of the Younger Dryas cooling event (Bement and Carter 2008; Fiedel 2011; Holliday, *et al.* 2011; Mithen 2003:239; Straus and Goebel 2011). Glacial and interglacial conditions in North America would have created chaotic environmental conditions (Fiedel 2011; 2014:11) and as such, may not have allowed human migrations from Asia into North America to occur until at least after 16,100-14,800 cal BP (Madsen 2004b:389). At some point during post-LGM, the Cordilleran and Laurentide glaciers receded creating an ice-free corridor, which may have been, or remained, impassable (Goebel, *et al.* 2008:1501). Overall, Clovis site dates, and the timing of migration routes from Asia along either proposed passageway of the Pacific or within an “ice-free” glacial interior continue to be research-worthy, albeit debatable, issues (Goebel, *et al.* 2008:1498-99; Madsen 2004a:11-12).

In summary, the Clovis fluted point, biface and blade technologies inexplicably appear and then vanish from the archaeological record within a few hundred years (Stanford and Bradley, 2012:31) and there are no technological predecessors for the Clovis fluted point in Alaska or Beringia (Frison 1993:2004; Goebel *et al.* 2008; Goebel, *et al.* 2013; Waters and Stafford 2013:541). As it seems, the sudden appearance and exodus of Clovis (Adovasio and Page 2002:14,108; Waters and Stafford 2007:1122-1126), reveal a fleeting, but successful legacy (Walker and Driscoll 2007:12) of Clovis technology that remains, at least for now, a continental phenomenon (Meltzer 1993:295).

The State of Clovis Research

Clovis research trends over the past two decades remain focused on searching for evidence, and the cultural origins, of Clovis technology. The dissemination of proposed hypotheses, investigations, as well as replies and rebuttals provide intellectual forage that draw lively and bitter debate on the subject (Bradley and Stanford 2004; 2006; Curry 2012; Eren, *et al.* 2013; 2014 Haynes, *et al.* 2007; Lohse, *et al.* 2014a; Morrow, *et al.* 2012; O’Brien, *et al.* 2014a; 2014b;

Oppenheimer, *et al.* 2014; Rasmussen, *et al.* 2014; Stanford and Bradley 2002; 2012; 2014; Straus 2000; Straus, *et al.* 2005; Waters, *et al.* 2011b; Waters and Stafford 2007).

The evidence shows that the advent of Clovis was abrupt, geographically widespread, and puzzlingly short-lived. The development of the Clovis fluted point was once presumed to be a technology that was imported from outside of North America (Wormington 1957:249). However, fluting seems to be an invention that is almost exclusive to the Americas (Stanford and Bradley 2012:29). Recent evidence in Collins, *et al.*, (2013:522) suggests that other cultures were already established in North America before the arrival of Clovis (Bonnichsen and Lepper 2005:11; Dillehay 1997; 2009; Waters, *et al.* 2015). If this were the case, then it is plausible to consider that Clovis technology was introduced to indigenous peoples and the technology could have spread then continued to be rejuvenated as a social movement in response to negative cultural stresses (Bradley and Collins 2013:252).

Ongoing investigations continue to refine our understanding of Clovis technology (*see* Huckell and Kilby 2014) and subsistence and mobility strategies of Clovis hunter-gatherers (Buchanan, *et al.*, 2014; Haynes and Hutson 2013; Sanchez, *et al.* 2014; Yohe and Bamforth 2013). The search for technological and ancestral origins of the Clovis culture has compelled archaeologists to expand their efforts and test the waters, literally (Mackie, *et al.* 2013:133-147). Furthermore, new evidence of “Older-than-Clovis” occupations (Waters, *et al.* 2011b) and alternative theories of migration and colonization of the New World (*see* Stanford and Bradley 2012), have effectively stimulated new research directions and dynamic debate (Eren, *et al.* 2013; Eren, *et al.* 2015; Lohse, *et al.* 2014a; Morrow, *et al.* 2012; Waters, *et al.* 2011b; Straus, *et al.* 2005).

The state of Clovis research also fundamentally influences molecular genetic research of the earliest Americans (Oppenheimer *et al.*, 2014), and research on human genome sequences (Rasmussen, *et al.*, 2014) which is intimately linked to alternative migration hypotheses (Goebel *et al.* 2008; Stanford and Bradley 2012).

The Clovis type-site of Blackwater Draw and other type-sites (*e.g.* Dent, Miami, and Lubbock Lake) remain the analytical benchmarks for researchers attempting to understand the initial peopling of the Americas (Collins 2002; Collins, *et al.* 2013:521). A catalyst and a touchstone (Stanford and Bradley 2012:31), the state of Clovis research has evolved well-beyond the confines of the Clovis-first model (Bonnichsen and Schneider 2005). This dissertation expands upon our need to understand Clovis technology in greater detail by focusing on unretouched flakes and debitage.

Clovis Biface Technology

The term "biface" in this section refers to *complex bifaces* (Fig. 4) based on the definition in Bradley, *et al.* (2010:62) as having been made using multiple, independent or interrelated actions or behaviors.

Figure 4 -- A large, abandoned, early/middle phase Clovis biface from the Gault Site, Texas, (41BL323). Note the overshot flake scar in the center of the biface (Spec. # UT-1040-103) (Photo by M. Samuel Gardner, used with permission from the Gault School of Archaeological Research).

Clovis technology research is often of the functional elegance of the fluted point (Frison 1993:247; 2004:43; Johnson 1993; Morrow and Morrow 1999:215-230). From a broader perspective, the Clovis fluted point was an integral, yet small component, of a specialized weapons delivery system (Frison 1993:247; 2004:43). In that respect, it was part of an overall hunting strategy explicitly designed to quickly take down and kill large animals (Frison 1993:241, 245, 247). Our understanding of Clovis bifacial technology has been ascertained primarily from Clovis caches (Butler 1963; Collins 1999b; Frison 1991b; Frison and Bradley 1999; Huckell 2014; Huckell and Kilby 2014; Jennings 2013; Kilby and Huckell 2014;

Lohse, *et al.* 2014:153-175; Stanford and Jodry 1988), as well as encampments and kill-sites (Bement and Carter 2010; Frison and Todd 1986; 1987; Johnson and Holliday 1989; Leonhardy 1966).

Evidence from cached bifaces indicate that Clovis knappers preferred toolstone materials that were visually appealing (Collins, *et al.* 2007:103; Frison 1991a:41; Frison and Bradley 1999:56-70) and of superior quality. It has been reported that that Clovis caches are often found far from their original sources, and this suggests they traveled great distances, (Bradley 1991:370; Meltzer 1993:295; Stanford and Bradley 2012:47) in order to procure high quality and colorful knappable materials. This includes Edwards Chert (Kilby 2014:205-06) and more exotic materials such as Alibates (agatized dolomite), Utah agate (Frison and Bradley 1999:52), Phosphoria chert (Holen 2014:184), or quartz crystal (Bradley *et al.*, 2010, plate 1), just to name a few.

The proficiency in which Clovis knappers worked so many different types of raw stone is evident in Clovis caches (Frison and Bradley 1999). Biface caches often contain a number of bifaces of variable materials, shapes and sizes that range from early to late phases (Bradley, *et al.* 2010:78-79) of manufacture (Frison and Bradley 1999; Jennings 2013, [*see also* Huckell and Kilby 2014) although the Drake Clovis cache (Stanford and Jodry 1988) was mostly point preforms and finished points (Collins, *et al.* 2007:106). There are inconsistencies in relation to size and shape of Clovis projectile points (Buchanan, *et al.* 2014; Smallwood 2012), which is expected since modifications of Clovis points would have occurred throughout their use-life. Regardless, Clovis points have been shown to have a remarkable degree of conformity (Collins 1999a; 1999b; 2007:74; Sholts, *et al.* 2012).

Biface Production

Clovis was a well-developed biface-based industry (Bradley, *et al.* 2010:56) and it is suggested that Clovis knappers applied a complex series of behaviors to produce flaked stone tools (Bradley 2010:465; Bradley, *et al.* 2010; Collins 1999a:45-50, 69; Eren, *et al.* 2011; Frison 1982:150-52; Huckell 2007:185; Morrow 1995:167; Smallwood 2010). It is generally accepted that Clovis bifaces were made using specialized technology.

Merriam-Webster Dictionary online (2014) defines “technology” as the practical application of knowledge and specialization by the use of technical processes, methods, or techniques in order to produce something. The production of Clovis bifaces and resulting flaked debris would preserve a record of manufacturing traits created by knapping behaviors to produce a desired end product such as Clovis projectile points. Technical processes likely used by Clovis knappers to remove flakes are reported to have included careful preparation of platforms. This may provide researchers with additional distinctions in the form of traits and attributes in flaked stone debris that can be associated with Clovis biface production (Huckell 2007; 2014; Jenkins, *et al.* 2012; Jennings 2012; 2013:654; Stanford and Bradley 2012:22).

Overall, the means used to produce a Clovis point is likely similar in many aspects to most biface technologies (Bradley, *et al.* 2010:64). Bradley, *et al.* (2010:64) states that not everything about Clovis biface production is considered diagnostic. However, the techniques used by Clovis knappers are described as manifestly recognizable through traits, and are culturally specific of Clovis technology (Stanford and Bradley 2012:47). Furthermore, these occur with a certain degree regularity (Bradley, *et al.* 2010:60-67) on bifaces (Bordes and

Crabtree 1969:10-11; Bradley, *et al.* 2010:64; Huckell 2014:6), as well as flake platforms (Collins and Hemmings 2005:10; Frison 1982:152; Huckell 2007:171).

Careful preparation of flake striking platforms is often observed and reported as a technological distinction associated with Clovis biface and flake assemblages (Bradley, *et al.* 2010:65; Hemmings 2007:107-108; Huckell 2007:163; Morrow 1995). While Bradley, *et al.* (2010:64-66) acknowledge that not every flake platform was prepared, Clovis knappers invested time and attention to priming striking platforms. Thus far, this behavior of carefully preparing striking platforms during biface production appears as an idiosyncratic characteristic of Clovis technology (Frison 1982:153).

With few exceptions, (Bradley 1993:254-261), extant evidence related to other post-Clovis fluting or Paleoindian technologies has little to say about platform preparation traits on flakes or debitage (Straus and Goebel 2011; Haynes 1996). It can only be assumed that some form of platform preparation was likely used to remove flakes associated with post-Clovis flaked stone assemblages but is likely under-reported (Root, *et al.* 1999:58). However, this gap shows the need for more data in order to help distinguish or perhaps connect Clovis to assemblages from older-than-Clovis sites as well as post-Clovis sites (Jenkins, *et al.* 2012; Pevny 2009:218-219).

Experimental Flintknapping and Understanding Clovis Technology

Before continuing the discussion of Clovis biface technology, it is important to recognize the contribution that experimental replication studies have made to understanding Clovis Technology as a whole. Academic flintknapping was introduced to American archaeology during the 1950's and 1960's, (Jelinek 1965; Johnson 1978; Lamdin-Whymark 2009; Swanson 1966) and provided archaeologists with experimental options to scientifically test flintknapping techniques (Crabtree 1966; 1967a; 1967b; Bradley and Stanford 1987) and to explore differences in flaked stone technologies (Callahan 1979; *see* Clark and Collins 2002). Moreover, flaked stone tool replication and experimentation also generated (renewed) awareness of examining debitage associated with flaked stone assemblages (Bradley 1975; Collins 1974; 1975:15-34; Crabtree 1972; Wilmsen 1970; Fish 1979).

Experimental flintknapping has contributed valuable insights into Clovis technological concepts and reduction techniques based on observations that are unique to Clovis biface production (Hamilton 2006; Wilke 2002). While exact methods are hypothetical, academic knappers have proven skilled at removing channel flakes using several techniques that can successfully replicate flute scars (Crabtree 1966; Patten 2005; 2009; Whittaker 1994:237-242).

The most reliable means of investigating flaked stone tool manufacture and reduction patterns is through artifact refitting or conjoining analysis (Villa 1982:276-290). In rare cases, researchers have successfully reassembled entire manufacturing sequences (Almeida 2005). Clovis biface and blade reduction sequences have been reassembled from discarded flaked debris (Fig.5) (Bradley 1982:204; Ferring 2001:148; Collins and Link 2003:162-173; Frison and Stanford 1982:143).

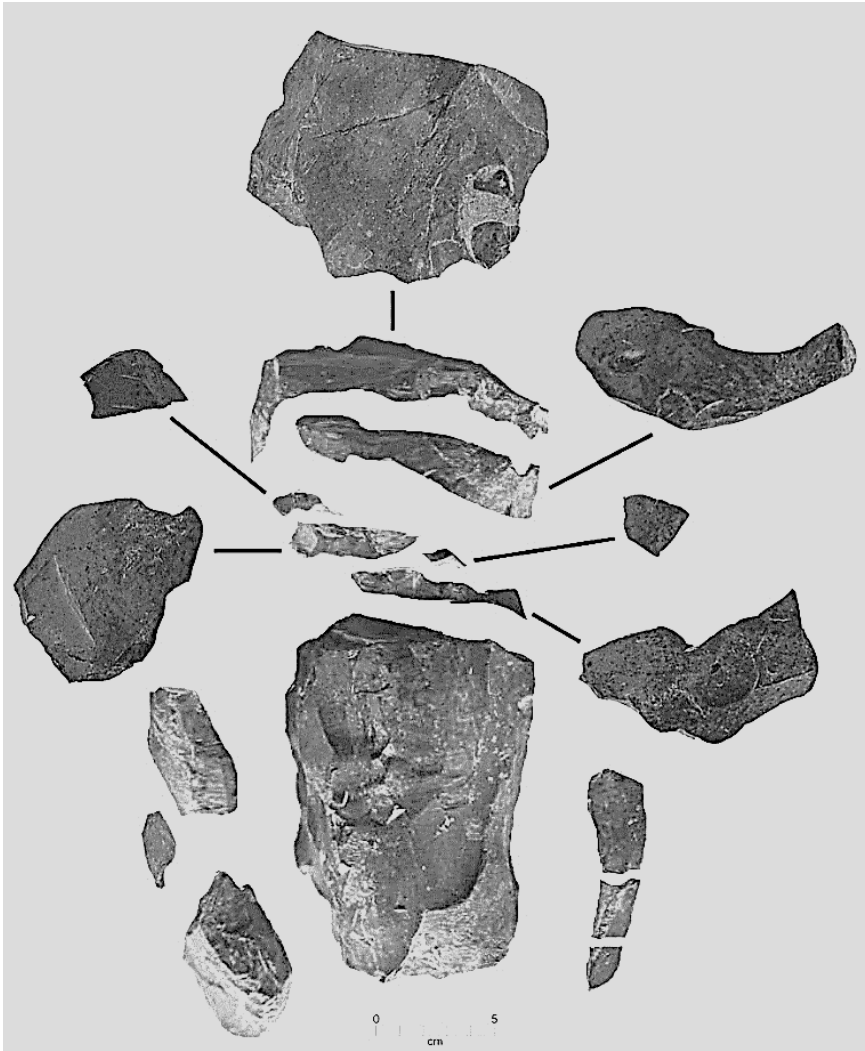

Figure 5– Successful refitting of a Clovis Blade core #17P1-13 from the Pavo Real Site, Texas (41BX52) (Composite photo adapted from Collins and Link 2003:162-173).

Some of the biface thinning flakes recovered at the Sheaman Clovis Site in Wyoming (Bradley 1982:204; Frison and Bradley 1999:111; Frison and Stanford 1982:143) were reassembled. This exercise provided evidence not only of how Clovis flintknappers serially spaced the removal of biface thinning flakes (Frison

1982:154), but also established the earliest claim that Clovis purposely overshot flakes as a biface flake removal technique (Bradley 1982:203-208).

Two large Clovis overshot flakes recovered from the Gault Site were successfully refitted during this study (Fig.6).

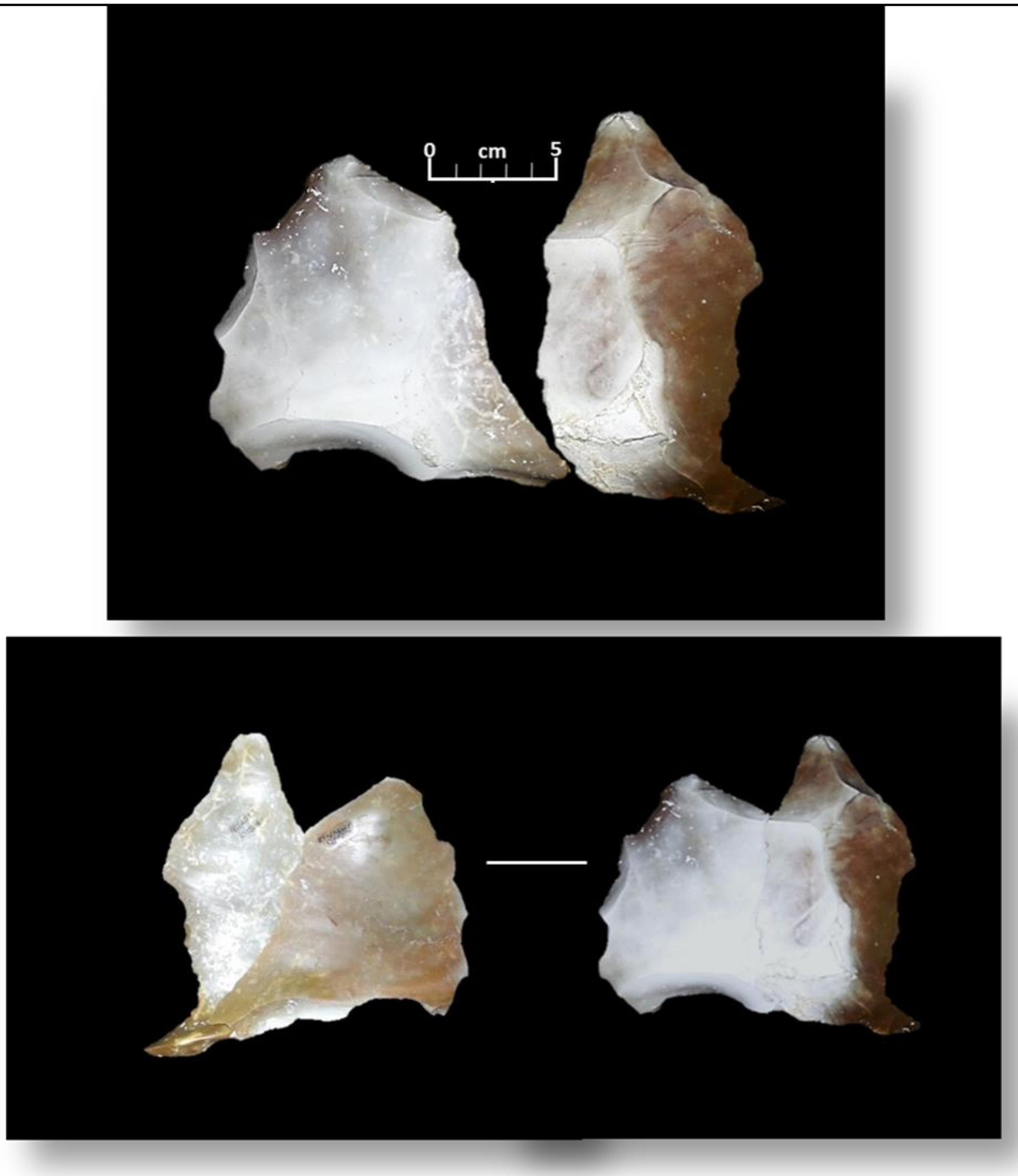

Figure 6 – Recent refitting attempts were successful of two large Clovis overshot flakes recovered from the Gault Site, Texas, 41BL323.

Clovis knappers adhered to most universal reduction practices to regularize bifaces and often strived for average width-to-thickness ratios of 3:1 or width-to-thickness ratios of 4:1 (Bradley, *et al.* 2010:64-65). While in general the thinness of Clovis bifaces do vary (Bradley, *et al.* 2010; 84-85), Clovis knappers preferred their bifaces to be proportional. As discussed earlier, there are technological distinctions found in flake scars of Clovis bifaces that provide clues as to how and/or what type of flake was removed. Flake scars such as those made by overshot terminations or full-face flakes, are for the most part reported in Clovis cached bifaces, but also from Clovis manufacturing sites (*see above* Fig. 4) (Frison and Bradley 1999; Huckell 2014:133; Lohse, *et al.* 2014b:153; *see also* Huckell and Kilby 2014). Occasionally, remnants of these overshot and full-face flake scars can be visible on used/abandoned Clovis points (Fig. 7) (Bradley, *et al.* 2010:64-65; Smallwood 2012:689-713).

Figure 7— Abandoned Clovis point from the Gault Site, Texas (41BL323) with visible overshot flake or full-face scar (Spec# UT-1040-113) (Photo by M. Samuel Gardner, used with permission from the Gault School of Archaeological Research).

The exact means by which Clovis knappers held or stabilized the bifaces as they worked or fluted them remains speculative (Bradley, *et al.* 2010:64).

However, we do know that Clovis knappers primarily used direct percussion for production shaping and thinning of bifaces. Pressure flaking, on the other hand, was most extensively used in reworking damaged points and tools (Bradley, *et al.* 2010:64, 96). As such, pressure flaking may be a technological trait that separates Clovis technology from later (post-Clovis) fluted technologies.

In early phases of biface production, Clovis knappers would remove a few large, well-spaced flakes (Bradley 1982:207; 2010:467; Collins, *et al.* 2007:103). As the reduction continued, the flakes that were being removed guided the next step. In order to flatten the biface, thinning flakes were removed that would have terminated just past the midline traveling across the thickest portion of the biface (Fig. 8). This may have been followed by another thinning flake, but this was removed from the opposite margin and would truncate and/ or completely remove previous termination scars. The classic Clovis biface outline would be maintained by shaping it from the removal of short percussion flakes along the margins. These flakes generally terminated well before the midline and helped adjust the margins as needed throughout production (Fig. 8.1 and 8.6).

Full-face flakes (Fig. 8.5) travelled through the thickest portion of the biface to the opposite edge without removing the opposite margin. This would thin the biface through the reduction of mass in relation to the proportion of width loss. Controlled overshot flakes (Fig. 8.3) not only reduced mass from the biface but a portion of the opposite edge. In order to control the outcome of a Clovis biface, techniques were combined to remove specific flake types throughout the reduction process to flatten (Pers. Comm. Bradley 2014) or maintain biface shape (Collins 2007:103). Occasionally, opposed alternating diving flakes (Fig. 8.2) terminated as a hinge, or step fracture, near the midline of the biface in order to enhance the thinning process. Thinning of the biface was also accomplished by intermittent removal of longitudinal thinning flakes from the basal edge (Fig. 8.4) throughout the reduction process (Callahan 1979; Bradley, *et al*. 2010:64-65; Huckell 2007:192).

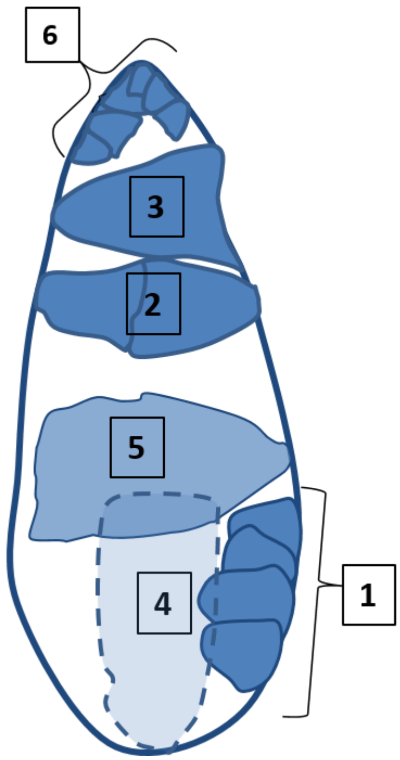

Figure 8– Schematic illustration of possible Clovis biface flaking options. (1 & 6) shaping flakes (2) opposed alternating diving flaking; (3) overshot flake (4) longitudinal thinning or channel flake; (5) full face flake; (*sensu* Bradley, *et al.* 2010:65).

Longitudinal thinning by removing a channel flake to create flute is essentially a thinning flake (Bradley 1993:254), and is often associated with Clovis (Fig. 9) and Folsom projectile points. However, fluting seems to be a specialized technology that is unique to early North American point production technologies (Stanford and Bradley 2012:29). Flute scars on Clovis points have been reported to occur on one or both faces (Bradley, *et al.*, 2010:66,89,95; Sholts, *et al.* 2012:3019). Fluting techniques have been well documented but these studies mainly explored post-Clovis fluting technologies such as Folsom of North America (*see* Clark and Collins 2002; Crabtree 1967a; 1967b; Crabtree 1966; Lassen 2013; Patten 2005; 2009).

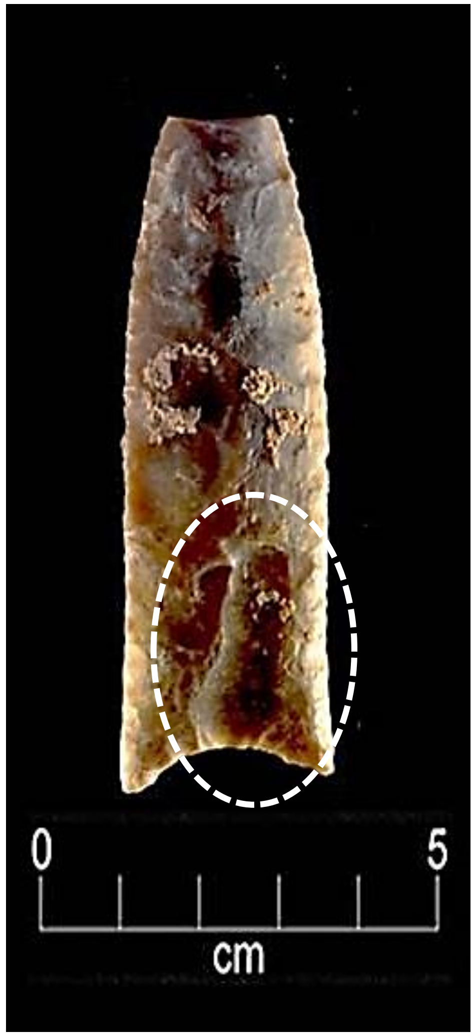

Figure 9 – Clovis point recovered from the Gault Site, Texas, (41BL323) exhibiting a flute or longitudinal thinning scar on the basal edge (Spec # UT 2624-1). (Photo courtesy of the Gault School of Archaeological Research)

With regard to Clovis biface technology, both end thinning and channel flakes are essentially the same type of longitudinal thinning flake. Several researchers have tried to clarify these differences between the two flake types. Flakes that were removed from the basal edge of a biface during early and middle phases of manufacture (Collins 1999b:17, fig.4C), are usually referred to as end thinning flakes (Bradley, *et al.* 2010:66), while the removal of channel flakes is usually removed during final and finish-out of projectile points (Morrow 1995; Stanford and Bradley 2012:52). However, Haynes (2002:83) describes the process of fluting as occurring in the 'middle stage' of Clovis biface production. Conversely, Huckell (2007:192) states that attempting to end thin during this stage does not constitute the specialized actions of 'true' fluting. With respect to the general differences between end thinning and channel or fluting flakes, there are no distinctions made in this dissertation as they both accomplish the same action of removing mass through thinning.

Clovis Biface Production Flakes

As discussed earlier, Clovis biface thinning flakes often retain reduction clues in their overall morphology – *e.g.* overshot terminations and large dorsal flake scars – as well as in the striking platforms. Biface thinning flakes observed in the Clovis archaeological record have been reported as exhibiting low dorsal flake scar counts (Bradley 2010:470). Furthermore, the dorsal side often retain material flaws or knapping error scars, such as hinges, that were skillfully removed by the knapper (Bradley 2010:469; Kooyman 2000:109). According to Bradley (1982:208) flakes that terminated as a hinge can be considered intentional if they occurred because of opposed diving flaking (Bradley 1982:208). These same flake types were later noted in the archaeological record at the Aubrey Clovis Site in Texas, (41DN479) (Ferring 2001:154).

In Clovis biface technology, longitudinal thinning in the form of end thinning flakes or channel flakes frequently retain hinged terminations. Hinge scars on the dorsal side of flakes can be easily identified as being produced by longitudinal thinning if the scar runs parallel to the lateral edges of the flake (Fig.10). This has been observed on Clovis overshot flakes and strongly suggests they were removed to 'clean' the biface of these scars (M.B. Collins, Pers. Comm. 2013).

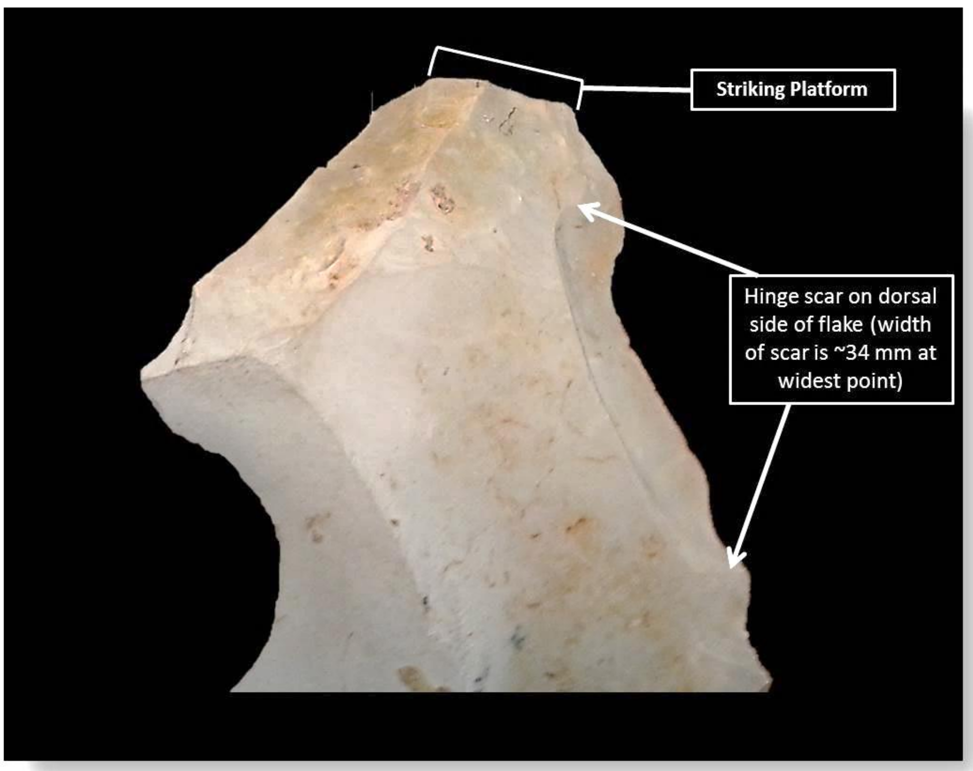

Figure 10 – A Clovis overshot flake from Area 4 at the Gault Site, Texas, (41BL323). Arrows point to a hinge scar (right lateral edge) that was likely caused by longitudinal thinning during the middle phase of biface reduction (Spec # UT-4384-4)

While channel flakes are a distinctive flake type, the technology can be ascribed to Clovis as well as some post-Clovis fluting cultures such as Folsom.

Overshot flakes are also distinctive and are considered one of the more interesting, and informative type of flakes produced in the Clovis biface reduction repertoire. The frequent occurrence of overshot flaking has been well documented. Overshot flakes have been recovered, but are often observed as prominent flake scars on bifaces, or are retained as dorsal scars on biface thinning flakes (Bradley *et al.* 2010:68-77; Eren, *et al.* 2011; Ferring 2001:151-154; Frison and Bradley 1999:31-35, 64-67, 85-89, 90-95; Hill, *et al.* 2014:79-106; Huckell 2007:190-191; Huckell 2014:133-152; Huckell and Kilby 2014:1-9).

It has been accepted that Clovis intentional overshot flaking is a technique known to occur during all phases of Clovis biface production, and the flakes vary in size and proportions (Bradley, *et al.* 2010:68). However, some consider it a flaking disaster or common mistake produced by all knappers (Bordes 1968:42; Callahan 1979; Eren, *et al.,* 2013; 2014; Sellet 2015; Whittaker 1994:163).

Striking Platforms

Blades are defined as a type of flake that is twice as long as they are wide (Bordes 1961; Collins 1999a:7; Bradley, *et al.* 2010:10-11; Williams 2014). Although blades are not included in this study, it should be noted that complex platform preparation traits on Clovis blades have long been considered a conspicuous characteristic of Clovis blade manufacture (Collins 1999a:5). While this statement is similar to what is being observed in striking platforms on biface thinning flakes, there are few supporting data in the matter.

François Bordes and Don Crabtree (1969) both experimented with possible techniques to remove large flakes observed in the “large, thin, precision flaked bifacial implements” (Bordes and Crabtree 1969) of the Simon Cache (Butler 1963). Both were struck by the “incredibly large, rapidly expanding flakes” which had been removed “from both faces and all margins” (Bordes and Crabtree 1969:10-11). Bordes and Crabtree (1969:11) agreed that Clovis knappers’ technique for removing such flakes must have been “unique” because the platforms, which were very small in relation to the flake body, had to be “strong enough to withstand the force” needed to remove them.

Based on observations of Clovis biface thinning flake platforms, they may retain preparation traits that are easily recognized (Hall 2000). Clovis flake platforms have often been described as having wide, straight platforms, that are sometimes faceted, often isolated, and ground. Bradley, *et al.* (2010:66) defines the platform of a “typical” Clovis thinning flake as being “ground, projected, isolated, reduced, faceted, released, and straight” (Fig.11). Previous observations of preparation on Clovis flake platforms has been primarily associated with channel flakes (Morrow 1995), as well as overshot flakes where the grinding on platforms appears as quite heavy or “frequently extending from the platform surface around to the proximal dorsal surface” (Bradley 2010:470).

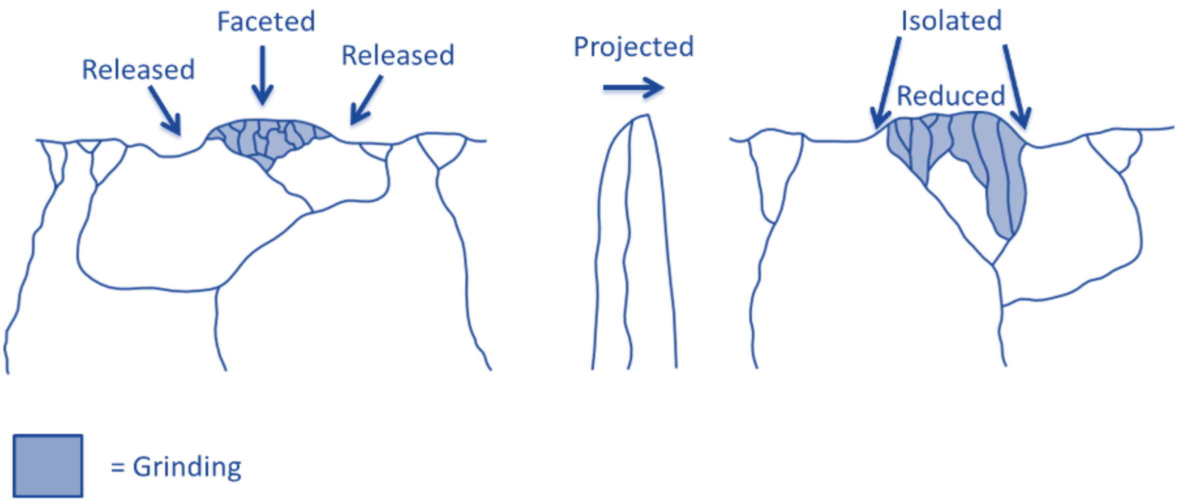

Figure 11 -- Illustration depicting complex platform preparation traits on a Clovis biface margin (Adapted from Bradley, et al. 2010:67).

Overshot Terminations: Flake Type or Technique?

As discussed in the previous section, one of the most fascinating flakes identified as part of Clovis biface technology is the overshot flake. Understanding the use of controlled overshot flaking as a technique continues to challenge researchers. However, before discussing overshot flaking in Clovis biface production, the use of the term "overshot" should be explored.

In terms of Clovis technology, Bradley, *et al.* (2010:68) describe an overshot flake as a piece that when struck travels from "one margin across a face of a biface (or any other form)" ultimately removing the opposite margin of the parent piece. However, Inizan, *et al.*, (1999) describe overshots as a "plunging" flake where the termination arches "sharply" forward. Inizan, *et al.* (1999) acknowledge that overshooting a flake can be either accidental or intentional, and moreover, their existence within an archaeological assemblage reveals a great deal regarding technical behaviors and methods applied by individual knappers (Inizan, *et al.* 1999:151).

Regardless of being technological, morphological, or a fatal error, the use of the terms “overshot” and “plunging” are synonymous within the realm of fracture mechanics, specifically the load, force, and energy that is required to create them (Baker 2000; 2003). The key is recognizing the differences between flake technology and flake typology. In an effort to create a suitable distinction in this study, the term “plunging flake” (Fig. 12) will be used to describe a flake type that dives prematurely, sometimes to a disastrous outcome (Callahan 1979; Eren, *et al.* 2011; Morrow 1995). The term “overshot termination” will be used, mainly in Chapter 7 of this study, to describe a flake termination type.

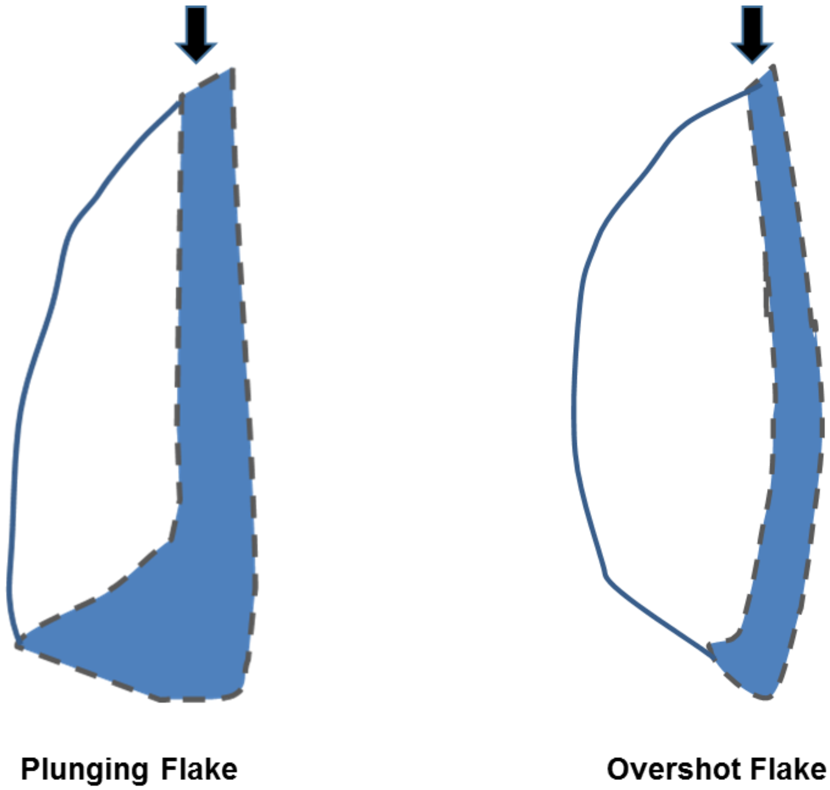

Figure 12 – Simplified schematic showing the possible mass removal differences between a plunging flake and an overshot flake.

Plunging flakes can have catastrophic results and have been identified in Clovis biface assemblages (Bradley, *et al.* 2010:72) and usually occur as end-shock during removal of end thinning or channel flakes (Eren, *et al.* 2011; Morrow 1995). This can be a result of many factors such as improper platform preparation, material inconsistencies, poor load delivery and/or low-skill; or in simple terms, if the force load doesn't deliver enough energy, that energy instead may rapidly dissipate thus causing the flake to terminate prematurely. Plunging flake failure can occur during longitudinal thinning when it dives prematurely, *i.e.* at the medial section of the biface plane, removing the distal end of the biface (Fig. 13).

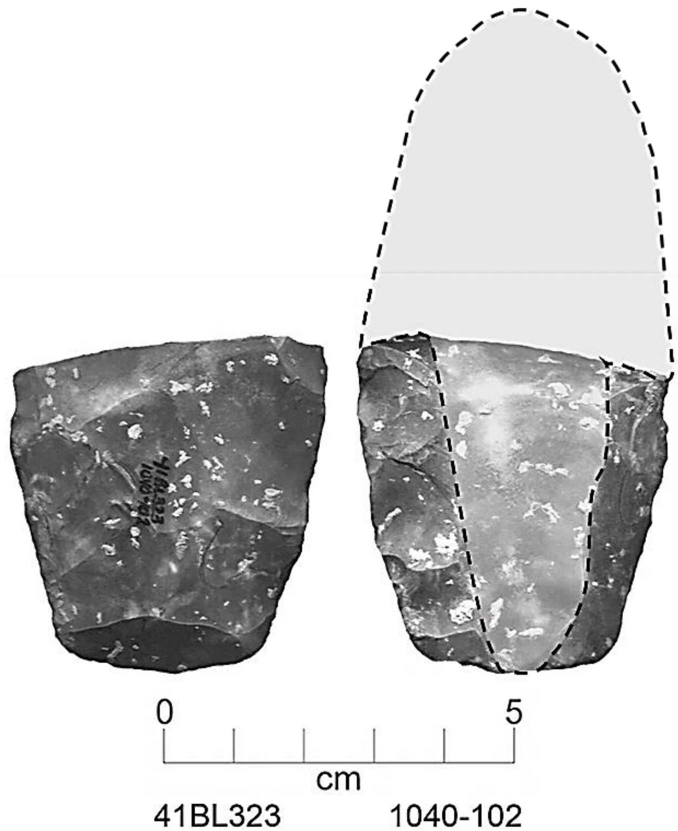

Figure 13— A discarded proximal fragment of a Clovis preform from the Gault Site, Texas (41BL323) exhibiting evidence of a catastrophic plunging flake failure caused by longitudinal thinning. The shaded area is a reconstruction of the missing distal portion. (Photo by M. Samuel Gardner, and used with permission from the Gault School of Archaeological Research)

Some morphological characteristics can help distinguish between a plunging failure (Fig. 13) and a failed overshot flake (Fig.14). A failed overshot flake will likely retain very specific morphologies. For example, where the lateral “shearing” in two of a biface occurs (*see also* Callahan 1979:135, figure 62.4CIIbii(2)).

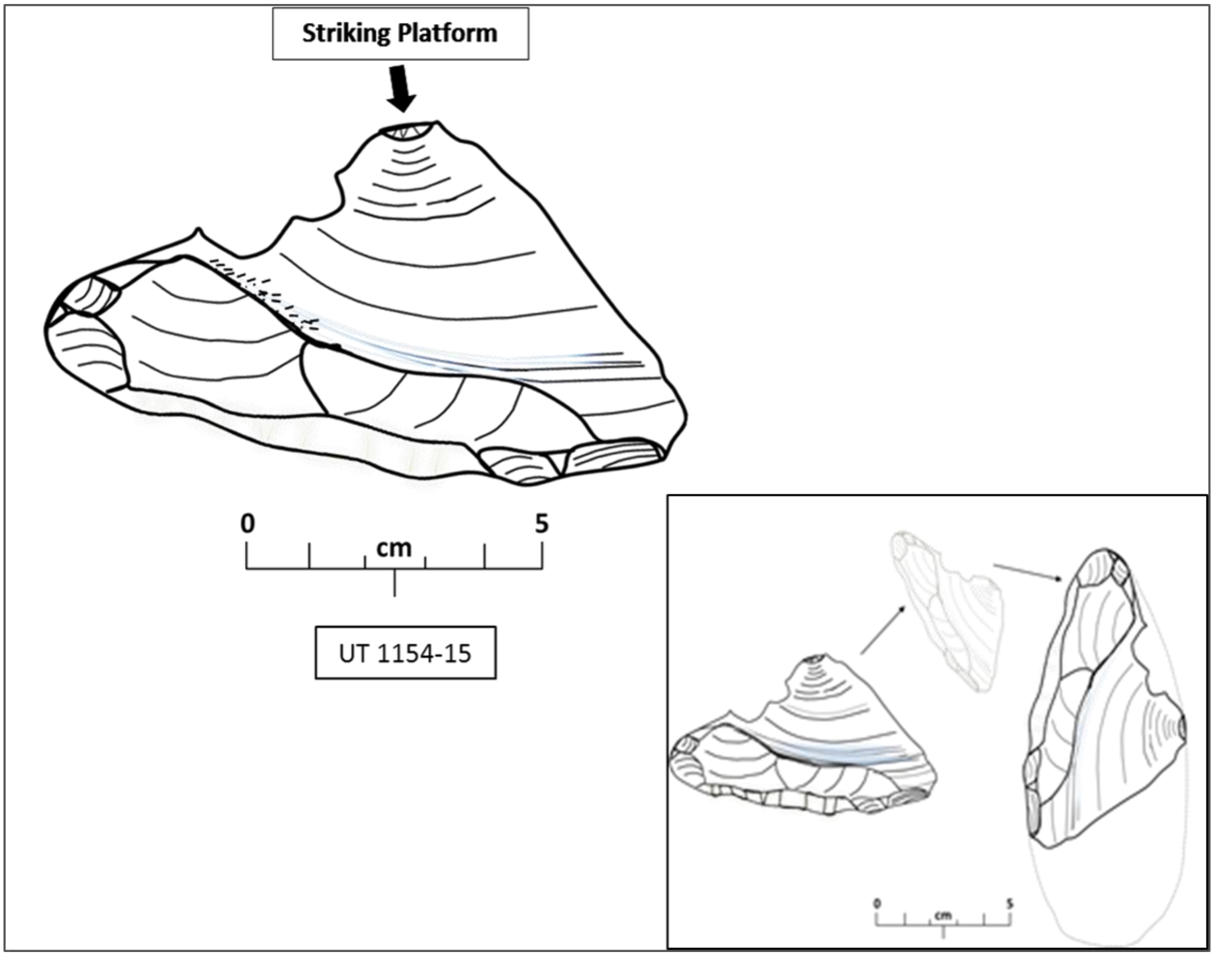

Figure 14— Drawing of a failed Clovis overshot flake that ruined a biface. Inset is probable reconstruction of original size of biface. (Drawn from Spec. No. UT-1154-15).

Some Clovis flakes have been identified as “partial cortical” overshot flakes (Waters, *et al.* 2011a:83) and the terminology confuses what is technically a plunging flake. As a Clovis reduction technique, the plunging flake was likely employed in a controlled manner by Clovis knappers to remove cortical edges or square edges (Bradley, *et al*. 2010:71; Wilke, *et al.* 1991:242-272) which are physical properties common to Edwards chert that can be found in nodule, cobble, or tablet forms.

This section addressed common terminological issues and discussed differences associated with the terms “overshot flake” and “plunging flake.” While it is a matter of perspective, the term “plunging” or “plunging flake” will refer to the mechanical agent associated with brittle fracture of stone. With regard to the term “overshot flake,” it is acknowledged that it is also a plunging flake (Inizan, *et al.* 1999), but in the field of debitage analysis, ‘overshot’ is a classification of flake termination that differentiates it from other commonly used flake terminations like “feathered,” or “hinged” (Brezillon 1968; Bordes 1961).

It is apparent the term “overshot flake” has become a dichotomy used to describe a flake type as well as a controlled flaking technique with respect to Clovis biface technology (Bradley 1982:203-207; Frison 1982:152; Bradley and Stanford 2006; Wilke, *et al.* 1991; Wilke 2002:247). For the purposes of this research, the use of the terms “overshot” or “overshot flake” will be used in this manner but distinctions will be made where appropriate.

Chapter 2 -- Exploring the Interpretive Potential of Clovis Waste Flakes

Most lithic analysts agree that platform bearing flakes retain clues about knapping technologies (Andrefsky 2001:10; 2005:15-18, 91-96). Clovis technology experts agree that Clovis knappers frequently invested effort before removing flakes by preparing striking platforms (Bradley *et al.* 2010:66; Collins 1999a:66; Huckell 2007:197; Morrow 1995) thereby exerting control over the removal of manufacturing flakes which includes mastering control of overshot flaking (Bradley 2010:466). However, the extent of use or distribution of striking platform (platform) preparation traits on flakes remain ambiguous and as such, expose a critical need for basic quantitative and comparative data particularly from Clovis workshop settings.

Observational data of the archaeological record has played a key role in informing researchers about Clovis technology. This is particularly true regarding platform preparation traits. Platform preparation traits are frequently reported in Clovis biface reduction flakes and as a result, these common observations have become assumptions (Bradley, *et al.* 2010:66; Bradley 1991:369-373; 2010:463-497; Collins 1999a:46; Hall 2000; Hemmings 2007:83-137; Huckell 2007; 2014; Morrow 1995). As such, questions exist as to whether Clovis knappers were consistent in their application of platform preparation traits, and if platform traits were applied uniformly across flake types. To rectify this, a model was developed on individual flake platform details, (*e.g.* -- by flake phase and by flake type) of biface manufacturing flake data from a well-documented Clovis workshop/encampment site known as the Gault Site (41BL323) in Texas (Collins 2002). These study data reveal the extent and nature of platform preparation traits and techniques observed from dense Clovis deposits produced from tool manufacturing activities at the Gault Site. These platform preparation trait and flake data can serve as a comparative model between other Texas Clovis sites (Mallouf 1989; Masson 1998, Jennings 2012), as well as older-than-Clovis and post-Clovis stone tool cultures.

Aims and Objectives

Theoretically, manufacturing debris at Clovis sites located at or near tool stone sources, provides an ideal opportunity to examine Clovis biface manufacturing technology (Bradley, *et al.* 2010:56). The data gaps associated with Clovis biface technology forms the basis of this research.

Aims

1. Elucidate empirical and observational evidence reported on Clovis biface manufacturing flakes and striking platforms (platforms).
2. Examine lithic assemblages from secure Clovis components at the Gault Site for evidence of manufacturing debris related to primary biface production activities.
3. Conduct an in-depth data collection and subsequent statistical assessment of Clovis biface reduction flakes that focuses on individual attributes and platform traits using acceptable standards and methods in the field of debitage analysis.
4. Enhance our understanding of Clovis biface technology from the perspective of manufacturing debris through comprehensive analysis of individual waste

flakes that can be applied to the broader acuity of Clovis biface, blade, and flaked stone tool technologies.

Objectives

1. To identify particular issues, turning points and advancements based on previous literature regarding the field of debitage analysis and how it relates to and/or affected Clovis debitage studies.
2. To review all documentation concerning Clovis excavations from the Gault site in order to identify an area with clearly defined Clovis stratum and workshop debris.
3. To assess current database and artifact inventory records to help determine sample size.
4. To create a coding form based on Bradley (2009:414) in order to collect and record multiple independent variables of flake attributes and individual platform preparation traits on Clovis biface production debris.
5. To compare and contrast these variables across flake phase and type to determine if any patterns exist during biface manufacture.
6. To explore how the data contribute to and enhance our understanding of Clovis technology.

Research Validation

Our understanding of platform preparation traits has been largely influenced by expert research and first-hand experience, and as such, can be summarized as follows in order of year published (respectively):

1. (Bordes and Crabtree 1969) -- François Bordes and Don Crabtree's (1969:10-11) experimental work included observations of the Simon Clovis biface cache (Butler 1963) and remarked on the large flake scars describing them as "rapidly expanding" with "small platforms." Their comments were the earliest published suggestions that Clovis intentionally prepared small platforms but that they had to have been very "strong" to withstand the energy load needed to remove such large flakes (Bordes and Crabtree 1969:10-11)
2. (Frison 1982) --Frison states, "[A]n unusual amount of platform preparation [of a Clovis channel flake] in relation to other [Clovis] flakes" (Frison 1982:153).
3. (Bradley 1991) -- "Early stage biface thinning flakes have wide, straight platforms that are faceted, reduced and ground (often heavily)" (Bradley 1991:373).
4. (Morrow 1995) -- "The key to Clovis biface thinning lies in specially prepared striking platforms" … "[for] the successful removal of biface thinning flakes. "Isolation of the striking platform focuses the [energy of the] percussion blow…" (Morrow 1995:173).
5. (Collins 1999a) -- "[M]inimal platform preparation" was used during early stage biface reduction, and "Platforms were produced by roughly chipping a bevel along the edge, with platform grinding used increasingly as flaking progressed" (Collins 1999a:46).
6. (Hall 2000) – Dennis Stanford remarks that Clovis [flake] platforms are "very wide, very well set up and very heavily ground." (Stanford In: Hall 2000).

7. (Kooyman 2000) -- “Early stage [Clovis] thinning flakes have wide, straight platforms and are faceted and heavily ground” (Kooyman 2000:110).

8. (Ferring 2001) -- Regarding flakes recovered at the Aubrey Clovis site, located in north Central Texas; in “Area G,” the debitage were observed as having “finely facetted [sic] and ground platforms” (Ferring 2001:133 [Table 9.5:G-1]).

- (Collins and Hemmings 2005) -- “As flaking progressed, platforms for the removal of large thinning flakes were sometimes isolated and more commonly ground, resulting in bifacial thinning flakes with small, ground platforms” (Collins and Hemmings 2005:10).

9. (Huckell 2007) –

    a. With regard to knapping clusters identified as associated with bifacial retouch Huckell states “These flake clusters are typified by thin, expanding flakes with faceted striking platforms, often strongly lipped and abraded” (Huckell 2007:189).

    b. There were “three clusters of debitage from Murray Springs [that are] interpreted as representing projectile point manufacture or repair ... interestingly, almost no abraded striking platforms are observed on any of these flakes [and] the striking platforms are only slightly convex [and] not particularly well isolated from the surrounding margin” (Huckell 2007:197).

10. (Bradley, *et al.* 2010) -- “A ‘typical’ Clovis thinning flake platform is projected, isolated, reduced, faceted, released, straight and ground” (Bradley, *et al.* 2010:66).

Research Hypotheses

Based on the aims and objectives of this research, two distinct hypotheses were tested:

Hypothesis 1

Null

Clovis knappers applied, in a consistent means, a complementary suite of platform preparation traits before striking and removing flakes during biface manufacture.

Alternate

Clovis knappers did not consistently apply a complementary suite of platform preparation traits before striking and removing flakes during biface manufacture.

Hypothesis 2

Null

The observations and interpretations reported by Bordes and Crabtree (1969:10-11), Bradley *et al.* (2010:66), Bradley (1991:373), Collins (1999a), Collins and Hemmings (2005:10), Ferring (2001:133), Frison (1982:153), Huckell (2007:189,197), Kooyman (2000:110), Morrow (1995:173), and Stanford (Hall 2000), are an accurate reflection of the nature of preparation traits commonly observed on Clovis biface flake platforms and is supported by the data in this study.

Alternate

The observations and interpretations reported by Bordes and Crabtree (1969:10-11), Bradley *et al.* (2010:66), Bradley (1991:373), Collins (1999a), Collins and Hemmings (2005:10), Ferring (2001:133), Frison (1982:153), Huckell (2007:189,197), Kooyman (2000:110), Morrow (1995:173), and Stanford (Hall 2000) do not accurately reflect the nature of preparation traits commonly observed on Clovis biface flake platforms.

This research is a positive step forward that will expand current knowledge of Clovis technology by addressing specific data gap issues using both quantitative and qualitative production flake data directly related to Clovis biface manufacture. This research will contribute a greater understanding of the reductive processes associated with Clovis biface flaked stone manufacturing techniques used at the Gault Site that can be used as a comparative baseline for intra-site and inter-site use.

Chapter 3 -- Debitage Analysis

Flakes or Debitage?

Stone tool production waste flakes are often referred to as debitage, a term adapted from the French word *débiter* (*v*) meaning to dispense or discharge (Oxford Dictionary online 2014). French prehistorians' use of the term *debitage* describes the action of being detached -- *e.g.* 'preferential' flakes (Inizan, *et al.* 1999:30; 65-67) -- from knappable raw materials for intentional fabrication of stone tools (Bordes 1961:13-16; Brezillon 1968:93-99; Heinzelin de Braucourt 1962:6). For the purposes here, the term *debitage* is used interchangeably with the term *flakes* or *flake* and will be differentiated where appropriate either collectively or individually (Shott 1994:70).

Debitage Analysis – What Flakes Can Tell Us

Every artifact has a story to tell (Fagan 2006:17) and therefore, examination of all flaked stone tools including all associated debris is essential for properly interpreting the archaeological record (Bordes and Crabtree 1969:1). Analysis of flaked stone assemblages can provide evidence to help understand explain human prehistoric stone tool cultures, how they lived, socialized, moved, exploited, and worked local and non-local tool stone sources (Magne 2001:21).

All archaeological sites are unique; formed through site use (Whittaker and Kaldahl 2001:49) and by waste-generating activities such as stone tool production, tool-use and, discard (Renfrew and Bahn 1996:305). Other factors contribute to site formation such as post-depositional actions like trampling (Odell 2003:67-69) and cumulative effects of organic litter, formation, and deflation of soils, and faunal-turbation (Wood and Johnson 1978).

However, despite a site's uniqueness, most prehistoric archaeological sites are composed of similar artifacts such as stone tools and any associated flaked stone debris (Bradley 1975:5). The debris often makes up the vast majority of flaked stone tool assemblages (Andrefsky 2005:1; Odell 2003:118). Unless otherwise disturbed, flakes struck from a core usually remain where they fell (Almeida 2005; Brezillon 1968:93; Henry *et al.*, 1976:61). Flakes *en masse* are usually stable in that they are reliably copious (Boldurian and Cotter 1999:37; Odell 2003:120), and are generally repulsive to relic hunters (Shott 1994:71).

In analytical lithic hierarchies, the sluggish rise of the "lowly" flake (Baker 2006) resulted from the recognition by some lithic technologists of behavioral information that flakes and debitage preserve (Crabtree 1972:1). It is known that flakes produced by bifacial or core reduction activities often exhibit traits that provide clues that can be associated with specific flaked stone tool industries (Frison 1982:153-54).

Theoretically, an individual flake can retain more diagnostic clues than flake scars on stone tools themselves (Crabtree, 1972:1; 1975:106, Odell, 2003:88). For example, some of the oldest stone tools of Middle Palaeolithic Neanderthals (Mortillet 1869:172) employed a technique of core reduction known as Levallois technology (Bordes 1968:30). Levallois technology has been extensively documented and has been defined as an "industry of flakes" (Sonneville-Bordes 1961:77; Fish 1979:32). Some Mousterian age sites indicate the presence of flake-production to make tools using specially shaped Levallois cores to facilitate the removal of distinctive, thick, flakes (Eren and Lycett 2012; Whittaker 1994:30-32) that were then modified into tools (Bordes 1961:2, 13, 71-72).

Debitage analysis is defined as the systematic study of waste and debris produced from flaked stone tool manufacture, use, and maintenance. Michael J. Shott (1994; 2004) provides a fine historical synthesis on analytical approaches to flakes and debitage. Analysis of debitage can be accomplished through a number of methods using sorting, measuring, counting, weighing, and may include qualitative and quantitative data (Boisvert 1985:1-103). Debitage, especially flakes in large quantities, affords analysts a surplus of raw data that makes it an ideal sampling medium for statistical analyses (Boldurian and Cotter 1999:37).

With the surge of academic experimental flintknapping during the 1950s and 1960s, (Andrefsky 2005:4; Jelinek 1965), some sporadic developments have positively affected the progress and advancement of debitage analysis. The development of theoretical and philosophical perspectives (Crabtree 1966; 1967a; 1967b; 1972) fell upon a few archaeologists who recognized that all flaked stone artifacts and debris were fundamentally linked to understanding the archaeological record (Bordes 1961; Bordes and Crabtree 1969; Bradley 1972; 1975:5-13; Crabtree 1972; 1975; Collins 1974; 1975:15-34; Fish 1979; 1981; Wilmsen 1970).

By the mid-1970s and into the 1980s experimental flintknapping was firmly ensconced in the field of lithic analysis (Andrefsky 2005:8; Jelinek, *et al.* 1971; Johnson 1978). Experimental flintknapping provided lithic analysts a viable means to address problems in the archaeological record (Jelinek, *et al.,* 1971; Outram 2008). However, with few exceptions, (Henry, *et al.* 1976; Patterson and Sollberger 1978) methods and approaches for examination of and management of vast amounts of debitage saw no tangible standard industry practices being tested or developed during this time.

Eventually this problem reached a crisis point. In 1985, Alan P. Sullivan and Kenneth C. Rozen (1985) wrote and published an article that threw debitage analysis into the pitch of analytical debate (Andrefsky 2001:1). Their *American Antiquity* article was a critical turning point for debitage analysis. By proposing a new method, now known as the Sullivan and Rozen Technique, or SRT, Sullivan and Rozen (1985) were attempting to address serious problems with standards of practice for analyzing debitage (Shott 1994:78). Put simply, the SRT method was a form of individual flake analysis that provided an objective approach to flake classification, but unfortunately, no theoretical basis was discussed for the application of this typology (Ahler 1989:87).

The SRT method was met with criticism and an unequivocal backlash, (Amick and Mauldin 1989a; Prentiss and Romanski 1989). In spite of the reproach for the SRT, it brought about much needed attention to the field by compelling lithic analysts to rethink all practices and principles (Andrefsky, 2001:2-3) associated with debitage analysis (Andrefsky 2001; 2005; Amick and Mauldin, 1989b; Bradbury and Carr 1995; Hall and Larson 2004; Ingbar, *et al.* 1989; Odell 2003; Henry and Odell 1989).

As a subfield of lithic analysis, any examination of by-products generated from flaked stone tool manufacture comprises the basis of debitage analysis. A general standardization of terminology and flake types (Andrefsky 2005:86) have developed through time (Andrefsky 2001; 2005; Crabtree 1972; Inizan, *et al.* 1999; Marois, *et al.*, 1997; Shott 1994), as have reliable techniques of measurement (Andrefsky 2005:100-01; Inizan, *et al.* 1999:107).

Along with the proposed SRT, a variety of methods have been tried and tested providing options for lithic analysts to choose or combine, to deal with individual specimens or entire populations (Ahler 1989; Andrefsky 2005:113; Henry and Odell 1989).

Vast amounts of debitage in the archaeological record can be an overwhelming nuisance (Whittaker and Kaldahl 2001:32-60). Lithic analysts on some level might assume fleeting empathy for those scholarly predecessors who rarely noticed 'flake chips', or recorded them as rubbish (Stevens 1870:104, 511), ignored them altogether, or worse, tossed them away (Wilmsen and Roberts 1978:16).

There is no "best" method or approach to deal with debitage. Nevertheless, there are options to deal with particularly large amounts of debitage such as mass analysis or "aggregate analysis." Aggregate analysis is used to sort through vast amounts of debitage using a graduated series of screens (Henry, *et al.* 1976). The most positive aspect of aggregate analysis is the reduction of time spent sorting, examining, and weighing artifacts (Odell 2003:130).

On the other hand, if issues exist such as mixing of knapping activities within the archaeological record (Andrefsky 2007:392-402), technological or other trait data may be overlooked if using only aggregate analysis (Andrefsky 2007; Odell 2003:131-32). As such, aggregate analysis may fall short, unless there is allowance for initial organization of flakes and debitage such as sorting by technological contexts, traits or by tool maintenance activities (Andrefsky 2005:140). Some approaches may be more suitable than others (Andrefsky 2001:13), contingent on a number of factors such as time, money, or research objectives (Ahler 1989:85-118). However, combining aggregate (or mass) analysis with individual flake analysis -- (Andrefsky 2005:142; Bradbury and Carr 2004) is likely the best holistic approach to analyzing debitage (Odell 2003).

Other subtleties can also be inferred from analyzing debitage in the archaeological record which provide insight into toolstone economy, stone tool technology, tool use, and maintenance (Collins 1998c; 1998b; Ferring 2001:124; Huckell 2007:170; Hemmings 2007:83). In addition, manufacturing behaviors and unusual knapping techniques can be inferred via the presence of flaked stone debris, including stone tool production failures (Aubry, *et al.* 2008). Reassembling of flake reduction sequences (Almeida 2005:41-42) can also provide clues into individual or group skill levels of knappers (Frison 1982; Lohse 2010:161; Whittaker and Kaldahl 2001:32).

Despite the tremendous progress made during the past three to four decades, analyzing debitage is no less a tedious endeavor (Whittaker and Kaldahl 2001:33), but an endeavor well worth the effort. Recording individual flake variables from hundreds of biface thinning flakes is time consuming, but the data is worth collecting. While individual flake analysis is considered useful, it is rarely undertaken. Instead, the standard practice remains either graduated sieves or counts, weights or cluster analysis. However, none of these would expose a Clovis technology manufacturing process.

Chapter 4 -- The Gault Site

The Gault Site is located in Central Texas in the southwestern portion of Bell County, near the small town of Florence, approximately forty miles north of the state Capital of Austin, Texas (Fig.15). The Gault site is a multicomponent site and has a well-documented record of prehistoric stone tool cultures known in the Central Texas region initially ranging from Clovis to Late Prehistoric (Fig. 16) and more recently, the discovery of even older cultural materials below the Clovis horizon (Collins, *et al.* 2013:521-539).

Excavations at the Gault site have occurred intermittently since 1991 until April of 2013 when Area 15 excavations were concluded. The course of investigations has revealed information regarding the geoarchaeological integrity of the Gault site and as such, the understanding of the geologic formations and hydrologic activities of Texas informs our interpretations of why early Texans were drawn to this Central Texas region.

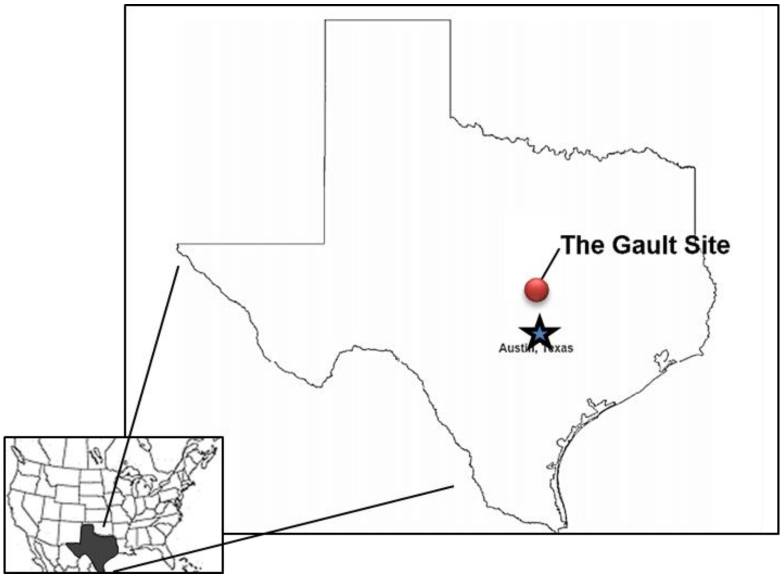

Figure 15 -- The location of the Gault Site (41BL323) relative to the Texas State Capital of Austin, U.S.

RCYBP	Texas Archaeological Periods and Subperiods	Associated Point Types		
	LATE PREHISTORIC	Perdiz		
		Scallorn		
1000		Edwards		
	LATE ARCHAIC	Darl		
2000		Ensor, Frio Montell		
		Marshall		
3000		Pedernales		
		Bulverde		
4000	MIDDLE ARCHAIC	Nolan		
		Early Triangular		
5000		Calfcreek	Bell	Andice
6000	EARLY ARCHAIC	Martindale		
7000		Early Split Stem		
8000		Angostura		
	LATE PALEOINDIAN	St. Mary's Hall		
		Golondrina		
9000		Wilson		
		Dalton		
10,000	EARLY PALEOINDIAN	Folsom		
11,000 12,000 13,000		Clovis		
		Older-Than-Clovis		

Figure 16 – Basic chronology of Central Texas Archaeology (*sensu* Collins 2004:101-126.

Geology of Texas and the Gault Site

Physiographic Setting

The Edwards Plateau (Fig. 17) is a prominent limestone feature in Central Texas, and forms part of the Southern High Plains periphery (Collins 2007:74).

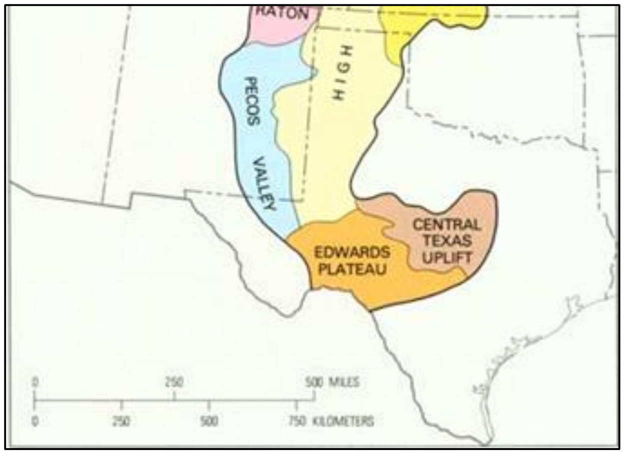

Figure 17— Edwards Plateau region relative to the Southern High Plains (Color overlay of Great Plains is modified from Trimble 1980. Used with permission from the U.S. Geological Survey, Dept. of the Interior U.S.G.S., U.S. Geological Survey).

The Edwards Plateau is one of the most abundant sources for high quality chert in North America (Banks 1990:59). The plateau forms the eastern upland boundary that abuts the rolling Gulf coastal plains (aka Texas Blackland Prairie) that spread south and east into the Gulf of Mexico. These adjoining landscapes form a transitional line known as the Balcones Ecotone (Fig. 18) and attracted prehistoric people for millennia for its wide range of floral and faunal resources as well as other amenities in the form of limestone rock shelters, quality raw toolstone, rivers and artesian springs (Collins 2002; 2004:103; 2007:74).

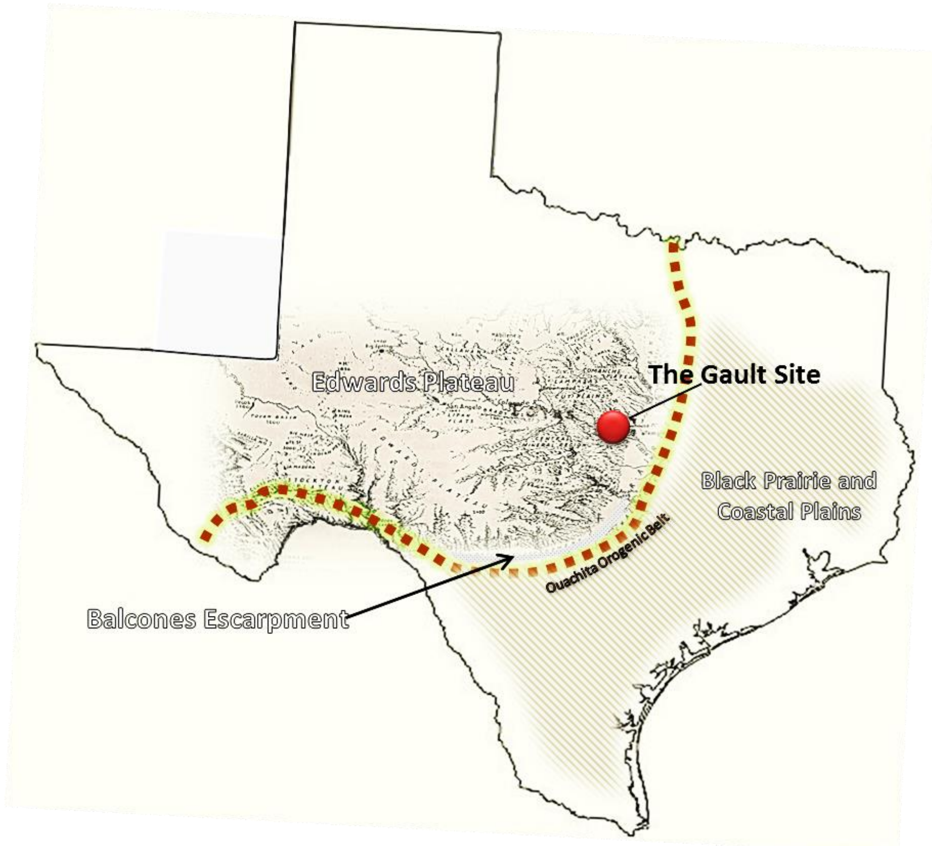

Figure 18—Edwards Plateau and Coastal Plains (*sensu* Collins 2002)

Regional Geology and the Texas Landscape

The Jurassic period in North America saw dramatic geologic events that included the formation of the Cordilleran Mountain belt along the Pacific west margin of North America (Fig. 19). Tectonic shifting, (continental colliding, and rifting) triggered mountain building events along the Pacific margins (Stoffer 2003). These geologic events created a basin in the middle of the North American continent. Around 115 million years ago during the Early Cretaceous, the basin flooded with seawater from both northern and southern inlets of the North

American continent (Fig. 19) forming an inland water feature known as the Western Interior Seaway (WIS) (Rice and Shurr 1983; Stoffer 2003). At its peak, some 80 million years ago, this inland ocean stretched from the Arctic Ocean all the way to the Gulf of Mexico and covered most of, or perhaps the entire area that is now Texas (Cobban and McKinney 2013; Ferring 2007; Rice and Shurr 1983).

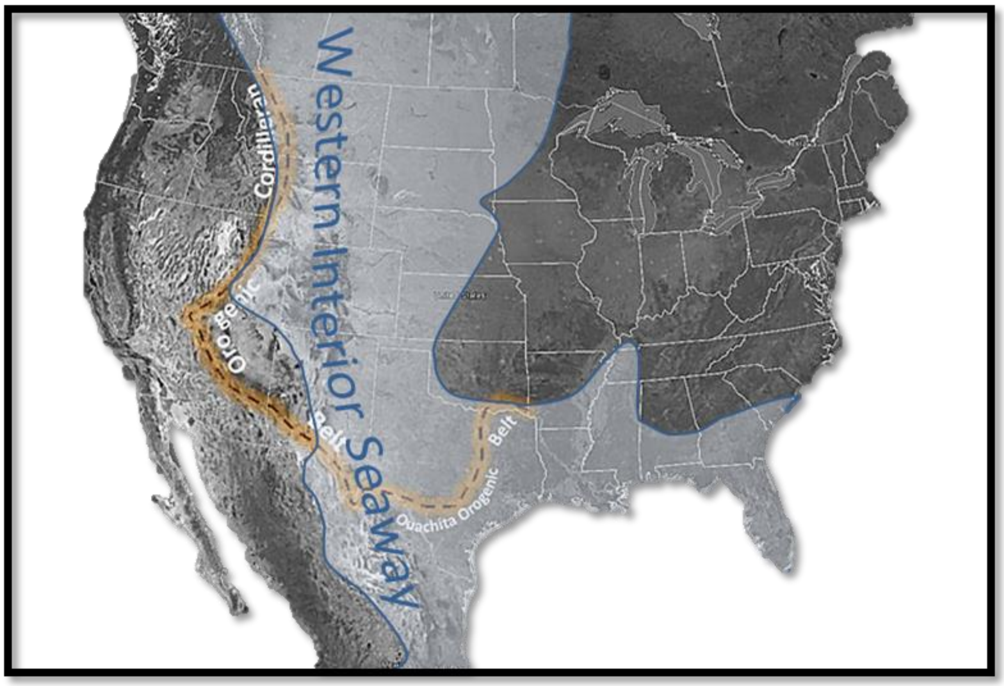

Figure 19— Composite illustration showing the Cordilleran and Ouachita Orogenic belts and their relevance to the Western Interior Seaway shown at its most extensive point. These events respectively helped formed the geology of the Great Plains, as well as the Central Texas Region of the Edwards Plateau (The extent of the WIS is based *sensu amplo* on Cobban and McKinney, 2013, U.S. Geological Survey, Dept. of the Interior/USGS)

The depositional remnants of the WIS are still visible in the modern landscape of Central Texas. Limestone features formed under the warm shallow waters of the WIS from layers of thick marine carbonate and chalk sediments that were laid down during marine transgressive episodes (Ferring 2007).

Regression/transgression episodes also caused massive amounts of water to down cut into the eastern edges of the Edwards Plateau transporting sediments that were deposited to the east forming the Coastal Plains (Ferring 2007).

A topographic limestone feature known as the Balcones Escarpment formed along a fault zone that separates the Edwards Plateau from the Gulf Coastal Plains (Woodruff and Abbott 1979; 1986). The fault zone -- known as the Balcones Fault Zone -- tracks along the same axes of the buried Ouachita orogenic belt (Fig. 19 & 20) that formed during the Late Paleozoic (Budnik 1986; Ferring 2007).

The juxtaposition of the Balcones Escarpment, which follows along the buried axes of the ancient Ouachita Mountains, (Fig. 20) forms part of the Edwards Plateau water regeneration zone that recharges the Edwards Aquifer. For instance, as rainwater sieves through the karstic Edwards limestone it eventually contacts with impermeable Comanche Peak limestone, where water is forced out as artesian springs along drainage areas from the edges of the plateau (Swanson 1995:23-28; Woodruff and Abbott 1986).

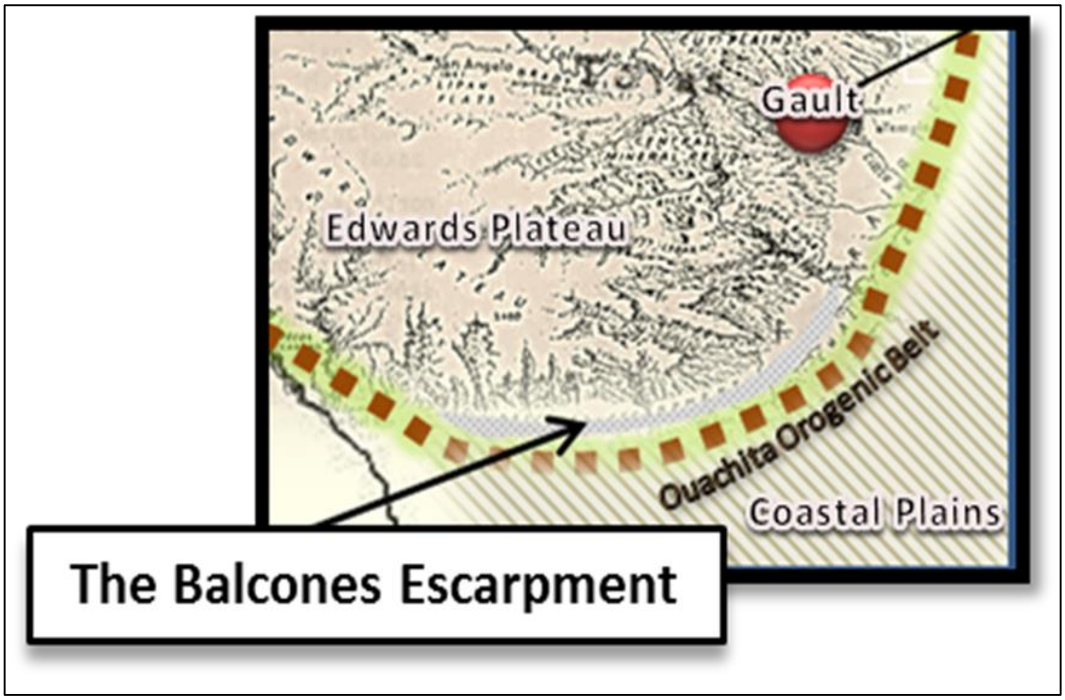

Figure 20– Illustration showing the formative association between the Edwards Plateau, the Balcones Escarpment, and the Balcones Fault Zone, which trend along the buried Ouachita-Marathon mountain belt axes and its relevance to the Gault Site (*sensu* Collins 2002).

This discussion summarizes the major geologic events in Texas that continues to have, a significant influence over economic and cultural behaviors of its human inhabitants from prehistoric to modern times. The enduring effects of these dramatic events created long-lasting viable environments with a wide range of raw resources that include water as well as silicified chert as prehistoric toolstone, to modern petroleum products (Swanson 1995:29; Woodruff and Wilding 2007).

Local Geology and Soils

The Gault site is situated near the spring-fed headwaters of Buttermilk Creek (Boyd 2010:181-194) where incised limestone outcrops contact undulating valley fill of colluvial toe slopes, alluvial, and floodplain deposits. Erosional events through millennia transported sediments that filled the valley. Minor tributaries cut down from the plateau in the upper (south) valley and drain into Buttermilk Creek during heavy rains (Fig. 22).

Buttermilk Creek flows near limestone outcrops that form part of the Lower Cretaceous formation of the Fredericksburg Group (Proctor, *et al.* 1974; Collins 2002). These rock formations are comprised of karstic and dolomitic Edwards Limestone atop impervious limestone clays (Fig. 21). The thin rocky soils and xeric uplands of the Edwards Plateau are host to live oaks, prickly pear cacti, and ashe juniper (Collins 2002). The floodplain valley of Buttermilk Creek was filled with clay and rock sediments of colluvium, and alluvium that were eroded over time from soft limestone and chalks in the Plateau's uplands (Ferring 2007; Swanson 1995:27-28).

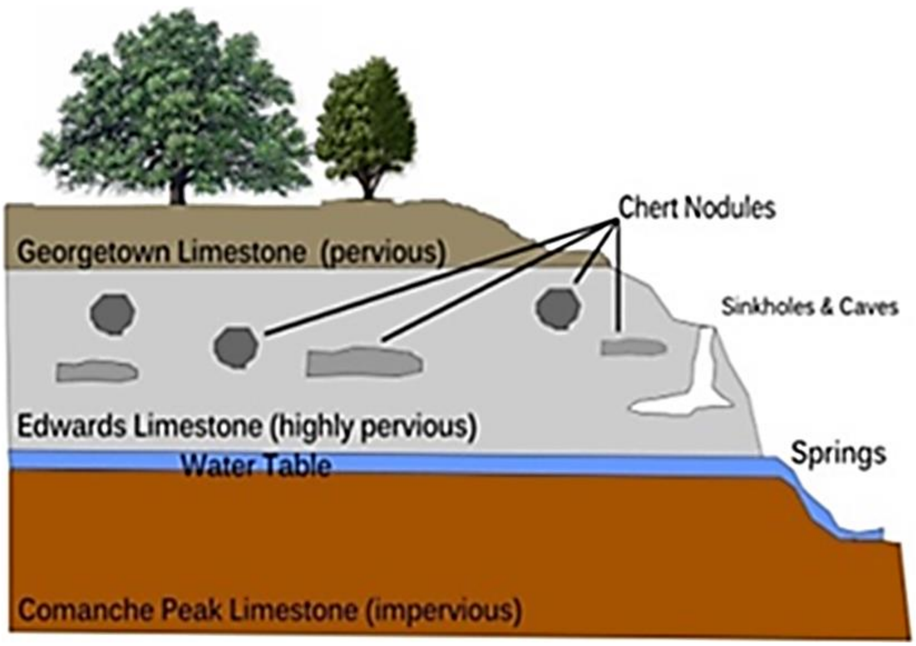

Figure 21– Basic schematic of the bedrock geology at the Gault Site. (Graphic used with permission from the Gault School of Archaeological Research. Illustration by D. Clark Wernecke).

The modern soils of the Buttermilk Creek valley are comprised of the Lewisville Series of deep clayey soils that form on stream terraces and limestone toe slopes (Huckabee 1977). Buttermilk Creek is a first-order stream and tributary of Salado Creek that forms part of a regional watershed basin of the Brazos River (Tyler 1936). The modern history of the valley in and around the Buttermilk Creek valley records its use as being primarily for livestock grazing (Gilpin and Longley 1995:396).

The surrounding edges of the Buttermilk Creek floodplain are lined with larger trees of oak (including burr oak) pecan, black walnut, and hackberry. A small population of bois d'arc trees (*Maclura pomifera*), -- *aka* Horse Apple or

'Bodark' – are currently found along the outer edges of the floodplain valley as well as some upland areas, whose dense wood properties were highly favored by prehistoric peoples for crafting bows and other tools (Collins 2002).

The local geology at the Gault Site (*see* Figs. 21 & 22) is vital for supplying fresh water to the area, and likely provided in a similar means for prehistoric peoples who lived there.

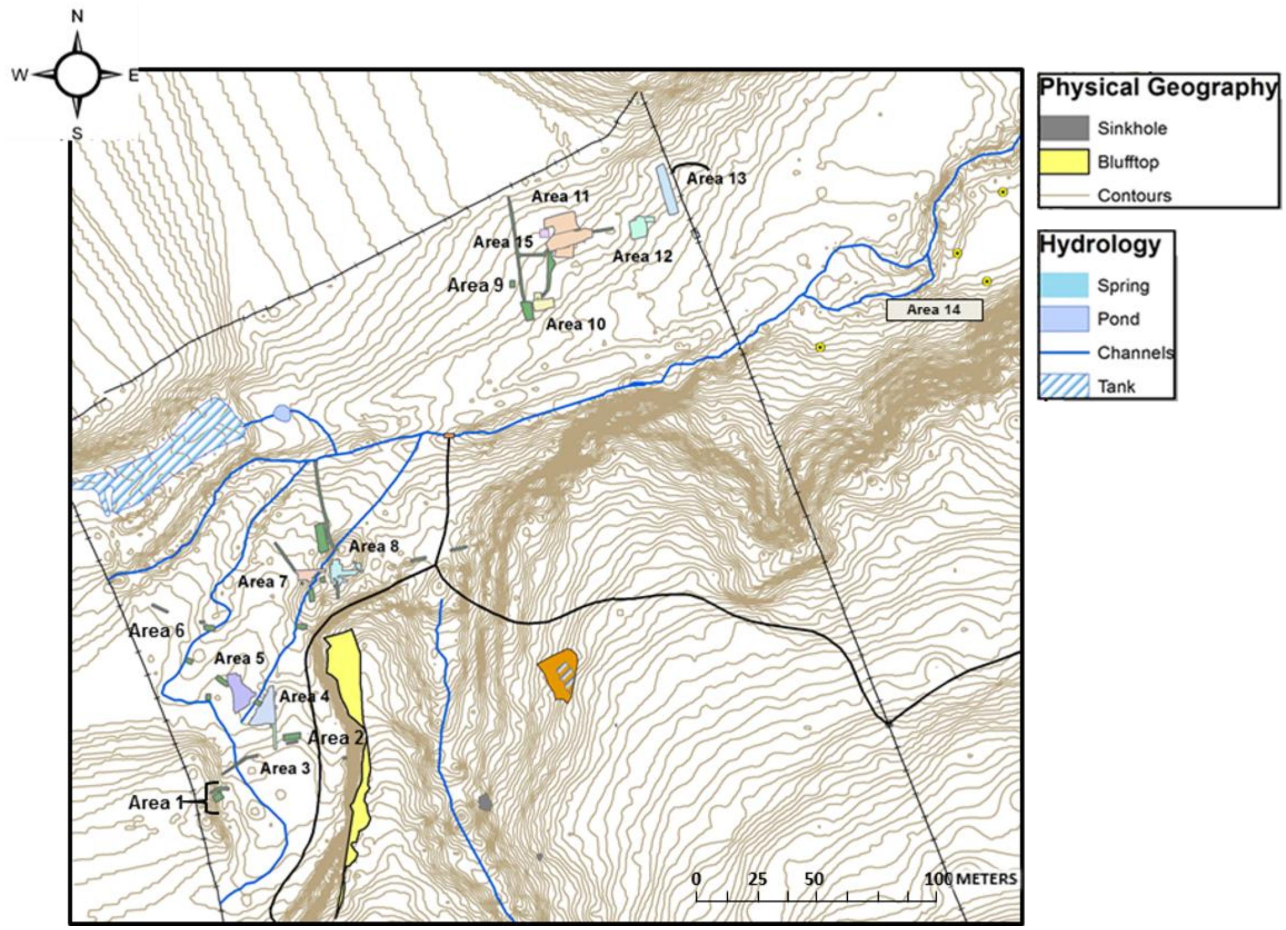

Figure 22– Topographic illustration of the Gault Site and excavation areas since 1991. (Map graphic used with permission from the Gault School of Archaeological Research).

Gault History and Excavations

Henry Gault's Farm

In 1904, Henry C. Gault purchased a parcel of land known as the Charles Meyers Survey in southwestern Bell County, Texas from landowners Mr. and Mrs. G. I. Cannon. After his wife Jodie died in 1942, Henry sold the farm to his neighbor Mr. Nealy Lindsey in 1943 and Henry lived with them until his death in 1960. In the mid-1980's, Nealy began charging people to access the valley area now known as the Gault Site to dig for arrowheads. In 1988, after a brief site visit, a few professional archaeologists deemed the Gault Site "nearly destroyed" from decades of damage caused by pothunters and collectors. The pay-to-dig operation continued, even after Nealy's death in 1986, until 1997 when the property was purchased and divided into tracts by a developer. One of those divided parcels containing the Gault Site was purchased in 1998 by Nealy's son, Howard Lindsey, and grandson, Ricky Lindsey.

Gault Site Excavations

The valley of Henry Gault's farm in the early nineteen hundreds contained a common central Texas feature known as a burnt rock midden. This midden was unusual due to its massive size, which was reported to be around 240 meters-long by 30 meters-wide, and reached a height of nearly two meters tall. Word of the Gault midden eventually reached J. E. Pearce, founder of the Department of Anthropology at the University of Texas at Austin who was interested in Central Texas "kitchen middens." Pearce visited the site and reported to his benefactor that the entire Gault Site was a vast workshop that spanned the entire valley and “over this whole field are such quantities of flint chips, broken artifacts, and human refuse generally as I have ever seen at any other place” (Pearce 1930).

Pearce was granted permission by Henry to send workers to cut a trench into the large midden. By the fall of 1929, a three-man crew headed by H. B. Ramsaur trenched the large midden in the valley (Fig. 23). However, by November, after eight weeks, the crew was routed by bad weather, and the excavation was abandoned.

Figure 23-- H. B Ramsaur (left) and crew (top & bottom right) trenching into the Gault Site middens (*circa* 1929). (Photos J.E. Pearce Manuscript Collection, used with permission from the Texas Archaeological Research Laboratory, Univ. of Texas at Austin and the GSAR).

In 1988, prominent Texas archaeologists who were familiar with the site's pay-to-dig history, visited with Elmer Lindsey, a relative who continued Nealy's pay-to-dig operations at Gault. Pat Mercado-Allinger of the Texas Historical Commission and Dr. Thomas Hester with Texas Archeological Research Lab (TARL- Univ. of Texas at Austin) and others, were interested in interviewing Elmer and surveying Gault as a possible site for an upcoming field school, but negotiations with Elmer failed to come to an agreement. Hester later wrote up the visit and described the site as completely devastated due to years of pay-to-dig looting (T. Hester, Pers. Comm. 2013). While the damage is incalculable, most of the damage to site was contained to the midden and subsurface finds of Archaic "arrowheads" which were more profitable to collectors.

A collector named David Olmstead paid to dig at the Gault Site sometime during the 1980's. Olmstead reportedly dug below the disturbed midden and uncovered a heavily resharpened Alibates Clovis point 'sandwiched' between two ornately incised limestone pebbles (Fig. 24). Peter Bostrom, of the Lithic Casting Lab in Troy, Illinois, contacted Dr. Thomas Hester (TARL) regarding Olmstead's unusual finds. Hester subsequently contacted Olmstead and arranged for he and TARL colleague Dr. Michael B. Collins, a renowned Clovis expert, to photograph the artifacts. Olmstead was asked to co-author a paper with Hester and Collins on the unusual engraved artifacts (*see* Collins, *et al.* 1991).

Figure 24—Re-construction of a Clovis Alibates point reported as found between two incised limestone pebbles from the Gault Site, Texas (41BL323). (Photo reconstruction by M. Samuel Gardner based on 2003 photo re-creation by Peter Bostrom, Lithic Casting Lab, Troy, Illinois . (http://lithiccastinglab.com/gallery-pages/gaultstackcachelarge.htm).

1991 Olmstead Excavation of Area 1

Elmer allowed Hester and Collins to excavate the area of the Olmstead finds for twelve days. With the help of a student crew, the excavation recovered more than 91,000 artifacts that were brought back to TARL. Among the provenienced artifacts were another six engraved stones and a Clovis point. The 1991 excavation revealed undisturbed strata with *in situ* Paleoindian artifacts. Figure 25 shows the location of Area 1 as well as other excavations and testing conducted at the site since 1991.

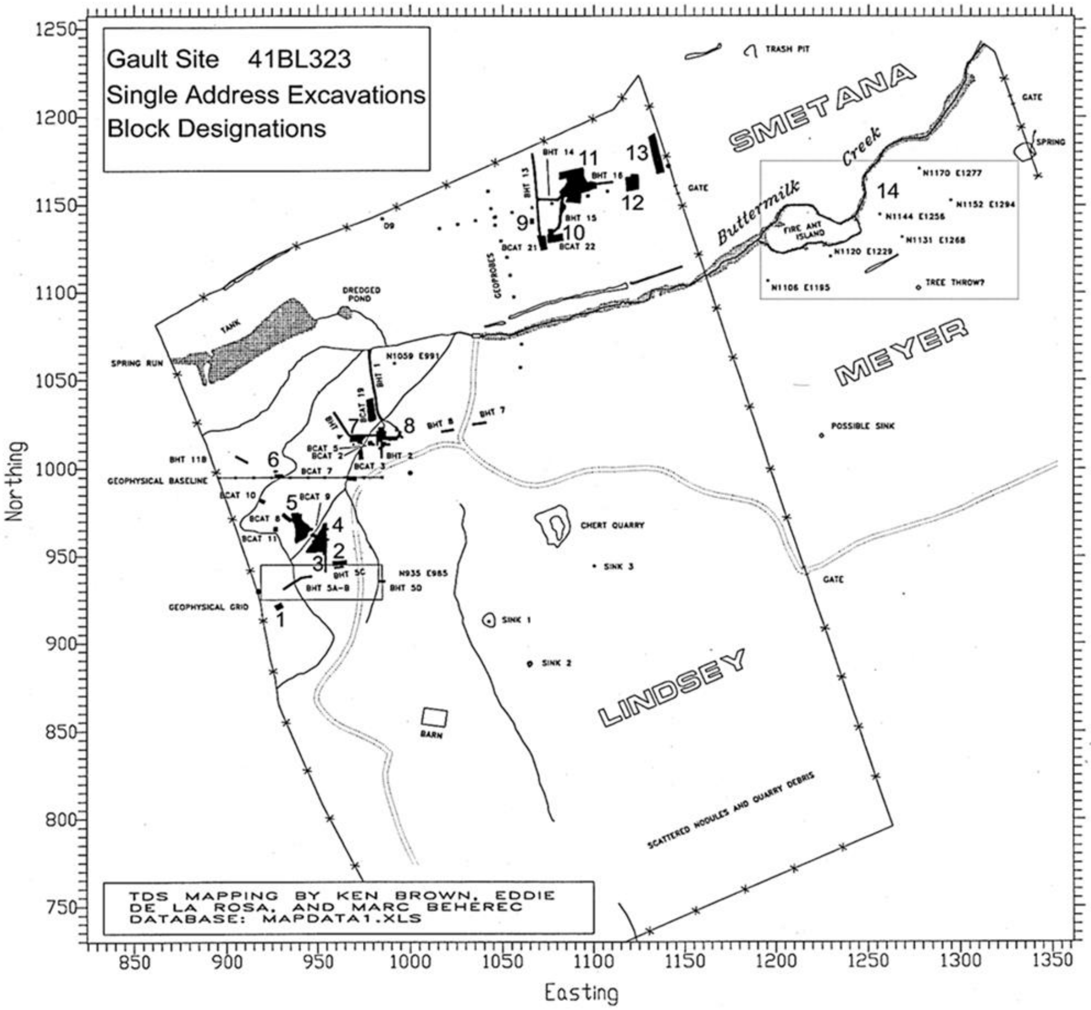

Figure 25 – Block designations for excavations at the Gault Site from 1991 through 2002 and their locality within the Buttermilk Creek Valley. (Mapping by Ken Brown, Eddie De La Rosa, and Marc Beherec. Graphic provided courtesy of the Gault School of Archaeological Research)

1998 Salvage Excavation (Areas 7 and 8)

Although Howard and Ricky Lindsey halted all pay-to-dig operations, they were themselves avid collectors of 'arrowheads.' In 1998 while using heavy equipment to dig along the western upper valley of the site, Howard Lindsey uncovered the remains of a large animal. Dr. Collins was contacted to examine the remains, which turned out to be the mandible of juvenile mammoth (*M. columbi*). This discovery led to a salvage operation being permitted by the Lindseys. During the salvage, several Clovis points as well as flake tools and blade artifacts were found associated with the proboscidea remains.

1999-2002 Excavation Highlights (Areas 2-14)

After the successful salvage in 1998, the presence of Clovis-age artifacts associated with the mandible provided further evidence to support the 1991 findings that the deeply buried Paleoindian deposits at Gault were relatively untouched by pothunters. This encouraged Dr. Collins to negotiate a three-year arrangement with the Lindseys who agreed to allow unfettered access, testing, and excavation around the site.

At the end of the three-year investigation in May of 2002 an additional 500,000 artifacts, 300k being from Clovis deposits, had been recovered from fourteen excavations and test areas from less than three percent of the entire estimated site. These investigations also established that the entire Texas Prehistoric chronological record (*see previous* Fig. 16) was represented at the Gault Site which reveals a nearly continuous occupation by humans extending over 13,000 calendar years (Collins 2002; 2007:59-80).

After the three-year investigation was concluded, Dr. Collins remained in close contact with the Lindseys who came to understand the scientific value of the Gault Site. After careful negotiations, the Lindseys agreed to sell the property in 2006. Attempts to acquire funding from donors and interested parties were unsuccessful. However, knowing this would likely be the only chance to help the Gault Site get the protection it needed, Dr. Collins purchased the site using personal funds and immediately donated it to the Archaeological Conservancy, a U.S. nonprofit that protects archaeological sites nationwide.

The excavations in Area 8 extended investigations of the 1998 *M.columbi* salvage. Area 8 was an important excavation in terms of understanding the site history and the complex geology that preserved the Gault Site. Area 8 has also been the subject of numerous graduate research projects as well as a publication on Clovis technology (Waters*, et al.*, 2011a).

2007-2013 Excavation of Area 15

Based on evidence from several test excavation areas where cultural materials have been found below the known Clovis horizon at the site, a grant from the National Science Foundation was awarded to the Gault School of Archaeological Research, a Texas non-profit organization that manages the Gault Site. The grant was specifically earmarked to fund the excavations in Area 15, which started in 2007. With the help of thousands of volunteers, comprised of Gault staffers, academics, professional colleagues, and students, the excavations were eventually completed when bedrock was reached in June of 2013. Area 15 excavations exposed intact Archaic components not destroyed by looting, as well as Late to Early Paleoindian deposits. Area 15 also recovered evidence of cultural materials, approximately 15 to 20-centimeters, below the Clovis horizon, not yet classified.

Recently, Optically Stimulated Luminescence (OSL) dates for the Gault Site include the latest OSL samples collected during the 2007-2013 excavations. The

Gault Clovis dates are currently estimated between 13,400 to 12,900 Cal BP (Collins, *et al.* [forthcoming]).

Gault Geomorphology

Since E. B. Howard introduced the concept in the 1930s, multidisciplinary approaches have been vital for archaeological investigations and the geosciences are an essential part of Paleoindian studies (Holliday 1997:1-20). Geomorphology is a geologic based science that has gained the interest of North American archaeologists. Geomorphology in essence “bridges” the gap between archaeological science and earth sciences (Goldberg, *et al.* 2001:vii). Geomorphological processes—*e.g.* alluvial systems, formation of soils, and sedimentation -- directly affect the integrity of archaeological sites (Goldberg and MacPhail 2006). Knowledge of how various systems shape and modify past landscapes helps archaeologists to understand depositional issues in the archaeological record (Goldberg, *et al.* 2001: vii-xi).

Brandy Gibson in 1997 conducted a geoarchaeological site potential study of the Buttermilk Creek valley for a master’s thesis (Gibson 1997). Gibson was not able to collect data directly associated with the Gault Site due to restricted access by the landowner at the time. She was able to construct a proxy model of the Buttermilk Creek valley based on her identification of six alluvial units. These units included her findings of a “Brown Paleosol” that contained a chronometric series of Late Paleo to Early Archaic diagnostic projectile points (Gibson 1997:46, 51). Gibson’s research provided data that helped with later geomorphic studies at the Gault Site.

Research was conducted by Heidi Luchsinger (2002) for a master's thesis at the Gault Site. The study focused on the stratigraphic integrity of Area 8, which was excavated into the floodplain deposits in the southwest (upper) Buttermilk Creek valley of the site. Luchsinger's study analyzed micromorphological data and included stratigraphic profiles of not only the excavated floodplain facies, but an adjacent channel facies as well. Luchsinger's floodplain profile drawings identify development of the Royalty Paleosol (Nordt 1992) that formed along an alluvial deposit atop what appeared to be a Clovis-age surface area that Luchsinger identified as a "Clovis Soil" (Luchsinger 2002:17, 31).

Dawn Alexander (2008) conducted a study for her master's thesis that investigated post-depositional disturbances within Area 8 as well (Alexander 2008). Her analysis of data revealed the good stratigraphic context of the artifacts in the Clovis component and concluded that disturbance of Clovis artifacts within Area 8 were primarily due to cultural activities and not natural processes.

Anastasia Gilmer (2013) conducted a magnetic susceptibility study for her master's thesis in Area 15 (Gilmer 2013). Gilmer (2013:122) found no evidence of artifact movement in Area 15 by natural processes nor evidence of high-energy scouring known to occur in the Buttermilk Creek valley and surrounding areas (Gibson 1997; Nordt 1992) stating that distinctive stratigraphic deposits contained the Clovis component and the older-than-Clovis component, respectively. These studies by Gibson (1997), Luchsinger (2002), Alexander (2008), and Gilmer (2013) contributed valuable data regarding the state of the Buttermilk Creek valley area that indicated high preservation of Paleoindian deposits in the Gault Site.

This body of knowledge and research has enabled Gault researchers to understand the Paleoindian occupation of the site as well as the favorable environments that have preserved the archaeology. The WIS inland Cretaceous ocean left behind a rich plateau environment with one of the largest chert deposits in North America (Banks 1990:59) and a continual water supply within the limestone. This coupled with the flora and fauna of both the uplands and lowlands made the Gault Site an attractive and sustainable location.

Chapter 5 – Area 4 Excavations (Study Area)

As discussed previously, Clovis knappers were known for actively procuring high quality stone materials, and therefore, would have been drawn to the abundant quality of chert found at the Gault Site. The archaeological record at Gault reveals Clovis knappers heavily exploited the chert resources during frequent or long-term occupations of the site. The excavations in the locality known as Area 4 were conducted specifically for documenting the well-preserved stratigraphic record of the Clovis component (Pertulla 2004:34). Based on this as well as interviews of the principal investigators and detailed assessment of the existing excavation records, Area 4 is the focus for this research study.

Area 4 is located roughly 70 meters to the southwest of Area 8. During the 1999-2002 field seasons, test units around Gault penetrated through the heavily looted midden that measured up to 60-centimeters in depth in places, and consistently turned up modern rubbish, such as discarded beer and soda cans, plastic wrappers from cigarette packs and candy, abandoned tools, etc. The disturbed layer was usually removed as one level or stripped off before excavation began.

Area 4 (Fig. 26) is located in an alluvial fan in the upper valley just southwest of the modern stream of Buttermilk Creek. Based on field records, the arbitrary datum was set at an elevation of 100m -- located at N1000 E1000 – and the starting elevation of Area 4 was around 97.50 meters. The grid area of Area 4 included seventy-three (n=73) one-by-one meter squares (Fig. 27). Once the disturbed midden layers were removed, all levels were excavated in one-by-one meter squares, initially dug in 10-centimeter increments until contact was made with the Royalty Paleosol (Luchsinger 2002; Nordt 1992), when the levels were excavated in five-centimeter levels that penetrated into Clovis and reached below Clovis stratum.

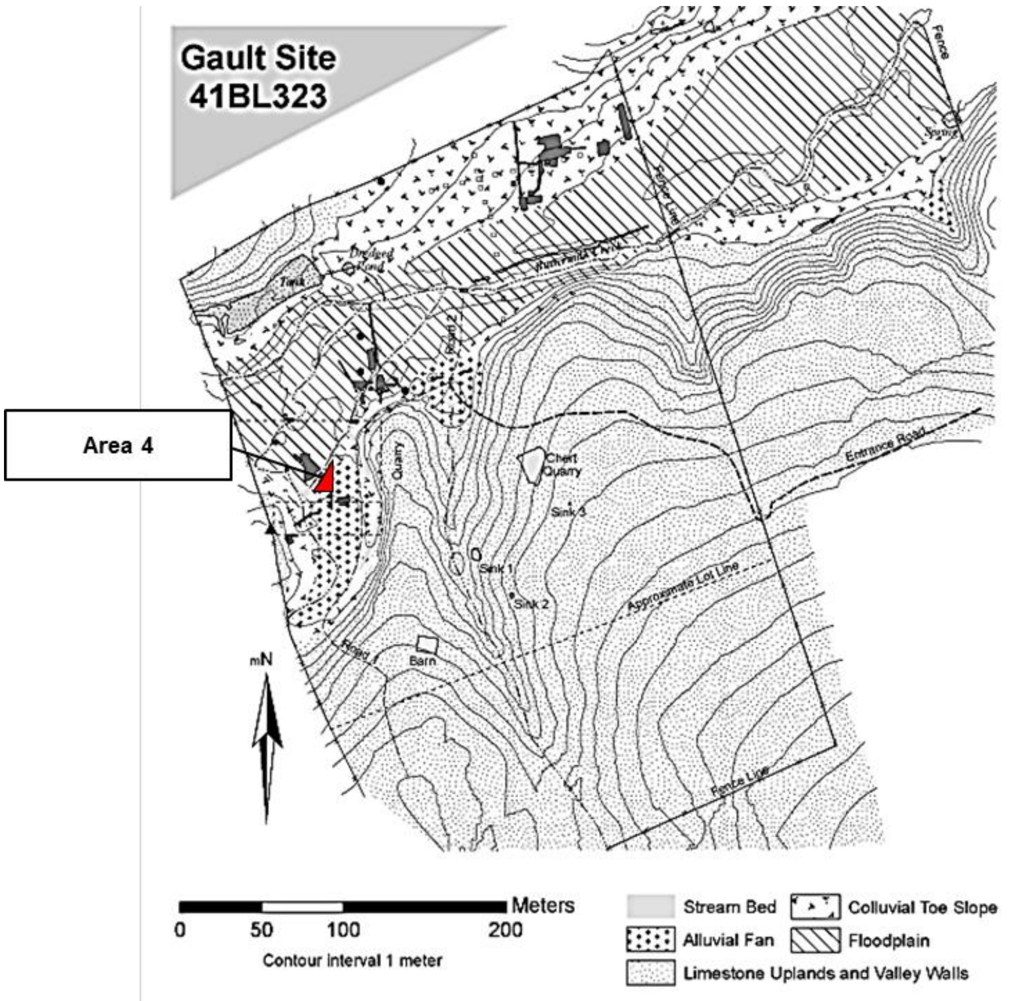

Figure 26 – Contour map of the Gault Site, Texas (41BL323) showing the location of Area 4 within an alluvial fan. (Map used with permission from the Gault School of Archaeological Research)

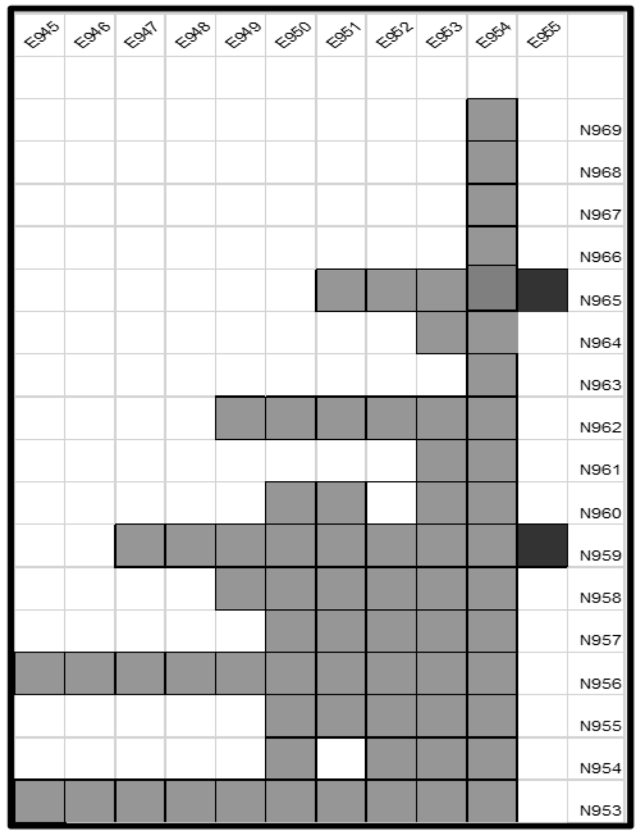

Figure 27—Area 4 Basic Excavation Grid

The highest elevation recorded for a diagnostic Clovis artifact in Area 4 was around 96.91m and the lowest elevation of a Clovis diagnostic was recorded at 96.51m. The highest concentrations of Clovis flakes and debitage occur between the elevations of 96.88m and 96.61m. The total depth of the Clovis stratum in Area 4 is approximately thirty-five to forty centimeters and gently undulates across the excavation area (Fig.28).

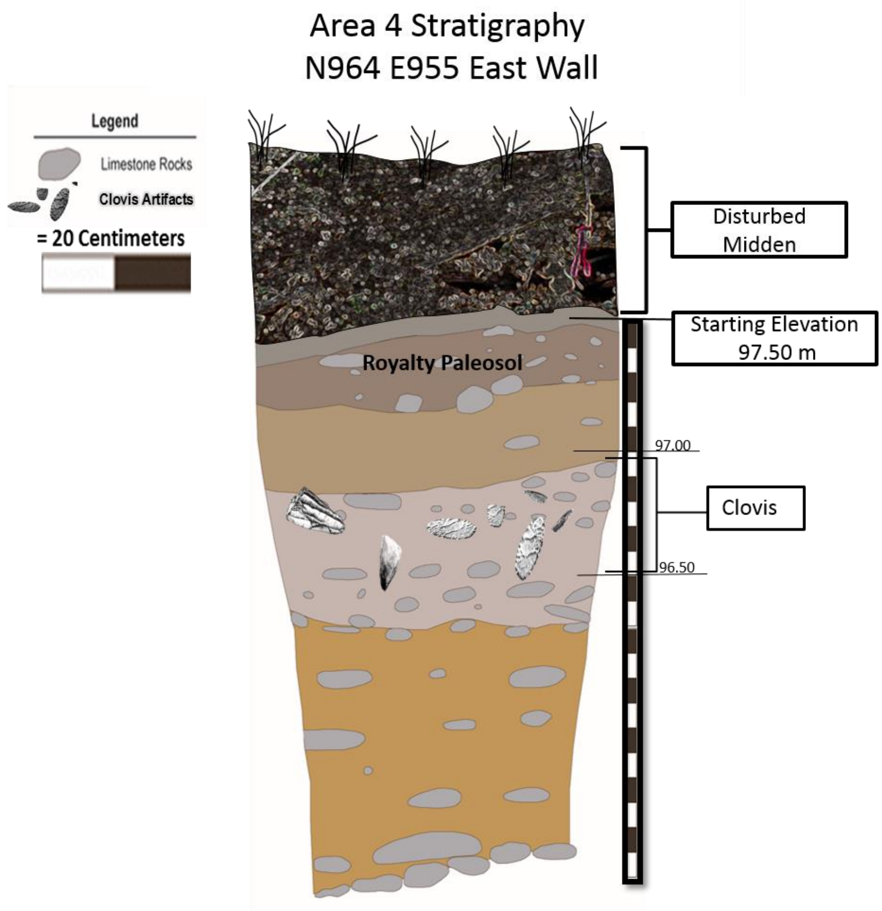

Figure 28– Stratigraphic representation depicting general elevation of Clovis stratum in Area 4. (Graphic Modified used with permission from the GSAR).

By the time Area 4 was completed in 2002, the number of artifacts cataloged from the Clovis component in Area 4 was estimated to be around 16,000 artifacts. As of this research, the Area 4 Clovis flaked stone tool and faunal assemblage is approximately 125,328, with ninety-percent being flakes, and related debris. Since Area 4 is only meters away from outcrops of high quality Edwards chert, the vast amount of Clovis manufacturing debris supports the inference that Area 4 excavated into a Clovis workshop setting. Amongst the tools recovered from the Clovis stratum in Area 4 were at least thirteen broken, heavily re-worked, or exhausted/discarded Clovis projectiles. This number is proportionally low when compared to the amount of manufacturing debris. Although recent geochemical analysis of Edwards Plateau chert and Clovis points from the Gault Site indicated that Clovis points were carried some distance from the original source and discarded only when broken (Speer 2014). This provides a likely explanation as to why the number of Clovis points is relatively low.

The Clovis manufacturing debris revealed abundant biface production flakes as well as unremarkable flaking debris and/or cortical flakes likely produced from shaping-out of lenticular nodules or other tabular forms of Edwards variety chert. Other distinctive artifacts usually associated with Clovis biface production were identified from the Clovis stratum in Area 4 included end thinning flakes, channel flakes, and overshot flakes.

Furthermore, the Clovis flake and tool assemblage included indicative debris associated with blade production including discarded or failed blades and blade cores (Bradley, *et al.* 2010:10; Collins and Link 2003:157-182), blade core preparation flakes (Bradley, *et al.* 2010:19; Ferring 2001:146), and platform rejuvenation flakes as well as corner blades (Williams 2014). The large amount of manufacturing debris not only provides an ideal opportunity to study flaking technology produced in a Clovis workshop setting (Bradley, *et al.* 2010:56), but theoretically is the ideal situation for analytical sampling (Shott 1994).

Chapter 6 -- Methodology

Individual flake analysis, (IFA) was chosen as the most beneficial approach for this study in order to collect a robust amount of data in the form of technological values that are often indicators of stone tool cultures (Andrefsky 2005:114). Approaches used for observation, recording and measuring techniques were based on well-known theoretical principles of debitage and lithic analysis defined by Andrefsky (2001:6-13; 2005:91-142), Bradley (1975:5-13; 2009:265) Collins (1974:160-178; 1975:15-34), Crabtree (1972; 1975:105-114), Odell (2004:121-130) and Inizan, *et al.*, (1999:33).

As discussed in Chapter 5, examination of Area 4 field records including profiles, diagrams and plan drawings were helpful in assessing the location and elevation of Clovis stratum in each unit. Three-hundred and twelve (312) five-centimeter levels had been identified as containing Clovis-bearing deposits in Area 4. Each Clovis level-per-unit had 300 to 400-pieces of flakes/debris/debitage on average per five-centimeter level. The highest concentrations of flakes, debitage, and debris occur between the elevations of ~96.88m and ~96.61m. However, further analysis would be necessary in order to confirm this, such as GIS computation and 3D analysis, but is beyond the scope of this research.

Before sampling, excavation field notes, level record forms, inventory, and inventory databases were thoroughly examined to determine temporal and spatial clarity of Clovis levels in Area 4 in particular where diagnostic Clovis tools had been confidently identified.

Finally, as a student of aboriginal flintknapping, personal knapping experience provided and continues to provide a greater understanding of how and why some flakes are made, and how flakes create stone tools. As Pellegrin (2004:57) states, “one can only recognize what one already knows”.

Sampling Methods

The benchmark for this study included recording of both broken and whole flakes with observable striking platforms. Broken flakes, which included step flakes, were limited to proximal fragments that retained observable striking platforms. All flakes were measured linearly and the minimum size was set at ten millimeters (10 mm) with no maximum limits on either whole or broken flakes.

The Gault database and inventory records show that 130,707 flaked stone artifacts and faunal items were recovered from Area 4. Of these, 124,478 pieces (Table 1) were identified as either general debitage, flakes (piece plotted, etc.) or angular debris.

The amount of flakes and debitage (Table 2) recovered from Area 4 excavations equaled 114,406 pieces. Approximately 74,048 of these were flakes sorted from 1/4” inch screens with the remaining 40,358 (35%) being sorted from 1/8” inch screened materials. All bulk flake and debitage materials included indeterminate angular pieces such as chert fragments and flake shatter.

Table 1 -- Clovis Flakes Debitage and Debris from Area 4

AREA 4 CLOVIS FLAKES, DEBITAGE, DEBRIS		
Description	**n**	**Percentage (%)***
General Debitage	114406	88%
Flakes (point prov.)	3243	2.0
Angular chert	6829	5.0
TOTAL	124478	95%
* Of Area 4 Assemblage (n=130707)		

Table 2 -- Clovis General Debitage from Area 4

Description of Sorted Clovis bulk flakes and debitage	**n**	**%**
1/4" inch*	74048	(65%)
1/8" inch**	40358	(35%)
Total	114406	(100%)
* contains flakes larger than >10mm ** contains flakes or debris smaller than <10mm		

The flake sample and analytical data sets were chosen from materials that were clearly identified from excavated units containing diagnostic artifacts associated with Clovis technology (Bradley, *et al.* 2010:64; Collins 1999a; Jenkins, *et al.* 2012; Waters, *et al.* 2011a), such as Clovis bifaces, preforms, projectile points, overshot flakes, channel flakes, and blades and blade production debris.

Based on the area and Clovis parameters discussed above, as well as information gathered from artifact inventory records, field notes, profiles, and paperwork generated during the excavation Area 4, a flake population of ~23,939 flakes and debitage were extracted for sampling. This population consisted of bulk flakes, as well as 599 piece-plotted flakes, (*see* Table 1 and 2), from fifty, well-defined Clovis bearing lots in Area 4. These lots represent thirty-seven (37) of the seventy-three (73) one-by-one meter square (1x1 m^2) units excavated in Area 4.

These flakes were systematically examined and sorted based on sampling benchmarks allowing whole or broken flakes, but retained observable striking platforms, and were at least 10 mm and larger. The final data set of (n=) 2185 flakes were recorded and analyzed for this study.

Of note, blades or blade fragments were not considered for this study and any reference to blades has strived to be unambiguous. Flake study parameters did not include any flaked debris identified as angular debris or shatter. Likewise, any flakes where striking platforms were heavily obscured by the precipitation of calcium carbonate ($CaCO^3$) (Durand, *et al.* 2010) were excluded.

Finally, unless otherwise stated, the debitage and flakes recovered from Area 4 assemblage are primarily made from local Edwards variety chert.

Data Collection

The aim of this study is to collect platform preparation data primarily from Clovis biface manufacturing flakes in order to assess the technology of biface production. The final data set of 2185 flakes was sorted using flake criteria stated above. The data set includes flakes associated with Clovis biface manufacturing activities and other stone tool production flakes associated with blade production, as well as, general or indeterminate flakes. The following is the recording criteria for this flake study, and meets or exceeds acceptable standards of practice for macroscopic examination of flakes and debitage (Andrefsky 2001; 2005). A copy of the flake and data collection form is located in Appendix 1 and is adapted from

Bradley 2009:265, 414 for Clovis biface technology. A more in-depth glossary and definition of terms based on this form is located in Appendix 3.

Measuring Striking Platforms

The body of this study focuses on flake striking platform and platform preparation traits. Platforms were measured in millimeters using digital calipers, (Andrefsky 2005:95, 101) to record length (L) and depth (D) (Fig. 29) of individual platforms.

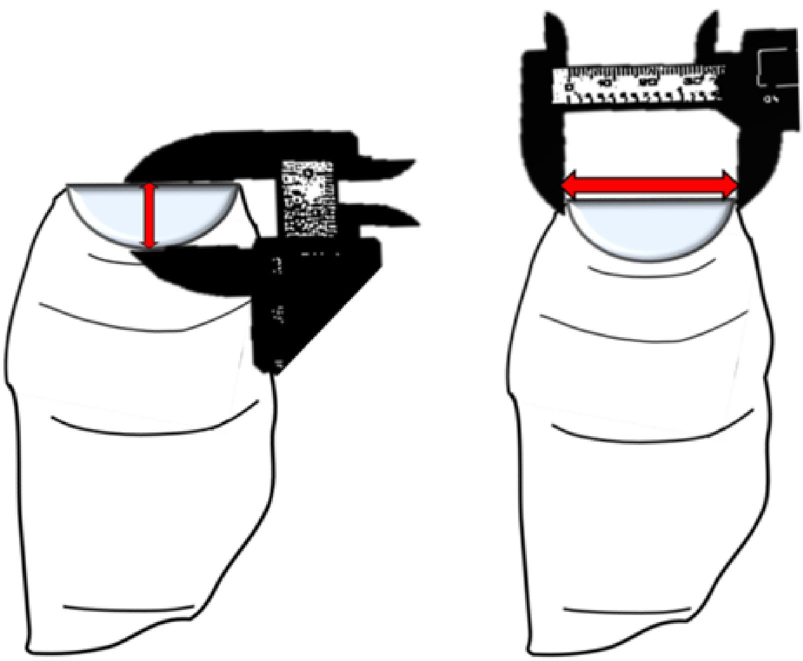

Figure 29-- Measuring striking platform depth (left) and striking platform length (right)

Striking Platform Preparation Traits

Platform attributes as well as complex platform preparation traits were broken down into three subcategories -- platform status, platform shape (Fig.30) and platform preparation (Fig. 31). Individual preparation traits were recorded as present or absent, except for lipping and grinding, which were broken down further to quantify the degree of their presence/use and are presented in Table 3.

Table 3 -- Platform Attributes and Preparation Traits Recorded

Platform Status	Remnant (partial)
	Shat/Crushed
	Lipped
	Plain
	Cortical
Platform Shape	Straight
	Concave
	Convex
	Dihedral
Platform Preparation	Grinding edge
	Grinding obverse
	Grinding reverse
	Faceted
	Reduced
	Released
	Isolated

Grinding was recorded as 'present' along the edge, obverse, or reverse of the platform. Grinding on a platform-bearing flake can be detected by observation and/or feel. The use of a magnifying glass, visor, or microscope between 10X and

20X magnification also helped determine the presence and extent of grinding on some of the 10-15mm size flakes. With regard to lipping, a coding system was used to identify the degree of lipping or prominence that a platform retained (Table 4).

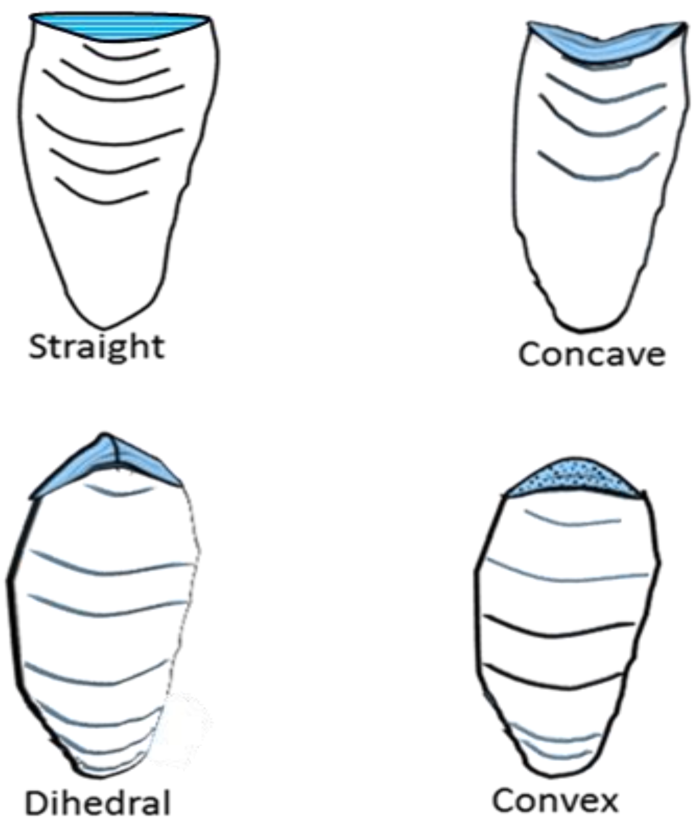

Figure 30 – Simple schematic of basic platform shapes

Table 4 – Coding used for Platform Lipping

Lipping Code	**Description of Code**	**Qualifiers**
L (normal	Lipping	Lipping is present and visually detectable
ML	Minor Lipping	Detectable by "feel"
H/E	Heavy/Extreme Lipping	Lipping is heavy (prominent) or extreme lipping *e.g.* "Edge-Bite" or "Edge-Collapse" (Collins 1974:160-175)
O	No lipping	Lipping not detected visually or by feel; bulb is usually prominent

Figure 31 illustrates the platform preparation traits identified above (*see* Table 3). Grinding was divided into three categories ('edge/margin' – 'dorsal/obverse' and 'ventral/reverse'). Faceting reduces the platform on the ventral/strike-side of platform. The platform may exhibit two or more flake scars that can be parallel, radiate or transect previous flake scars. Reducing removes material overhangs or weak spots but from the dorsal (obverse) side of the platform and may exhibit two or more flakes scars (Fig. 31) that can be parallel to the striking-axis. Releasing a platform is intended to weaken the area around the platform by removing small flakes that often create small or truncated scars on the ventral/reverse (strike-side) of the flake. An isolated platform can mean flakes were removed from the dorsal/obverse side of the striking platform prior to removal and the platform appears prominent and separated.

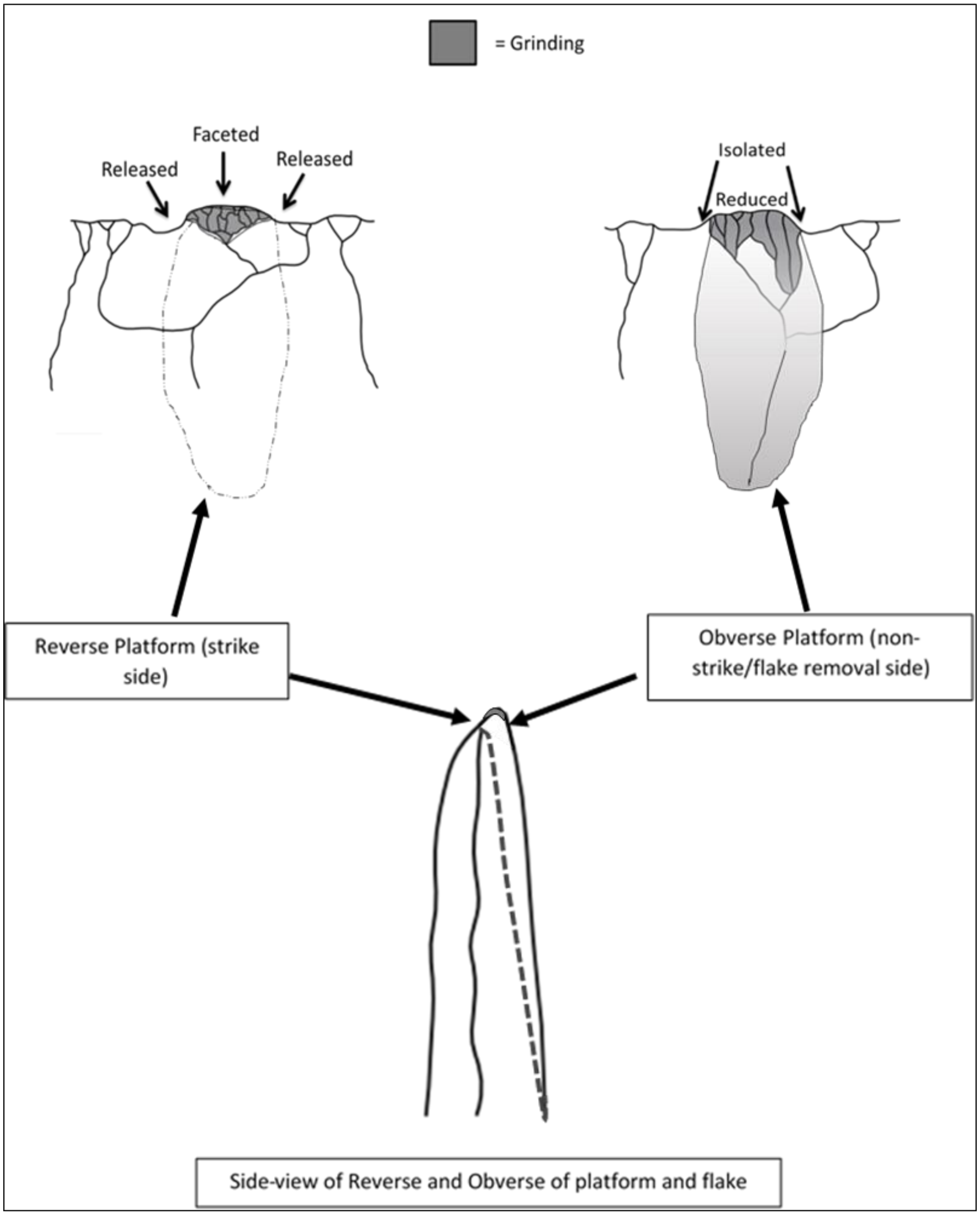

Figure 31 –Diagram of platform preparation traits on a biface margin prior to the outlined area of flake is removed. Grinding is represented in dark gray (adapted and modified from Bradley, *et al.* 2010:67).

Plain and cortical platforms were coded as shown in Table 5.

Table 5 – Coding for recording plain and cortical platforms

Plain or Cortical Code	Platform Status Trait Description
P =Plain	No preparation detected
C =Cortical	The striking platform retains the original surface, or subcortex of the parent material.

Measuring Flake Dimensions

Flake length (L), width (W), and thickness (Th) (Figures 32 and 33) were measured in millimeters using digital calipers. These measurements were taken of the morphological length of the flake.

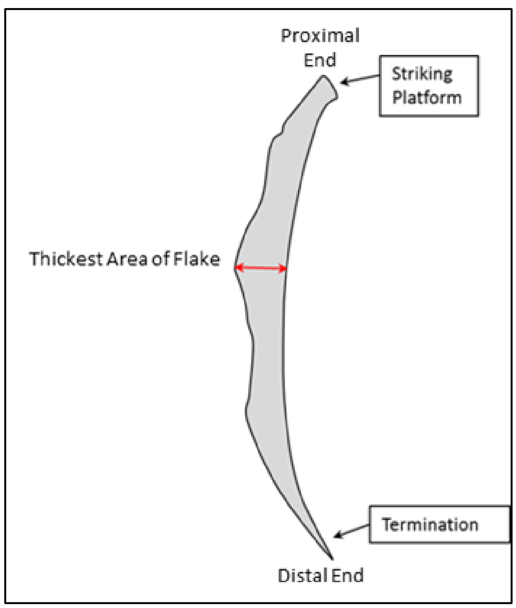

Figure 32– Profile drawing of a flake arrow indicates measurement of thickest area of the flake body.

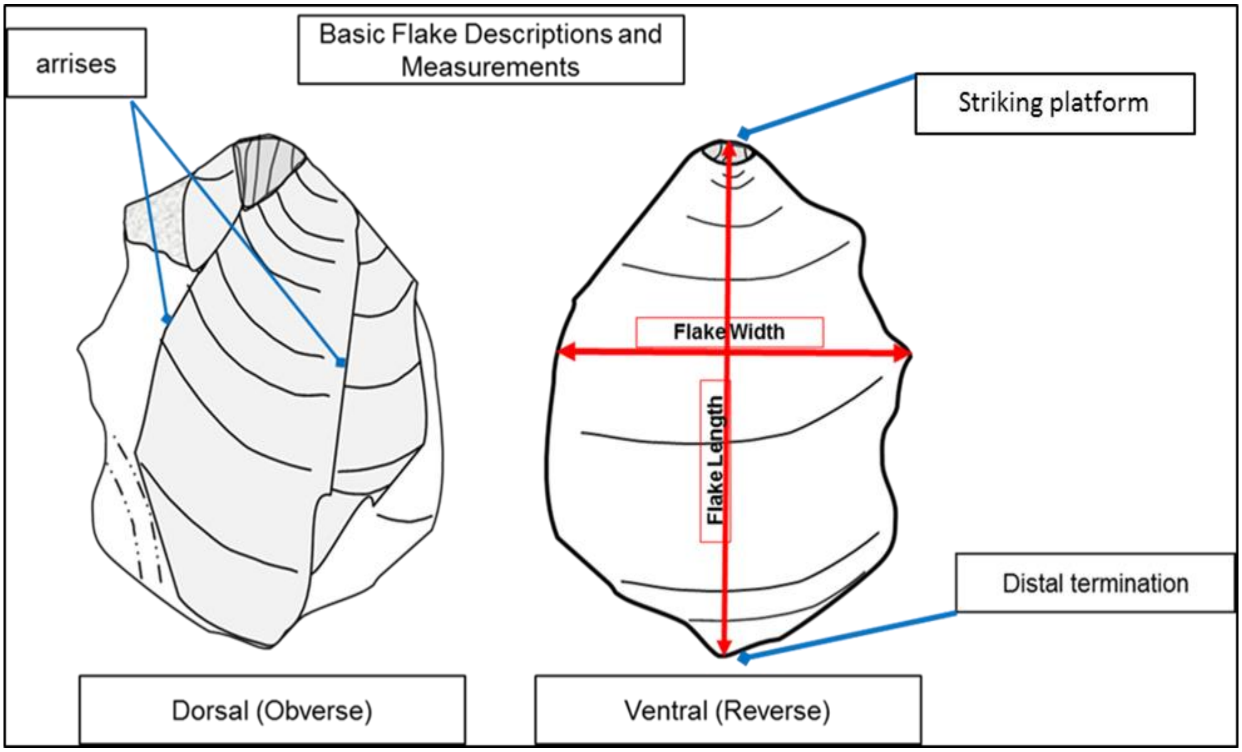

Figure 33–Basic flake descriptions of the dorsal and ventral view of a Clovis biface thinning flake from Area 4. The red arrows represent measurements taken of the flake body at its widest and longest points.

Flakes were recorded as being complete (whole) or incomplete (proximal end). Termination types were recorded as feathered, overshot, hinged, or broken/step (Table 6 and Figure 34).

Table 6 – Flake condition and status

Flake Status	Complete
	Incomplete
Flake Termination	Feathered
	Overshot
	Hinged
	Broken / Step
Flake Phase	Early
	Middle
	Late
Flake Type	Biface Shaping
	Biface Thinning
	End Thinning/Channel
	Other
	Indeterminate

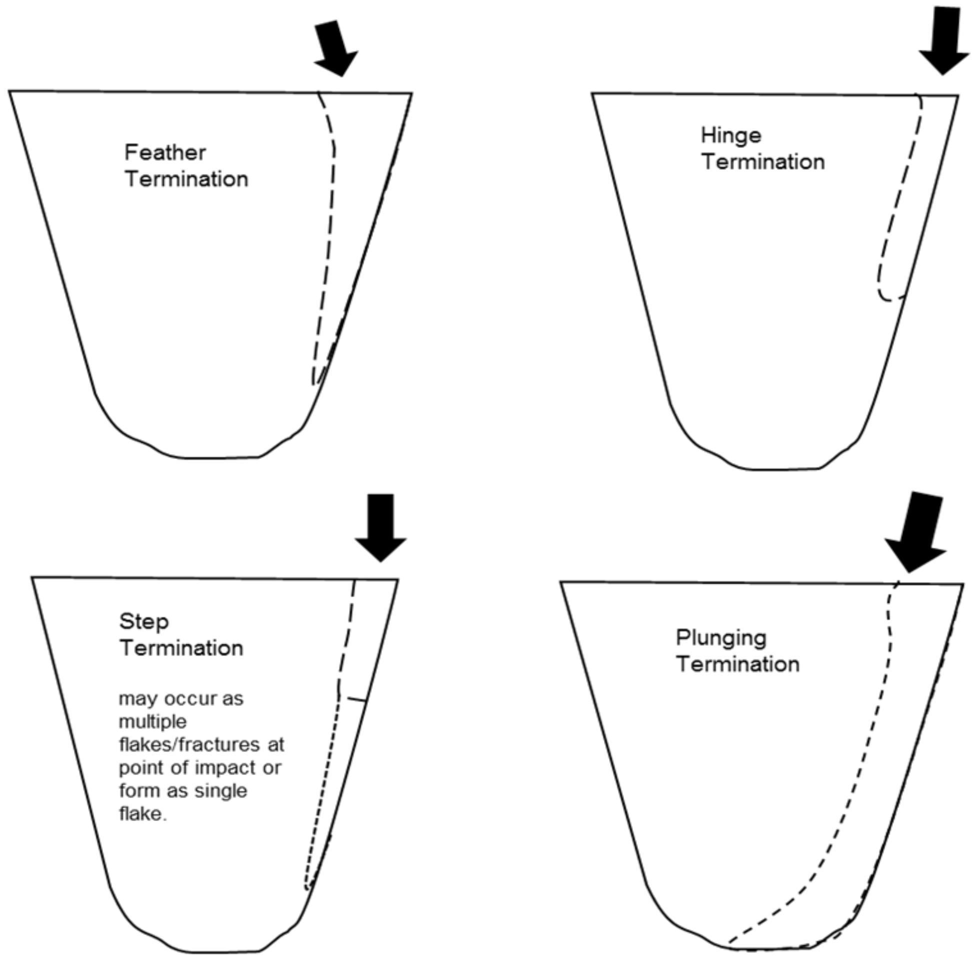

Figure 34-- Flake formation and terminations (*sensu* Cotterell and Kamminga 1987).

Analytical Phases of Clovis Biface Reduction

The value of establishing reduction sequences to flaked stone tools is a dated concept (Holmes 1894:136) that was modernized by Don Crabtree (1972). The theory has since been refined by Bradley, *et al.* (2010:77), Bradley and Giria (1996), Callahan (1979), Morrow (1995), and Sanders (1990). With regard to biface manufacture, it is a process that can occur in stages (Andrefsky 2005:31; Callahan 1979:18), or as a continuum, (Bradley, *et al.* 2010:77), and has been debated on several fronts (Bradley, *et al.* 2010:78-79; Bradbury 1998; Bradbury and Carr 1999; 2014:20-38; Huckell 2014:137; Miller and Smallwood 2012; Shott 1996; 2007).

Clovis biface production is assumed to follow a logical order of reduction based on primary, secondary or finishing (Huckell 2007:193). Following Bradley, *et al.* (2010:78), the term 'stage' will denote production discontinuities and 'phase' will refer to the reduction continuum using multiple flaking actions. All flakes in this data set were assigned progression values based on Clovis biface technology (Bradley, *et al.* 2010:77-79), and were recorded as early, early/middle, middle, middle/late, or late.

Assignation of a flake to a phase and flake type was determined using as many clues from the flake to classify it (Andrefsky 2005:124). This included, but was not limited to, the overall complexity of the striking platform, the number of dorsal flake scars, the overall size and shape, as well as thinness or thickness, and, amount of cortex the flake retained. For example, if a flake retains more than fifty-percent of the original cortical rind, it is commonly associated with early reduction stages. However, other clues should be considered before making a determination. Finally, any flake in the sample that could not be confidently determined as a type or placed within a phase was recorded as 'other or 'indeterminate.'

Qualifying Analytical Biface Flake Types

Four separate biface flake types were identified on specific flake traits discussed early as well as what each flake accomplished – *e.g.* shaping or thinning, or longitudinal thinning. Any flakes that were ambiguous, were coded either 'indeterminate' or 'other' if they could be ascribed to a different activity such as blade manufacturing.

With regard to biface shaping flakes (BFS), Inizan, *et al.* (1999), broadly define these as a series of flakes that are removed to create a particular outline of a biface, but normally do not travel through the thickest portion of the biface (Inizan, *et al.* 1999:39-40). Root, *et al.* (1999) suggest biface outlines are shaped by removing short flakes along the edge of the biface (Root, *et al.* 1999:15). BFS flakes in this study were identified as being bifacial if they retained three or more dorsal scars and the flake body is often wider than long. However, the overall morphology, size, or thickness of shaping flakes can vary. Finally, BFS flakes may or may not have a prepared striking platform.

With regard to biface thinning flakes (BFT), these are usually identified as flakes with three or more dorsal scars (Huckell 2007:171). Platform preparation traits vary (Bradley, *et al.* 2010:66). Dorsal flake scars can be situated in a crossed pattern, overlap, or be opposed or multidirectional. BFT flakes can vary in size, thickness, and ventral curvature – *e.g.* straight or curved. End thinning/channel flakes (ET/Ch) were identified by their morphology recognized as multiple flake scars that overlap in a perpendicular manner to the striking axis of the flake (Fig. 35).

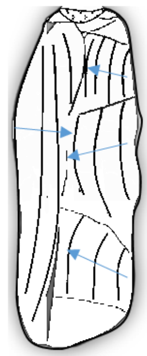

Figure 35 – Flake scar characteristics of a Clovis end thinning or channel flake

A fourth flake type, biface shaping/thinning flakes (BfST) were added to include those flakes that exhibited traits characteristic of both biface thinning and biface shaping flakes and are analyzed .

All data was hand-recorded onto a coding form adapted from Bradley (2009:414). See Appendix 1 for flake and data collection form and Appendix 3 for breakdown of the terminology relevant to data collection form.

Statistical Methods

Statistical analysis was conducted by looking at platform and flake traits by both flake phase and flake type. Analysis looked at counts and percentages of each trait and compared them across flake phase and flake type to assess if any discernable patterns were present. This was tested using Pearson's chi-squared analysis. The test was used to discern if there was a statistically significant difference in the data. This is tested using the following null (H_o) and alternate (H_a) hypotheses:

H_o: The distribution of the data across each group is not statistically different

H_a: The distribution of the data across each group is statistically different.

The Chi-square test calculates a p-value, and the null hypothesis is rejected at <0.05. If the results indicated a statistically significant difference, standardized residuals were used to assess where this difference was derived. The calculation for this is as follows:

$$z = \frac{[observed - expected] - 0.5}{\sqrt{expected}}$$

Standardized residuals were calculated for each cell and values greater than ± 2 were discussed.

For the analysis of flake and platform metrics, the mean and standard deviations were calculated and compared as well as range, and the maximum and minimum sizes. For an analysis of flake type, several statistical tests were used to determine any significant differences. In order to conduct these tests the distribution of the data was first tested for normality. This was conducted using the Shapiro-Wilk test that assessed the statistical significance of the distribution. This test used the following null and alternate hypotheses:

H_o: The population is normally distributed.

H_a: The population is not normally distributed.

The null hypothesis is rejected if the p-value is less-than 0.05. Normality testing was important as subsequent testing depended on whether or not the data were normally or non-normally distributed. As the data were non-normally distributed, the Kruskal-Wallis non-parametric significance test was used. In essence, this test determines if two or more populations were statistically significantly different using the following hypotheses:

H_o: The populations from which the data sets have been drawn have the same mean.

H_a: At least one population has a mean larger or smaller than at least one other population.

In essence, the null hypothesis indicates no statistically significant differences whereas the alternate hypothesis indicates statistically significant differences. Furthermore, the null hypothesis is rejected if the ρ-value is < 0.05.

Following the Kruskal-Wallis Test, the Tukey-Kramer HSD (Urdan 2010) test was used as a method for identifying the statistical significance on populations of three or more. Tukey-Kramer HSD compares each population in the analysis and provides a ρ-value for each group-to-group comparison. If the ρ-value is < 0.05 then the difference between those two specific groups is statistically significant. Any statistically significant result presented was further analyzed to determine where the significance was derived.

With regard to the five platform preparation traits that are the focus of the analysis, – ground, faceted, reduced, released, and isolated – (Bradley, *et al.* 2010:66), platforms were assigned a score based on how many preparation traits were present. In this respect, a score of “1” equates to one preparation trait present, while a score of “5” indicates all five traits were present. This was then used as a proxy for complexity: Wherein the number of traits used likely denotes the extent of attention given, essentially knapping behaviors, during biface reduction and/or flake production.

Prior to the complexity analysis, correlation of the five platform preparation traits were explored using non-parametric correlation tests using Spearman's P and Hoeffding's D analytical tests and are presented in Chapter 7.

With regard to small cell values, chi-square analysis cannot be conducted so Fisher's Exact Test was used instead.

All raw data were entered into Microsoft Access ® and then imported to Excel ® spreadsheets for analysis. Statistical analysis was conducted using SAS Institute Inc. JMP ® Pro 11.0.0.

Chapter 7 -- Clovis Flake Study Results and Analysis

The first section of the analyses presents basic distribution and metrics of all flakes and flake types in the 2185 flake data set. The flake data are broken down by flake type and reduction phase and are presented in Table 7 and Table 8. Six hundred seventy-five flakes represent a fifth category of flake assigned as “other” which represents 30.89% of the 2185 data set. “Other” flakes are those not associated with biface manufacturing, such as flakes that were deemed ambiguous, or associated with other knapping activities like blade manufacture (*e.g.* blade core tablet flake Ferring 2001:146).

To sum up, the aim of this research is to understand the technology of Clovis biface reduction from the perspective of Clovis manufacturing, explicitly biface flakes, and platform preparation traits. From the original data set of 2185 flakes, 1510 (69.12%) were confidently identified as flake by-products of Clovis biface manufacturing and are the primary focus for most sections of analyses.

Finally, unless otherwise stated, most statistical analyses conducted will analyzed the data using two comparative groupings of flake type and flake phase.

Descriptive Statistics of All Flakes

Twenty one hundred eighty-five (2185) flakes were recorded in the original data set that was recovered from *in-situ* well-stratified Clovis deposits from Area 4 of the Gault Site. Out of these, nearly seventy-one percent (70.94%) were complete flakes while the remaining 29.06% percent were incomplete or broken flakes.

Overall biface thinning flakes (BFT) occurred in the highest number, followed by biface shaping flakes (BFS) and biface shaping/thinning flakes (BfST). Forty flakes were identified as end thinning/channel flakes (ET/Ch), (Table 7).

Table 7 – Percentages/Counts of Data Set by Flake Type (n= 2185)

Flake Type	Count (n)	Percent (%)
Biface Shaping (BFS)	392	17.94
Biface Shaping/Thinning (BfST)	184	8.42
Biface Thinning (BFT)	894	40.92
End Thinning/Channel (ET/Ch)	40	1.83
Other	675	30.89
TOTAL	**2185**	**100**

Table 8 shows the counts and percentages of these same flakes by phase. The middle phase contained the highest number of flakes (n=684, 31.30%) followed by the late to finish phase with 483 (22.11%) flakes. The early phase (n=303, 13.87%), early to middle phase (n=274, 12.54%), and middle to late phase (n=361, 16.52%) all have similar numbers of recorded flakes. Finally, 80 (3.66%) flakes were not assigned to any phase due to the ambiguous nature of those flakes.

Table 8—Percentages/Counts of Data Set by Flake Phase (n=2185)

Flake Phase	Count (n)	Percent (%)
Early	303	13.87
Early/Middle	274	12.54
Middle	684	31.30
Middle/Late	361	16.52
Late/Finish	483	22.11
Indeterminate	80	3.66
Total	**2185**	**100**

A descriptive analysis of platform preparation traits on all 2185 flakes was undertaken and presented in Table 9. Seventy-five (3.43%) flakes exhibited unprepared or 'plain' platforms. This indicates that, in the majority of cases, some form of platform preparation was conducted prior to flake removal. According to Bradley, *et al.* (2010:66), Clovis biface thinning flakes often exhibit specific preparation traits that are ground, faceted, reduced, released, and isolated and were recorded individually.

It is important to note that these platform preparation traits were not mutually exclusive; therefore, they can occur as a single preparation or in combinations with other platform preparation traits. Thus, the percentages reported in Table 9 do not equal 100%.

Platform reduction was the most common recorded preparation trait with 1407 (64.39%) flakes exhibiting this form of preparation. This was followed by platform isolation (n=1324, 60.59%) and ground platforms (n=1283, 58.72%). Faceting was recorded in only 954 (43.66%) flakes while released platforms were recorded in 498 (22.79%) flakes.

Table 9 -- Descriptive Analysis of Platform Preparation Traits of All Flakes (n=2185)

Platform Preparation Traits	*Count (n=)	*Percent (%)
Faceted	954	43.66
Reduced	1407	64.39
Released	498	22.79
Isolated	1324	60.59
Ground	1283	58.72
***Due to number of variables, counts and percentages will not equal 100/100%**		

This analysis indicated that while 96.57% of platforms were prepared, no single trait was used on every flake detachment. An analysis of the number of different combinations used on all platforms indicated that 28 different combinations of those traits listed above in Table 9 were used. The most frequent combination was the use of all five traits with 265 examples. However, this only represents 12.13% of the entire sample. This highlights the fact that Clovis platform preparation was a complex technique with no single unified method utilized.

The next section examines the metric dimensions using refined flake and platform data sets. Over fifteen-hundred flakes in the original data set were identified as being produced during biface manufacture.

Analysis of Clovis Biface Flakes -- Refining the Data Set

As discussed in the Methodology (Chapter 6), all observational data and metric data were collected separately. During data collection, observational data were used to ascertain flake phases and flake types. On the other hand, metric data were collected, not only as standard practice associated with individual debitage analysis, but also to be used as a benchmark, or control *per se*, to gauge the subjectivity of biface flakes being placed within a reduction phase.

Based on the premise of this research, the next section of analyses and results examined a refined dataset of 1510 flakes (69.12% of 2185) identified as produced or associated with biface manufacture. The following analyses start with presenting results of the general attributes of biface flakes as well as basic platform attributes, again, related to biface manufacture.

Biface Flake Metrics

One thousand eighty-two (1082) or 71.65% of the 1510 data set were whole flakes and the remaining 428 or 28.34% were incomplete or broken. The following section analyzed whole flakes only.

The mean length, width, and thickness of the biface flake data are reported in Table 10 along with the maximum, minimum, and ranges of flake lengths, widths, and thicknesses. These data were then analyzed using two specific analytical groups of biface phase (Table 11 and Figure 36) and biface flake type (Table 12 and Figure 37).

Table 10 – Biface Flake Metrics of Whole Flakes -- Length/Width/Thickness (n=1082)

	Length	Width	Thickness
Mean	30.74	26.60	4.93
Standard Deviation	20.84	17.39	3.84
Standard Error	0.63	0.53	0.12
Range	149	134.3	24.4
Minimum	4.2	3.9	0.6
Maximum	153.2	138.2	25

The mean dimensions of flakes by phase are presented below in Table 11 and Figure 35.

Table 11-- Biface Flake Metrics of Whole Flakes (L/W/Th) by Phase

		Early	Early/Middle	Middle	Middle/Late	Late
Length	Mean	54.03	41.99	35.46	25.88	17.16
	Std Dev	28.26	19.84	18.27	14.30	9.31
	Std Err	2.56	1.80	1.05	1.03	0.50
Width	Mean	47.93	36.53	30.59	22.05	14.63
	Std Dev	23.01	15.26	15.03	11.14	7.16
	Std Err	2.08	1.39	0.87	0.80	0.39
Thickness	Mean	10.45	7.42	5.50	3.69	2.30
	Std Dev	4.66	3.03	3.27	2.04	1.68
	Std Err	0.42	0.28	0.19	0.15	0.09

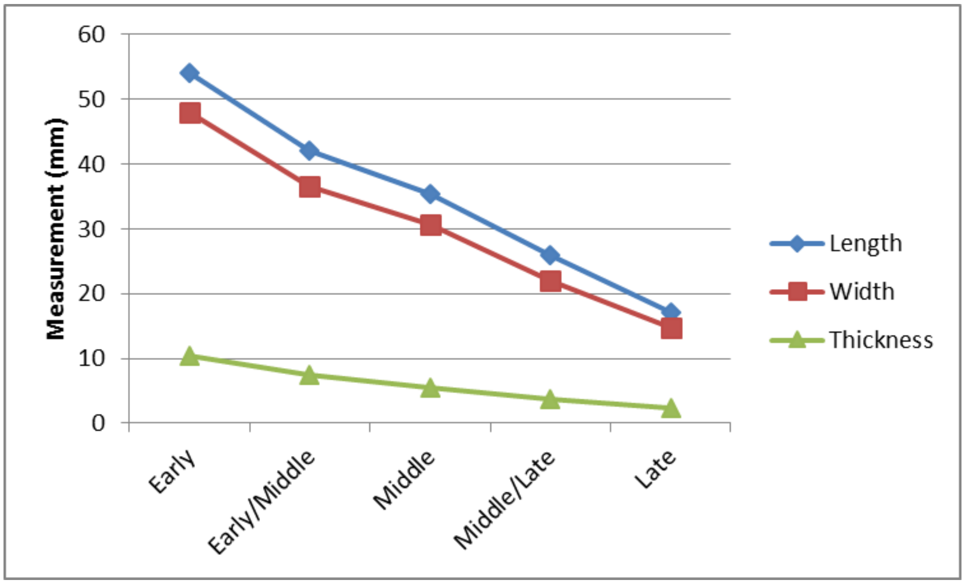

Figure 36 – Biface Flake Mean Dimensions of Whole Flakes L/W/Th by Phase.

Analyses of the overall flake averages are presented by flake type in Table 12 and Figure 37. These indicate that BFS flakes are wider and shorter than the three remaining flake-type categories, BFT flakes, BfST, and ET/Ch flakes, with ET/Ch being on average the longest flake type.

Table 12 – Biface Flake Metrics of Whole Flakes (L/W/Th) by Flake Type

		FLAKE TYPE			
		Shaping	**Shaping & Thinning**	**Thinning**	**End Thinning/Channel**
Length	Mean	19.81	29.43	36.28	42.15
	Std Dev	13.93	19.55	21.74	22.05
	Std Err	0.79	1.62	0.90	3.90
Width	Mean	22.11	27.70	28.57	29.34
	Std Dev	13.60	18.45	18.68	13.14
	Std Err	0.77	1.53	0.77	2.32
Thickness	Mean	4.37	5.51	5.04	5.82
	Std Dev	3.96	4.28	3.63	3.81
	Std Err	0.22	0.35	0.15	0.67

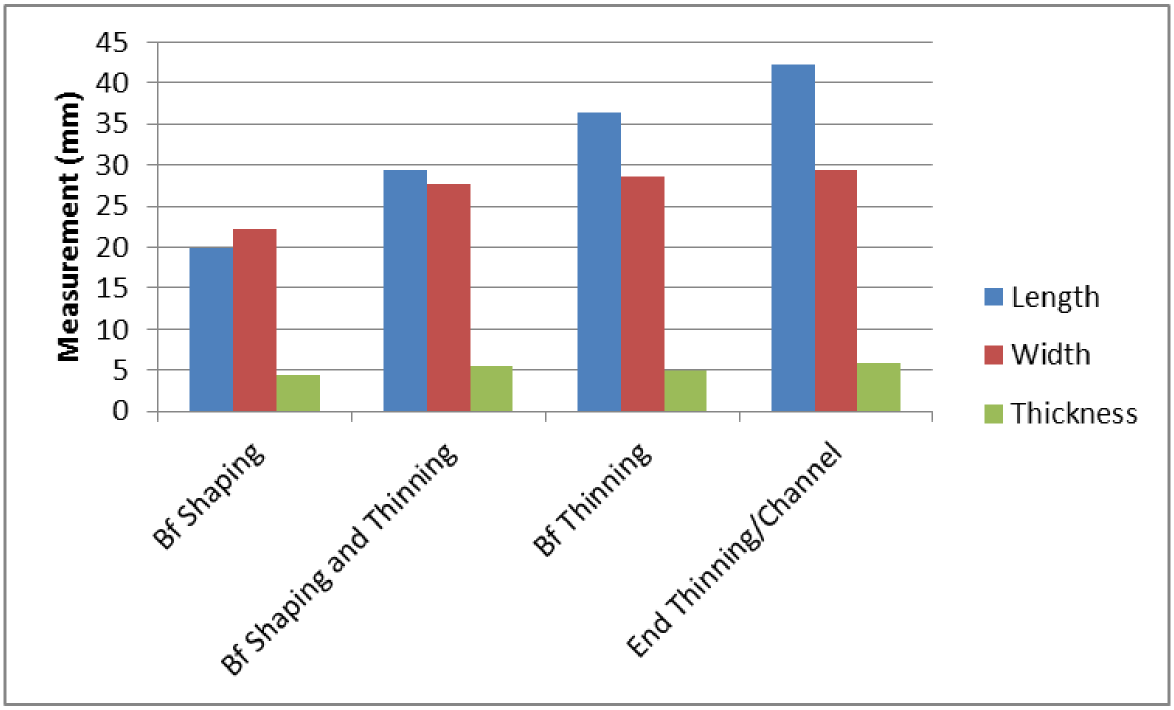

Figure 37 -- Biface Flake Mean Dimensions of Whole Flakes (L/W/Th) (mm) by Flake Type

Biface Platform Metrics

Analyses of the metric measurements were recorded of striking platforms on all 1510 biface flakes.

The results of the analysis of these measurements indicate an average platform width of 10.09 mm and an average platform depth of 2.97 mm (SD = 7.20 x 2.44) (Table 13).

Table 13 — All Platform Metrics (W/D) (n=1383)

	Width (mm)	Depth (mm)
Mean	10.09	2.97
Standard Deviation	7.20	2.44
Standard Error	0.19	0.07
Range	53.20	22.81
Minimum	1.30	0.09
Maximum	54.50	22.9

Table 14 and Figure 38 breaks the platform dimensions down into phase and Table 15 and Figure 39 by type.

Table 14 – Platform Metrics (mm) by Phase (n=1383)

		Early	Early/Middle	Middle	Middle/Late	Late
Pf Width	**Mean**	18.05	14.40	10.69	8.37	6.59
	Std Dev	11.21	8.27	6.20	4.61	3.73
	Std Err	.96	0.68	0.31	0.27	0.18
Pf Depth	**Mean**	6.05	4.45	3.12	2.36	1.73
	Std Dev	3.86	2.56	2.02	1.64	1.10
	Std Err	0.33	0.21	0.10	0.10	0.05

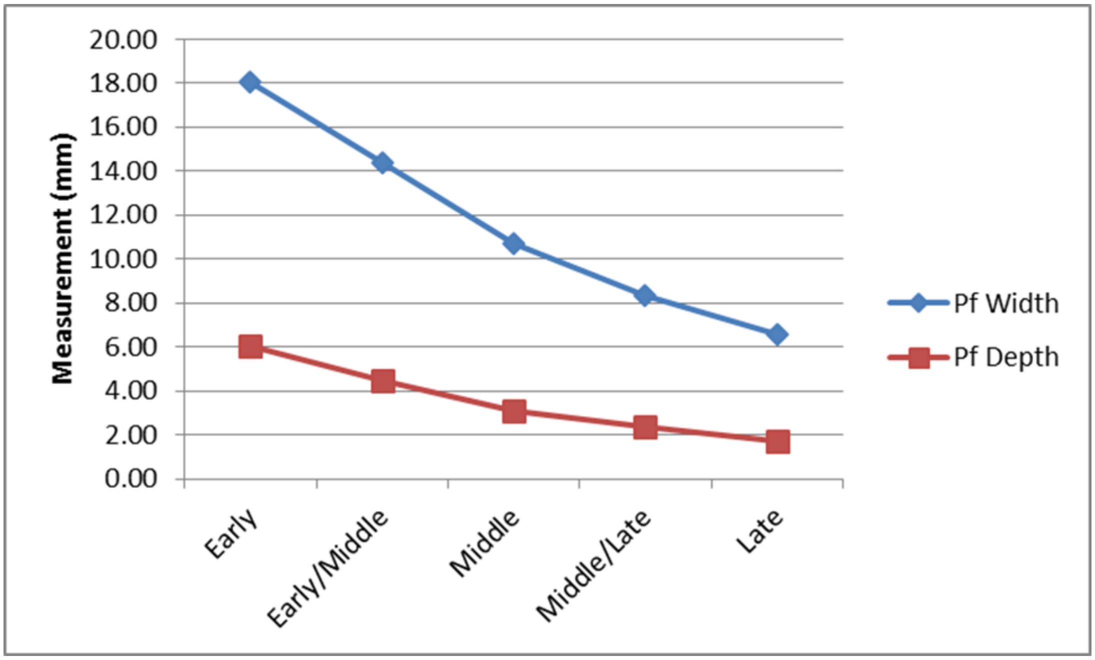

Figure 38 – Platform Metrics (mm) by Phase (n=1383)

Table 15 – Platform Metrics (mm) by Flake Type (n=1383)

		Shaping	Shaping and Thinning	Thinning	End Thinning/ Channel
Pf Width	Mean	11.77	11.22	9.06	10.57
	Std Dev	8.60	7.96	6.11	6.32
	Std Err	0.45	0.61	0.22	1.04
Pf Depth	Mean	3.12	3.20	2.83	3.56
	Std Dev	2.99	2.46	2.14	2.11
	Std Err	0.16	0.19	0.08	0.35

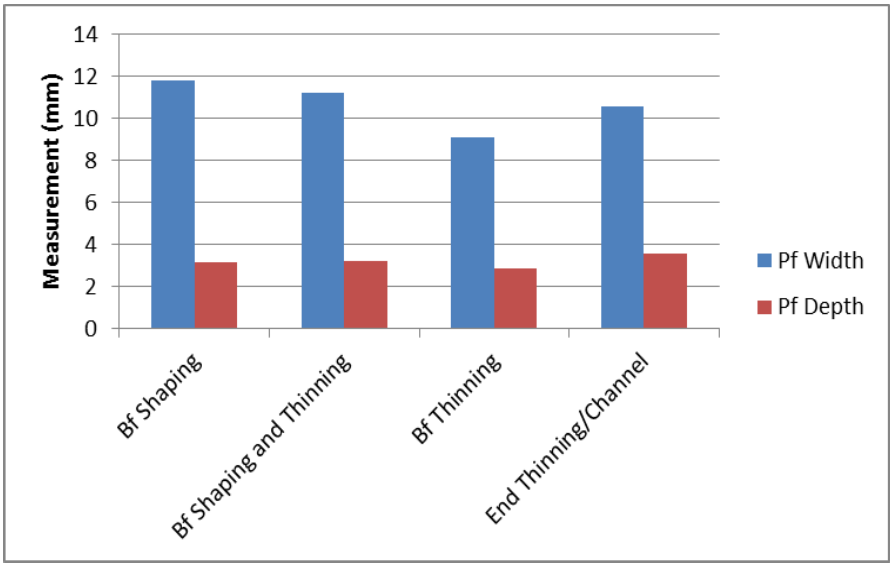

Figure 39— Platform Metrics Platform Mean Dimensions (W/D) by flake type (n-1383)

These biface flake and platform metric data together indicate that as biface reduction progressed, the overall dimensions of the flakes and flake platforms also decreased by phase (*see* Patterson 1982 and Patterson 1990).

The above results of biface flake and platform metric data by phase and type provide a basic accounting of the data set. Based on the value of the means, it is noted that the standard deviations are high. However, this is expected due to the variability of the refined biface data set. As such, to help characterize the degree of variability, further analysis was conducted and the results are presented using a box-and-whisker plot along with a “scatter” diagram of the platform dimensions by phase (Figure 40), and flake dimensions by phase (Figure 41). The results support a steady decrease of the overall dimensions of flakes and platforms within their respective ranges of variability.

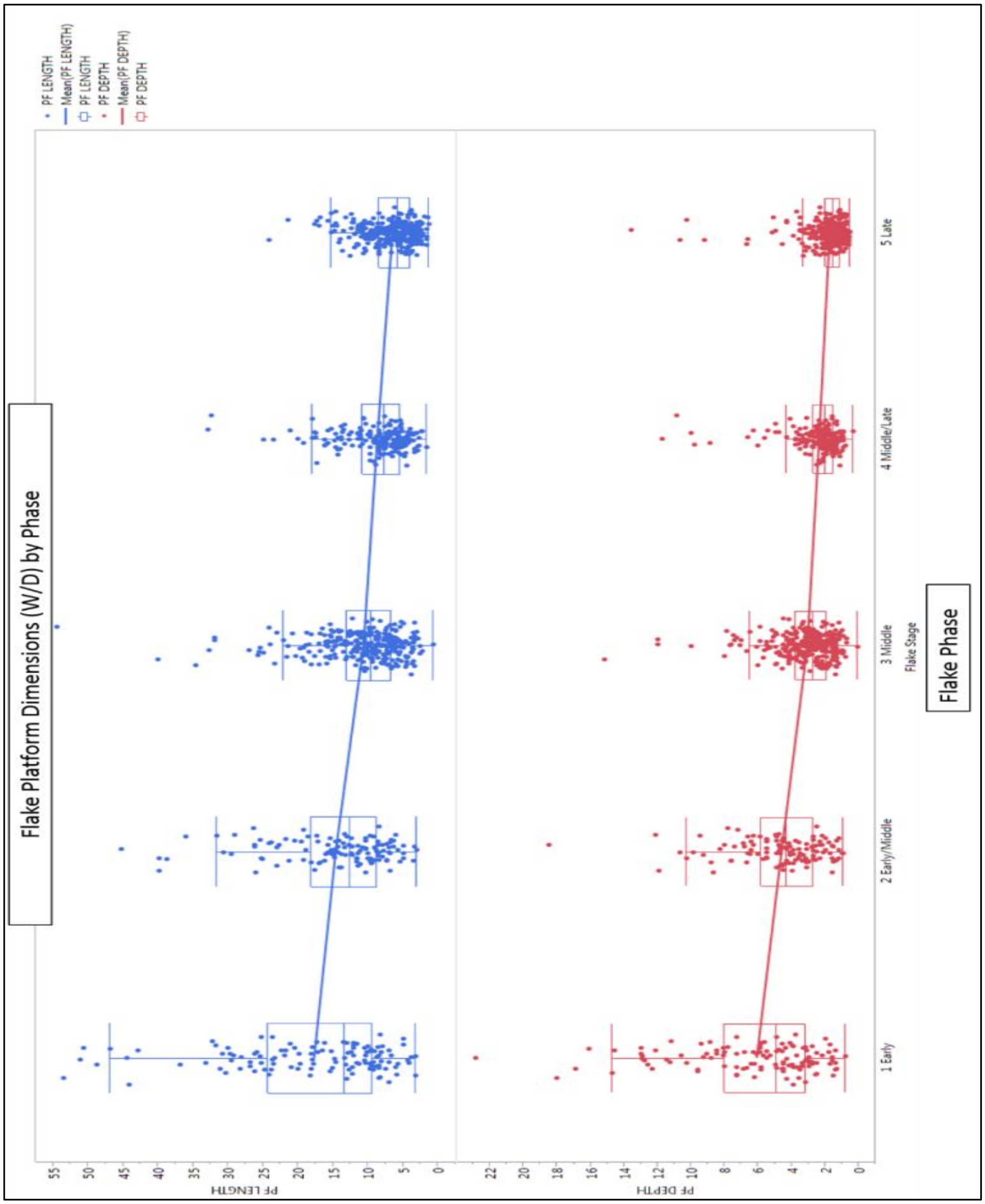

Figure 40 – Box Plot Platform Dimensions (W/D) by Phase (n=1383)

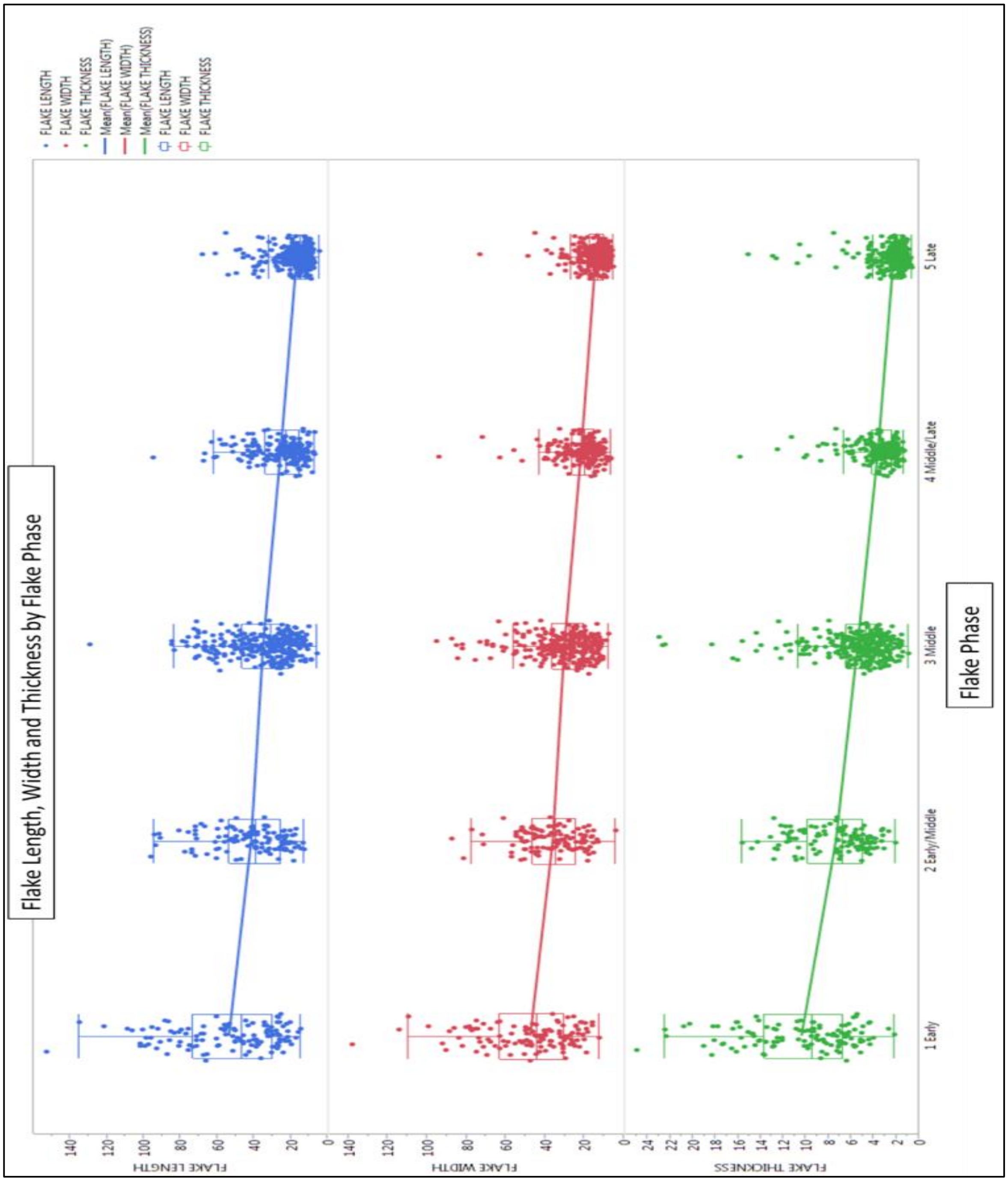

Figure 41– Box Plot Whole Flake Dimensions (L/W/Th) by Phase

Further analysis of overall platform metrics by type indicated that platforms were longer than deep. This result can be seen in the depth-to-width ratios in Table 16, which indicate that BFS flakes have the largest depth-to-width ratio of 1:3.77, followed by BfST with 1:3.51, with BFT at 1:3.20 and ET/Ch having the lowest at 1:2.97. This is seen in table 13 earlier, which indicates in all cases that 70% or more of the overall platform size is derived from the width.

Table 16-- Platform Depth to Width Ratios by Flake Type (n=1383)

Platform by Type	Pf Width	Pf Depth	D:W ratio	w+d	w/w+d	d/w+d
BFS	11.77	3.12	3.77	14.89	0.79	0.21
BfST	11.22	3.20	3.51	14.42	0.78	0.22
BFT	9.06	2.83	3.20	11.89	0.76	0.24
ET/Ch	10.57	3.56	2.97	14.13	0.75	0.25

Differentiating Between Biface Thinning Flakes and Biface Shaping/Thinning Flakes

Further statistical analysis was conducted on the flake metrics to determine if any differences between BFT and BfST were significant. The first step was to determine the distribution of these data.

Figure 42 indicates that the data is positively skewed. A Shapiro-Wilk goodness-of-fit test confirmed that the data were non-normally distributed, and are presented in Table 17.

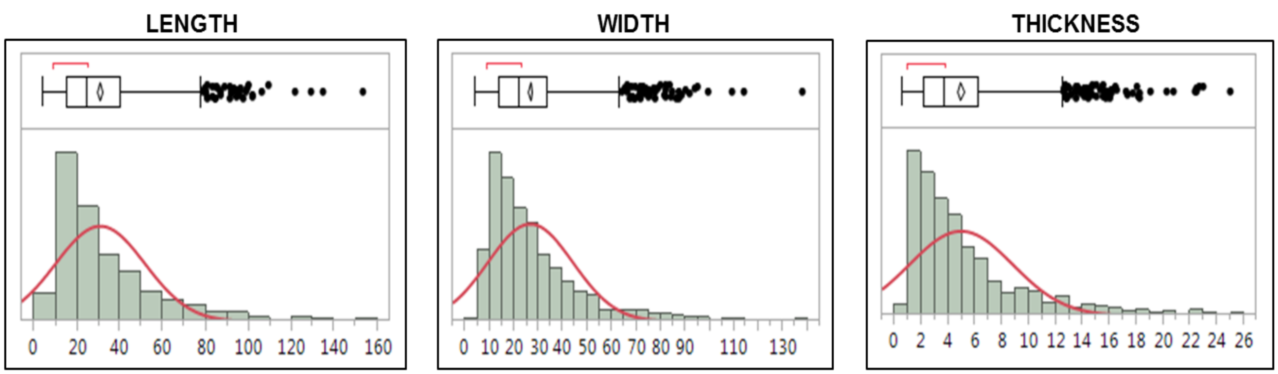

Figure 42—Distribution histograms for flake metric length, width, and thickness.

Table 17 -- Shapiro-Wilk Goodness-of-Fit Test to confirm non-normal distribution

Flake L/W/Th Metrics	W	Prob<W
Length	0.854925	<.0001
Width	0.848864	<.0001
Thickness	0.824619	<.0001

Because these data have non-normal distributions, (*see above*, Fig. 42 and Table 17) non-parametric tests were used to assess statistical significance. Kruskal-Wallis is a non-parametric significance test (Urdan 2010) and was used in the first phase of the analysis. The results of the Kruskal-Wallis test (Table 18) shows in all cases that the null hypothesis must be rejected and the alternate hypothesis accepted. While the results of this test indicate that for each metric at least one population has a *mean* that is significantly different from one other population, it does not reveal any specific group.

Table 18 -- Kruskal-Wallis test

Flake Metrics	**Chi-Square**	***df***	**Prob>Chi-Sq**
Length	218.9085	3	<.0001
Width	36.4696	3	<.0001
Thickness	35.1407	3	<.0001

Following the Kruskal-Wallis Test (Table 18), the Tukey-Kramer HSD (Urdan 2010) test was used. Analysis of length (Table 19) and width (Table 20) shows the results of the Tukey-Kramer HSD test on the metrics by flake type. This test indicated there was a statistically significant difference between the lengths of each flake type except ET/Ch flakes and BFT flakes. In terms of flake width, the analysis indicated there are statistically significant differences between BFT flakes and BFS flakes as well as statistically significant differences between BfST flakes and BFS flakes.

Table 19 -- Tukey-Kramer HSD Analysis of Flake Length

Flake Groups Compared Type by Type		Difference	Std Err Dif	Lower CL	Upper CL	p-Value
ET/Ch	**BFS**	22.334	3.617	13.026	31.641	<.0001
BFT	**BFS**	16.463	1.362	12.958	19.968	<.0001
ET/Ch	**BfST**	12.714	3.805	2.924	22.504	0.005
BfST	**BFS**	9.620	1.953	4.595	14.644	<.0001
BFT	**BfST**	6.844	1.802	2.206	11.481	0.001
ET/Ch	**BFT**	5.870	3.538	-3.234	14.975	0.346

Table 20 -- Tukey-Kramer HSD Analysis of Flake Width

Flake Groups Compared Type by Type		Difference	Std Err Dif	Lower CL	Upper CL	p-Value
Channel	BFS	7.232	3.187	-0.970	15.433	0.106
BFT	BFS	6.460	1.200	3.372	9.548	<.0001
BfST	BFS	5.591	1.721	1.163	10.018	0.007
Channel	BfST	1.641	3.353	-6.986	10.268	0.961
BFT	BfST	0.869	1.588	-3.217	4.955	0.947
Channel	BFT	0.772	3.118	-7.251	8.794	0.995

The significant differences in those flakes designated, as BfST flakes can be further explored using a technique outlined by Collins (1999). The first step is to compare the width-to-length (w:l) ratios of each flake type. Table 21 lists these ratios and demonstrates that ET/Ch has the highest w:l ratio at 1:1.44. This is followed by BFT flakes w:l 1:1.27 with BFS flakes having the lowest w:l ratio of 1:0.90. The second step in this analysis was to calculate the ratio of length, width, and thickness. The first step of this calculation is to sum the length, width, and thickness measurements then divide each metric by this value (outlined in Table 21). This gives an indication of how much of the total shape of a flake is derived from each measurement. This analysis indicates that BFT flakes derive fifty-two percent (52%) of their size from length, forty-one percent (41%) from the width, and just seven percent (7%) from thickness.

BFS flakes are opposite of this pattern in terms of length and width wherein BFS flakes derive forty-three percent (43%) of their size from length and forty-eight percent (48%) derived from the width.

Table 21 -- Size and Dimension Analysis by Flake Types

Metric by Flake Type	Length	Width	Thickness	*w:l* ratio	l+w+t	l/(l+w+t)	w/(l+w+t)	t/(l+w+t)
BFS	19.81	22.11	4.37	0.90	46.30	0.43	0.48	0.09
BfST	29.43	27.70	5.51	1.06	62.65	0.47	0.44	0.09
BFT	36.28	28.57	5.04	1.27	69.88	0.52	0.41	0.07
ET/Ch	42.15	29.34	5.82	1.44	77.31	0.55	0.38	0.08

This analysis can also be graphically depicted to highlight these differences. Figure 43 articulates the mean length and width of each bifacial flake type. This is depicted by superimposing square outlines to represent each flake type. This illustrates the differences in length and width between not only BFT flakes, BFS flakes but BfST flakes as well. These differences can be further expressed, again using the calculations in Table 21, by taking the calculations of size (ratio) of length and width (l:w) the magnitude differences are removed from the samples providing a better expression of size whereby the specific differences between BFT, BfST and BFS flakes become more tangible (Figure 44). By removing the magnitude differences, for comparative purposes, it becomes apparent that BFT remove less mass but is the most invasive flake type, whereas BFS remove mass from the edge but are less invasive. However, the BfST flakes fall between both BFS and BFS flakes; in essence, bridging the gap between the previous two flake types by removing mass from the edge they are more invasive than BFS flakes.

While these data presented are based on subjective typologies, the findings highlight an important part of the Clovis reduction continuum. Clovis knappers would remove different types of flakes depending on what was necessary during phase of reduction and that knappers would seek to alter the length of flake removals depending on these necessities.

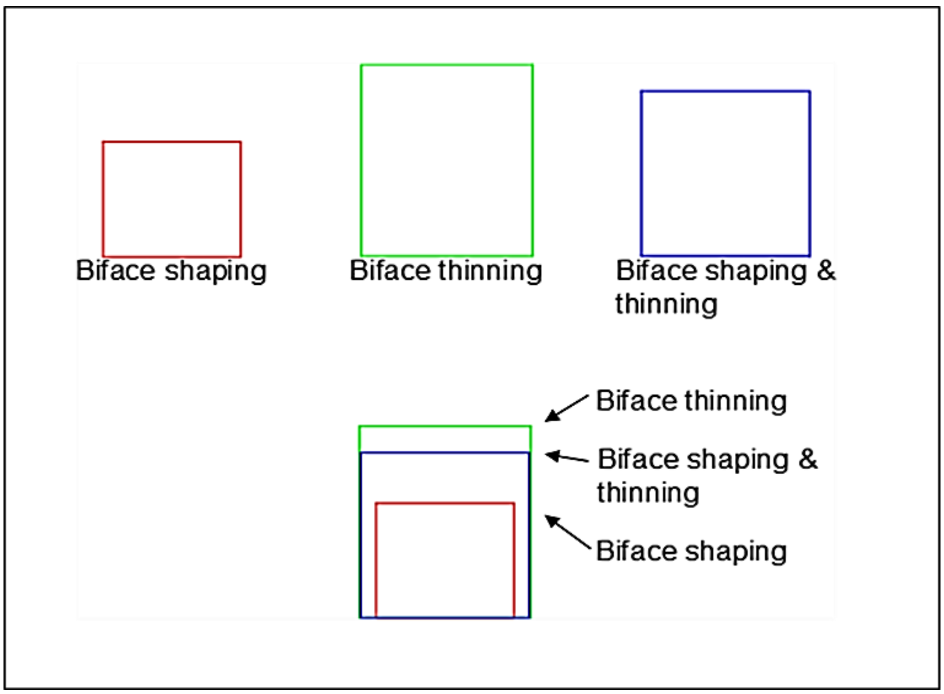

Figure 43 – Comparison of flake lengths and widths articulated as squares to represent size of flake types -- biface shaping (BFS), biface thinning (BFT), and biface thinning/shaping (BfST).

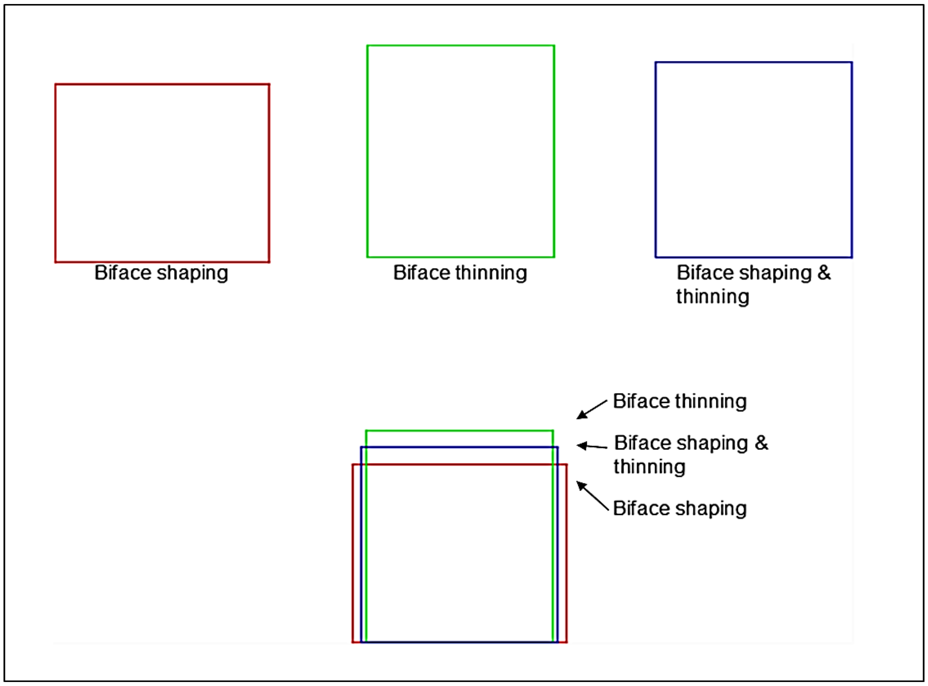

Figure 44 -- Comparison of expressions of flake size ratios with magnitude removed

While these data presented are based on subjective biface flake typologies, the findings highlight an important part of the Clovis reduction continuum. Clovis knappers would remove different types of flakes depending on what was necessary during phases of reduction by altering the length of flake removals needed.

Analysis of Flake Type Frequencies by Phase

As discussed, analyses were conducted only on those flakes produced during of biface production. Out of the original dataset consisting of 2185 flakes recorded, 1510 flakes were found to be related to specific aspects of biface manufacture. Table 22 summarizes these data and provides a breakdown of the different flake types by phase.

Table 22-- Summary of Flake Type by Phase (n=1510)

Type / Phase	BFS n	BFS (%)	BfST n	BfST (%)	BFT n	BFT (%)	ET/Ch n	ET/Ch (%)	Total n (%)
Early	62	(42.47)	30	(20.55)	46	(31.51)	8	(5.48)	146 (100)
Early/Mid	42	(25.93)	28	(17.28)	86	(53.09)	6	(3.7)	162 (100)
Mid	65	(14.98)	42	(9.68)	315	(72.58)	12	(2.76)	434 (100)
Mid/Late	70	(22.8)	22	(7.17)	210	(68.4)	5	(1.63)	307 (100)
Late	153	(33.19)	62	(13.45)	237	(51.41)	9	(1.95)	461 (100)

Analysis of these data indicates that the use of BFT increases towards the middle phase of manufacture, while BFS flakes decreases. The use of end thinning decreases throughout production. This is illustrated in Figure 45.

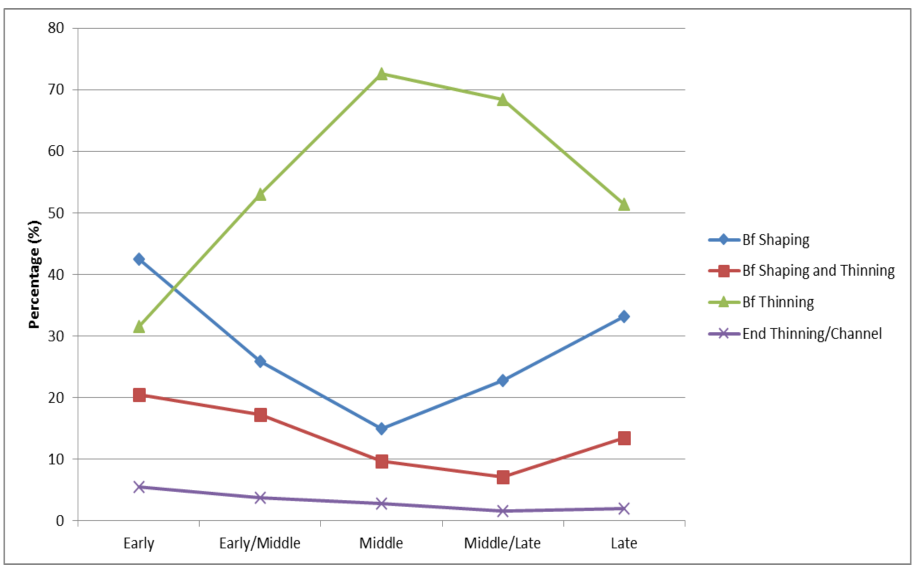

Figure 45 -- Comparison of Flake Types by Phase

Chi-squared analysis indicates that there is a statistically significant difference ($X^2(12, N=1510) = 116.320$, $p = <0.0001$). Further analysis of standardized residuals of the chi-squared tests reveals that the significance is largely derived from the differences in percentages of BFS flakes and BFT flakes in the early phase and middle phase.

Analysis of Flake Terminations

Termination by Phase

Analysis of flake termination by phase is presented in Table 23. The results indicated that feather terminations were the most common across all phases.

Table 23 -- Termination by Phase (n=1510)

Phase \ Termination	Overshot n (%)	Hinged n (%)	Step/Broken n (%)	Feathered n (%)	Total n (%)
Early	25 (17.12)	25 (17.12)	13 (8.9)	83 (56.85)	146(100)
Early/Middle	3 (1.85)	25 (15.43)	38 (23.46)	96 (59.26)	162(100)
Middle	33 (7.6)	67 (15.44)	125 (28.8)	209 (48.16)	434(100)
Middle/Late	6 (1.95)	38 (12.38)	111 (36.16)	152 (49.51)	307(100)
Late	7 (1.52)	29 (6.29)	113 (24.51)	312 (67.68)	461(100)

Figure 46 (below) further illustrates this and demonstrates a negative trend in both hinged and overshot terminations towards the latter phases of production. Chi-squared analysis indicates that there is a statistically significant difference ($X^2(12, N=1510) = 139.93$, $p = <0.0001$). Analysis of the standardized residuals indicated that this difference was derived from the higher numbers of overshot flakes occurring in the early and middle phases while the numbers of hinged flakes were lower than expected in the late phase. Flakes with a broken/step termination were lower than expected in the early phase and higher than expected in the middle/late phase. While feathered terminations were lower than expected in the middle phase and higher than expected in the late phase.

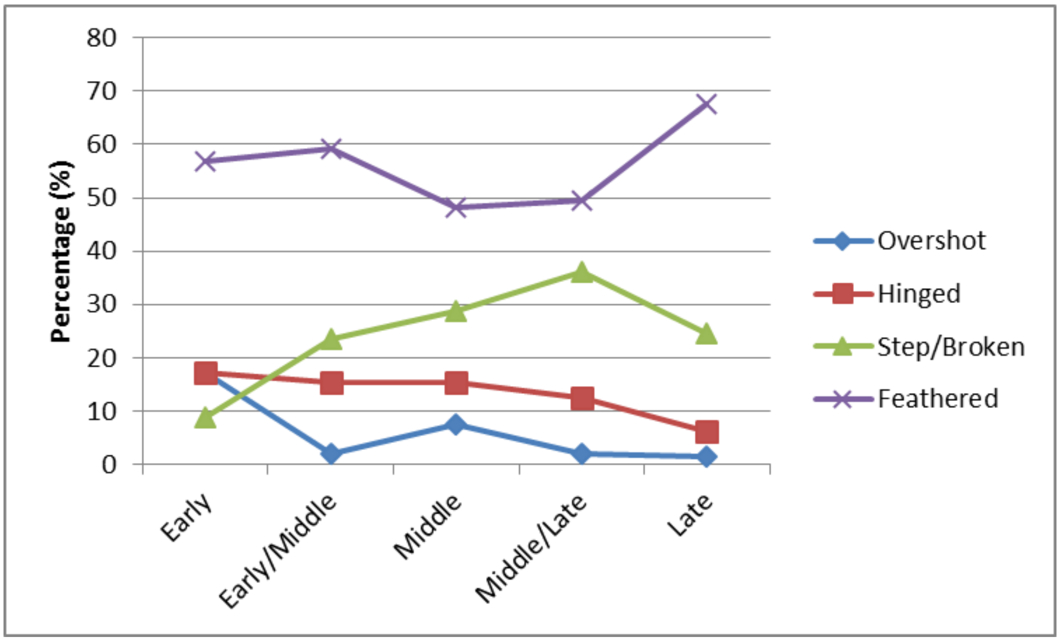

Figure 46 -- Terminations by Phase

This analysis was conducted a second time with step/broken flakes removed (Table 24) as it is difficult to assess if the step occurred during manufacture or later. This is illustrated in Figure 47.

Table 24 -- Termination by phase – w/ step/broken flakes removed

Termination / Phase	Overshot n (%)	Hinged n (%)	Feathered n (%)	Total n (%)
Early	25 (18.8)	25 (18.8)	83 (62.41)	133 (100)
Early/Middle	3 (2.42)	25 (20.16)	96 (77.42)	124 (100)
Middle	33 (10.68)	67 (21.68)	209 (67.64)	309 (100)
Middle/Late	6 (3.06)	38 (19.39)	152 (77.55)	196 (100)
Late	7 (2.01)	29 (8.33)	312 (89.66)	348 (100)

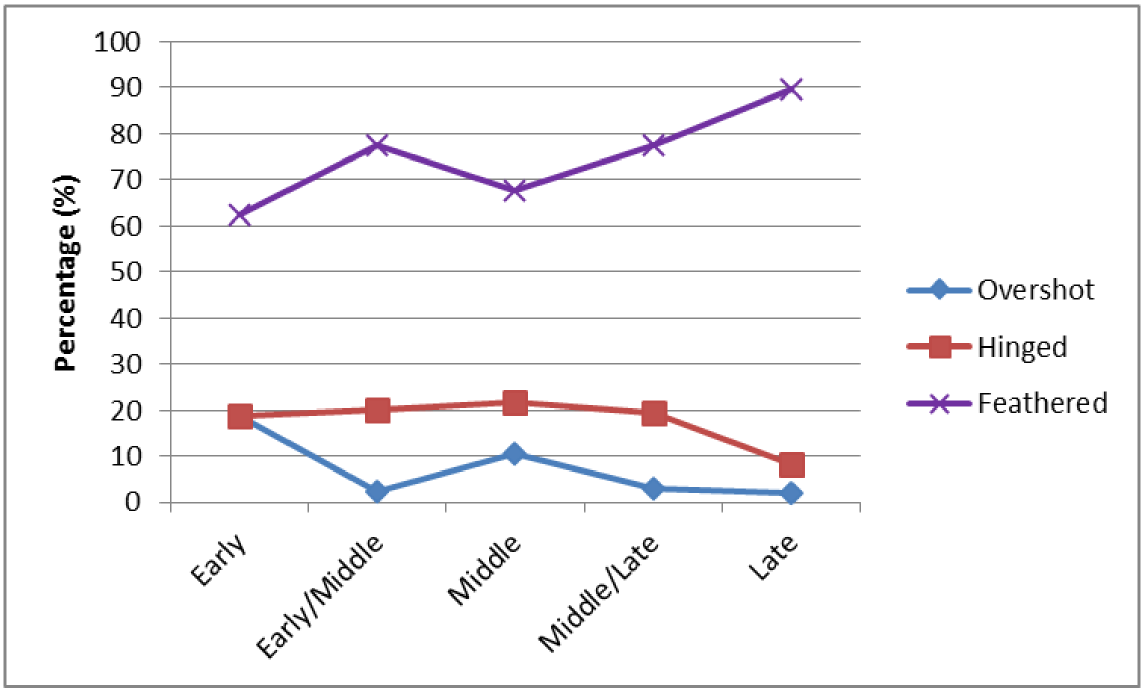

Figure 47 -- Terminations by Phase (w/ step/broken flakes removed)

This analysis demonstrates more clearly the decrease in numbers of overshot flakes towards the latter phases, conversely the number of feathered terminations increase. Hinged terminations stay relatively even until the late phase of production.

A final analysis was conducted looking specifically at the snap/broken flakes by thickness and platform preparation to determine if there were any correlations, but this analysis revealed no correlations.

Termination by Type

Analysis of termination by flake type indicated that the proportions of overshot, hinged and step/broken terminations were similar (Table 25). Conversely, with regard to the production of ET/Ch flakes, hinging was more common (Figure 48).

Table 25 --Terminations by Flake Type (n=1510)

Termination / Type	Overshot n (%)	Hinged n (%)	Step/Broken n (%)	Feathered n (%)	Total n (%)
BFS	6 (1.53)	47 (11.99)	68 (17.35)	271 (69.13)	392 (100)
BfST	6 (3.26)	21 (11.41)	36 (19.57)	121 (65.76)	184 (100)
BFT	61 (6.82)	106 (11.86)	288 (32.21)	439 (49.11)	894 (100)
ET/Ch	1 (2.5)	10 (25)	8 (20)	21 (52.5)	40 (100)

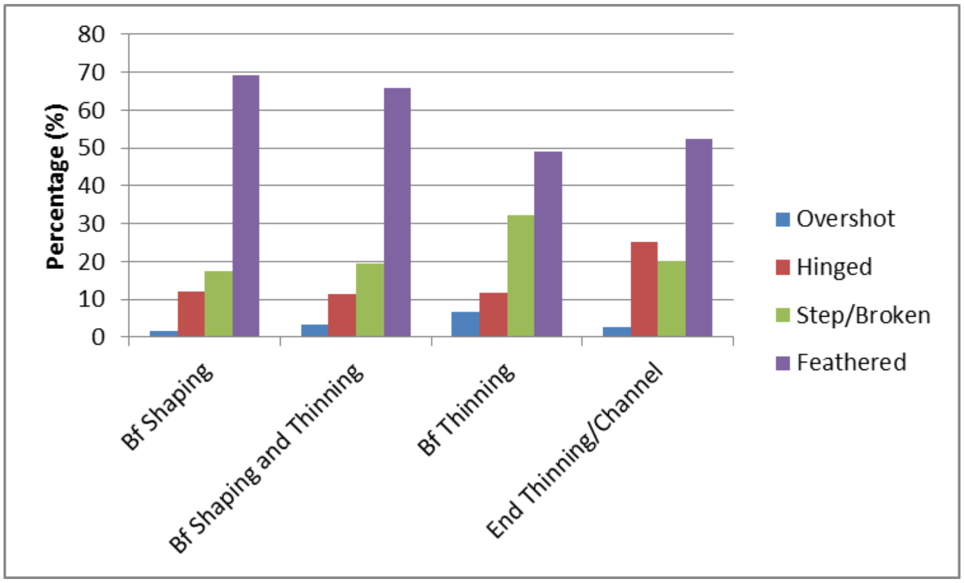

Figure 48 -- Terminations by Flake Type

Analysis of Lipping on Platforms

Lipping on a platform is defined by Andrefsky (2005:257) as a projection on the proximal ventral surface (strike-side) of the flake. Whittaker (1994) states, based on the theory of soft-hammer percussion, that this load technique initiates a bending fracture away from the actual point of contact (1994:189, fig.8.10b) which forms a lip. However, this theory is still open to debate (*see* Henry, *et al.* 1976:57).

Lipping by Phase

Analysis of the lipping indicated that the proportions of normal, minor, heavy, and no lipping were consistent in occurrence across all phases. These results are presented in Table 26 and are demonstrated in Figure 49.

Table 26 – Lipping by Phase

Lipping / Phase	Normal n (%)	Minor n (%)	Heavy n (%)	None n (%)	Total n (%)
Early	41 (28.08)	75 (51.37)	4 (2.74)	26 (17.81)	146 (100)
Early/Middle	52 (32.1)	80 (49.38)	8 (4.94)	22 (13.58)	162 (100)
Middle	141 (32.49)	224 (51.61)	28 (6.45)	41 (9.45)	434 (100)
Middle/Late	91 (29.64)	148 (48.21)	22 (7.17)	46 (14.98)	307 (100)
Late	145 (31.45)	233 (50.54)	18 (3.9)	65 (14.1)	461 (100)

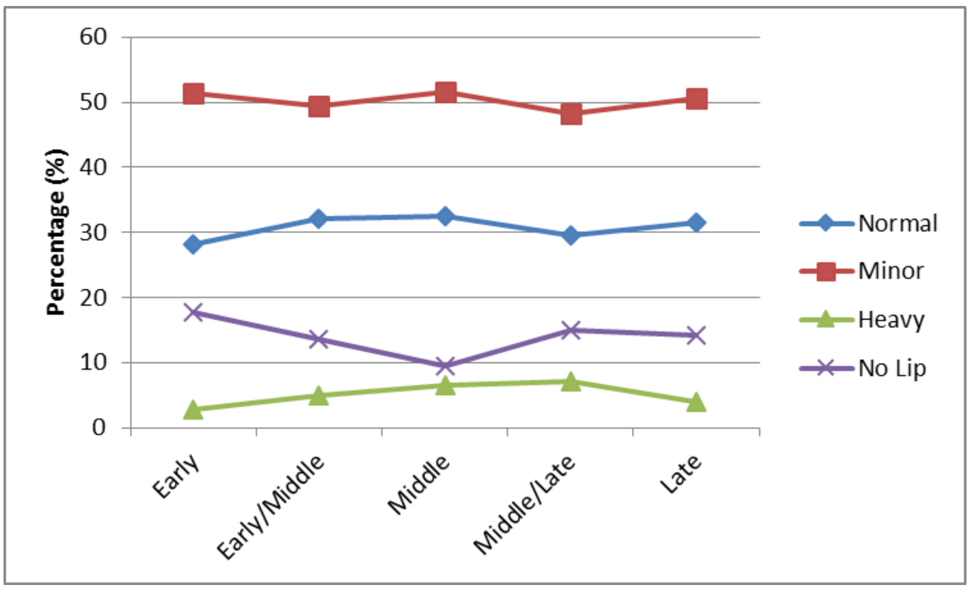

Figure 49 — Lipping by Phase

This general occurrence of lipping was confirmed using chi-squared testing which indicated no statistically significant difference ($X^2(12, N=1510) = 16.09, p = 0.1871$).

Lipping by Type

Likewise, the occurrence of lipping was evenly distributed between BFS, BfST, and BFT flakes, and the results are presented in Table 27 and Figure 50. Conversely, an exception to these results was the increase in normal lipping on ET/Ch flakes that also had smaller proportions of heavy lipping and no lipping.

Table 27 -- Lipping by Flake Type (n=1510)

Lipping / Type	Normal n (%)	Minor n (%)	Heavy n (%)	None n (%)	Total n (%)
BFS	99 (25.26)	204 (52.04)	14 (3.57)	75 (19.13)	392 (100)
BfST	52 (28.26)	100 (54.35)	9 (4.89)	23 (12.5)	184 (100)
BFT	294 (32.89)	443 (49.55)	56 (6.26)	101 (11.3)	894 (100)
ET/Ch	25 (62.5)	13 (32.5)	1 (2.5)	1 (2.5)	40 (100)

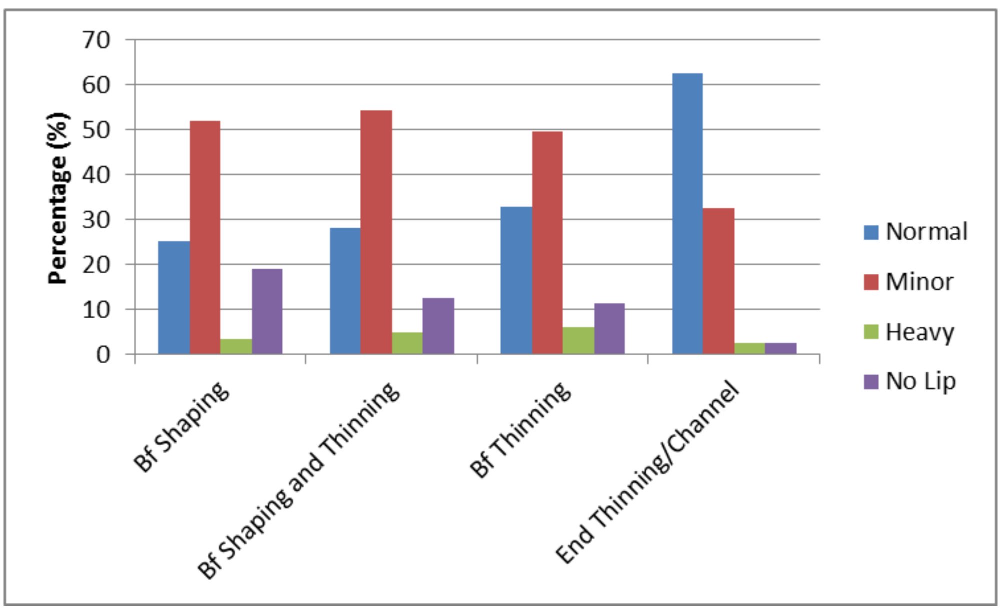

Figure 50 -- Lipping by Flake Type

Chi-square analysis indicated that this was statistically significantly different (X^2(12, N=1510) = 42.629, p = <0.0001).

The final analysis of lipping was conducted on individual flake type groups to determine the frequency and degree of lipping for each by phase.

While some patterns emerged in the data, including the increase in minor lipped platforms on BFS flakes in the middle phase. Statistical analysis indicates that there were no statistically significant differences. Table 28 and Figure 51 present the results of analysis of lipping on BFS flakes by phase. Chi-square analysis indicated no statistically significant difference (X^2(12, N=392) =20.090, p = 0.0654).

Table 28 -- Lipping on BFS Flakes by Phase

BFS	Normal n (%)	Minor n (%)	Heavy n (%)	No Lip n (%)	Total n (%)
Early	14 (22.58)	28 (45.16)	2 (3.23)	18 (29.03)	62 (100)
Early/Middle	9 (21.43)	19 (45.24)	2 (4.76)	12 (28.57)	42 (100)
Middle	19 (29.23)	39 (60)	2 (3.08)	5 (7.69)	65 (100)
Middle/Late	15 (21.43)	32 (45.71)	4 (5.71)	19 (27.14)	70 (100)
Late	42 (27.45)	86 (56.21)	4 (2.61)	21 (13.73)	153 (100)

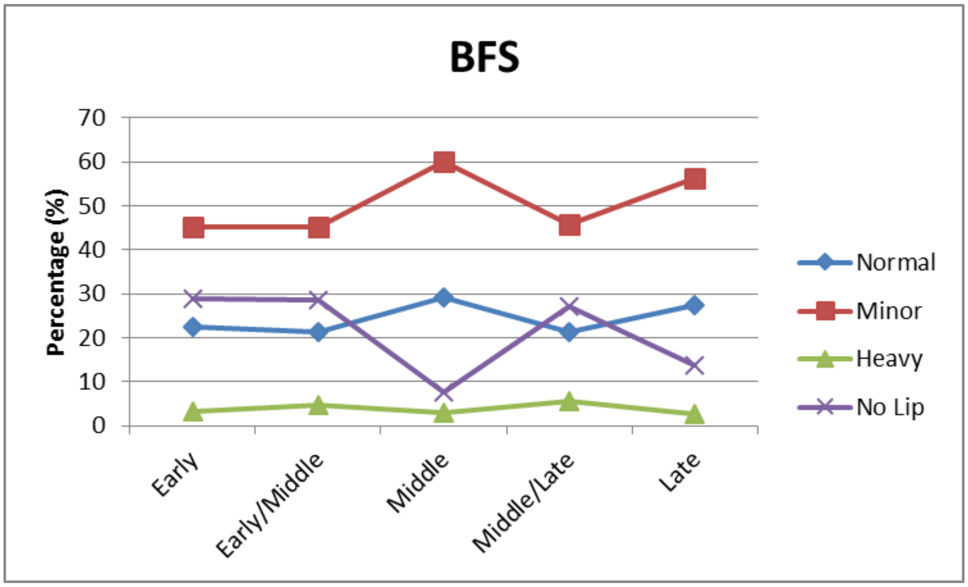

Figure 51 -- Lipping on BFS Flakes by Phase

Table 29 and Figure 52 shows lipping on BfST flakes by phase. Chi-square analysis could not be conducted due to the small cell values and so Fisher's exact Test was used instead. This test indicated no significant difference (s = 8.957, p = 0.699).

Table 29 -- Lipping on BfST by Phase (n=184)

BfST	Normal n (%)	Minor n (%)	Heavy n (%)	No Lip n (%)	Total n (%)
Early	7 (23.33)	18 (60)	1 (3.33)	4 (13.33)	30 (100)
Early/Middle	9 (32.14)	16 (57.14)	1 (3.57)	2 (7.14)	28 (100)
Middle	9 (21.43)	27 (64.29)	3 (7.14)	3 (7.14)	42 (100)
Middle/Late	5 (22.73)	13 (59.09)	1 (4.55)	3 (13.64)	22 (100)
Late	22 (35.48)	26 (41.94)	3 (4.84)	11 (17.74)	62 (100)

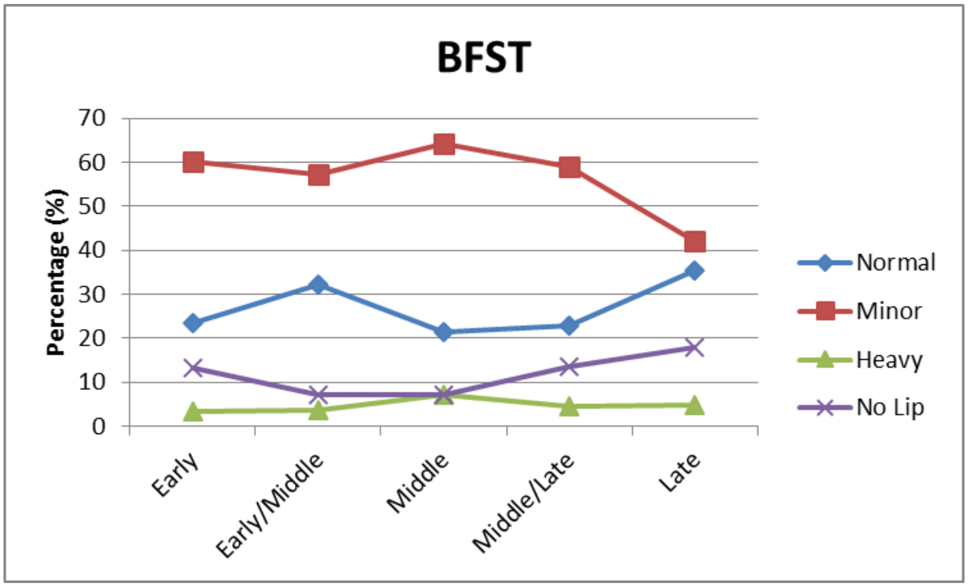

Figure 52 -- Lipping on BfST Flakes by Phase

Table 30 and Figure 53 presents the analysis of lipping on BFT flakes by phase. Chi-square analysis indicated no statistically significant difference (X^2(12, N=894) = 7.644, p = 0.8123).

Table 30 -- Lipping on BFT Flakes by Phase (n=894)

BFT Flakes	Normal n	(%)	Minor n	(%)	Heavy n	(%)	No Lip n	(%)	Total n	(%)
Early	13	(28.26)	28	(60.87)	1	(2.17)	4	(8.7)	46	(100)
Early/Middle	30	(34.88)	43	(50)	5	(5.81)	8	(9.3)	86	(100)
Middle	105	(33.33)	155	(49.21)	23	(7.3)	32	(10.16)	315	(100)
Middle/Late	70	(33.33)	100	(47.62)	16	(7.62)	24	(11.43)	210	(100)
Late	76	(32.07)	117	(49.37)	11	(4.64)	33	(13.92)	237	(100)

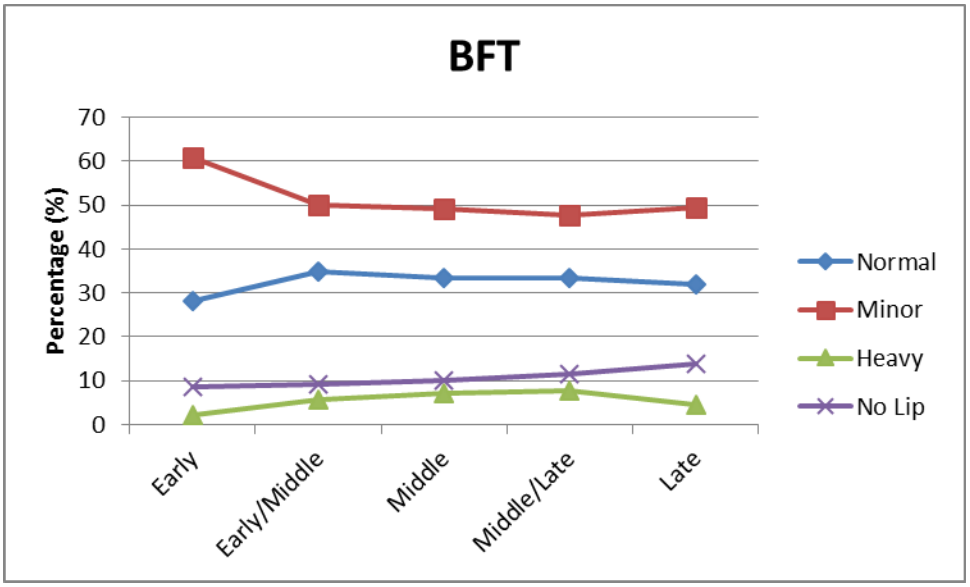

Figure 53 -- Lipping on BFT Flakes by Phase

Table 31 and Figure 54 presents ET/Ch flakes by phase. Again, Chi-square analysis could not be conducted due to small cell values, so Fisher's exact Test was used. This test indicated no significant difference (s =13.520 p = 0.282).

Table 31 – Lipping on ET/Ch Flakes by Phase

ET/Ch	Normal		Minor		Heavy		No Lip		Total	
	n	***(%)***	**n**	***(%)***	**n**	***(%)***	**n**	***(%)***	**n**	***(%)***
Early	7	(87.5)	1	(12.5)	0	(0)	0	(0)	8	(100)
Early/Middle	4	(66.67)	2	(33.33)	0	(0)	0	(0)	6	(100)
Middle	8	(66.67)	3	(25)	0	(0)	1	(8.33)	12	(100)
Middle/Late	1	(20)	3	(60)	1	(20)	0	(0)	5	(100)
Late	5	(55.56)	4	(44.44)	0	(0)	0	(0)	9	(100)

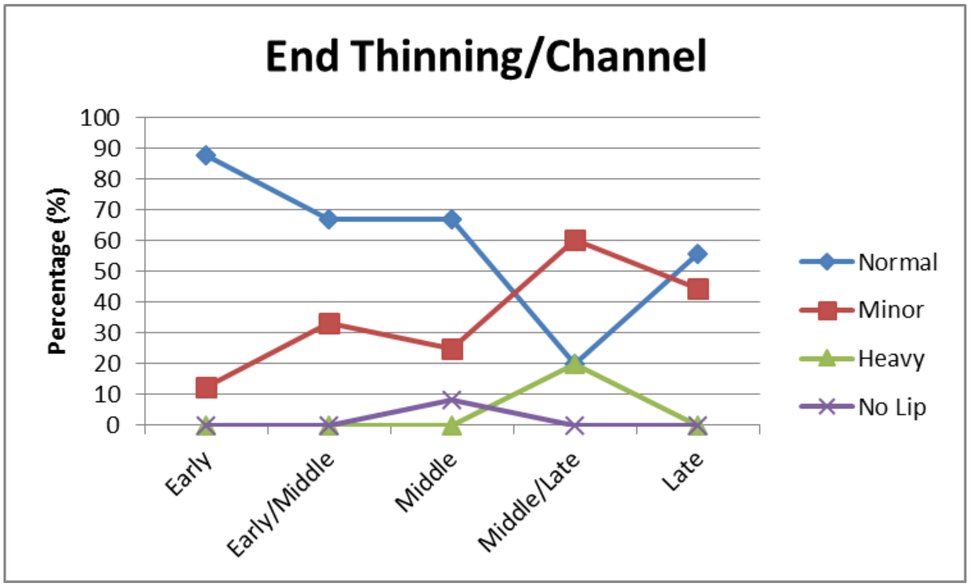

Figure 54 -- Lipping on ET/Ch Flakes by Phase

This analysis indicates that lipping is not influenced by flake type or phase. Analysis of platform preparation and lipping indicated no significant correlations between any platform traits and the occurrence of lipping.

Analysis of Striking Platform Attributes and Traits

Analysis of Platform Grinding by Phase

In order to measure the intensity of grinding on striking platforms, grinding was divided into three analytical units in order to record "where" grinding occurred in the striking platform area -- *e.g.* "edge," "obverse" (ventral), "reverse" (dorsal).

Of these, there were eight possible combinations– *e.g.* edge only -- obverse only -- reverse only -- edge + obverse -- edge + reverse -- obverse + reverse – full grinding (all) -- no grinding. However, only seven combinations were detected during analysis because "obverse only" grinding was not detected on any flakes.

The counts and proportions of grinding by phase are presented in Table 32 and the proportions are illustrated in Figure 55.

Table 32 –Grinding Combinations by Phase n / %

Grinding / Phase	None	Edge	Reverse	Obverse	Edge + Reverse	Edge + Obverse	Obv/Rev	Full	Total
Early	49 (33.56)	38 (26.03)	0 (0)	0 (0)	5 (3.42)	29 (19.86)	0 (0)	25 (17.12)	146 (100)
Early/Mid	57 (35.19)	29 (17.9)	0 (0)	0 (0)	7 (4.32)	45 (27.78)	1 (0.62)	23 (14.2)	162 (100)
Mid	133 (30.65)	102 (23.5)	1 (0.23)	0 (0)	14 (3.23)	95 (21.89)	0 (0)	89 (20.51)	434 (100)
Mid/Late	115 (37.46)	75 (24.43)	0 (0)	0 (0)	3 (0.98)	72 (23.45)	1 (0.33)	41 (13.36)	307 (100)
Late	238 (51.63)	112 (24.3)	0 (0)	0 (0)	9 (1.95)	62 (13.45)	0 (0)	40 (8.68)	461 (100)

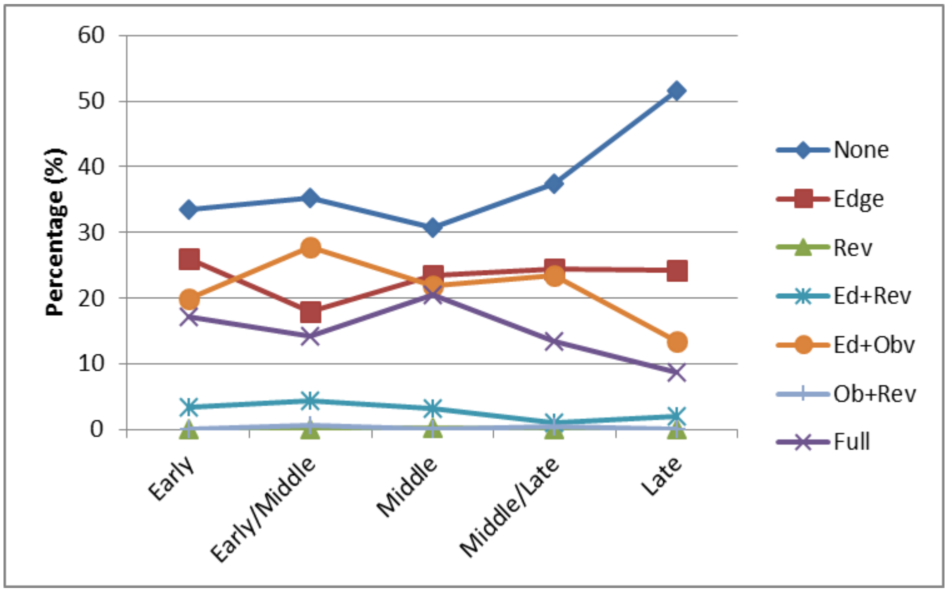

Figure 55—Platform Grinding Combinations by Phase

Two patterns present themselves in these data; the first is the decrease in the use of grinding in the latter phases of production (indicated in Figure 55 by the increase in the proportion of "None" or no grinding present). This is reflected by decreasing levels of edge and obverse grinding and full grinding while the remaining four combinations stayed relatively constant. This is confirmed with chi-square analysis which indicated a statistically significant difference ($X^2(12, N=1510) = 78.003, p = <0.0001$).

Analysis of Grinding Combinations by Type

Analysis of grinding by type indicated the grinding was used in a number of different ways and no consistent patterns of grinding combinations emerge (Table 33 and Figure 56).

Table 33 – PF Grinding Combinations by Type n / %

Flake Type	None	Edge	Reverse	Obverse	Edge + Reverse	Edge + Obverse	Obv/Rev	Full	Total
BFS	250 (63.78)	75 (19.13)	(0)	(0)	5 (1.28)	42 (10.71)	(0)	20 (5.1)	392 (100)
BfST	70 (38.04)	49 (26.63)	(0)	(0)	6 (3.26)	37 (20.11)	(0)	22 (11.96)	184 (100)
BFT	261 (29.19)	223 (24.94)	1(0.11)	(0)	26 (2.91)	218 (24.38)	2 (0.22)	163 (18.23)	894 (100)
ET/Ch	11 (27.5)	9 (22.5)	(0)	(0)	1 (2.5)	6 (15)	(0)	13 (32.5)	40 (100)

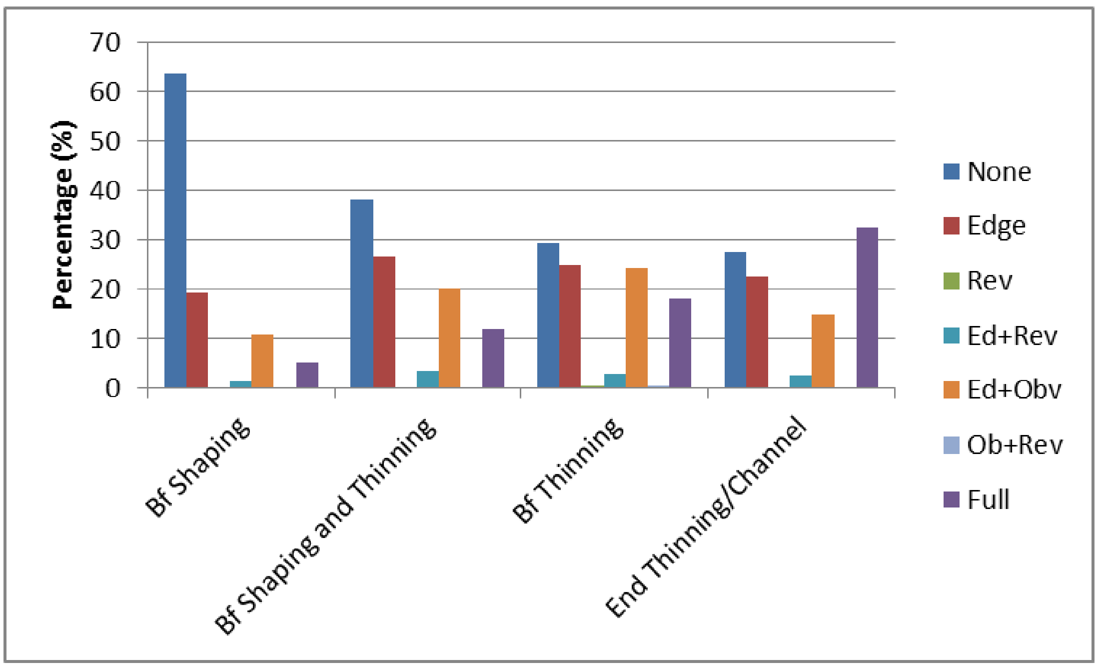

Figure 56 – Grinding Combinations by Type

Chi-square analysis indicated that there were statistically significant differences in the use of grinding ($X^2(12, N=1510) = 78.003, p = <0.0001$). Analysis of standardized residuals indicates this is due to the higher than expected occurrence of no grinding for BFS flakes.

Presence or Absence of Grinding

The analysis was simplified to look at cases where grinding was compared based on presence or absence. This is presented by phase in Table 34. This analysis shows that while the combinations of grinding showed differences in their application, the use of grinding in some form was a relatively common method of platform preparation. Figure 57 illustrates this and highlights that in the final phase of production, grinding was used slightly less.

Table 34 -- Presence/Absence of Grinding by Phase (n=1510)

	Present **n (%)**	**Absent** **n (%)**
Early	97 (66.44)	49 (33.56)
Early/Middle	105 (64.81)	57 (35.19)
Middle	301 (69.35)	133 (30.65)
Middle/Late	192 (62.54)	115 (37.46)
Late	223 (48.37)	238 (51.63)

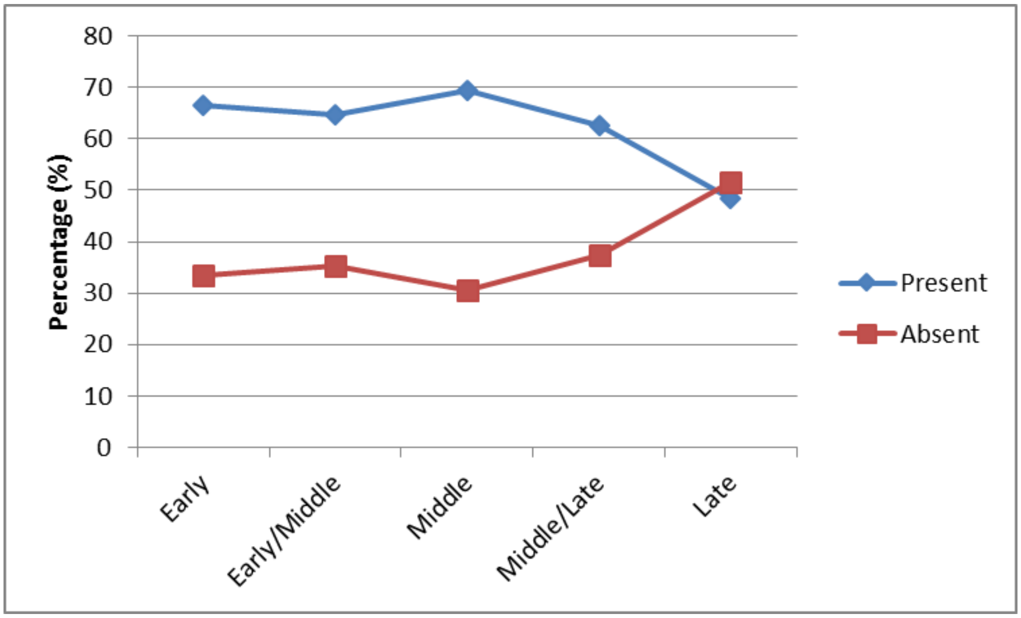

Figure 57 -- Presence/Absence of PF Grinding by Phase

Analysis of the presence or absence of grinding by flake type presented in Table 35 and Figure 58 indicated that BFS flakes generally had less grinding on them than any other flake type.

Table 35 -- Presence/Absence of PF Grinding by Type (n=1510)

	Present n (%)	Absent n (%)
BFS	142 (36.22)	250 (63.78)
BfST	114 (61.96)	70 (38.04)
BFT	633 (70.81)	261 (29.19)
ET/Ch	29 (72.5)	11 (27.5)

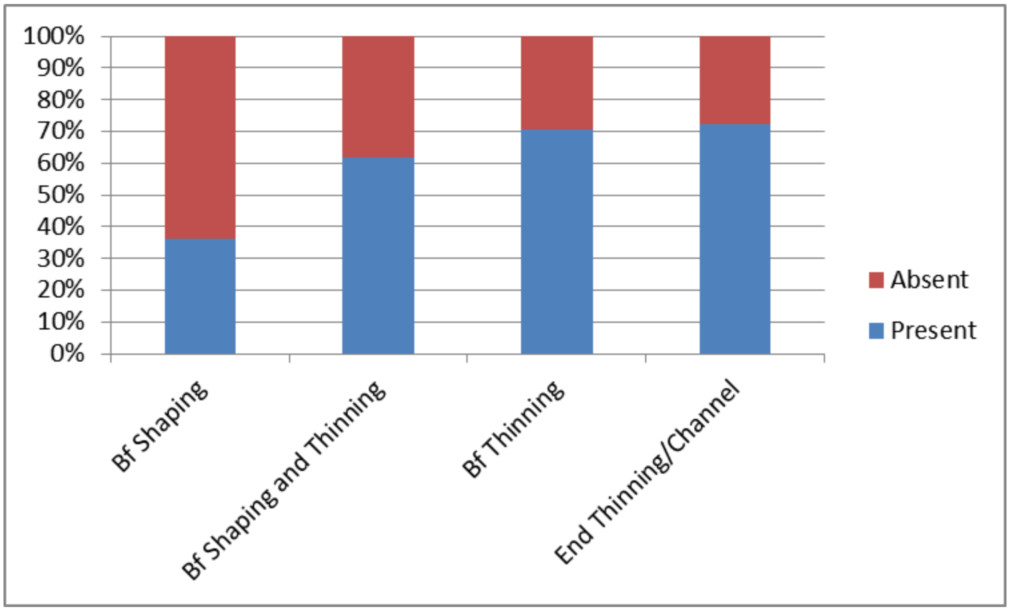

Figure 58-- Presence/Absence of Grinding by Type

A final analysis was conducted looking at grinding by flake type and phase. The analysis of this is presented in Table 36 and Figure 59 for BFS flakes, Table 37 and Figure 60 for BfST flakes, Table 38 and Figure 61 for BFT flakes, and Table 39 and Figure 62 for ET/Ch flakes. Due to the small cell values for grinding by phase and type it was not possible to run any form of statistical analysis on these data. What is clear from this analysis is the same pattern of increasing levels of unground flakes towards the late phase of production.

Table 36 -- Grinding on BFS by Phase (n=1510)

BFS	None	Edge	Reverse	Obverse	Edge + Reverse	Edge + Obverse	Obverse+ Reverse	Full	Total
Early	26 (41.94)	16 (25.81)	0 (0)	0 (0)	0 (0)	11 (17.74)	0 (0)	9 (14.52)	62 (100)
Early/Mid	25 (59.52)	1 (2.38)	0 (0)	0 (0)	2 (4.76)	11 (26.19)	0 (0)	3 (7.14)	42 (100)
Mid	42 (64.62)	14 (21.54)	0 (0)	0 (0)	1 (1.54)	5 (7.69)	0 (0)	3 (4.62)	65 (100)
Mid/Late	42 (60)	16 (22.86)	0 (0)	0 (0)	1 (1.43)	7 (10)	0 (0)	4 (5.71)	70 (100)
Late	115 (75.16)	28 (18.3)	0 (0)	0 (0)	1 (0.65)	8 (5.23)	0 (0)	1 (0.65)	153 (100)

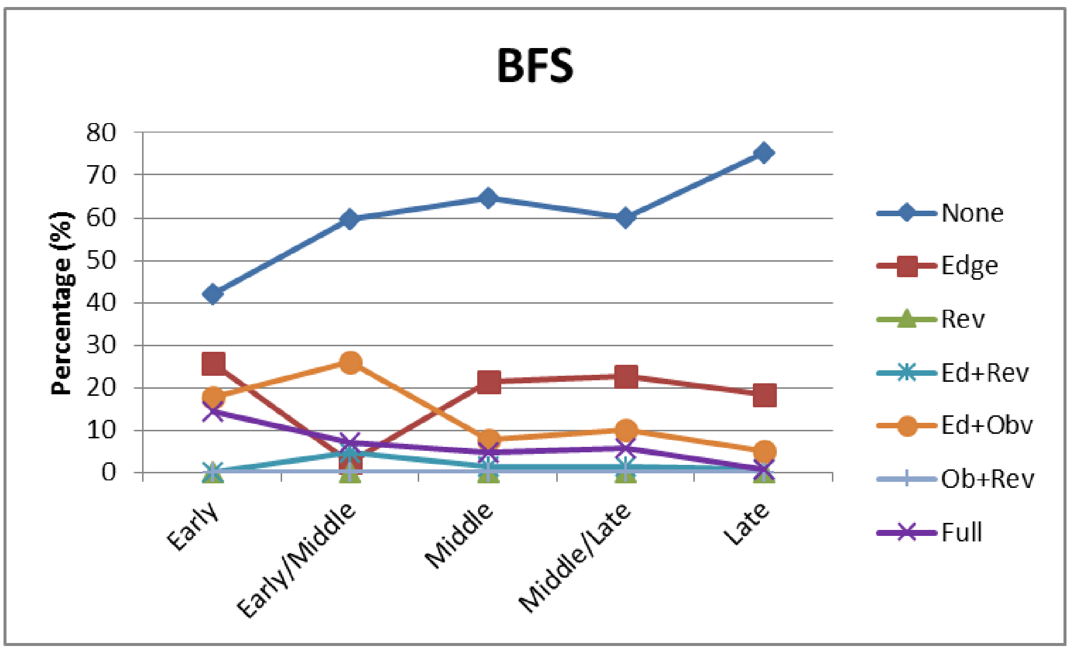

Figure 59 – PF Grinding on BFS Flakes by Phase

Table 37 -- Grinding on BfST by Phase

BfST	None	Edge	Reverse	Obverse	Edge + Reverse	Edge + Obverse	Obverse+ Reverse	Full	Total
Early	8 (26.67)	8 (26.67)	0 (0)	0 (0)	2 (6.67)	9 (30)	0 (0)	3 (10)	30 (100)
Early/Mid	7 (25)	6 (21.43)	0 (0)	0 (0)	2 (7.14)	9 (32.14)	0 (0)	4 (14.29)	28 (100)
Mid	16 (38.1)	9 (21.43)	0 (0)	0 (0)	2 (4.76)	10 (23.81)	0 (0)	5 (11.9)	42 (100)
Mid/Late	8 (33.33)	9 (37.5)	0 (0)	0 (0)	2 (8.33)	3 (12.5)	0 (0)	2 (8.33)	24 (100)
Late	31 (50)	17 (27.42)	0 (0)	0 (0)	0 (0)	6 (9.68)	0 (0)	8 (12.9)	62 (100)

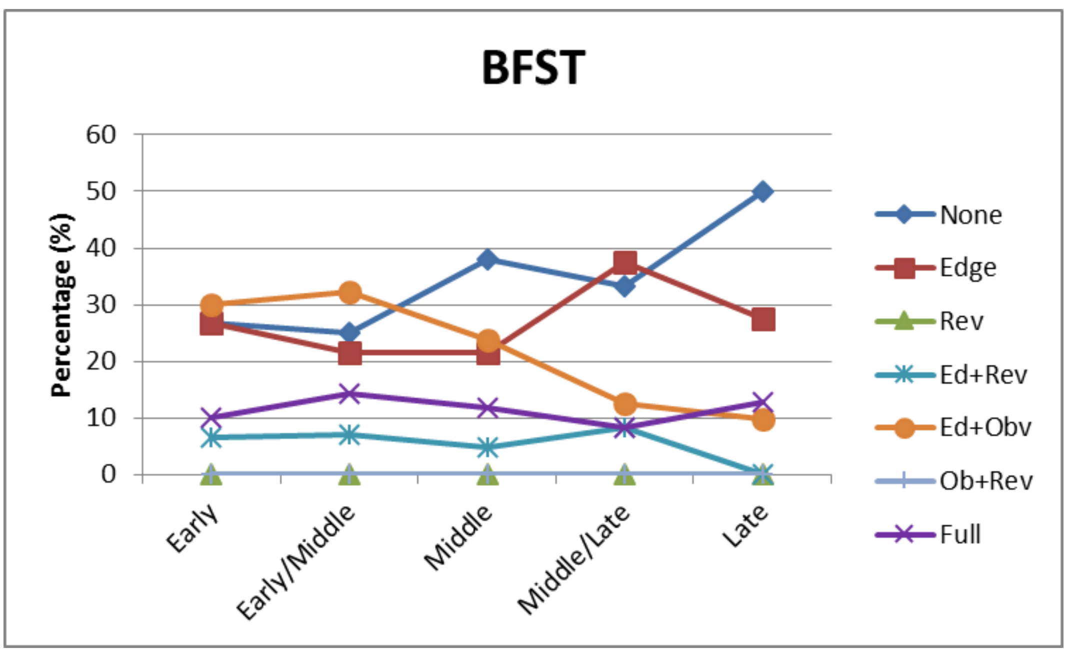

Figure 60 -- PF Grinding on BfST Flakes by Phase

Table 38 – PF Grinding on Biface Thinning Flake by Phase (n=1510)

BFT	None	Edge	Reverse	Obverse	Edge + Rev	Edge + Obv	Obv+ Rev	Full	Total
Early	10 (21.74)	12 26.09)	0 (0)	0 (0)	3 (6.52)	9 (19.57)	0 (0)	12 (26.09)	46 (100)
Early/Mid	24 (27.91)	20 (23.26)	0 (0)	0 (0)	3 (3.49)	24 (27.91)	1 (1.16)	14 (16.28)	86 (100)
Mid	73 (23.17)	78 (24.76)	1 (0.32)	0 (0)	10 (3.17)	78 (24.76)	0 (0)	75 (23.81)	315 (100)
Mid/Late	63 (30.29)	48 (23.08)	0 (0)	0 (0)	0 (0)	61 (29.33)	1 (0.48)	35 (16.83)	208 (100)
Late	91 (38.4)	65 (27.43)	0 (0)	0 (0)	8 (3.38)	46 (19.41)	0 (0)	27 (11.39)	237 (100)

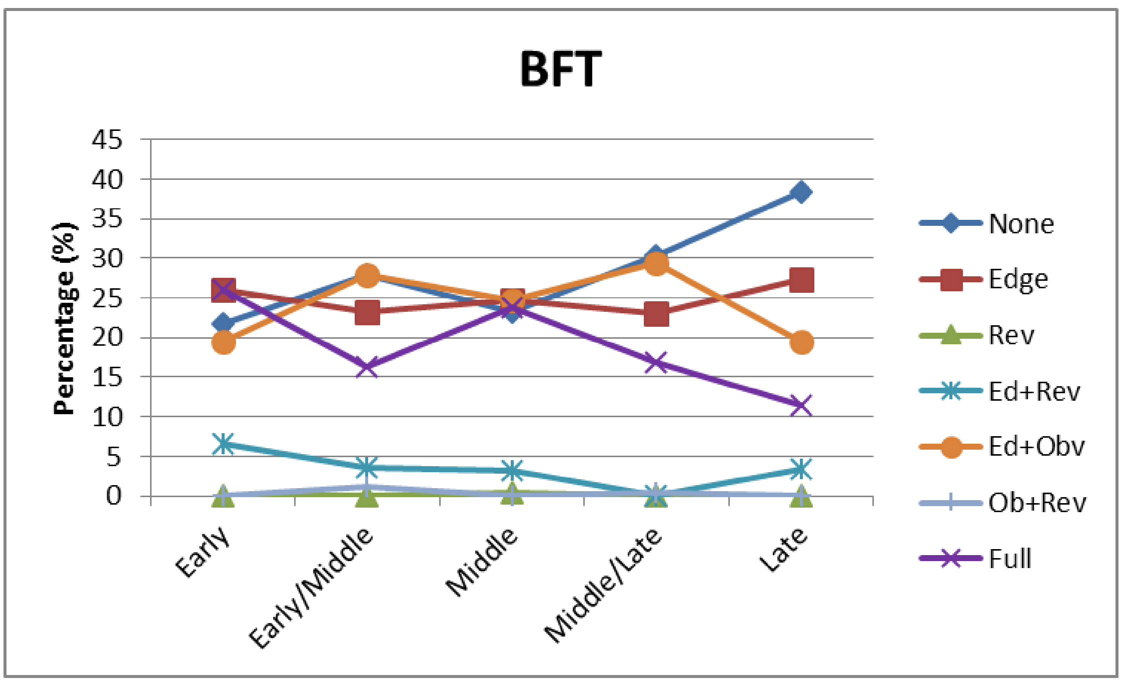

Figure 61 – PF Grinding on BFT Flakes by Phase

Table 39 – PF Grinding on ET/Ch Flakes by Phase

ET/Ch	None	Edge	Reverse	Obverse	Edge + Reverse	Edge + Obverse	Obverse+ Reverse	Full	Total
Early	5(62.5)	2(25)	0(0)	0(0)	0(0)	0(0)	0(0)	1(12.5)	8(100)
Early/Mid	1(16.67)	2(33.33)	0(0)	0(0)	0(0)	1(16.67)	0(0)	2(33.33)	6(100)
Middle	2(16.67)	1(8.33)	0(0)	0(0)	1(8.33)	2(16.67)	0(0)	6(50)	12(100)
Mid/Late	2(40)	2(40)	0(0)	0(0)	0(0)	1(20)	0(0)	0(0)	5(100)
Late	1(11.11)	2(22.22)	0(0)	0(0)	0(0)	2(22.22)	0(0)	4(44.44)	9(100)

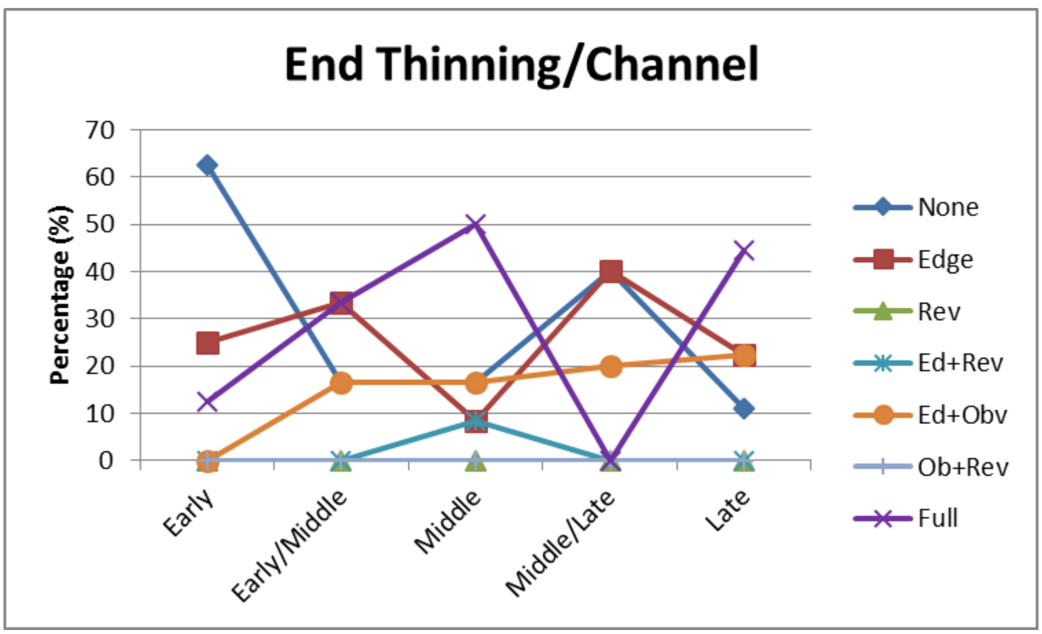

Figure 62 -- PF Grinding on ET/Ch Flakes by Phase

A question was raised during the analysis if heavy grinding influenced platform shapes. Analysis of those platforms that were heavily ground indicated that 80 (36.7%) were convex while 71 (32.57%) were straight, 64 (29.36%) were indeterminate and only 3 were concave (1.38 %). When compared to the general frequencies of these shapes, the data indicate that the levels of heavily ground platforms are proportionate to the numbers present in the entire assemblage. Platform shapes by phase and flake type are analyzed later in this section.

Platform Status

Three attributes relating to the state of the platform were recorded as cortical, plain, and remnants that had been shattered or crushed.

Analysis of Remnant /Shattered/Crushed Platforms

Rem/Shattered/Crushed by Phase

Analysis of the remnant, shattered, or crushed platforms indicated that the general trend was an increase in the proportions of this type but there was a noticeable peak during the middle phases of manufacture (Table 40 and Figure 63).

Table 40 – Remnant/Shattered/Crushed Platforms by Phase

Phase	Rem/Shattered/Crushed n	*(%)*
Early	9	(7.09)
Early/Middle	14	(11.02)
Middle	41	(32.28)
Middle/Late	24	(18.9)
Late	39	(30.71)
Total	127	(100)

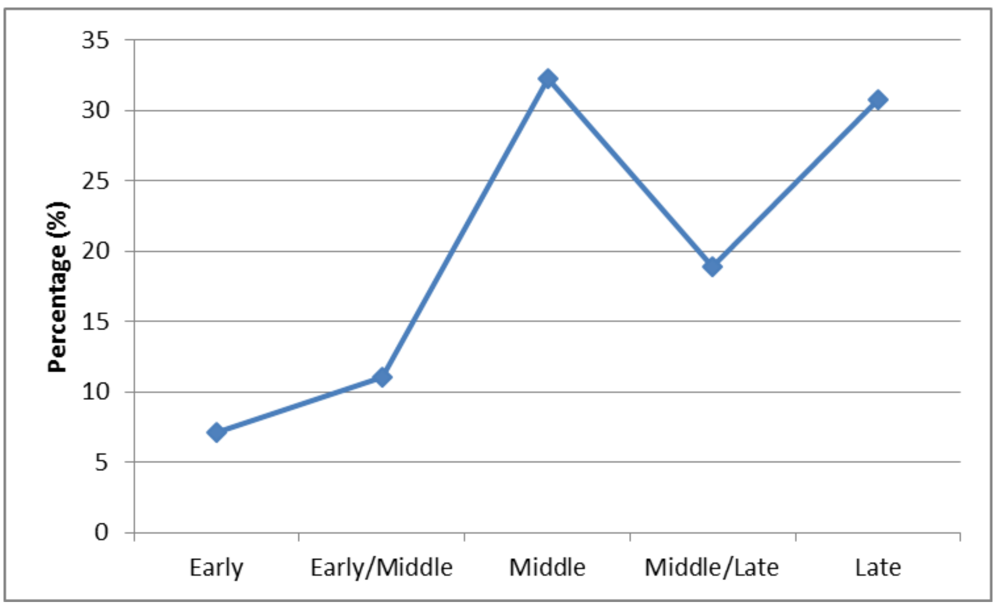

Figure 63 – Remnant/Shattered/Crushed Platforms by Phase

Rem/Shattered/Crushed by Type

Analysis of the remnant, shattered, or crushed platforms by type indicated that there was a high incidence of this in the production of BFT flakes (Table 41 and Figure 64).

Table 41 – Remnant/Shattered/Crushed Platforms by Type

Platform by Flake Type	Rem/shattered/crushed n	(%)
BFS	23	(18.11)
BfST	12	(9.45)
BFT	89	(70.08)
ET/Ch	3	(2.36)
Total	127	(100)

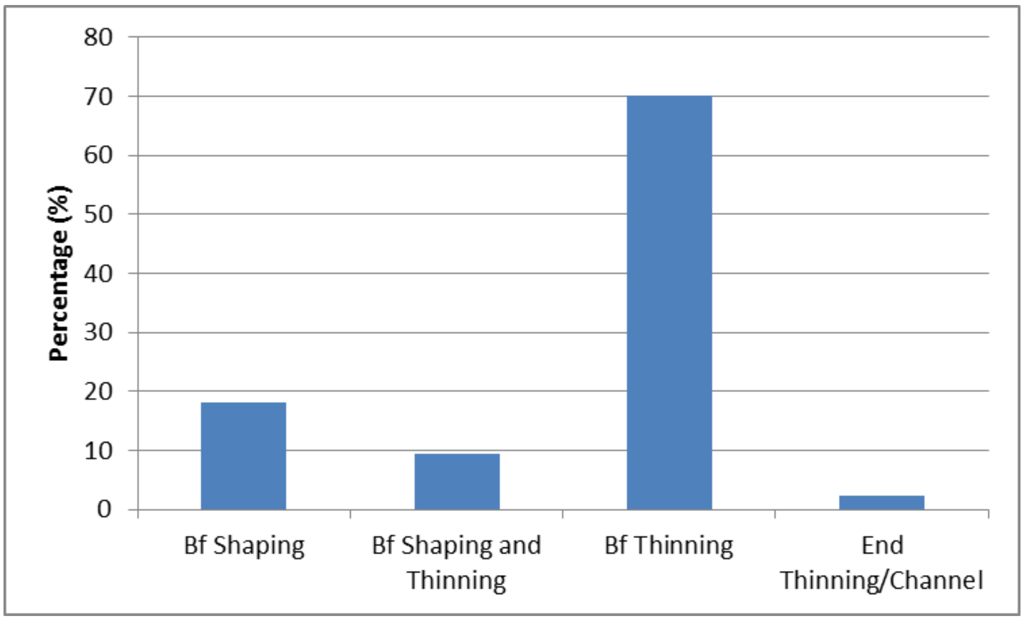

Figure 64 -- Remnant, Shattered, or Crushed Platforms by Flake Type

Analysis of Plain Platforms

Remnant, shattered, or crushed platforms were removed from this next analysis as shattered platforms made it difficult to determine if a “plain” platform was truly plain.

Plain Platforms by Phase

Analysis of the plain platforms (Table 42 and Figure 65) indicated that there was a slight increase in the use of plain platforms in the middle and late phase however, generally the number remained consistent.

Table 42 -- Plain Platforms by Phase

by Phase	Plain	
	n	%
Early	22	(18.18)
Early/Middle	22	(18.18)
Middle	28	(23.14)
Middle/Late	21	(17.36)
Late	28	(23.14)
Total	121	(100)

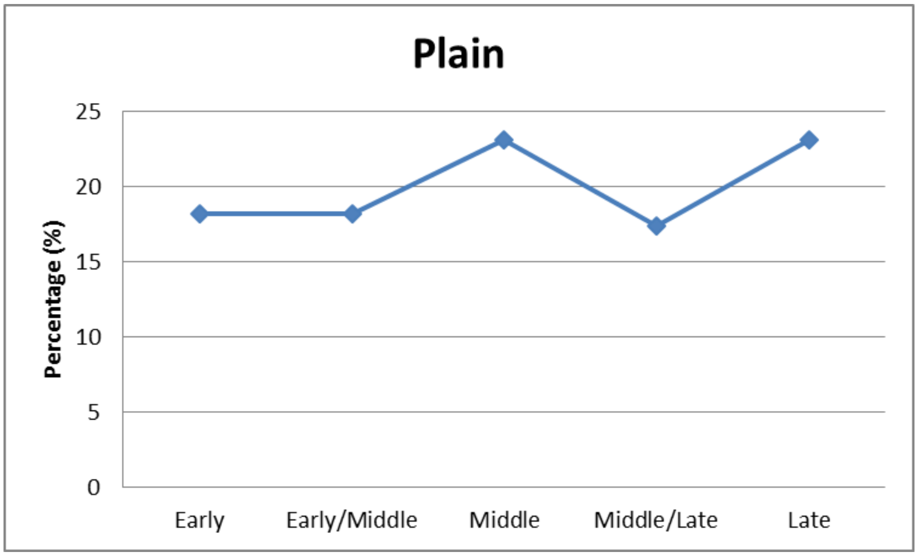

Figure 65 -- Plain Platforms by Phase

Included within this sample was a small number of platforms (n=8, 21.62%) that were recorded as plain and cortical.

Plain Platforms by Type

Comparison by type indicated that plain platforms were used most extensively on BFS flakes (Table 43 and Figure 66).

Table 43 -- Plain Platforms by Flake Type

Flake Type	Plain n (%)
BFS	64 (52.89)
BfST	9 (7.44)
BFT	46 (38.02)
ET/Ch	2 (1.65)
Total	121 (100)

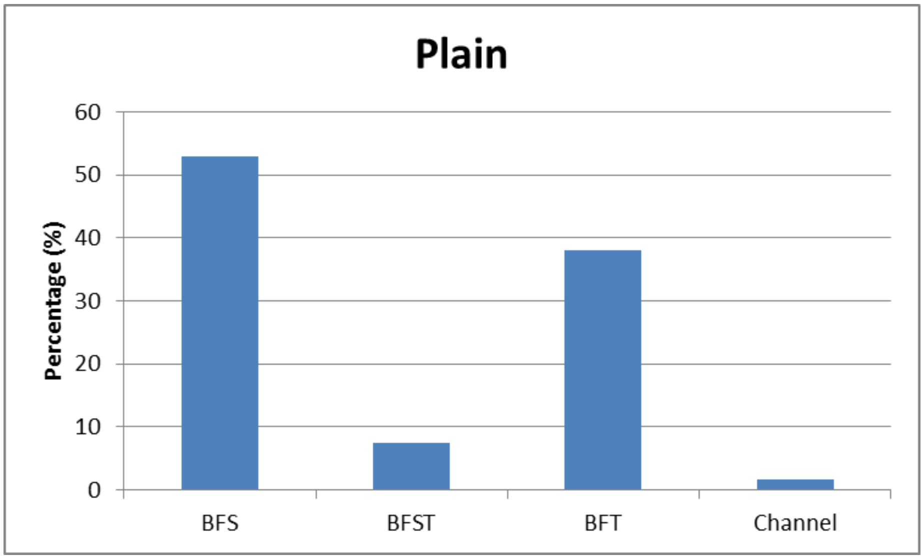

Figure 66 -- Plain Platforms by Flake Type

Analysis of Cortical Platforms

Cortical Platforms by Phase

Analysis of cortical platforms by phase indicated that, while there was a general overall trend in the decline of cortical platforms, both the middle and late phase had higher proportions of cortex (Table 44 and Figure 67).

Table 44 -- Cortical Platforms by Phase

Phase	Cortical n (%)
Early	87 (21.91)
Early/Middle	73 (18.39)
Middle	101 (25.44)
Middle/Late	55 (13.85)
Late	81 (20.4)
Total	397(100)

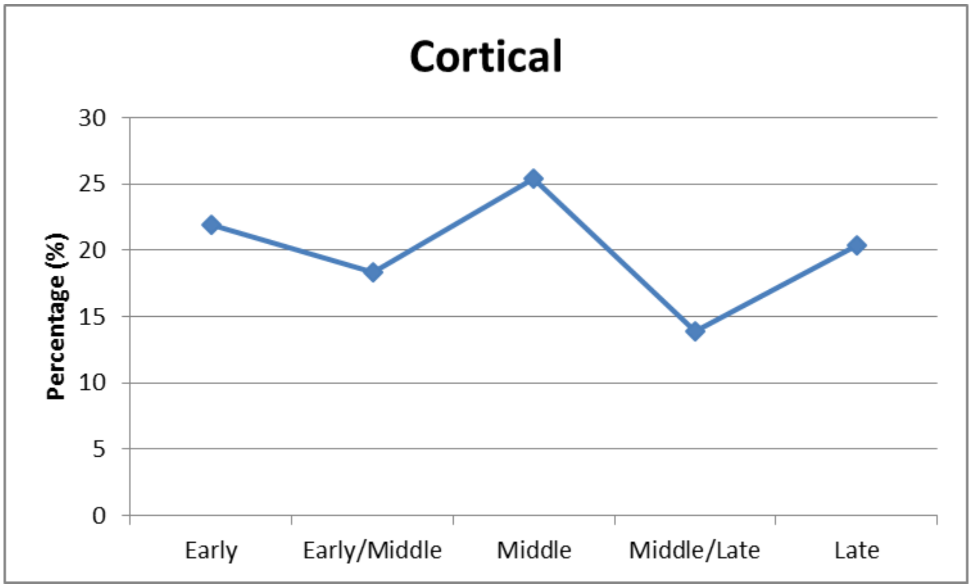

Figure 67 -- Cortical Platforms by Phase

Cortical Platforms by Type

Cortical platforms were most common on BFT flakes, followed by BFS flakes (Table 45 and Figure 68).

Table 45 -- Cortical Platforms by Type

Flake Type	Cortical n (%)
BFS	134 (33.75)
BfST	46 (11.59)
BFT	208 (52.39)
ET/Ch	9 (2.27)
Total	397 (100)

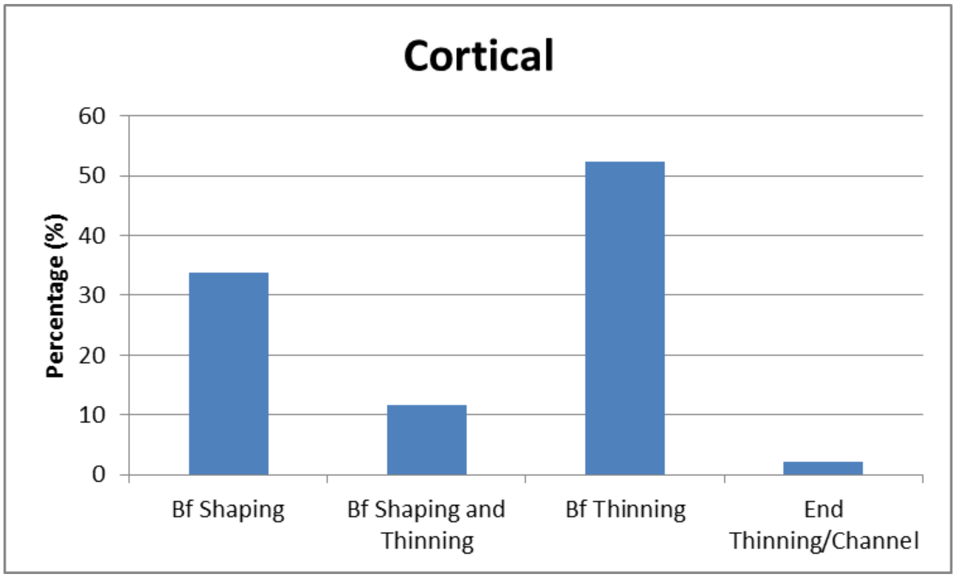

Figure 68 -- Cortical Platforms by Type

Statistical Analysis of Platform States (Platform Status/Condition)

Statistical analysis using chi-square tests indicated that there was a statistically significant difference in the distribution of plain (p=<0.0001) and cortical (p=<0.0001) platforms by phase (Table 46).

Table 46 -- Chi-square Test of Platform State by Phase

	X2	df	p-value
Plain	32.051	4	<0.0001
Cortical	144.232	4	<0.0001
Rem/shat/crushed	1.714	4	0.7881

The significant differences are derived from higher than expected occurrence of plain platforms during the middle and late phases, and the higher than expected occurrence of cortical platforms in the middle phases, as well as a lower than expected occurrence of cortical platforms in the late phases.

Chi-square analysis of platform state by type (Table 47) Indicated that there was a statistically significant difference in the distribution of plain (p=<0.0001) and cortical (p=0.0006).

Table 47 -- Chi-square Test of Platform State by Type

	df	X2	p-value
Plain	3	36.861	<0.0001
Cortical	3	17.277	0.0006
Rem/shat/crushed	3	6.956	0.0733

The significant differences are derived from the higher than expected occurrence of plain platforms for BFS flakes and the higher than expected occurrence of plain platforms in BFT flakes.

Analysis of Platform Shape

Platform shapes were recorded as straight, concave, convex, and dihedral. However, some platform shapes were recorded as ‘indeterminate’ due to their ambiguous nature. All were analyzed for significance by phase and flake type.

Shape by Phase

The results presented in Table 48 indicate that straight platforms appear in higher percentages in the early and late phases. The percentage of concave platforms increased towards the late phase of biface production with convex platforms being most prevalent in the middle and middle/late phases. These results are also presented in Figure 69.

Table 48 – Platform Shapes by Phase

Shape / Phase	Straight n (%)	Convex n (%)	Dihedral n (%)	Concave n (%)	Indet. n (%)	Total n (%)
Early	57 (39.04)	27 (18.49)	16 (10.96)	3 (2.05)	43 (29.45)	146(100)
Early/Mid	52 (32.10)	39 (24.07)	17 (10.49)	10 (6.17)	44 (27.16)	161(100)
Mid	144(33.18)	142(32.72)	28 (6.45)	23 (5.3)	97 (22.35)	434(100)
Mid/Late	98 (31.92)	99 (32.25)	27 (8.79)	22 (7.17)	61 (19.87)	307(100)
Late	194(42.08)	112(24.30)	33 (7.16)	49 (10.63)	73 (15.84)	461(100)

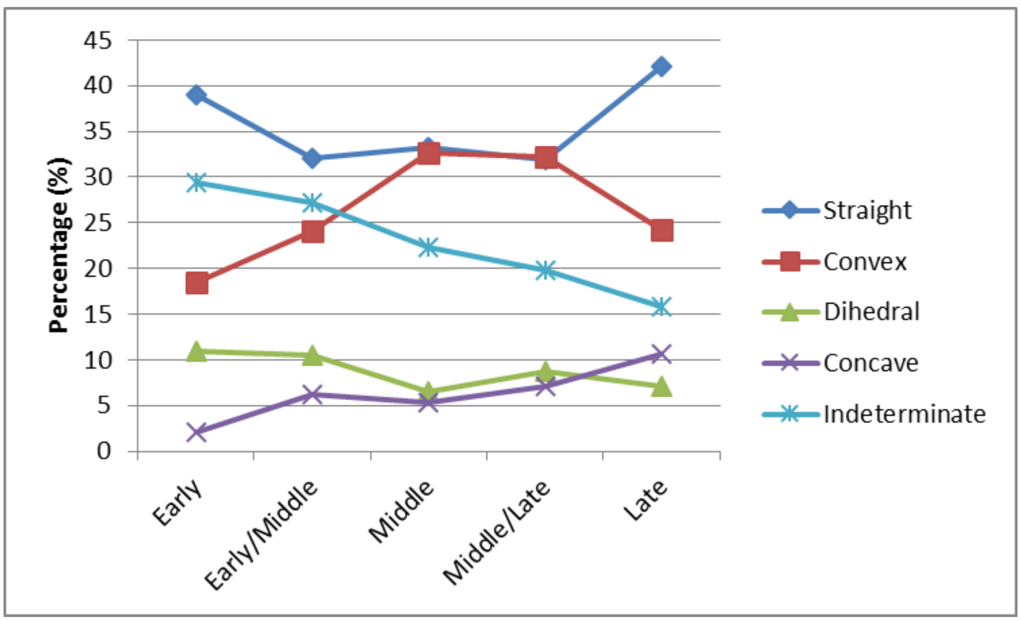

Figure 69 -- Platform Shapes by Phase

Chi-square testing indicated that there was a statistically significant difference in the distribution of shape ($X^2(16, N=1510) = 56.132$, $p = <0.0001$). Further analysis of the standardized residuals of platform shape by phase show the significance is derived from the lower than expected counts of concave and convex platforms in the early phase, as well as higher than expected straight platforms in the late phase.

Shape by Type

Analysis indicated that the percentages of platform shapes in BFS flakes and BfST flakes were relatively similar in distribution (Table 49 and Figure 70). However, percentages of straight platforms were higher for BFT flakes, with ET/Ch flakes having a nearly equal distribution percentage of platforms that were straight or convex.

Table 49 -- Platform Shape by Type

Shape / Type	Straight n (%)	Convex n (%)	Dihedral n (%)	Concave n (%)	Indeterminate n (%)	Total n (%)
BFS	124 (31.63)	87 (22.19)	68 (17.35)	32 (8.16)	81 (20.66)	392 (100)
BFST	64 (34.78)	45 (24.46)	20 (10.87)	9 (4.89)	46 (25)	184 (100)
BFT	345 (38.59)	274 (30.65)	28 (3.13)	64 (7.16)	183 (20.47)	894 (100)
ET/Ch	12 (30)	13 (32.5)	5 (12.5)	2 (5)	8 (20)	40 (100)

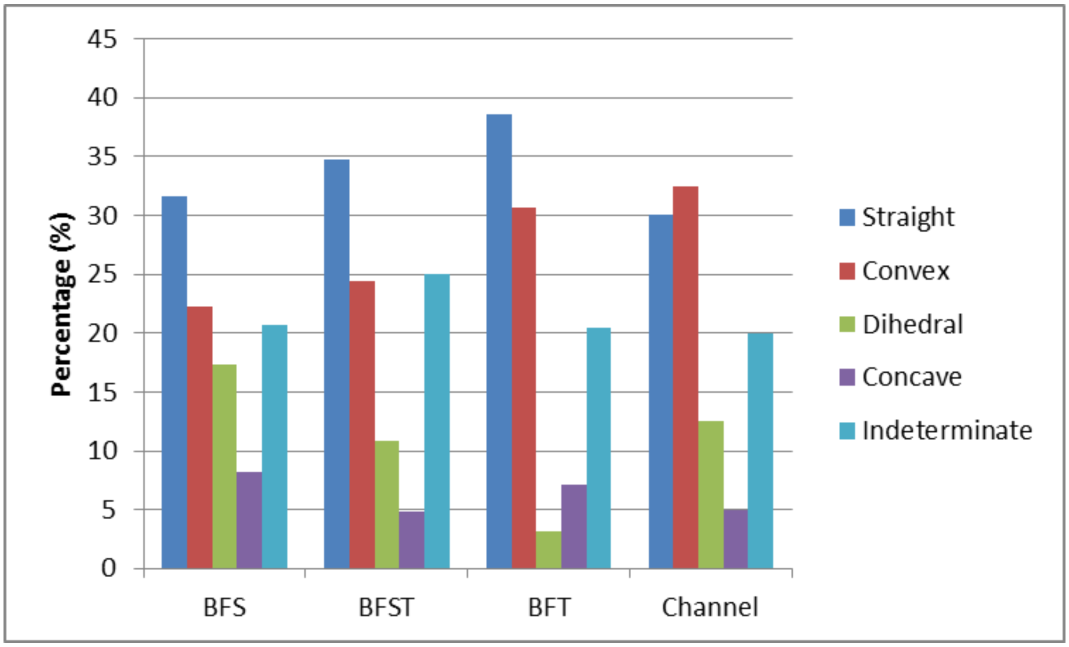

Figure 70 -- Platform Shape by Type

Chi-square analysis testing indicated that there was a statistically significant difference in the distribution of platform shape by flake type (X^2(12, N=1510) = 88.095, p = <0.0001). Further residual analysis shows the significance is derived from a higher than expected counts of dihedral in BFS flakes as well as lower than expected counts of dihedral platforms in BFT flakes.

Analysis of Platform Preparation Traits

Basic platforms are defined as 'plain' and refer to any flake striking platform that is devoid of preparation traits. Therefore, only striking platforms exhibiting preparation traits – *e.g.* ground, faceted, reduced, released, and isolated -- were made part of this next phase of analyses. The number of flakes with platforms identified as 'plain' (n=121) were removed, leaving 1389 flakes for this next analysis. Furthermore, grinding will be included, but will be simplified as a presence or absence trait.

Preparation by Phase

Table 50 presents flake counts and percentages of platform preparation traits by phase. Analysis indicated that the occurrence of ground platforms progressively declined from early to late phases and supports previous findings. Conversely, the percentage of reduced and isolated traits increased as phases progressed. While released and faceted reflect a slight increase in the middle phase, they remain relatively consistent. This is illustrated in Figure 71.

Table 50 -- Platform Preparation by Phase*

Prep / Phase	Ground n (%)	Faceted n (%)	Reduced n (%)	Released n (%)	Isolated n (%)	Total n (%)
Early	97 (28.87)	49 (14.58)	89 (26.49)	30 (8.93)	71 (21.13)	336(100)
Early/Mid	105(25.06)	75 (17.9)	95 (22.67)	47 (11.22)	97 (23.15)	419 (100)
Mid	301(22.99)	248(18.95)	317(24.22)	142(10.85)	301(22.99)	1309 (100)
Mid/Late	192(23.08)	148(17.79)	206(24.76)	79 (9.5)	207(24.88)	832(100)
Late	223(19.44)	187(16.3)	33 (29.47)	80 (6.97)	319(27.81)	1147(100)
* counts and percentages do always not equal 100						

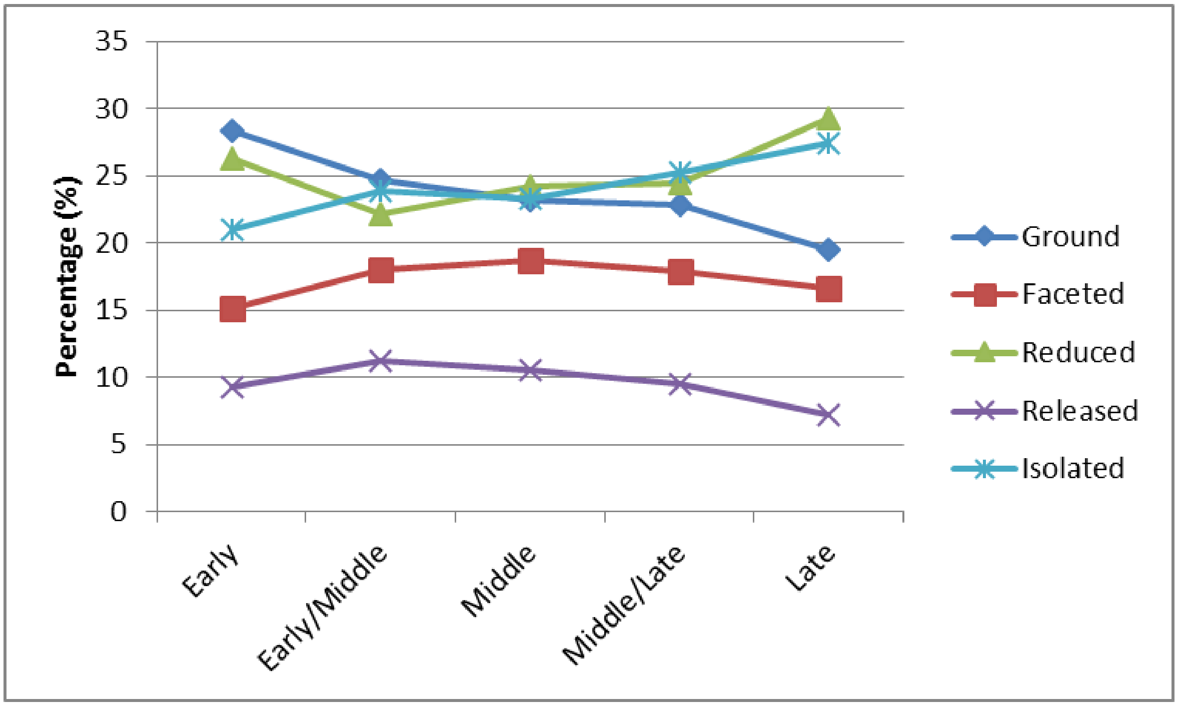

Figure 71 -- Platform Preparation by Phase

Chi-square testing indicated that there was a statistically significant difference in the distribution of platform preparation by phase ($X^2(16, N=4043) = 45.487$, $p = 0.0001$). Further analysis of standardized residuals of platform preparation by phase show the differences are derived from:

a) Higher than expected percentage of ground platforms in the early phase.
b) Lower than expected occurrence percentage of ground platforms in the late phase.
c) Reduced platform percentages were higher than expected in late phase.
d) Released platform percentages were lower than expected in the late phase.
e) Isolated platform percentages were higher in the late phase.

Preparation by Type

Analysis of platform preparation traits by flake type indicates a complex pattern of use (Table 51 and Figure 72). Overall, the relative percentages of each trait are similar across each flake type; however, some trends do occur. BFS flakes have the highest number of platforms that are reduced. On BFT flakes, isolated platforms are the most common preparation trait, followed by ground, and reduced platforms. ET/Ch flakes reveal that reduced and ground platforms were the most common.

Table 51 -- Platform Preparation by Type*

	Ground n (%)	Faceted n (%)	Reduced n (%)	Released n (%)	Isolated n (%)	Total n (%)
BFS	142 (19.75)	101 (14.05)	248 (34.49)	39 (5.42)	189 (26.29)	719 (100)
BFST	114 (22.31)	88 (17.22)	136 (26.61)	54 (10.57)	119 (23.29)	511 (100)
BFT	633 (23.45)	496 (18.38)	632 (23.42)	272 (10.08)	666 (24.68)	2699 (100)
ET/Ch	29 (25.44)	22 (19.3)	29 (25.44)	13 (11.4)	21 (18.42)	114 (100)
*do not always equal 100						

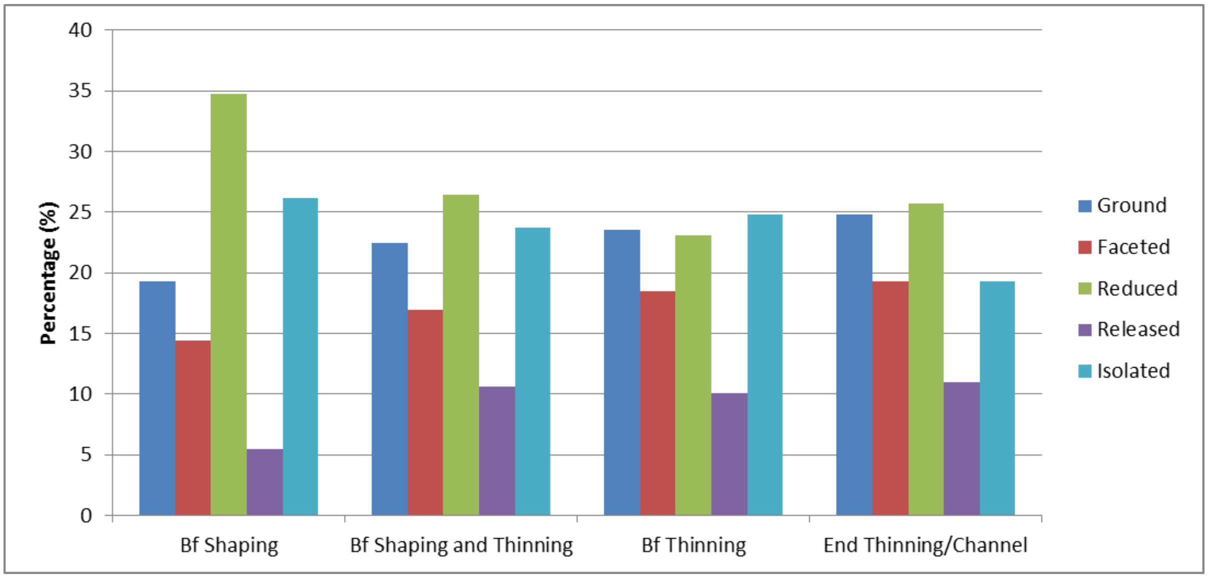

Figure 72 -- Platform Preparation by Type

Chi-square testing indicated that there was a statistically significant difference in the distribution of platform preparation by type ($X^2(12, N=4043) = 54.918, p = <0.0001$). Standardized residual analysis reveal the significance comes from BFS flakes which reveal a lower than expected count (*n* =) of Faceted, Ground and Released platform traits as well as a higher than expected (*n* =) of Reduced.

Platform Preparation Correlation Analysis

Before continuing platform trait analysis, a decision was made to conduct a correlation analysis to determine if the platform preparation traits were independent, or, if any of the preparation traits were used systematically in conjunction with each other. As the present data set consists of presence/absence data, non-parametric correlation tests were conducted using Spearman's P and Hoeffding's D and Table 52 presents the results of this analysis by trait groupings.

Spearman's ρ correlation indicates a perfect-positive relationship at **+1** with a perfect-negative relationship at **-1**. Trait group "Reduced by Faceted' is -0.07 indicates that there is almost no relationship present and that this is not statistically significant (p=0.0158). The results of all remaining groups of two variables indicate weak-positive relationships that are statistically significant. These results were then confirmed by applying Hoeffding's D, which measures the difference between the two variables in each group and the product of their marginal ranks. Hoeffding's D confirms the weak relationship (Spearman's ρ) between the remaining group's two variables.

The results of this correlation analysis indicate that while these traits (faceted, ground, reduced, released, isolated) do occur together, the relationship, in terms of correlation, is weak which concludes that the platform preparation traits are not dependent upon any others.

Table 52 -- Platform Trait-Non-parametric Correlation Tests

Trait by Trait Groupings		**Spearman's ρ**	**Prob>|ρ|**	**Hoeffding's D**	**Prob>D**
Faceted	**Ground**	0.24	<.0001	0.0054	<.0001
Reduced	**Ground**	0.1459	<.0001	0.001	0.022
Reduced	**Faceted**	-0.0657	0.0158	-0.0004	0.9985
Released	**Ground**	0.2804	<.0001	0.0058	<.0001
Released	**Faceted**	0.1996	<.0001	0.0028	0.0003
Released	**Reduced**	0.1912	<.0001	0.0018	0.0032
Isolated	**Ground**	0.2011	<.0001	0.0029	0.0002
Isolated	**Faceted**	0.1962	<.0001	0.003	0.0002
Isolated	**Reduced**	0.2123	<.0001	0.0027	0.0004
Isolated	**Released**	0.3582	<.0001	0.009	<.0001

Platform Preparation Complexity by Score

A common characteristic ascribed to Clovis flake platforms is that they were complex, but the level of complexity is not understood. Using the same delineation for platform preparation traits, platforms were assigned a score based on how many preparation traits were present. In this respect, a score of "1" equates to one preparation trait present, while a score of "5" indicates all five traits were present. This was then used as a proxy for complexity: Wherein the numbers of traits likely denote the extent of attention given (knapping behaviors) during biface reduction and/or flake production.

Analysis of Platform Preparation Scores

Preparation Scores By Phase

The first analysis looked at the distribution in terms of relative percentages of platform scores by phase presented in Table 53 and Figure 73.

Table 53 -- Platform Scores by Phase

Score by Phase	1 n (%)	2 n (%)	3 n (%)	4 n (%)	5 n (%)	Total n (%)
Early	28(22.58)	31 (25)	28 (22.58)	23 (18.55)	14 (11.29)	124 (100)
Early/Mid	27(19.29)	29 (20.71)	27 (19.29)	32 (22.86)	25 (17.86)	140 (100)
Mid	43(10.59)	88 (21.67)	91 (22.41)	103(25.37)	81 (19.95)	406 (100)
Mid/Late	41(14.34)	84 (29.37)	70 (24.48)	42 (14.69)	49 (17.13)	286 (100)
Late	74(17.09)	144 (33.26)	110 (25.4)	70 (16.17)	35 (8.08)	433 (100)

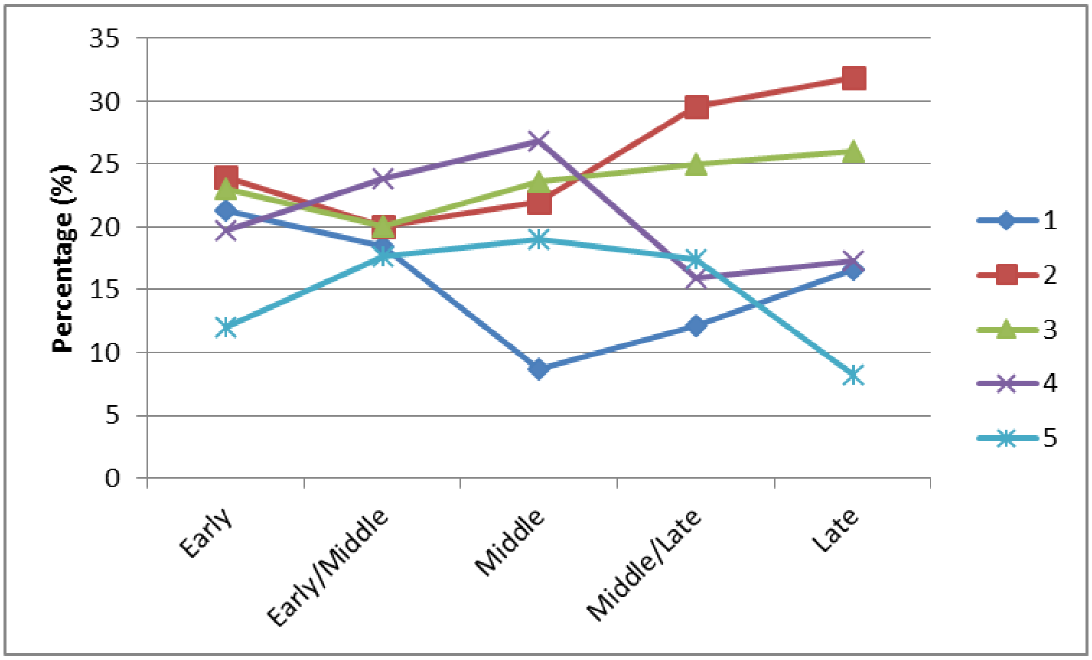

Figure 73 -- Platform Scores by Phase

While the analysis indicates no strong correlation in the data, platform scores appear to alternate throughout production and follow no set pattern. Chi-square analysis indicates there is a statistically significant difference ($X^2(20, N=1389) = 65.671, p = <0.0001$). Analysis of the standardized residuals reveal that the statistical differences are derived from statistically higher than expected counts of platforms scoring “1” in the early phase, and statistically lower than expected counts of platforms with scores of “1” and “2” in the middle phase. Analysis also indicated that a score of “4” and “5” was statistically higher than expected in the middle phase.

Preparation Scores by Type

An analysis of platform scores by flake type reveals a similar pattern above that indicates more complex behaviors, which are presented in Table 54 and Figure 74. BFS had the highest percentage of platforms scoring “1” and “2.” The platforms on ET/Ch flakes reveal all platforms were prepared to some degree. BFT flakes and ET/Ch had the highest percentage of platforms scoring “4” and “5.”

Table 54 -- Platform Scores by Type

PF Score by Flake Type	1 n (%)	2 n (%)	3 n (%)	4 n (%)	5 n (%)	Total n (%)
BFS	93 (28.35)	133(40.55)	63 (19.21)	24 (7.32)	15 (4.57)	32 (100)
BFST	27 (15.43)	45 (25.71)	42 (24)	37 (21.14)	24 (13.71)	175(100)
BFT	83 (9.79)	192(22.64)	217(25.59)	199(23.47)	157 (18.51)	848(100)
ET/Ch	10 (26.32)	6 (15.79)	4 (10.53)	10 (26.32)	8 (21.05)	38 (100)

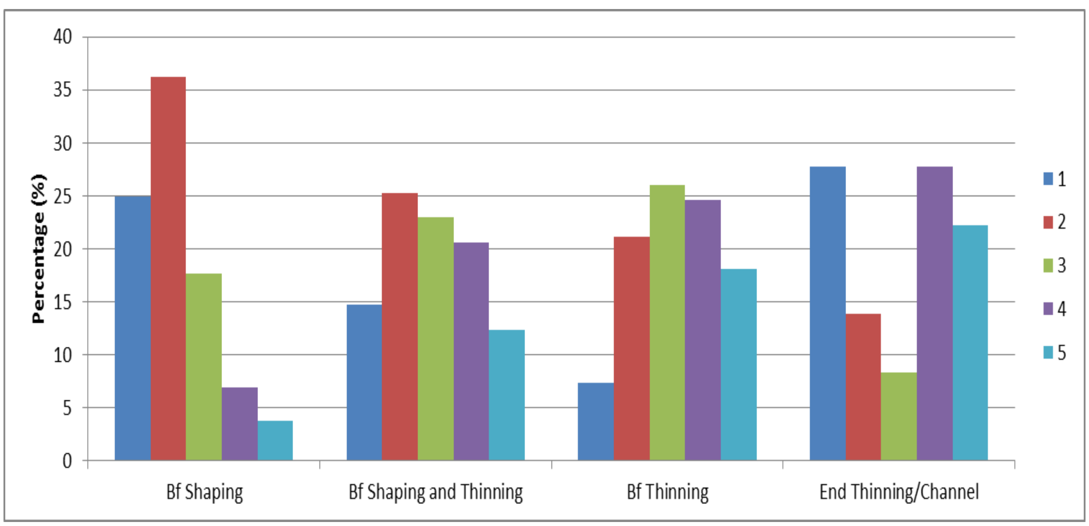

Figure 74 -- Platform Scores by Type

Chi-square analysis indicated a statistically significant difference ($X^2(12, N=1389) = 158.737$, $p = <0.0001$) in platform scores by type. Further analysis of the standardized residuals indicated that this was derived from the higher proportions of scores "1" and "2" in BFS flakes, compared with lower than expected percentages of "4" and "5" as well in BFS. Analysis also indicated that BFT flakes had a higher than expected percentage of platforms scoring "4" and "5" compared to other flakes with the same scores and compared to BFT platforms scoring "1" and "2".

These results were further explored by calculating the mean average platform score for each phase. The results reveal that the middle phase had the highest average platform scores, while the early and late phases had the lowest (Fig. 75).

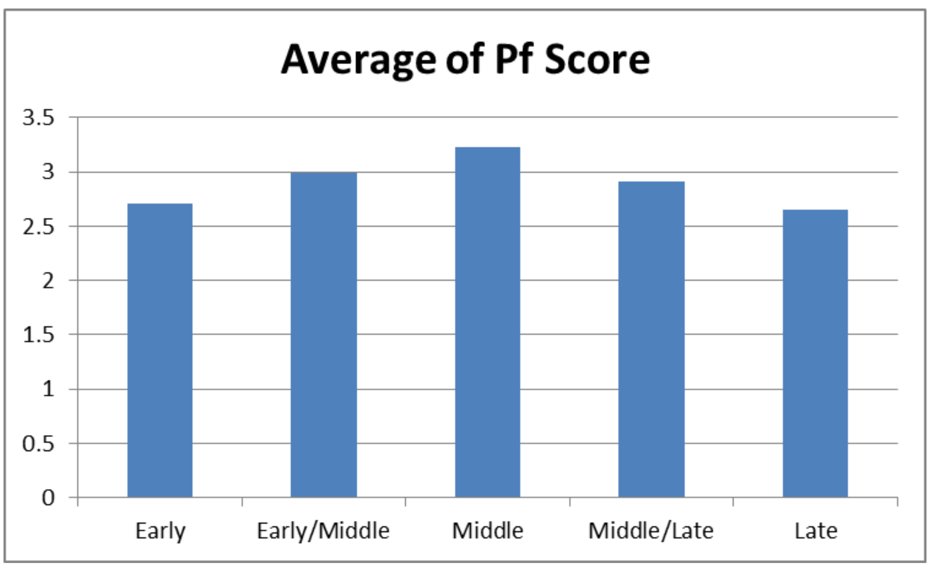

Figure 75 -- Mean Average Platform Score for Each Phase. (y axis = average score)

Average platform scores for each type indicated that BFT flakes and ET/Ch flakes had the highest average platform scores (Fig. 76), but overall indicate no emerging pattern.

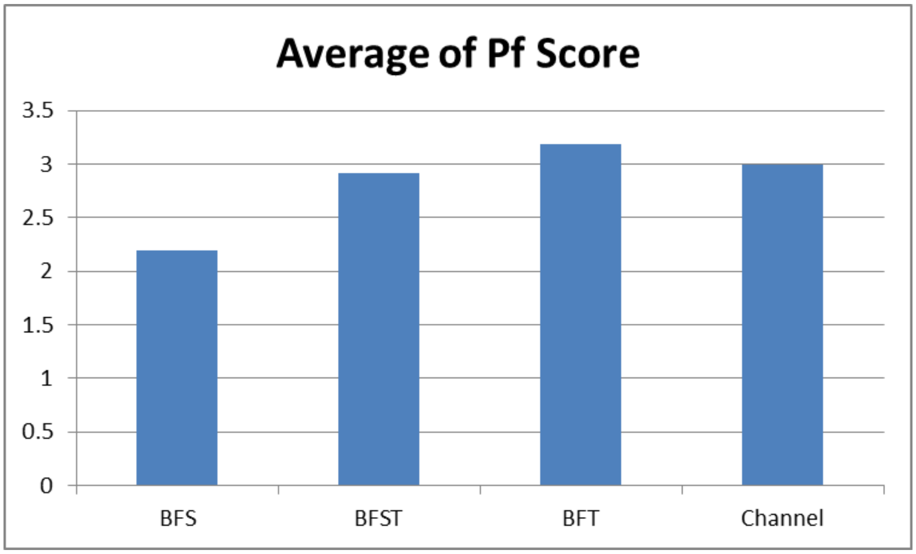

Figure 76 -- Mean Average Platform Score for Each Type (y axis = average score)

Analysis of Platform Complexity – Preparation Traits in Flake Types by Phase

Platform complexity was further explored of individual flake groups (BFS, BFT, BfST, and ET/Ch) in order to analyze the complexities of each by preparation trait and phase for any detectable patterns.

BFS Flakes by Trait and Phase

Table 55 and Figure 77 present the results of platform preparation on BFS flakes.

Table 55 –BSF Flakes -- Platform Preparation Traits by Phase

Trait by Phase	Ground n (%)	Faceted n (%)	Reduced n (%)	Released n (%)	Isolated n (%)	Total n (%)
Early	36 (31.03)	11 (9.48)	36 (31.03)	10 (8.62)	23 (19.83)	116 (100)
Early/Mid	17 (26.56)	10 (15.63)	17 (26.56)	6 (9.38)	14 (21.88)	64 (100)
Mid	23 (20.35)	23 (20.35)	38 (33.63)	4 (3.54)	25 (22.12)	113 (100)
Mid/Late	28 (20.14)	18 (12.95)	47 (33.81)	8 (5.76)	38 (27.34)	139 (100)
Late	38 (13.24)	39 (13.59)	110 (38.33)	11 (3.83)	89 (31.01)	287 (100)

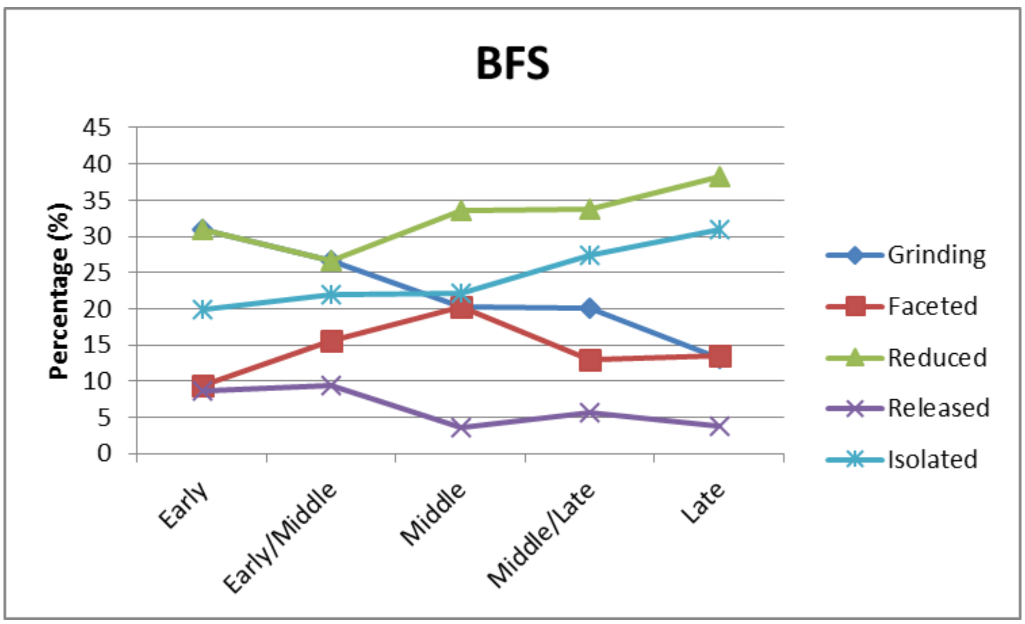

Figure 77 – BFS Flakes --Platform Preparation Trait by Phase

Chi-square analysis indicated a statistically significant difference $X^2(16, N=719) = 34.894$, $p = 0.0041$. However, analysis of standardized residuals indicate the significance is derived from BFS flakes having higher than expected occurrence of ground platforms in the early phase and lower than expected occurrence of ground platforms in the late phase.

BfST Flakes by Trait and Phase

The results of the analysis on BfST flakes is presented in Table 56 and illustrated in Figure 78.

Table 56 -- BfST Flakes -- Platform Preparation Traits by Phase

Trait by Phase	Ground n (%)	Faceted n (%)	Reduced n (%)	Released n (%)	Isolated n (%)	Total n (%)
Early	22 (26.51)	15 (18.07)	21 (25.3)	8 (9.64)	17 (20.48)	83 (100)
Early/Middle	21 (26.25)	14 (17.5)	17 (21.25)	10 (12.5)	18 (22.5)	80 (100)
Middle	26 (19.7)	21 (15.91)	34 (25.76)	21 (15.91)	30 (22.73)	131 (100)
Middle/Late	14 (27.45)	9 (17.65)	13 (25.49)	4 (7.84)	11 (21.57)	51 (100)
Late	31 (18.79)	29 (17.58)	51 (30.91)	11 (6.67)	43 (26.06)	165(100)

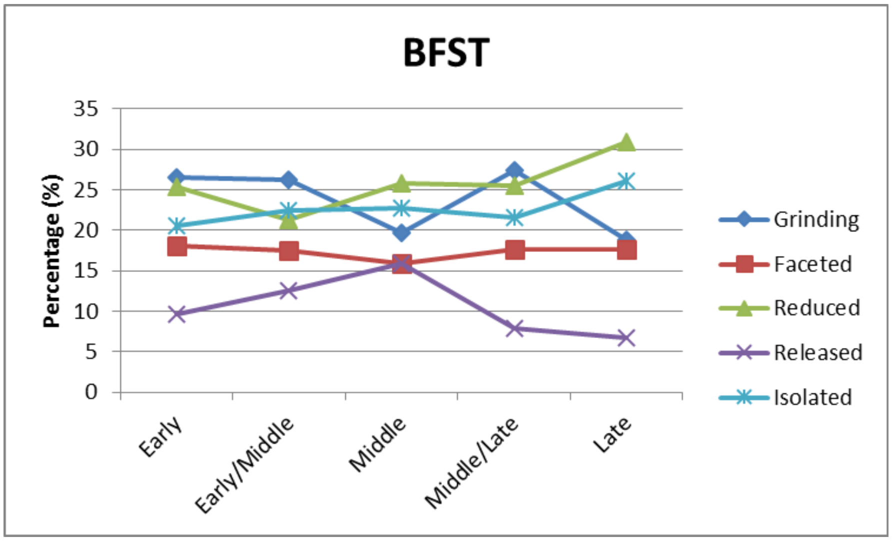

Figure 78 – BfST Flakes - Platform Preparation Traits by Phase

Chi-square analysis indicated no significant difference in platform preparation traits BfST flakes by phase $X^2(16, N=511) = 13.026, p = 0.6709$.

BFT Flakes by Trait and Phase

Analysis of BFT flakes indicated little variation in the percentages of these traits by phase (Table 57 and Figure 79).

Table 57 – BFT Flakes - Platform Percentage Preparation Traits by Phase

Trait By Phase	Ground		Faceted		Reduced		Released		Isolated		Total	
	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Early	36	(27.91)	22	(17.05)	29	(22.48)	12	(9.3)	30	(23.26)	129	(100)
Early/Middle	62	(24.03)	49	(18.99)	57	(22.09)	28	(10.85)	62	(24.03)	258	(100)
Middle	242	(23.73)	195	(19.12)	234	(22.94)	111	(10.88)	238	(23.33)	1020	(100)
Middle/Late	147	(23.41)	118	(18.79)	143	(22.77)	65	(10.35)	155	(24.68)	628	(100)
Late	146	(21.99)	112	(16.87)	169	(25.45)	56	(8.43)	181	(27.26)	664	(100)

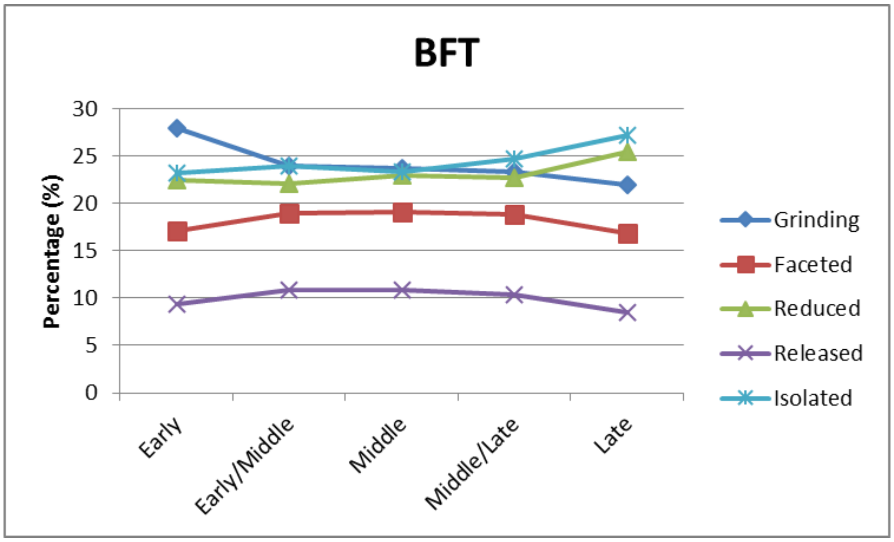

Figure 79 – BFT Flakes – Preparation Traits by Phase

Chi-square analysis confirmed this finding indicating no statistically significant difference in platform preparation traits in BFT flakes by phase $X^2(16, N=2699) = 10.159, p = 0.8582$.

Platform Complexity of ET/Ch Flakes by Trait and Phase

Analysis of ET/Ch flakes are presented in Table 58 and illustrated in Figure 80.

Table 58 – ET/Ch – Percentage of Preparation Traits by Phase

Trait by Phase	Ground n (%)	Faceted n (%)	Reduced n (%)	Released n (%)	Isolated n (%)	Total n (%)
Early	3 (37.5)	1 (12.5)	3 (37.5)	0 (0)	1 (12.5)	8 (100)
Early/Mid	5 (29.41)	2 (11.76)	4 (23.53)	3 (17.65)	3 (17.65)	17 (100)
Middle	10 (22.73)	9 (20.45)	11 (25)	6 (13.64)	8 (18.18)	44 (100)
Mid/Late	3 (21.43)	3 (21.43)	3 (21.43)	2 (14.29)	3 (21.43)	14 (100)
Late	8 (25.81)	7 (22.58)	8 (25.81)	2 (6.45)	6 (19.35)	31 (100)

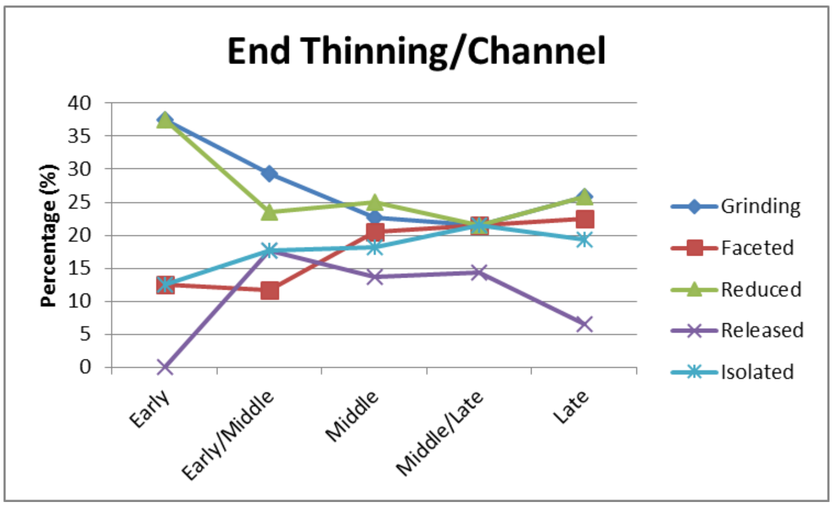

Figure 80 – (ET/Ch) Flakes –Platform Preparation Traits by Phase

Due to the small sample size of ET/Ch flakes, Fisher's Exact Test was used in lieu of Chi-square, to deal with analyzing small or unequal proportions. Analysis indicated that there was no statistically significant difference ($p = 0.994$).

Analysis of Platform Complexity in Flakes with Overshot Terminations (OST)

This next section further refines the 1510 data set by analyzing only those flakes recorded with overshot terminations (OST). Seventy-four flakes with overshot terminations (OST) were identified as being associated with biface reduction and were analyzed by flake type and phase to determine the levels of platform preparation traits. The results of this analysis will be used later to help inform the separate supplement overshot study presented in Chapter 9.

OST by Phase

Platform traits on overshot terminations (OST) were first analyzed by phase to assess their distribution. Table 59 and Figure 81 present results of these data.

Table 59 – Platform Preparation Traits on Overshot Terminations by Phase

Traits By Phase	Ground n (%)	Faceted n (%)	Reduced n (%)	Released n (%)	Isolated n (%)	Total *reflects more than actual # of flakes in sample
Early	22 (26.51)	14 (16.87)	19 (22.89)	9 (10.84)	19 (22.89)	83 (100)
Early/Middle	3 (23.08)	3 (23.08)	2 (15.38)	2(15.38)	3 (23.08)	13 (100)
Middle	28 (24.78)	23 (20.35)	29 (25.66)	12 (10.62)	21 (18.58)	113 (100)
Middle/Late	5 (25)	3 (15)	3 (15)	3 (15)	6 (30)	20 (100)
Late	5 (20)	6 (24)	5 (20)	2 (8)	7 (28)	25 (100)

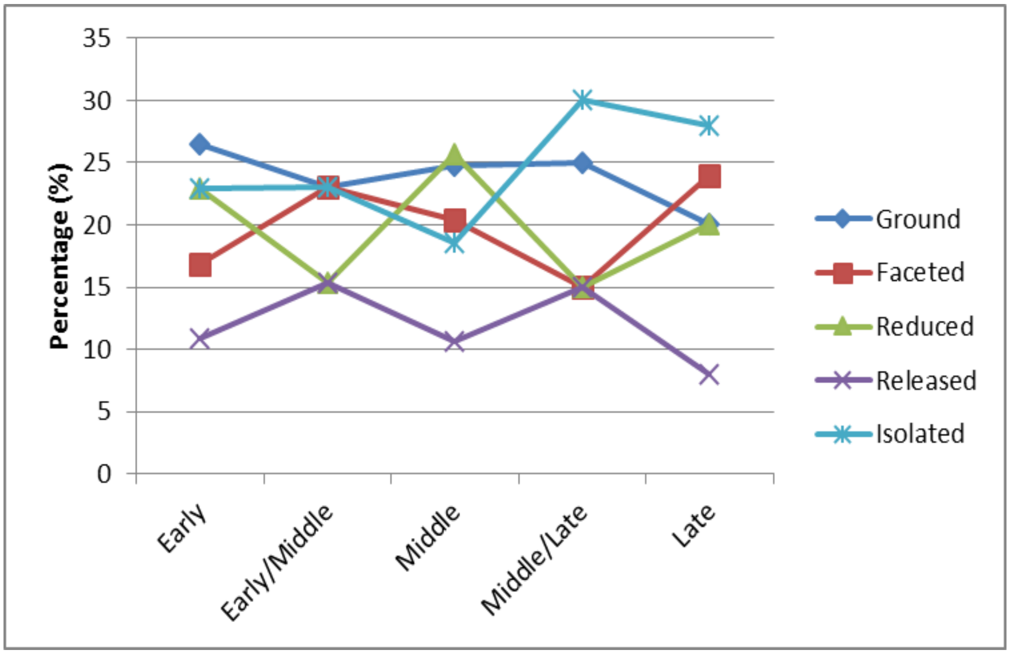

Figure 81 – Platform Preparation Traits on OS Terminations by Phase

Analysis indicates all but one of the overshot termination platforms by phase were prepared and these preparation traits are found in various combinations. Chi-square statistical analysis reveal no statistically significant difference in the distribution of these traits by phase ($X^2(12, N=254) = 4.938, p = 0.9961$).

OST by Type

Platform traits on flakes with overshot terminations were analyzed by flake type (Table 60 and Fig. 82).

Table 60 – Platform Preparation Traits on Overshot Terminations by Flake Type

Traits by Type	Ground n (%)	Faceted n (%)	Reduced n (%)	Released n (%)	Isolated n (%)	Total n (%)
BFS	4 (33.33)	0 (0)	5 (41.67)	0 (0)	3 (25)	12 (100)
BFST	4 (21.05)	4 (21.05)	4 (21.05)	2 (10.53)	5 (26.32)	19 (100)
BFT	54 (24.77)	44 (20.18)	48 (22.02)	25 (11.47)	47 (21.56)	218 (100)
Channel	1 (20)	1 (20)	1 (20)	1 (20)	1 (20)	5 (100)

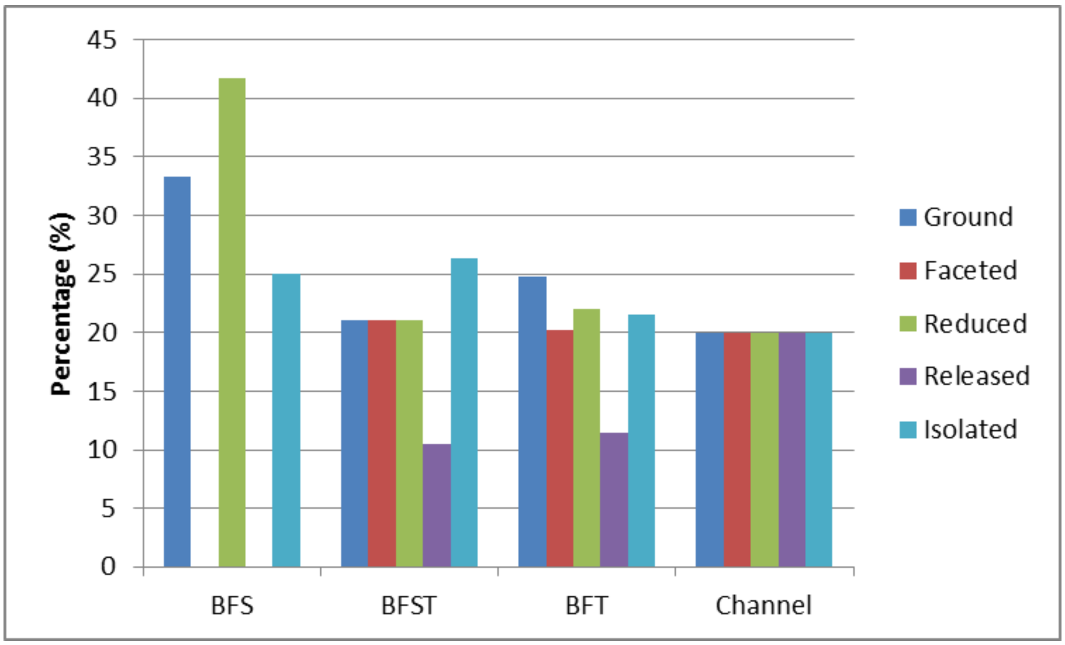

Figure 82 – Platform Preparation on OS Terminations by Flake Type

Results indicate that twelve BFS flakes with overshot terminations were not faceted or released.

These results raise an interesting paradox of an overshot termination being identified as a 'shaping' flake as defined in Chapter 6. A closer look at the raw data shows that twelve BFS flake specimens were assigned to early biface reduction phases and retained square and/or cortical edges. While overshots in general affect both sides of the objective biface piece, they do not fit within the definition used here in the strictest sense because these had a simultaneous effect on two lateral edges of the objective biface. Based on the mechanics of plunging flakes, the BFS flake terminations likely removed more mass from at least one lateral edge to create workable edges and may indicate that not all overshot flakes were strictly used for thinning.

Regarding the only ET/Ch in this sample with an overshot/plunging termination retained a platform that was well prepared exhibiting all five platform preparation traits. This is interesting since this particular ET/Ch flake ruined a Clovis preform.

Statistical analysis indicated that no statistically significant differences were found in the distribution of these platform traits by type ($X^2(12, N=254) = 6.884$, $p = 0.8652$).

OST Platform Preparation Score

This analysis indicated that flakes with overshot terminations were prepared prior to detachment and that heavy preparation occurred across all phases and on different flake types. Further analysis of these platform terminations indicated an average platform trait-use score of 3.43. Analysis of overshot flake platforms indicated that nineteen (19) different trait combinations were used. The most common combination was the use of all five traits in sixteen (16) specimens representing 21.62% of this OST data set. These data strongly suggest that platforms on OS terminated flakes had carefully prepared platforms.

The results reveal an overall consistent, but highly complex use of individually applied platform preparation traits of no particular hierarchy, from which no system or pattern emerges.

Qualifying the Typical Clovis Thinning Flake

Bradley, *et al.* (2010:66) stated that a typical Clovis thinning flake platform is straight, reduced, released, isolated, faceted, and ground. To assess this statement, a count of all the biface flakes that matched these criteria was conducted and converted into a percent. Figure 83 illustrates the results and demonstrates that, overall, a very small number of BFT flakes exhibit this combination of traits.

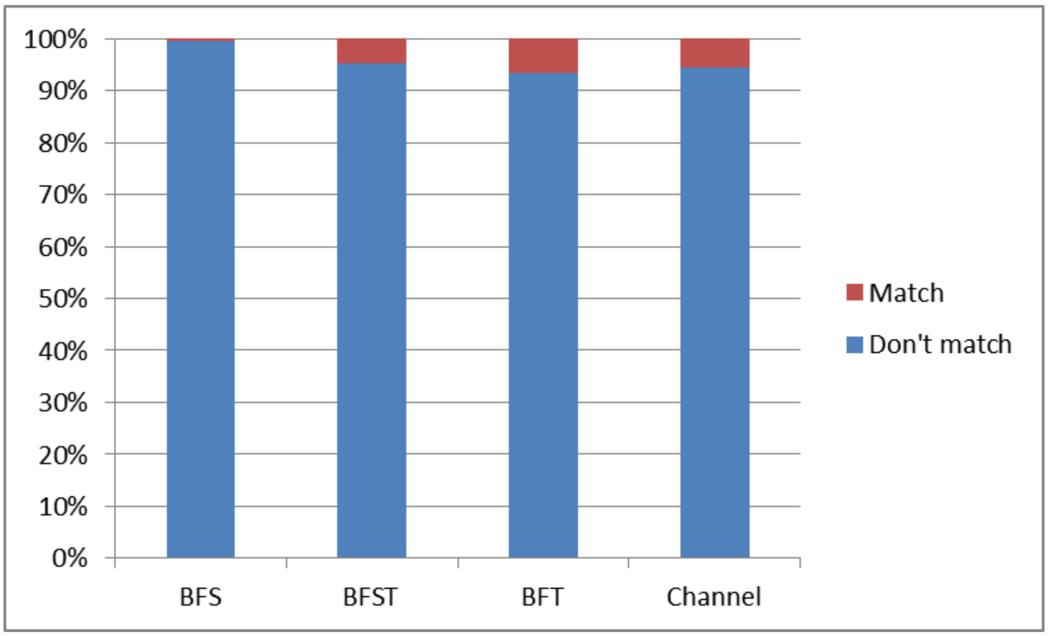

Figure 83 –flake platforms matching criteria of Bradley et al. (2010:66)

The difficulty with this analysis is that, as the analysis above indicates, while general trends emerge in individual traits, there are statistically significant differences between the traits, and this suggests a more complex pattern of preparation. Another way to assess the claim of a typical Clovis thinning flake platform flake is to assess the most common combination of platform traits. This analysis indicated that the use of straight, reduced, released, isolated, faceted, and ground platforms was the third most common combination used to prepare BFT flakes. The first most common combination was the use of ground, faceted, reduced, released, and isolated platforms, a pattern that was shared with BfST flakes and ET/Ch flakes. BFS flakes were not so heavily prepared and the most common "combination" used was singular use of reduction.

The analysis of preparation traits also reveals another aspect of platform preparation. Forty-seven (47) different combinations of platform preparation traits were used on BFT platforms, forty-four (44) on BFS, thirty-nine (39) on BfST, and eighteen (18) on ET/Ch flakes. This high number of different combinations indicates that there was no set method for preparing a striking platform and preparation was dependent on the requirements of removing a particular flake from the biface.

While the number of flakes that match the criteria outlined by Bradley, *et al.* (2010:66) do not suggest they are typical, but may be diagnostic. Analysis of different combinations of traits used in this study regarding platform preparation indicate that the most common combination included all five platform preparation traits of grinding, faceting, reducing, releasing, and isolating. Thus, the platform traits stated by Bradley, *et al.* (2010:66) should be amended with "straight" removed.

However, these data strongly suggest that Clovis knappers did not prepare platforms that followed any specific pattern. Instead, it represents a complex approach to flake detachment where individual platforms were created and adjusted according to the needs of the knapper to fashion or improve angle of detachment or strengthening for a successful detachment.

While this is true in general, certain trends are present in the data that may highlight certain aspects of a Clovis manufacturing ‘mental template’ (Bamforth 1991; Bradley and Giria 1996). Specifically, platform preparation traits being combined and used most intensely during the middle phase of production. The majority of thinning flakes are also removed during the middle phase. This is possibly indicative of behaviors where greater attention was given to remove flakes that thinned the biface and as such, minimized the amount of errors being made or lessened the chances of critical failures. A second trend in the data occurs in the late phase where platform preparation is used to a lesser degree, but this may be the result of a well-established bifacial margin that required less preparation to remove the desired flakes.

While analyses reveal Clovis knappers in general did not follow a set pattern in the application of platform preparation traits, there are trends in the use of preparing platforms, and removal of BFT flakes during the middle phase. This trend highlights the possibility that Clovis bifacial reduction sequences followed a ‘template’ about specific technological choices were made during each phase of reduction.

Qualitative Analysis of Clovis Flakes

Small flakes are often associated with sharpening or reworking of stone tools (Frison and Bradley 1999; Gandy 2013). Only one flake was found that may indicate re-sharpening activities, but no others were immediately identified. These flakes may not have been present in the original sample since the minimum size criterion was ten millimeters, which may have eliminated the detection of small re-sharpening flakes in the final data set. The overall lack of re-sharpening flakes in the data set, and considering the results of this study, may simply indicate the primary nature of Area 4 as a manufacturing area.

BFT flakes and BFS flakes were the most prominent types in the original 2185 data set. Some flakes in the original data set were noted as exhibiting non-specific thermal damage, which was identified by the pot lidding, spalling, and crazing or fissures; these characteristics on chert are often associated with severe heat damage (Patterson 1995). On the other hand, freezing temperatures can produce similar damage as heat damage (Lautridou, *et al.* 1986). In addition, there were about a dozen or so large decortation flakes where the ventral side appeared to exhibit a reddish hue, and may infer the possibility of controlled thermal treatment. However, given the nature of these observations, these notations do not provide enough evidence to suggest heat-treating of chert was common practice by Clovis knappers at Gault. Further study is needed to assess the question of Clovis heat-treating chert at the Gault site, but is outside the scope of this research.

Approximately 2.7% of flake specimens in the 2185 data set were noted as unusual in that some appeared to be made entirely from fine-grained chert that is similar in color and texture to 'porcelain.' This material is likely the subcortical material of Edwards chert, which fits the nature of the local Edwards material at Gault (Figure 84). Their overall occurrence ranged from early to late phases, but most of the flakes were described as small, late phase, BFT flakes. Drawing on personal experience, this subcortical material in the Edwards chert is of high quality and easily knapped. Clovis knappers may have found this to be the case as well, or these flakes were simply produced by chance. Regardless additional study would be needed to assess this statement, but is beyond the scope of this research.

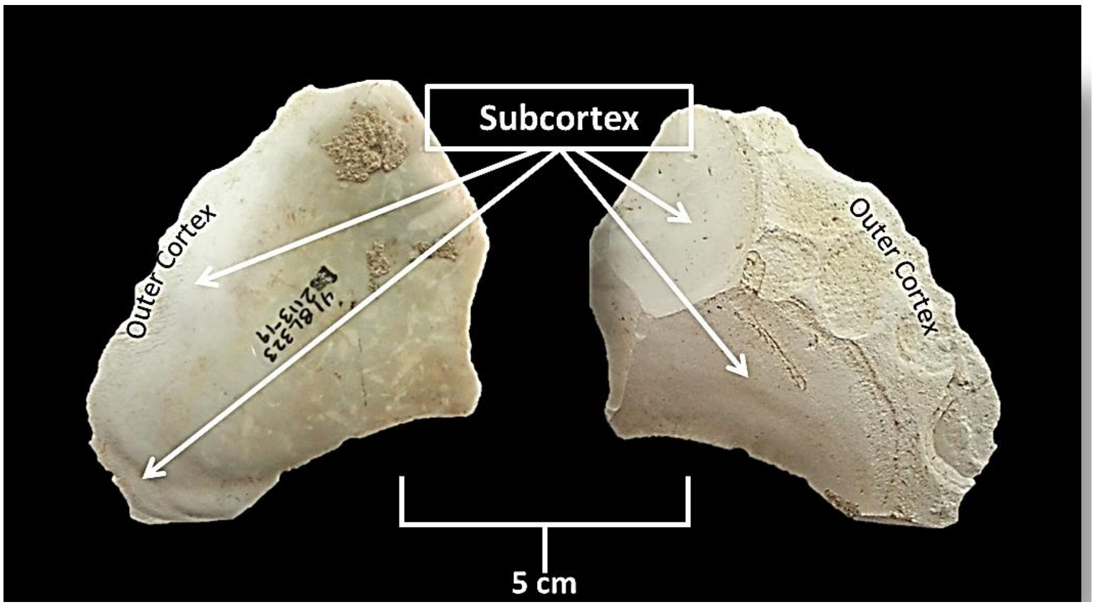

Figure 84 - Example of fine-grained "porcelain-like" subcortical material on a Clovis Flake (Spec# BB-2113-19)

During initial sorting for this study, it was noted that the flaked debris revealed multiple manufacturing activities that occurred in Area 4. This observation correlates with the *in-situ* Clovis artifacts that include manufacturing failures of Clovis bifaces as well as Clovis preforms, discarded Clovis spear points and distinctive manufacturing debris such as overshot flakes and end thinning flakes in Area 4 Clovis deposits. There were also discarded and exhausted blades and blade cores; blade fragments and debitage associated with distinctive blade core maintenance or preparation flakes such as core tablet flakes or platform rejuvenation flakes (Dickens 2008).

There were some BFT flakes noted as having a prominent dorsal “hump” situated nearest the striking platform. Around a dozen of these flakes were noted as having a prominent arris and exhibited multidirectional flake scars on the dorsal side. An illustration of one of these flakes is presented in Figure 85 below.

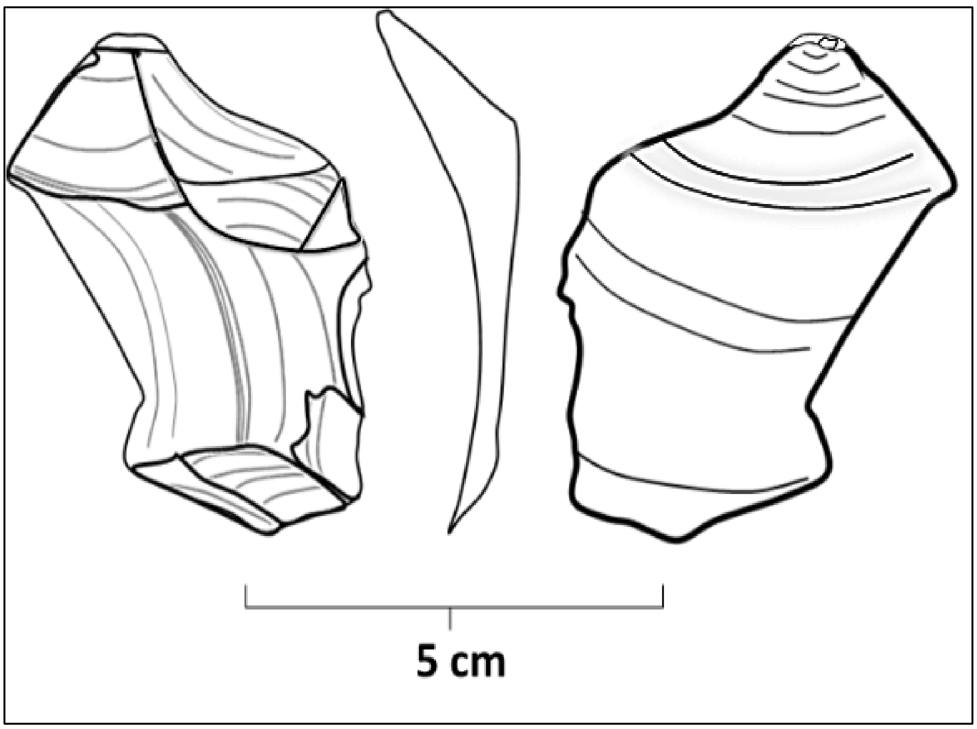

Figure 85—Drawing of Clovis flake UT-4321-(G4) exhibiting a prominent arris and multidirectional scars on the dorsal side and may represent manufacture or maintenance debris associated with multidirectional biface flake cores described as discoidal cores from Gault Clovis assemblage (Bradley, *et al.* 2010:58).

These flakes appear to be atypical to the biface reduction flakes in the overall data set. However, research provides a possible answer as to their production origins. The Aubrey Clovis site recovered flakes that were interpreted as being produced from ‘discoidal’ (disk-shaped) bifaces (Ferring 2001:148). Several discoidal bifaces were recovered from Clovis context at Gault, including at least one from Area 4 (Bradley, *et al.* 2010:58, fig 3.2). A general assessment was made using the illustrations in Ferring (2001:148-149) to compare. While there were some similarities, the results were inconclusive. The function of these ovate-shaped bifaces were likely to produce large flake blanks (Bradley, *et al.* 2010:57), but there is little information on how they were produced or maintained and is beyond the scope of this research.

With regard to blade core production and maintenance flakes, these were produced during shaping and set up of wedge shaped cores (Bradley, *et al.* 2010:41) or to rejuvenate platforms (Bradley, *et al.* 2010:32; Ferring 2001:146). These unusual flakes are easily discerned from biface thinning or biface shaping flakes and usually exhibit some of the following traits.

The flake bodies are usually thick and exhibit irregular -- meaning not well spaced -- multidirectional flake scars on the dorsal side that often reveals hinged terminations, or retain multiple stacking errors. The striking platform exhibits very little preparation and the angle of the platform may be at a ninety-degree angle. The ventral side of these flakes will often have an exaggerated bulb of percussion. Finally, other common traits are blade removal scars that may or may not exhibit a negative bulb and these scars are often perpendicular to the striking platform axis. Flakes with at least three or more of the more-prominent traits listed above may be produced from blade manufacturing (Fig. 86).

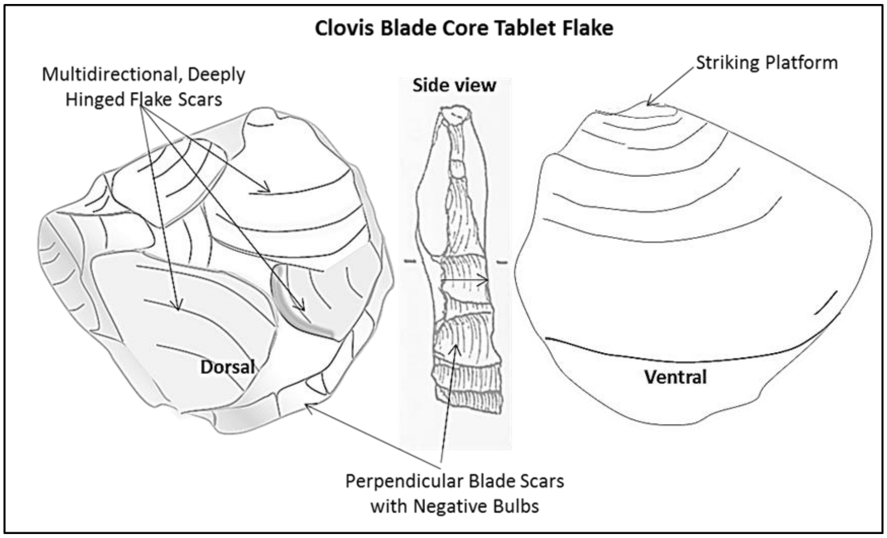

Figure 86—Schematic of blade core tablet flakes (*sensu* Bradley, *et al.* 2010:19)

Flake and striking platform data were collected on blade core tablet flakes and platform rejuvenation flakes as well as indeterminate flakes, but these data were not used and were outside the scope of this study.

With regard to lipping, normal to heavily lipped flakes usually exhibited flat bulbs and is expected due to the bending initiation of the fracture (Whittaker 1994:189) that likely created them. Also expected were either minor or no lipping associated with prominent bulbs of percussion. Analysis of lipping by phase indicates minor lipping as having the highest occurrence during the middle phase of reduction. Furthermore, minor lipping occurred in 49.21% of BFT during the middle phase compared to normal lipping (33.33%). This is an interesting comparison because minor lipping, (detected by 'feel') on BFT flakes may suggest that more than one load technique– *i.e.* soft-hammer stone, antler, or wood – could have been used to remove different flakes at different intervals of production. This needs to be explored through experimental work using Clovis biface reduction technology, but is outside the scope of this research.

With regard to non-local materials in the data set. While exotic materials – Alibates and quartz crystal -- have been recovered from Gault Clovis materials, none of the flakes examined in this study were noted as non-local materials. The majority of flakes and debitage in the study sample retained characteristics of the local Edwards chert materials on site. Only one flake was noted as being struck from a chalcedony core. While these are rare in this sample, chalcedony flakes are relatively common since chalcedony nodules are found in close proximity to chert nodules around the uplands. Brief experience with trying to knap chalcedony nodules is similar to knapping heavy nodes of dense plastic. Clovis knappers may have tested a few of these opaque-like cobbles but the Clovis archaeological record strongly suggests Clovis knappers did not waste their time.

Chapter 8 – Clovis Flake Study Discussion

The breakdown of the 2185 flakes in this sample was presented in the previous results and analysis section. In terms of flake phase, every phase was represented with the middle phase having the highest number of flakes. For flake type, BFT flakes were found in the greatest number, closely followed by the "other" category. The ET/Ch flake type was the least represented flake category.

This supports the initial observations of Area 4 as a manufacturing locality. The comparatively low numbers of early phase flakes may indicate that initial preforming may have been conducted in a separate location. Likewise, the low numbers of ET/Ch flakes may indicate that this activity, and in particular fluting, was also conducted in a separate area from the Area 4 manufacturing location.

For all Clovis flakes recorded in this sample, 96.57% exhibited some form of platform preparation; however, no single trait was used consistently. The most frequent combination of platform preparation was faceting, reducing, releasing, isolating, and grinding, however, this was only in 12.13% of the entire population sample.

This original data set was refined to remove the impartial, or indeterminate Clovis flakes not produced from biface manufacture.

Clovis Biface Flake Technology

Out of the 2185 data set, fifteen hundred-ten (1510) flakes were positively identified as being produced from Clovis biface reduction. This refined data set was analyzed using the same two groups of flake phase and flake type and the results will be discussed in the following sections.

Biface Platform Metrics

Platforms on Clovis biface flakes were found to be longer than they were deep and platform size decreased proportionally from early to late phases of reduction. Clovis platforms have often been described as being “small” (Bordes and Crabtree 1969:10-11; Collins and Hemmings 2005:10) or “wide,” (Bradley 1991:373; Stanford in: Hall 2000; Kooyman 2000:110). Analysis of platform metrics indicated that Clovis biface flakes retained a “wide” striking platform, but ‘small’ was difficult to assess due to ambiguity of the term. However, the term “rapidly expanding” used in Bordes and Crabtree (1969:10-11) provides a suitable description of many biface thinning flakes observed in this study (Fig. 87 and 88).

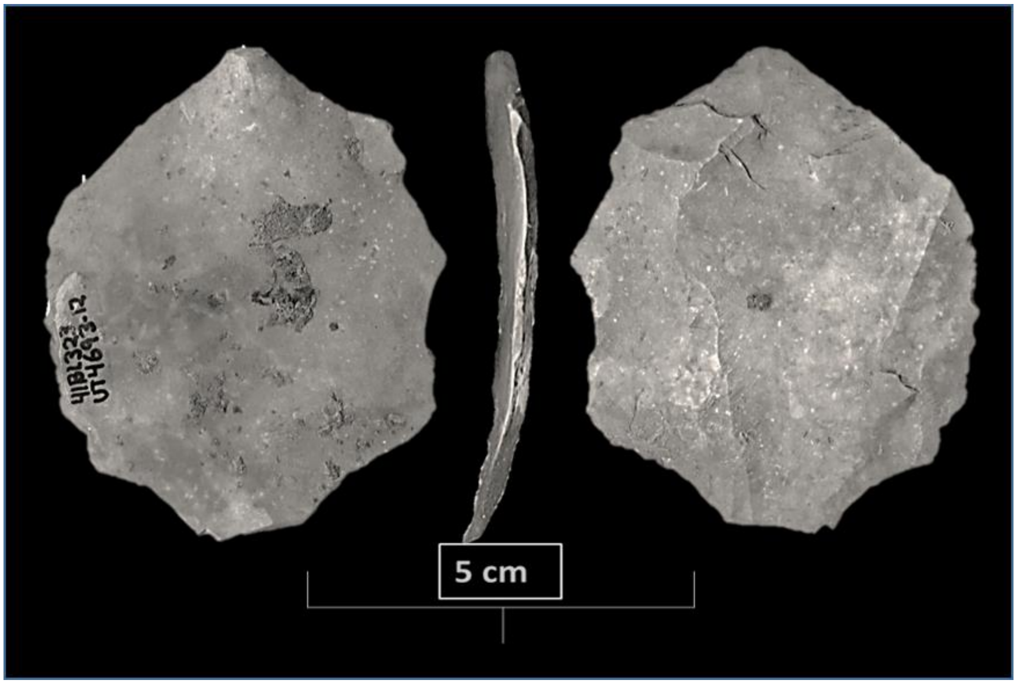

Figure 87 – A Clovis biface thinning flake from Area 4 exhibiting a "rapidly expanding" flake body in relation to a small striking platform. (Photo by M. Samuel Gardner courtesy of the GSAR).

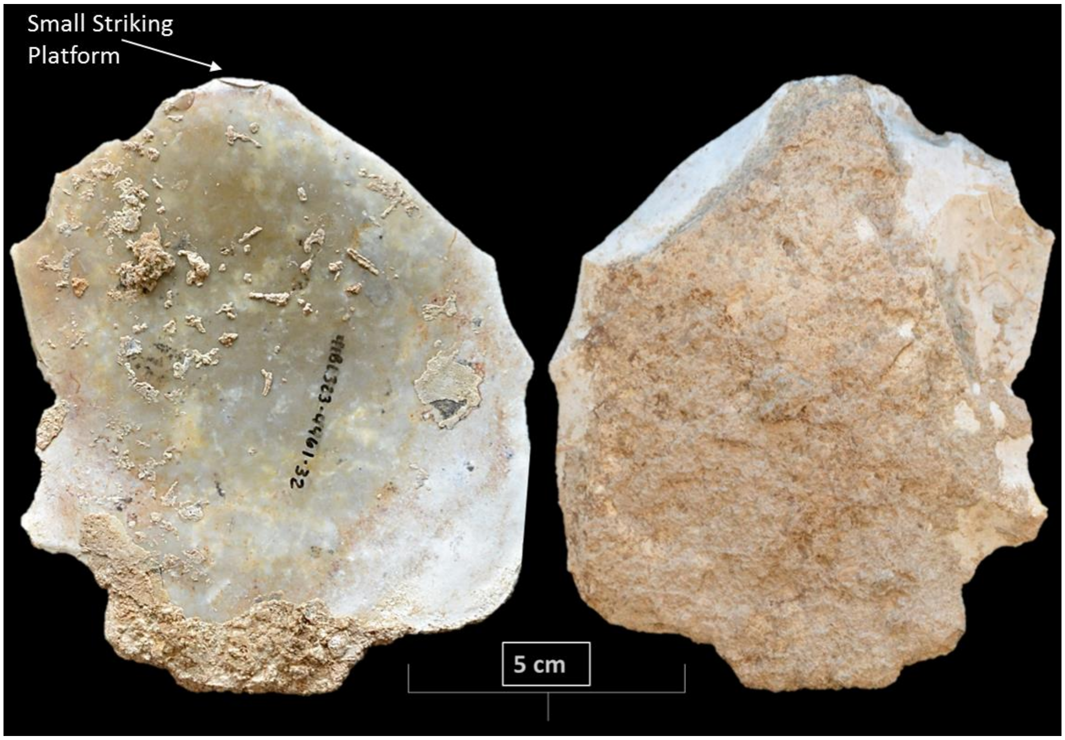

Figure 88 – A large Clovis cortical flake from Area 4 exhibiting a "rapidly expanding" flake body in relation to the small striking platform.

Differentiating Biface Shaping Flakes and Biface Thinning Flakes

Biface shaping flakes (BFS) were the only flake in this study that was statistically wider than long. Overall analysis of these flakes indicates that BFS flakes in essence 'modified' the edges of bifaces while BFT flakes removed mass by traveling across the bifacial plane. The BFS results generally support the definitions of Inizan, *et al.* (1999:39-43) and Root, *et al.* (1999:15) with regard to defining biface shaping flakes and further indicate that BFS flakes were removed throughout the biface reduction.

Overall, the results of this analysis suggest that BFS flakes were a versatile type of flake removal. BFS flakes can be used to modify a biface edge or adjust the lateral and basal outline (margins) of the biface. BFS flakes could have been used to set up areas along the margins to control morphology in order to focus platform preparation along, for instance, a guiding ridge (Bradley, *et. al* 2010:67). BFS flakes were used to prepare biface margins to enable BFT flake removals that would travel laterally across to thin the biface plane, or likewise, create a cross-sectional convexity to facilitate the removal of longitudinal thinning flakes. BFS flakes can also be applied to create and maintain the 'classic' biface outline seen in many Clovis bifaces, preforms, or finished projectile points (Bradley, *et al.* 2010:179-186; [*see also* Frison and Bradley 1999 *and* Waters and Jennings 2015]). BFS flakes may have been used to shape and control the basal edge of bifacial plane that facilitated the removal of ET/Ch flakes.

Biface Flake Analysis by Flake Type and Phase

The analysis of flake types by phase indicates a degree of patterning in the use of BFS and BFT flakes with an increase in BFT flakes towards the middle phase; this is mirrored by a decrease in BFS towards the middle phase. In the later phases of production, BFS increases once more. Coupled with the metric analysis this likely indicates that reduction followed a pattern of maintaining the bifacial plane throughout the reduction sequence although during the middle phase focus is shifted to thinning the biface.

These results broadly conform to the reduction sequence outlined in Bradley, *et al.* (2010:77). The use of BFS in the early phases of production is similar to the establishment of the biface plane and the regularization of the outline discussed by Bradley, *et al.* (2010:80) for early phase. Bradley, *et al.* (2010) define ‘middle interval’ as those bifaces that became more regularized as emphasis was placed on ‘flattening’ and thinning (2010:83). The data here show a shift as well to thinning during the middle phase of production and therefore supports the Bradley, *et al.* (2010:83) definition.

Bradley, *et al. (*2010) state ‘late interval’ Clovis bifaces reveal a shift in strategy from biface thinning to regularizing or shaping the bifacial outline and surface contours (Bradley, *et al.* 2010:91). The data here also show a decrease in BFT flakes with an increase in BFS flakes during the late phase and thus support the findings of Bradley, *et al.* (2010:91). Overall, there is good agreement between the Clovis biface reduction model in Bradley, *et al.* (2010:79-91) and the results of this study.

The result of BFS flakes produced during early phases in this study is equivalent to Callahan’s (1979:36) ‘stage 2’ of manufacture with the intent of forming the initial edging. Callahan (1979:36) also notes that flake scars in ‘stage 2’ cover less than half of the width of the biface to produce a ‘lenticular’ cross section. This is broadly equivalent to the BFS flakes here that remove more biface width than length. The increase of BFT flakes during the middle phase here corresponds to Callahan’s (1979:37) ‘stage 3’ and ‘stage 4’ of biface manufacturing.

Finally, similar to the late interval phase definition in Bradley, *et al.* (2010:91), Callahan’s (1979:37) ‘stage 5’ concerns shaping the outline of the biface. Again, this is highlighted in this study by the increased occurrence of BFS flakes in the late phase of biface production.

In contrast to the biface reduction stages at the Murray Springs Clovis site, Huckell (2007) states that ‘primary bifaces’ exhibit the removal of several large expanding flake scars (Huckell 2007:191). The data here highlight the use of BFS in the early phases of production to regularize the biface plane and outline. There is little of evidence for raw material procurement at Murray Springs (Huckell 2007:185). As such, the term ‘early stage reduction’ is relative to the Clovis biface assemblage at Murray Springs (Huckell 2007:192). Huckell (2007:191) notes the use of overshot flaking during the early phase of biface production. This is confirmed by the findings here that show overshot flaking is used in the early phase of biface production. Based on Huckell’s definition of ‘secondary’ bifaces (2007:191-192) the Murray Springs data converge with the data here in terms of the use of thinning during the middle phase of biface production.

In summary, the data here conform to the existing reduction sequences outlined by Bradley, *et al.* (2010:77-91) and Callahan (1979:63). While some differences are noted between Huckell (2007:170-213) and this study, it is interesting to note the use of overshot flaking in the early stages of production at the Murray Springs site as well as Area 4 of the Gault Site.

Likewise, with regard to Area 8 at the Gault Site, the reduction sequences used in this study are broadly similar to the reduction divisions used by Waters, *et al.* (2011a) -- *e.g.* ‘primary bifaces,’ ‘secondary bifaces,’ ‘preforms,’ and ‘completed points.’ (2011a:84).

Flake Terminations

Analysis of terminations by flake phase and flake type reveals that feathered terminations were by far the most common. Furthermore, overshot terminations occurred predominantly in the early and middle phases. However, overshot terminations occurred across all biface reduction phases in this study. Huckell (2007) notes the occurrence of overshot flaking on ‘primary bifaces’ (Huckell 2007:189-191), which is similar to results indicated above. Bradley, *et al.* (2010:74) note as well that overshot flakes occur throughout biface reduction (Bradley, *et al.* 2010:74), thus confirming the results in this study.

Lipping on Platforms

Lipping was quantified by degree as absent, present, minor, or heavy/extreme (i.e. “edge bite” or “edge collapse flakes”). Comprehensive analysis of lipping revealed no major differences or patterns by type or by phase. However, the discussion in the qualitative analysis regarding the occurrence of minor lipping on BFT flakes was noted as interesting. Regardless, the occurrence of lipping on Clovis flakes in the data did not reveal any significant difference in the degree of lipping by flake phase or type.

Theoretically, lipping occurs from soft-hammer direct percussion (Whittaker 1994:189), although it is generally accepted that Clovis manufacturing techniques included the application of direct percussion (Bradley, *et al.* 2010:64) using hard or soft percussors (Huckell 2007:172,177). Some experimental flintknapping studies have demonstrated that hard or soft load applications can produce similar flaking results (Henry, *et al.* 1976:57). Overall, the lipping analysis and results presented here may not be useful to infer any culturally specific technology.

Ground Platforms – Degree of Grinding

Grinding revealed much about knapping behaviors especially platforms with edge-only (marginal) grinding or those flakes recorded with edge/obverse (marginal and dorsal-side of platform) grinding which show to be the most prevalent means of platform preparation. Grinding appears throughout the reduction process, but does not fully support previous observations (Bradley 1991:373; Bradley, *et al.* 2010:66; Collins 1999a:46; Collins and Hemmings 2005; Ferring 2001:133; Hall 2000; Huckell 2007:189,197; Kooyman 2000:110).

Overall, the levels of grinding decreased towards the late phases of biface reduction. In contrast to previous observations in Collins (1999a:46), analysis of grinding in both phase and flake type revealed that, while statistically significant differences were present in the data, there was no dominant pattern of its application to any flake type or any particular phase. This may indicate that this trait was used only when required. Overall, striking platforms on BFS flakes were the least ground. Yet, analysis of BFS flake platforms also revealed the highest proportions of all platform preparation traits. However, statistical analysis was conducted on all platform preparation traits and revealed no correlation or dependency between grinding and reducing, as well as other preparation traits. Therefore, there may be a real world connection that points to knapping behaviors.

These data show that while Clovis knappers heavily ground their platforms, full grinding (margin, obverse, and reverse), in many cases, is the third or fourth most common combination of grinding degree traits. This highlights the problem of how previous authors define “heavily ground platforms” because there are no available data to compare. Therefore, these data provide a method for evaluating how heavy and to what degree platforms were being ground.

Platform State/Status

Analysis of the platform status indicated that there was a positive trend (increase) in the occurrence of remnant/shattered/crushed platforms throughout the reduction process from early to late phases with a peak in the middle phase and to a lesser extent, the late phase. Analysis by flake type indicates that BFT flakes had the highest number of Remnant/Shattered/Crushed platforms. This may be for several reasons that relate to the flakes getting thinner, load used to remove the flake or poorly prepared platforms or flaws in the material.

Plain and Cortical Platforms

Analysis of plain and cortical platforms indicates the percentages of these attributes remained constant and occurred throughout the reduction sequence. BFS flakes had higher numbers of plain platforms while BFT had a higher number of cortical platforms. Cortical platform data reveal that the presence of cortex was common throughout the reduction phase and flake types. Data also reveal that cortical platforms were prepared based on the results of the average cortical platform score of 2.61. Analysis of the combinations of platform preparation traits on cortical platforms indicated that 26 different combinations of preparation traits were used indicating that cortical platforms did undergo preparation.

An interesting point was made by an experienced flintknapper. It seemed 'intuitively illogical' for biface thinning flakes to have a higher occurrence of cortex on BFT flake platforms (Pers. Comm. B. Kooyman 2015). However, the data here show that Clovis flake striking platforms retained remnants of cortex and were a common occurrence throughout the reduction phase. Furthermore, the occurrence of platform preparation traits were applied to cortical platforms, and therefore, strongly suggests cortex was simple not an issue for Clovis knappers.

Platform Shape

The majority of platforms here were either straight or convex in shape. Concave shaped platforms only account for 7.1% of the entire biface flake assemblage (n=1510), but showed a positive trend or increase from early to late phases.

BFT flakes have the highest population percentage of straight platforms and the lowest occurrence of dihedral platforms. On the other hand, ET/Ch flakes had the highest number of convex platforms; this is likely due to the knapper's desire for a well-isolated striking platform for fluting (Morrow 1995), or removal of channel flakes from the basal margins. It is relevant to mention that research on post-Clovis (Folsom) fluting identified the need for strongly isolated or 'nipple' shaped platforms (Crabtree 1966) and this may be similar to the isolation identified here. However, the results here made no distinction between end thinning and channel flakes. Therefore, this warrants additional research of morphological differences to ascertain if channel flakes and end thinning flakes reveal any degree of platform isolation to facilitate fluting.

The presence of heavy grinding was also assessed across platform shape to determine if grinding was more prevalent on a particular shape. The analysis indicated that convex platforms had the highest percentage of heavily ground platforms, closely followed by straight platforms. Concave platforms had the lowest percentage of heavy grinding.

It is important to discuss that, while concave platforms occur in this Clovis sample, this platform shape has been associated with Old World indirect percussion techniques (Pelegrin 2004:55-71). Currently, there is no evidence that indirect percussion was ever a technique used by Clovis knappers. Most archaeological and experimental evidence supports the use of direct percussion as the preferred technique used to manufacture Clovis biface as well as blade technologies (Bradley, *et al.* 2010:64, Morrow 1995; Huckell 2007:171), and therefore, the data on convex platforms here do not provide any evidence to the contrary. With regard to their occurrence, observations indicate they are likely incidental due to raw material morphology or platform failure.

It is likely that the low frequency of grinding on concave platforms is perhaps because the shapes of concave platforms were already ideal. Meaning these platforms may not need much grinding to create an edge that already ‘bites’ into the hammer (Pers. Comm. Kooyman 2015).

Platform Preparation by Phase and Flake Type

Analysis of platform preparation by phase indicated that there were significant differences in the application of these five traits: ground (analyzed as presence/absence), faceted, reduced, released, and isolated. Grinding of platforms was applied more frequently in the early phases while reducing and isolating were more common in the late phases. This correlates to the higher proportions of reduced platforms on BFS flakes. The only trait that showed a relatively consistent application throughout all reduction phases was the use of faceting.

Analysis of platform preparation by flake type indicated that while all flakes had similar proportions of all five preparation traits as applied, BFS flakes had lower than expected counts of faceted, ground, and released.

In-depth analysis of these five platform preparation traits revealed that no particular trait correlated strongly to any other trait. In other words, all traits were applied independently with none being dependent upon another in their occurrence.

Platform Complexity Score

Overall, the platform preparation analysis may suggest that platform preparation traits were consistently applied throughout Clovis biface production. Therefore, further analysis was conducted to see if any patterns emerged. The first step of this analysis used a platform scoring system to gauge how many traits were being used or combined to determine the degree of complexity. Middle phase flakes had the highest number of all five traits being used (ground, faceted, reduced, released, isolated), but the most common score was 4 for platform preparation in the middle phase. The middle/late to late phases had the highest scoring numbers of 2 or 3 platform preparation traits being used in combination. In terms of scores by flake type, BFS flakes had higher proportions of scores 1 and 2, while BFT flakes had higher proportions of scores 4 and 5.

These data were further simplified to look at the average preparation trait score by phase and flake type. This simplified analysis confirmed the scores discussed above with middle phase flakes having the highest average platform preparation score, with both the early and late phase having the lowest. Compared to flake types, BFT flakes had the highest platform score and were closely followed by ET/Ch flakes, with BFS flakes having the lowest platform preparation score.

Middle phase is defined in this study based on biface phases defined by Bradley, et al. (2010:83, 86 fig.3.32). The data presented earlier show that BFT flakes represent 59.2% (n=894) of the 1510 biface flake data set. Analysis of flake types by phase revealed that the removal of BFT flakes peaks at 72.58% during the middle phase. Furthermore, BFT flake removals begin to slightly trend downward from middle to late phases. As stated previously, platform trait use scores were the highest for BFT, in addition, the results in table 56 show that BFT flakes platform prep traits peaked during the middle phase. When compared to other flakes, BFS flakes show that platform preparation trait use peaked during the middle phase, drops slightly, and then rises again in the late phase. With regard to BfST flakes, these peak during the late phase, but trait use on ET/Ch flakes only peak during middle phase.

The results of flake types were compared and show platform preparation trait-use as increasing or, in some cases, reaching their peak during the middle phase. That being said three of the flake groups, BFT, BfST, and ET/Ch all show increased attention given to their platforms during middle and late phases, with the exception of BFS flakes which platform trait-use peaked during the late stage.

Overall, the results here strongly indicate that platform preparation traits provide evidence of decision-making behaviors by Clovis knappers. These data further suggest that the middle phase was a crucial interval in the biface reduction process.

Platform Scores on Flakes with Overshot Terminations

Platform preparation traits were analyzed on a refined data set of 74 biface flakes identified with overshot terminations. The results indicated that platforms were more heavily ground, faceted, and released than the other bifacially produced flakes, BFS, BFT, BfST, and ET/Ch. The analysis also indicates that while the percentage of reduced and isolated platforms is higher for these flakes, there was no statistically significant difference in the application of platform preparation traits.

Analysis of platform preparation complexity using the platform scoring method here indicates that flakes with overshot terminations (OST) had an average platform score of 3.43. This is slightly higher when compared to overall platform scores of 3.16 for BFT flakes and 3.03 for ET/Ch flakes, and indicates that platforms on overshot terminations were heavily prepared if not more prepared in some instances than BFT and ET/Ch flakes. Likewise, the scores are higher than the 2.78 for BfST and 2.18 for BFS flakes, which were generally less prepared. It should be pointed out that the overshot terminations occurred in all biface flake types and the data indicate that striking platforms on overshot terminations were carefully prepared.

These data, combined with the above analysis indicate that striking platforms on overshot terminated flakes were carefully prepared. Analysis of trait combinations also revealed that all five preparation traits were the most frequently used for overshot terminated flakes. It is highly likely that Clovis knappers placed as much emphasis on the preparation of platforms to remove overshot terminated flakes as they did for BFT flakes and certainly in a greater degree when compared to BFS flakes where data show have a greater variability in platform preparation traits.

Assessment of the Typical Clovis Biface Thinning Flake

As discussed above, these data indicate that these five platform preparation traits on BFT flakes were applied throughout biface reduction, either singularly or in combinations thereof. However, additional analysis revealed no emerging or obvious patterns to their application. In other words, while these platform preparation traits were used to prepare platforms, their application and combinations varied greatly between flake types and biface reduction phases. In this respect, it is correct to say that Clovis striking platforms were prepared, but it is difficult to identify a set standard for platform preparation.

A 'typical' (Bradley, *et al.* 2010:66) or 'diagnostic' (personal comm. B.A. Bradley 2015) Clovis thinning flake platform is straight, ground, faceted, reduced, released, [projected] and isolated. Analysis of Clovis flake striking platforms here show, in all cases, that the percentage of platforms exhibiting all five traits was around five-percent (5%) or less.

It is of note that artifacts do not have to occur in significant proportions to be considered diagnostic. For example, end thinning as well as channel flakes are considered diagnostic flake artifacts for Clovis biface technology, yet as this research and analysis shows, they were the least represented artifact in the biface data set at 2.66%.

Although these data challenge the *typical* Clovis biface thinning flake platform, further analysis of platform preparation combinations indicate that the most common combination across all flake types and flake phases was the application of all five preparation traits. Thus it is reasonable to deduce that it was diagnostic or typical for Clovis to carefully prepare their platforms, but not in any systematic way.

Hypotheses Testing

The above data were used to test the original hypothesis introduced in Chapter 2 of this dissertation.

Hypothesis 1

Null	Alternate
Clovis knappers applied, in a consistent means, a complementary suite of platform preparation traits before striking and removing flakes during biface manufacture.	Clovis knappers did not consistently apply a complementary suite of platform preparation traits before striking and removing flakes during biface manufacture.

Analysis of the data indicated that platform preparation was not consistently applied in terms of a set recipe so to speak, and thus, does not support the simplified observations of Clovis biface flakes and striking platforms reported in previous Clovis research, therefore the null hypothesis is rejected. However, Clovis knappers consistently chose the best preparation techniques for their perceived needs. These data reveal a flexible application of preparation traits, from simple to complex, by Clovis knapper using various combinations of platform preparation traits as required for the striking and removal of biface manufacturing flakes. Additionally, the analysis identified trends in the use of platform preparation and the removal of biface thinning flakes during the middle phase and may highlight the possibility that Clovis bifacial reduction sequences followed a consistent “mental template” (Bradley and Giria 1996). Therefore, a consistent approach may have been used to produce Clovis bifaces, but individual preparation traits were not consistently applied.

Hypothesis 2

Null	Alternate
The observations and interpretations reported by Bordes and Crabtree (1969), Bradley *et al.* (2010), Bradley (1991), Collins (1999a), Collins and Hemmings (2005), Ferring (2001), Frison (1982), Huckell (2007), Kooyman (2000), Morrow (1995), and Stanford (Hall 2000), are an accurate reflection of the nature of preparation traits commonly observed on Clovis biface flake platforms, and is supported by the data in this study.	The observations and interpretations reported by Bordes and Crabtree (1969), Bradley *et al.* (2010), Bradley (1991), Collins (1999a), Collins and Hemmings (2005), Ferring (2001), Frison (1982), Huckell (2007), Kooyman (2000), Morrow (1995), and Stanford (Hall 2000) do not accurately reflect the nature of preparation traits commonly observed on Clovis biface flake platforms.

The observation and interpretations made concerning Clovis platforms are generally supported by these data. However, analysis has also shown a number of differing trends, which highlights the fact that not all platforms were prepared in the same way. Platform preparation traits were used in a complex manner and while certain traits are present in higher frequencies or different flakes, no dominant or repeated pattern was systematically applied to the preparation of biface flake platforms. Thus, the null hypothesis is rejected due to the oversimplification of the generalities observed or repeating regarding Clovis platform preparation. Clovis platforms were carefully prepared, but with a wide number of different trait combinations lacking a singular pattern in their application. These data also show that plain platforms were used through all biface reduction phases, further indicating that Clovis applied preparation traits only when required.

Clovis Flake Study -- Summary in Wider Context

François Bordes and Don Crabtree remarked on bifaces (1969:10-11) in the Simon Clovis cache (Butler 1963; Santarone 2014) describing bifaces that exhibited flake scars that were "rapidly expanding" relative to “small platforms.” Their comments are one of the earliest published observations that suggested Clovis knappers intentionally prepared small platforms. Bordes and Crabtree (1969:10-11) were impressed by the small size of Clovis striking platforms relative to the remarkably large flake scars. Observations on the biface flakes from Area 4 of the Gault site confirmed this description of rapid expansion of the flake body from a relatively small platform. This common description of Clovis flakes being ‘rapidly’ or otherwise ‘expanding’ (Huckell 2007:189) needs further research for clarification, which was outside the scope of this research.

The words ‘small’ (Bordes and Crabtree 1969:10-11) and/or ‘wide’ (Bradley 1991:373; Hall 2000; Kooyman 2000:110) are often used to describe the relatively small, but distinctive Clovis biface thinning platforms. However, the term as it stands is indefinite with no quantifiable measure as such. Furthermore, based on the platform metric data analyzed here, this term cannot be properly assessed, and, is outside the scope of this study.

Following Bordes and Crabtree (1969), later decades would reveal similar but more frequently expanded observations of Clovis flake platforms where the recognition of well-primed platforms on flakes associated with Clovis assemblages is the technological norm. This brings a common observation to issue, concerning post-Clovis flake and debitage assemblages, where it seems similar emphasis of platform and platform preparation is at best unequalled in reported frequency or enthusiasm.

The observations of Frison (1982) of a Clovis channel flake from the Sheaman Clovis site wrote that it exhibited an ‘unusual amount’ of platform preparation “…compared to other flakes…”(1982:153). This strikes a similar chord to Bordes and Crabtree (1969) who remarked about Clovis platforms being prepared for strength. Frison’s experience as a well-respected archaeologist was just getting into its third decade in 1982, but was impressed by something unusual about the channel flake as well as flakes in the Sheaman assemblage, which, in essence, provided strong evidence of distinct technological behaviors in Clovis flakes.

In addition, knowledge of Clovis technology informed the investigation of the Lincoln-Ready site collection (Morrow 1995:173). It was reported that particular attention had been paid to grinding and isolated fluting platforms that remained on discarded (failed) preforms (Morrow 1995:175) which supports the findings in Frison 1982:153).

Comparing the information reported of Clovis platform preparation traits by Frison (1982:153) and Morrow (1995:175) is relevant to the ET/Ch flake platform preparation traits in this study. There are few details about platform preparation in Frison (1982:153); however, Morrow (1995:175) provides some detail of grinding on the platform as light to moderate in nature. Analysis reveals that 25% of ET/Ch flakes exhibited platform isolation. It is interesting to note that one of the ET/Ch flakes analyzed here exhibited a catastrophic plunging termination, but the platform was well prepared and exhibited all five platform preparation traits. Overall, 32% of the ET/Ch flakes exhibited heavy grinding (full grinding = edge/margin - dorsal/obverse and ventral/reverse) on the striking platforms.

The platform preparation traits observed at the Clovis Lincoln-Ready Site (Morrow 1995) are present, but there are few details provided to allow a solid contribution using the results in this study. The comments made by Frison (1982:153) can also be attributed to the ET/Ch flakes analyzed here although it is important to reiterate that no differentiations were made for end thinning or channel flakes in this study.

Bradley (1991:373), Kooyman (2000:110), and Ferring (2001:133) make similar observations about Clovis platforms, indicating that platform preparation of early biface thinning flakes, along with being wide and straight, were also faceted, reduced, and heavily ground. The biface thinning flakes identified as being produced during early phase biface reduction in this study (n=129), revealed that faceting occurred on 17% of these flakes; reducing occurred on 22% of these flakes with the majority of these flakes, or 28%, exhibited ground platforms. Although, 23% of early phase BFT also exhibited isolated traits it is more common trait (at this early phase) than faceting or reducing. However, BFT flake platforms, in later phases, (early/middle to late) exhibited similar trait use in similar proportions the early phase BFT flakes. This suggests that, at Area 4 of the Gault site, some early phase flakes were as heavily prepared as later stage flakes.

In assessing the heavy grinding observed by Bradley (1991), Ferring (2001) and Kooyman (2000), analysis revealed that grinding on early BFT flake platforms occurred in 26% of specimens for both edge grinding as well as full grinding. This confirms the use of heavy grinding in the early stages. Finally, with regard to Bradley (1991), Ferring (2001) and Kooyman (2000) description of straight platforms in early BFT flakes, analysis here revealed that 38% of early BFT flakes exhibited straight platform shapes. While this supports their findings, this does not necessarily make it a distinguishing trait of these flakes.

Collins (1999a), and Collins and Hemmings (2005) indicated that platforms became more prepared as manufacturing progressed. In-depth analysis of platform traits was refined to represent scores, which enabled the amount of platform preparation to be quantified. Early phase BFT flakes exhibited platforms scores of “1” or “2” in 23% of the specimens. However, analysis also revealed the highest percentage (26%) of platforms scored “3.” Additionally, 19% of BFT flakes have a score of “4” with 11% that had a score of “5.” As such, while platforms were generally less well prepared in the early stage, it is clear that some platforms were heavily prepared.

With regard to grinding (Collins 1999a; Collins and Hemmings 2005), BFT flakes analysis here revealed that platform grinding noticeably diminishes during late phase of flake production and contrasts the findings in Collins (1999a).

Regarding Ferring's (2001:133, 154) observations of flakes recovered from the Aubrey Clovis site, Ferring modifies the description of faceting by using the word 'finely' to describe platforms in "Area G" at the Aubrey Clovis site. Overall, results of analysis here revealed that faceting occurred in 44% of the entire flake sample population (original data set n=2185) from Area 4 of the Gault site. However, in the refined biface flake data set (n=1510), analysis revealed faceting occurred at a slightly higher percentage (45%). With regard to heavy grinding, 18% of BFT flakes in the refined data set (n=1510) exhibit full (heavy) grinding. Ferring's (2001) statements are too general to encompass the range of variability seen at Area 4 of the Gault site.

Concerning Huckell's (2007:189) observation of heavy lipping, and for the purposes of the research here, it is assumed that bifacial retouch flakes in the Murray Springs assemblages were created from bifaces that would be considered finished. As such, in-depth analysis was conducted here on the occurrence of lipped platforms (data set n=1510). Analysis initially revealed that around 5% of biface flakes (excluding ET/Ch) exhibited heavy lipping. Lipping was then broken down further to analyze the occurrence of lipping in specific biface flake types compared by phase. The results revealed that heavy lipping in BFT flakes in the late phase had similar proportions (5%). As such, heavy lipping appears to be much less prevalent in Area 4 of the Gault site than it was at Murray Springs.

Huckell (2007:197) also discusses the absence of 'abraded' platforms. Here, it is assumed that 'abraded' is referring to grinding present on platforms.

Analysis of grinding (data set n=1510) revealed that 52% of all biface flake types (BFT, BFS, BfST, ET/Ch) show no grinding in late stage of reduction. This indicates some similarities in the final stages of production between Murray Springs and Area 4 of the Gault site. Finally, with regard to the “slightly convex” platform shape (Huckell 2007:197); convex shaped platforms in late phase biface flakes occur in 24% of this data set (n=1510) indicating similarities between these two sites.

In summary, many of the general observations regarding Clovis platforms can be applied to the data from Area 4 of the Gault site. This includes the ‘rapidly’ expanding flakes (Bordes and Crabtree 1969), the levels of preparation of channel flakes (Frison 1982; Morrow 1995), and the amount of grinding present on late phase biface flakes (Huckell 2007:197). Regarding the observation of Morrow (1995), Bradley (1991:373), Kooyman (2000), Ferring (2001), Collins (1999a), and Collins and Hemmings (2005) it is clear that the data from Area 4 of the Gault site does not exhibit the same characteristics. While the traits they discuss are present, they do no encapsulate the full range of variability that is present in the data here. This may be a result of differing practices in researcher observations but may also highlight differing technological approaches used by Clovis knappers at different sites. As such, investigating the diagnostic value of Clovis debitage from numerous different Clovis sites would further our understanding of regional variation.

Finally, with regard to previous research on Clovis debitage, some of the results of this study may help enhance findings on Clovis striking platforms in Area 8 at the Gault Site. Area 8 is located roughly 70 meters northeast of Area 4, and some areas of Pevny’s (2009) study are applicable to the results of this research.

In a study of Clovis debitage from Area 8 of the Gault Site, Pevny (2009:44) notes that platform preparation increases as reduction progresses and that in the “advanced state” exhibits well-isolated and “abraded” platforms. As the data above has shown, this is not the case in Area 4, where early phase flakes exhibited in some circumstances a high degree of platform preparation

Clovis Flake Study --Discussion

Overall, the data from Area 4 flake study reveal that the removal of biface shaping flakes (BFS) and biface thinning flakes (BFT) differed throughout the phases of Clovis biface reduction. Further analysis of flake sizes and dimensions indicated that another category of flake was found within the biface reduction continuum of BFS and BFT and was identified earlier as a ‘biface shaping/thinning flake or BfST. Further analysis of flake sizes and dimensions reveal that Clovis knappers focused on shaping out a biface in the early phases of reduction wherein more mass was removed along the biface margin (edge) that did not reach into the center biface plane. This coincides with the reduction sequences outlined by Callahan (1979) ‘stage 2’ and Bradley, *et al.* (2010) ‘early phase.’ With regard to Huckell’s (2007) reduction sequence, he does not discuss shaping of the biface in his ‘primary stage’ but does note the use of overshot flaking which was also identified in the initial biface flake study data set (n=1510).

During the middle phase, more biface thinning flakes were being removed, but few shaping flakes. Looking at this in a simplistic way, the biface reduction sequence during middle phase switched to striking off biface thinning flakes in order to even out the biface by removing mass from the center of the biface. This matches the middle phase identified by Bradley, *et al.* (2010:88), ‘stage 3’ and ‘stage 4’ identified by Callahan (1979), and ‘secondary bifaces’ identified by Huckell (2007:191). During the late phase, there is an increase in the production of biface-shaping flakes, which concurs with a drop in the production of biface-thinning flakes. The flakes were removed to regularize the margin, produce the final form and perhaps to strengthen the piece by reducing the width to thickness ratio and is in line with Bradley, *et al.* (2010:64) and Callahan (1979).

Analysis of Clovis flake platforms indicates that a number of platform preparation traits were used, including an increase in occurrence of platforms that were reduced and isolated throughout the biface reduction from early to late phases. However, the occurrence of grinding, in any degree, steadily decreased throughout biface reduction.

Early to late phase platform data indicated that the most common combination of platform preparation included the five traits provided by Bradley, *et al.* (2010:66) of ground, faceted, reduced, released, and isolated. However, further analysis reveal that while these traits were the most common combination, overall the numbers of striking platforms on flakes exhibiting all five traits are relatively low. Instead, the data reveal that Clovis knappers used different preparation traits in varying combinations.

Trends that did emerge included a high proportion of reduction traits on platforms in the biface shaping flakes, and slight increase of preparation traits used on overshot flakes. There was also a trend towards platform preparation traits being combined and used most intensely during the middle phase of production, which may be related to the increase in the production of thinning flakes. Finally, there is decrease in platform preparation in the late phase of production. These trends suggest that while there was no uniform application of platform preparation traits, it is likely that there was a consistent template in terms of the overall fabrication of the final product such as a Clovis projectile point.

Considering this, it is likely the platform preparation techniques were used based on numerous or hidden factors that cannot be accounted for by debitage analysis alone. Despite this, it is clear from the striking platform preparation data that Clovis technology was a complex but strategic reduction process that involved careful preparation of flake platforms for flaking and/or raw material control particularly in terms of BFS flakes and biface thinning flakes.

With regard to testing the first hypothesis, the rejection of the null hypothesis is based on data that indicated platform preparation traits were not used in a systematic manner. A consensus that Clovis platforms were complex in nature is supported by these data; however, the reports varied or were inconsistent regarding specific platform preparation characteristics of Clovis assemblages. Although, any reported inconsistencies of platform traits could have been due to the variability of site-types (*i.e.* camp, kill-site) or perhaps differences in techniques being used by Clovis knappers, but should be further explored. Overall, this research has demonstrated that Clovis Knappers often used various combinations of platform preparation traits at the Gault Site as required to remove flakes desired to thin and shape their bifaces.

With regard to the second hypothesis, while Clovis did carefully prepare platforms, a varied number of different trait combinations were used and no uniform approach in their application seemed to dominate the sample. This highlights the fact that platforms were made complex only when desired, but their application was flexible depending on other factors such as the flake type and stage within a biface reduction continuum.

Chapter 9 –

SUPPLEMENTAL RESEARCH SECTION

Chapter 9 – Exploring the Duplicity of the Clovis Overshot Flake (OSF) and the Question of Intentionality

9.1 – OSF Introduction

This research focuses on Clovis waste flakes. Therefore, overshot flakes are being included in order to contribute a greater understanding about these unusual flakes. Although overshot flakes are assumed as a diagnostic artifact of Clovis biface technology (Bradley *et al.* 2010:68-77; Collins and Hemmings 2005:15; Eren*, et al.* 2011; Huckell 2007:190-191; 2014:139), their value in the biface reduction process is not well documented. This research will also address recent debate (Eren, *et al.* 2013; 2014; Eren and Desjardine 2014:109-120; Lohse, *et al.* 2014a; Sellet 2015), specifically regarding the intentionality of overshot flaking relevant to Clovis biface technology. As such, a study was conducted using a new sample and data set from hundreds of contextual Clovis overshot flakes.

As discussed Chapter 2, an argument was proposed regarding the duplicitous nature of overshot flakes as being both a flake termination as well as a flaking technique. It is reasonable to assume that overshot flakes in the archaeological warrant attention because they likely represent technological behaviors used within a stone tool culture (Inizan, *et.al.*1999:149-151). With regard to Clovis technology, overshot flakes (OSF), and overshot scars on bifaces, have long been considered diagnostic of Clovis biface technology (Bradley, *et al.* 2010:71; Eren, *et al.* 2011; Frison 1982:203; Frison and Bradley 1999; Huckell 2007:190; 2014:133-152; Lohse, *et al.* 2014a; 2014b; Stanford and Bradley 2012; Waters, *et al.* 2011a:83).

While, there seems to be little question that many Clovis knappers had extensive functional experience with many different types of raw material (Frison and Bradley 1999; Huckell 2007:210-11), these skills have been called into question based on recent experimental overshot flaking data (Eren, *et al.* 2013; 2014).

Exploring the Intentionality of Overshot Flaking Techniques

The presence of overshot flakes or flake scars are frequently reported from cached Clovis bifaces (Frison and Bradley 1999; Waters and Jennings 2015:33; Wilke, *et al.*1991), and have been described as a bold means to thin mass from bifaces (Frison and Bradley 1999:65). Some consider overshot flakes to be the result of an incorrect act or decision by the knapper (Callahan 1979; Whittaker 1994:165). Unintentionally overshooting a flake is a common occurrence perhaps due to incorrect angle of platforms or trajectory of load contact (Callahan 1979), or a misplaced strike especially in the hands of an unskilled knapper or during the fluting process (Frison and Bradley 1999:110; Morrow 1995). Other influences such as material flaws, may contribute to the unintended overshooting of a flake, but it has been reported in another biface culture that the use of overshot flaking has been identified as a technique to clean up material flaws (*see* Almeida 2005; Aubry, *et al.* 2008).

As previously discussed, the application of controlled overshot flaking has been assumed as part of the Clovis technological repertoire, but its application or use is unclear. It is clear, however, that Clovis biface technology represents a highly skilled flaked stone tool industry of superbly flaked spear points and bifaces, based on extensive working knowledge of various raw materials.

9.2 – OSF Study Methodology

9.2.1 – OSF -- Data Collection

Please note that the flake sample in this section does not include any of the overshot terminated flakes from the previous study. This supplemental study uses a complete new sample of data consisting of overshot flakes from all excavation Areas at Gault. However, the sample does include some overshots from Area 4 that had been previously overlooked since most overshot flakes from the Gault Clovis deposits were pulled as soon as they were identified and up until this study, were placed in locked storage.

The overshot flakes were retrieved from locked storage and organized by specimen numbers. Each specimen was closely examined for any misidentification as overshot flakes (i.e. edge bite/edge collapse). The sample was sorted to include all whole or incomplete/broken (distal margin/edge) flakes. The obvious benchmark for broken flakes was a discernable distal terminal margin.

The recording sheet from the previous flake study was modified to record observable flake characteristics and included recording striking platform preparation traits. The dorsal side and distal margins were examined and the following traits recorded; errors such as hinges or stacks, and the presence of cortex on both the distal terminal edge and as well as the dorsal (obverse) side of the flake body. Battering along the distal termination was also noted if present (Butler 2005:35)

Platform preparation was recorded in this study as present or absent. However, the distal termination was examined for specific morphology such as bifacial edge, square edge or cortical edge. Evidence along the distal (margin) was examined for evidence of preparation such as the removal of flakes. This removal of small flakes changes the angle of the opposite margin's edge and has been observed, as well as used personally, during experimental flintknapping sessions to ensure overshooting a flake to rid biface of errors or remove material flaws. Preparation of both the platform (if whole) and the distal termination (whole and broken flakes) were assessed as present or absent.

Following Bradley, *et al.* (2010:77), the biface reduction phases were assigned if determinable and was ascertained using the Clovis biface reduction scheme used earlier (Bradley, *et al.* 2010:77:Tab. 3.3). In addition, bifaces from the Gault Clovis collection, as well as experimental Clovis bifaces, were used as reduction phase models, which helped in determining phases of overshot flake removals. Additional remarkable traits of overshot flakes were written as comments under "notes" section. If an overshot flake could not be confidently assigned a trait or phase, it was recorded as 'other' or 'indeterminate.'

When data was collected, statistical analysis was conducted using Pearson Chi square analysis along with Fishers Exact Test and Yule's Q to confirm the strength of correlations if any existed. Analysis followed similar protocol as the previous Clovis flake study in Chapter 7 in that the raw data was entered into Microsoft Access ® and then imported to Excel ® spreadsheets for further analysis with statistical analysis conducted using SAS Institute Inc. JMP ® Pro 11.0.0.

With regard to the overshot flake research presented by Eren, *et al.* (2013), their analysis was based on experimental data and the results were used to challenge the proposition of intentionality. This problem exposes at least two important issues: 1) When is a Clovis overshot flake deliberate; and 2) Is there a means of qualifying data that can help determine if an overshot flake was purposeful or a blunder?

The study conducted here is based on a model suggesting tactical overshot flaking was used to remove errors or material constrictions as originally defined by Almeida (2005) and expanded upon by Aubry, *et al.* (2008). The following hypothesis was tested:

9.3 – OSF Study Hypothesis

Null

Overshot flaking technique was an oversight or unintended mistake (*see* Eren, *et al.* 2013) made by Clovis knappers.

Alternate

Overshot flaking technique was used by Clovis knappers not as a systematic means to thin but as a tactical strategy used at the discretion of the knapper to remove flaws and errors in order to preserve overall trajectory of the bifacial plane that facilitated continuation of biface production (Aubry, *et al.* 2008).

9.4 – OSF Study – Exploring Overshot Intentionality

As discussed, a separate sample of 330 overshot flakes recovered from secure Clovis contexts at the Gault Site were individually examined for traits and characteristics to help to clarify whether or not Clovis knappers applied overshot flaking as a technique. Specifically, this analysis focused on recording data from the dorsal scars and the distal (overshot terminated) margin. The benchmark for this study used whole and only broken flakes that provided discernable evidence associated with overshot or plunging flakes by retaining a portion of the opposite margin from the objective piece. The results of the data were analyzed to determine if these morphologically unique flake artifacts were mistakes, happenstance, or if they exhibited/retained traits that would indicate intent thus infer purpose in their removal.

This supplemental Clovis flake study was conducted in order to examine first-hand the phenomenon that has generated recent debate associated with Clovis overshot flakes (*see* Eren, *et al.* 2013; 2014; Eren, *et al.* 2011; Eren and Desjardine 2014; Lohse, *et al.* 2014a; Sellet 2015). The Gault collection presented an opportunity to study hundreds of overshot flakes recovered from those excavations with documented Clovis bearing deposits.

9.5 – OSF Study -- Results and Analysis

Of the 330 overshot flakes ('OS' or 'OSF') examined in this supplemental study, 110 (33.3%) were whole and 220 (66.6%) were distal termination fragments.

9.5.1 -- OSF Platform Scores

Analysis of platform preparation traits were conducted on the 110 complete OS flakes in 330 OS flake data set. The results of platform preparation traits for OS flakes scored 2.73 traits per flake. These OSF results (2.73) were lower than the previous platform scores of overshot terminations (3.43) presented in Chapter 7. Further analysis was taken to test for any significance in the differences and the results indicated there were no statistically significant differences found in the use of the platform preparation traits between the OSF sample and the Chapter 7 sample either by production phase (p = 0.8354), or by flake type (p = 0.7002).

The results here partially support the independent findings reported earlier in Chapter 8, however, it is interesting to note that the platform preparation scores here were lower in this sample (n=110), which may be due to the higher proportion of OS flakes assigned to early and early/middle phases based on their retained square and/or natural edges.

The most common preparation trait combination in the OS flakes was grinding, reducing, and isolating. This indicates that some of the overshot flakes with platforms (n=110) show a slight drop in the level of preparation.

9.5.2 – OSF Platform and Margin Preparation

The next section of analysis uses all 330 OS flakes. Below the data are presented on the OS flake attributes collected for analysis.

Table 61 presents the breakdown in counts and percentages of OSF platforms that were prepared

Table 61 – OSF with Platform Preparation

Description	n	%
Prepared Platforms	78	70.91
No Preparation	32	29.09
Total	110	100%

Table 62 presents the breakdown of the counts and percentages of OS flakes exhibiting evidence of preparation on the distal margins.

Table 62 – OSF with Distal Margin Preparation

Description	n	%
Prepared Distal Margin	157	47.57
No Distal Preparation	173	
Total	330	100%

Table 63 presents a breakdown of two flake description groups used to delineate the variations of distal terminations, by counts and percentages.

Table 63 – OSF Distal Margin Description (n=330)

Distal Margin Description	n	%
Bifacial Margin	171	51.82
Square/Natural Margin	145	43.94
Indeterminate	14	4.24
Total	330	100%

9.6 – OSF Platform and Margin Preparatory Measures and Quantifying OS Flake Errors

Common error types were grouped separately and used to quantify the number of dorsal errors retained on each OSF. The breakdown of those error types per OS flake is presented in Table 64. The data shows 258 (or 78%) of the 330 OSF's have removed an error in the form of either stacks or hinges or both.

Table 64 – Number of OSF Dorsal Errors in Population Sample (n=330)

Error Type Description	# of OS Flakes per Error Type	**OSF Sample Percentage (n=330)
	*n	**%
Stack(s)	180	54.54
Hinge(s)	197	59.70
Cortex	186	56.36
Other	8	2.42
Total OSF with Error Correction	**258**	**78.18**

This provides strong evidence for the hypothesis that one of the functions of overshot flakes was a tactical means to remove errors on a biface by setting up flake removals that would intentionally travel across the whole flake. This criterion as such is a strong indicator for intentionality particularly when the distal end of the OSF exhibits preparation of the opposite margin. This factor also shows intentional actions by Clovis knappers when the biface edge was altered. This 'alteration' was accomplished by chipping off only enough material needed, usually from around the problem area, which would become the distal edge of the OS flake. These adjustments slightly changed the mass of the biface so when the force load was delivered, the energy would carry through and result in an OS flake. The adjustment to the biface margin essentially allowed the removal of an OS flake, which if successful would likely remove most, or perhaps all, of the problem. Furthermore, this margin adjustment technique would likely mitigate the amount of material being removed from the opposite edge. This concept is illustrated in Figure 89.

Overall, preparation of the opposite margin (Fig. 89), combined with error removals are strong indicators that cognitive control was being applied in order to manage common knapping problems. As such, these preparatory actions coupled with error removals in this OSF sample indicate that 288 OS flakes or 87% of the entire sample can be described as being intentionally removed.

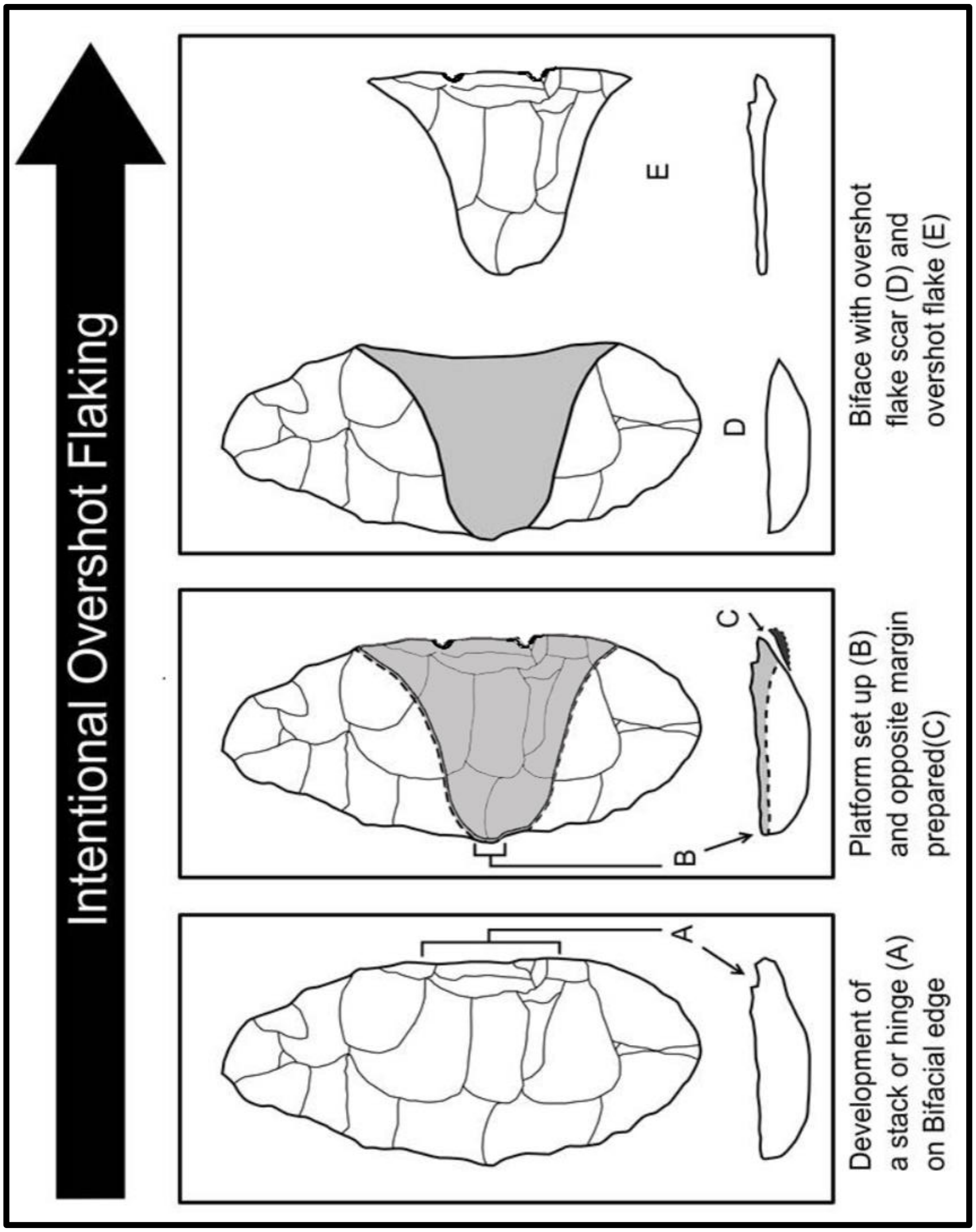

Figure 89 -- Schematic illustration depicting set up of striking platform as well as preparing the opposite margin before removing the overshot flake (*sensu amplo* Aubry, *et al.* 2008. Graphic by Tom Williams and Nancy Littlefield).

9.6.1 – OSF – Analysis of Whole OSF Flakes

The number of whole OS flakes that retained both a platform and a distal termination is 110, and were analyzed for number of errors per flake (Table 65). The data show that 92 or 83.63% of whole OS flakes retained errors consisting of hinges, stacks, or both.

Table 65 – OSF Whole Flake Error Removals

Error Type Description	*n	%
Stack(s)	69	62.64
Hinge(s)	74	67.27
Cortex	0	0
Other	77	70.00
Total Whole OSF with Error Correction	92	83.63
*numbers will not equal 100%		

9.6.2 – OSF – Analysis of OS Flakes with Bifacially Flaked Margins

A more conservative approach to the analysis of overshot flakes would be to refine the data set and remove flakes that terminated with square or natural margins. These types of distal margins may exhibit flaking that, although appear to be prepared, may have occurred at an early phase in manufacture.

One hundred seventy-one, (171) OS flakes were identified as having distal terminations that were bifacially flaked. Analysis of how many of these flakes exhibited a prepared distal margin show that 110 or 64% of OS flakes exhibited margin preparation characteristics.

The number of OS flakes with bifacially flaked distal margins that also retained errors and/or had a prepared distal margin show that 159 or 92% of the 171 OS flakes can be defined as intentional OS flakes.

A more conservative approach to the analysis of overshot flakes would be to exclude all flakes that have not removed a bifacial margin. Square and natural margins may exhibit flaking that, although it appears to be prepared, may have occurred at an earlier phase in manufacture. Based on these criteria of the presence of margin preparation on a bifacial edge, there were 110 (64%) out of 171 OS flakes that exhibit distal margin preparation characteristics.

In the final analysis, if the overshot flakes that retain a bifacial margin and also have removed an error and/or have a prepared distal margin, then 159 out of 171 flakes (92%) can be described as intentional overshot flakes.

9.6.3 – OSF – Square Edge Removals on OS flakes.

While these data indicate that overshot flakes were likely removed with intent in order to eradicate errors from Clovis bifaces, it neglects the fact that controlled overshot flaking can be used to remove a square edge. Personal participation in experimental flintknapping has provided many opportunities to experience working with Edwards variety chert. Based on this experience, it is possible that little or no preparation of the opposite edge was necessary in order to remove a square edge from tabular cherts or remove cortical edge from a chert nodule.

Controlled overshot flaking, unlike other forms of square edge removal, such as alternate flaking, can be useful not only to remove part or all of a square edge, but also shapes and reduces the overall mass of the biface. Likewise, overshot flaking as a measured technique, may also terminate at an angle suitable for removing thinning flakes from the reverse face of the biface (Pers. Comm. B.A. Bradley July 2013). Therefore, if square edge removal, distal margin preparation, and error removals are all considered intentional actions, then the results reveal that 96% (n=317) flakes in this study can be considered intentionally removed.

9.6.4 – OSF -- Statistical Analysis

It is important to understand the significance of preparing a bifacial margin as outlined above using the following conservative approach. Chi-squared analysis of prepared margins on bifacial edges and square edges indicates that it is statistically significant that the opposite margins were prepared on bifacial edges with an X^2 value of 47.51 (α=3.84), this is confirmed by Fishers exact test (two-tailed P value = <0.0001) and Yule's Q which indicates a positive relationship (0.68).

Those OS flakes that exhibit some form of preparation on either the striking platform or the distal margin, as well as prominent error scars provide further reasoning that Clovis knappers used OS flaking to correct problems. As such, the data indicate that 217 or 65.75% of OS flakes, out of the 330, exhibit some form of applied preparation to remove errors. Chi-squared analysis of preparation traits present and errors removed indicates that this is statistically significant (X^2=6.89, α=3.84), which is confirmed by Fishers exact test (two-tailed P value = 0.0113). Yule's Q confirms a positive relationship (0.33) between flake preparation and error removal using overshot flaking.

Another consideration of intentionality is how often the platform and the opposite margin are prepared on the same overshot removal. As discussed above, only 110 overshot flakes were recorded as whole flakes. Of the 110 OS flakes, eighteen (18) exhibited preparation on both the striking platform and the distal margin. Conversely, sixty (60) OS flakes exhibited prepared platforms, but no preparations were observed on the distal margin. Chi-squared analysis revealed that there was no statistical significance between these two characteristics (X^2=0.31, α=3.84). Further analysis using Yule's Q (-0.13) indicates a weak negative relationship. However, the Phi coefficient (0.008) suggests there is little to no relationship between these two factors. This result would suggest that Clovis knappers did not find it necessary to prepare the opposite margin along with the platform. As shown above, 70% of OS flake platforms were prepared. This would indicate that the angle of the opposite margin was altered on an as-needed basis for a successful removal of an overshot flake. These data strengthen the argument that controlled OS flaking is ascertainable when based on qualified flake error types and quantitatively analyzing the number and error types that were removed.

These data support previous research that Clovis knappers had deep working knowledge of knappable raw materials (Bradley, *et al.* 2010:105-106). The Clovis knapper could apply controls to manage the removal of error(s), which entailed platform preparation or, adjustment to the angle of the opposite edge (distal) that would remove a portion of the bifacial margin, but still maintain desired biface proportions.

This research was conducted to specifically address recent debates and issues that have been raised concerning Clovis controlled overshot flaking (Eren, *et al.* 2013; 2014, Eren and Desjardine 2014:109-120; Lohse, *et al.* 2014a, Sellet 2015). Therefore, these data provide a reasonable initiative for others to explore the intentionality of Clovis overshot flaking. In summary, controlled overshot flaking by Clovis knappers represents, in most specimens, a strategic decision that was made during the biface manufacturing process.

9.6.5 – OSF -- Qualitative Analysis

Some of the OSF specimens that retain what looks to be a portion of a natural/square margin and exhibited removal of flakes along the distal edge of the OSF. This indicates preparation of the bifacial margin (OSF distal edge) that entails changing the angle of the opposite margin, for example from ‘acute’ to at or near right angles, which allows a properly delivered energy load to travel cleanly across the biface and remove a portion of the opposite margin. Even if this is not the case, overshot flakes with identifiable square edges ultimately changed the angle of the lateral biface margin. The basic theory of fracture mechanics (Baker 2003) explains that the mass and angle help guide energy load, therefore. Clovis knappers likely knew how to rid the core of unwanted errors, or unwanted problems along the core’s edge.

At least two of the OS flake specimens exhibit what appeared to be unifacial manufacturing traits on the distal termination (4469-61 & UT 4469-39). Flake scars that were present on the dorsal side were absent on the ventral distal edge. This was interesting because OS flaking is usually associated with biface reduction. While there are unifacially modified flake tools in the Gault Clovis assemblage, it is important to mention that, a unifacial ‘projectile point’ fragment was recovered in situ from Area 4 (Figure 90). Therefore, overshot flakes struck from unifacial tool cores would not be an unreasonable consideration, but more information is needed and warrants further study, but is beyond the scope of this research.

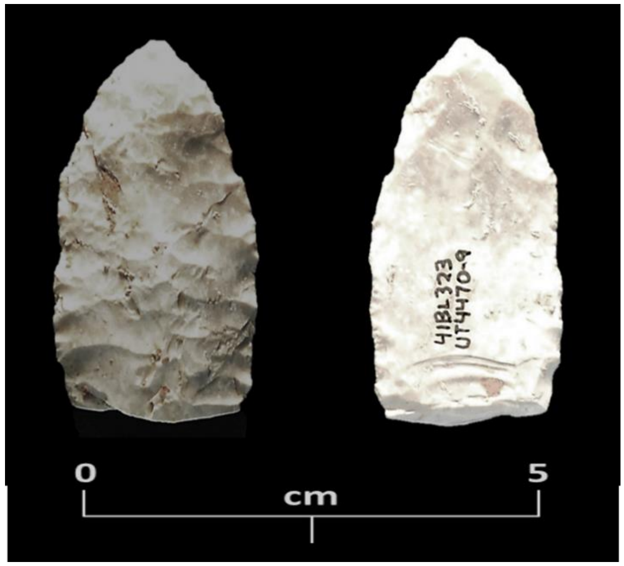

Figure 90 – A unifacially flaked distal 'point' fragment recovered *in situ* from Clovis deposits in Area 4.

A relatively small number of overshot flakes exhibited what can be described as "battering" or micro hinges observed along the distal margin. The battering was noted most often as associated with bifacial terminated distal margins, although these traits were also noted on one of the unifacial overshot flakes. The "battering" seems to be to be from failed flake removal attempts along the biface margin that is now the distal margin of the overshot flakes. The battering caused damage in the form of stacking, and micro hinges observed along the distal edge of the OS flake. This may indicate further evidence for Clovis knappers using controlled overshot flaking to preserve the objective piece by renewing the bifacial edge. This needs further investigation, but is outside the scope of this research.

Damage was also noted along lateral margins of a few OS flakes. In addition, there was damage or possible use-wear noted on one early phase plunging flake described as being along the ventral/distal edge (UT-4478-21). These observations are not enough to indicate one way or another if OS flakes were utilized but does warrant further study, but is beyond the scope of this research.

Five overshot flakes in this study are identified as conspicuous failures due to their morphological characteristics wherein the flake plunged early and removed too much mass, rendering the original biface, or preform, otherwise ruined. At least one of these failures was caused by longitudinal thinning when the knapper tried to remove a flake from the basal end of a biface. In this case, the platform was very carefully prepared, but may have been too strong, improperly supported, or simply a poorly delivered load that caused the energy to dive and exit the core, thus causing the biface to break at the midway point (Baker 2002:220). These types of failures (Collins 1999b:17-27; Ingbar and Hofman 1999:100-101; Titmus 2002:237) have been documented in post-Clovis (Folsom) industries, and usually occurred during the second fluting phase of Folsom points (Baker 2002:225) and seem to be the case as well with Clovis end thinning and fluting failures (Baker 2002:220-225).

Flakes that exhibit removal of parallel hinge scars (Fig. 91) were briefly discussed in Chapter 1. Approximately five-percent (5%) of the OSF specimens here (*n* = 20) exhibited lateral hinge scars. This indicates that during all reduction phases, longitudinal thinning hinge scars were eradicated by Clovis sometimes using the OS flaking technique. This further indicates that removal of these error type scars may have been for aesthetic purposes as well as thinning the biface.

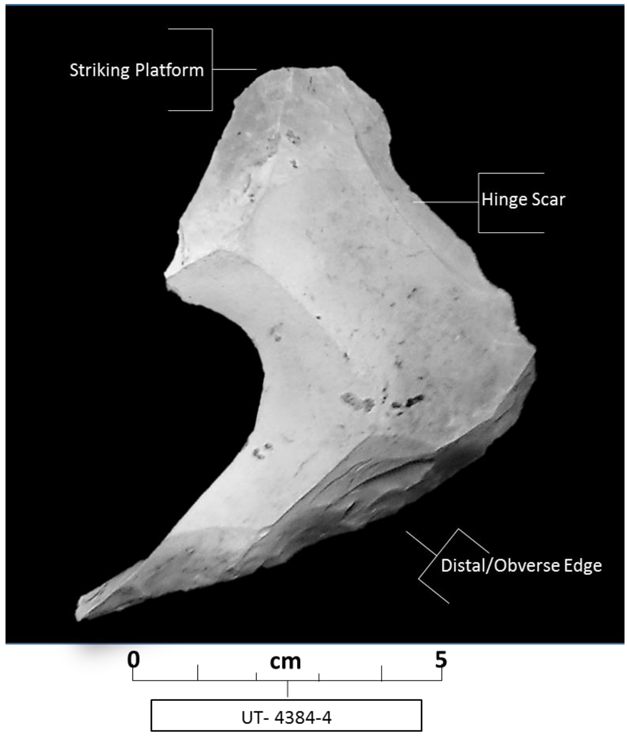

Figure 91 – Example of a Clovis overshot flake that removed, among other issues, a hinge scar that runs parallel to the right lateral edge of the flake.

9.7 – OSF Discussion

An in-depth search of the entire Gault database yielded approximately ten (10) flakes that have been identified as overshot flakes recovered from post-Clovis deposits. An examination of these flakes revealed that most were mistakes, plunging errors, or misidentified 'edge-bite' flakes. However, Clovis knappers were not beyond making mistakes and those OSF's have been accounted for in this study.

Furthermore, ongoing investigations of the Gault Clovis materials has provided a current ratio of Clovis OSF's to post-Clovis OSF's as 40:1. That means, conservatively, there are 40 Clovis overshot flakes to every 1 overshot flake recovered from post-Clovis deposits. In addition, the number of Clovis overshot flakes are expected to increase over this next year.

It is important for lithic analysts to recognize that the amount of mass retained on the distal edge of the OS flake is not a reliable indicator of success or failure, nor intention or mistake. Training and experience are key since multiple variables are individual, and each flake must be considered on an individual basis, case by case, before a flake can be confidently designated.

An in-depth search of the Gault artifact inventory database yielded approximately ten (10) flakes that were identified as overshot flakes from post-Clovis deposits. An examination of these flakes revealed that most were mistakes *e.g.* plunging errors, and some were simply misidentified. However, Clovis knappers were not beyond making similar plunging mistakes and those overshot flakes have been accounted for in this study.

Evidence of overshot flake scars on bifaces has been reported from caches, *e.g.* the Anzick Clovis cache (Wilke, *et al.* 1991), the Carlisle Cache (Hill, *et al.* 2014), East Wenatchee Cache (Huckell 2014:145) the Fenn Cache (Frison and Bradley 1999), the Hogeye Cache (Waters and Jennings 2015), the Simon Cache (Santarone 2014). There far fewer Clovis sites that report overshot flakes as well as bifaces with overshot flake scars *e.g.* the Gault Site (Bradley, *et al.* 2010:64), but OS flakes have been documented at the Aubrey Clovis Site (Ferring 2001:151), and the Murray Springs Clovis Site (Huckell 2007:190).

The Clovis OS flakes from the Gault site exhibit cognitive intentions by Clovis knappers. They not only remove primary or residual cortex in early and middle phases of biface flaking sequences, but more importantly, they regularly exhibit the removal of stacking, hinges, deep flake scars and/or *all* of these error traits. As such, they are an error correction technique that serves a dual purpose of removing the error while simultaneously thinning the biface. Overshot flaking as a technique also corrected or maintained the opposite biface margin via the removal of flakes to raise the intended overshot margin above the bifacial plane (*see* Fig. 89). Evidence of intention on overshot flakes is also demonstrated when the flake's distal edge exhibits damage from battering that either created a problem or was due to failed attempts to remove a flake from that margin.

Overall, this study supports previous findings of serial overshot flake removals (*e.g.* Huckell 2014:145) being part of the Clovis knapper repertoire. However, the results from this study indicate that Clovis knappers did not methodically apply overshot flaking, but chose how and when to apply this technique as desired.

9.8 – OSF Hypothesis Testing

Null	Alternate
Overshot flaking technique was a mistake (Eren, *et al.* 2013) made by Clovis knappers.	Overshot flaking technique was used by Clovis knappers not as a systematic process to thin but as a tactical strategy used at the discretion of the knapper to remove flaws and errors in order to preserve overall trajectory of the bifacial plane and the continuation of biface production.

The data from the OSF study reveals that the technique of overshot flaking removed problems such as primary or residual cortex during early and middle phases of the biface reduction sequence. Overshot flaking regularized or readjusted the biface plane and margin as well as flattened the biface surface (Bradley, *et al.* 2010:71). This supplemental study has shown that most overshot flakes removed errors such as stacking, hinges, and other issues such as square edges (Bradley, *et al.* 2010:72), battered biface margins, and material flaws. Therefore, as a viable error correction technique, the overshot flake was multi-purpose for removing errors while simultaneously thinning, flattening, and regularizing the biface and biface plane.

9.8.1 -- OSF Supplement Study Discussion

The platform preparation analysis of overshot platforms revealed they were well prepared. However, it is interesting to note that the platform preparation scores were lower (2.73) in the overshot supplemental study than the Area 4 sample. This may be because the OSF data set was comprised of 110 whole flakes (compared to 74 whole OS flakes in previous study), which have been collected from other excavation areas at Gault. Therefore, the lower score is representative of that variability. This OSF sample also had a higher proportion of flakes assigned to early phases and early/middle phases.

The supplemental overshot flake data presented here indicates that Clovis overshot flaking can be considered an intentional act. Overshot flakes exhibit preparation of the distal margin to increase the likelihood of a successful removal. Furthermore, the majority of these intentional overshot flakes were successful in that they got underneath errors and removed them from the biface surface while simuleoulsly thinning the biface.

Recently, the age of the Clovis Sheaman site (Frison 1982) has been called into question as being too young for Clovis (Sellet 2015; Waters and Stafford 2007). As a result, this has also raised issues concerning distinctive traits in some Clovis flakes such as overshot flakes (Sellet 2015). The problem with this is that Sellet (2015) disregards the actual assemblage and the technological similarities within the Clovis component. With regard to flake types and removal techniques, more data is needed particularly from flake analysis in order to help clarify flake removal techniques and help understand other cultures especially older-than-Clovis, as well as Clovis and post-Clovis stone tool cultures.

This study contradicts the findings of Eren, *et al.* (2013) who determined that overshot flakes were failures based on experimental replication. The pilot study here does not necessarily refute all of the findings presented by Eren, *et al.* (2013). However, in light of the refined nature that is Clovis biface technology, it seems highly unlikely that Clovis knappers committed serialized blunders by invariably creating overshot flakes and is therefore inconsistent with the archaeological evidence. The results of this OSF study reveal that Clovis overshot flaking should be explored as a corrective technique.

9.9 -- OSF Supplement Study Summary Conclusion

These OSF data reveal that overshot flakes were intended as a technique that was executed as desired by the knapper to remove square edges, cortex, or as an error correction method. By setting up a striking platform on a biface and/or changing the angle of the opposite margin *vis-a-vis* the energy load to dive under and remove the error as well as a portion of the opposite margin. Overshot flaking provided a method of correction that simultaneously maintained the biface margin to allow the biface reduction process to proceed.

Therefore, the utilization of overshot flaking was intentional, but represents a tactical decision made during the manufacturing process that, while in itself can lead to a critical error, was deemed a benefit that outweighed the risk.

Chapter 10 -- Future Research and Overall Summary Conclusion

Future Research

The archaeology of Area 4 Clovis deposits included artifacts that were produced from multiple manufacturing activities. Therefore, many flakes that were designated as “other” included general flakes and debitage, but many were identified as being produced from Clovis blade core preparation. The data has already been collected, but were excluded.

There is a problem in distinguishing end thinning flakes from fluting flakes, in that there are few data on the issue. As such, a study of these flakes is warranted to ascertain if there are differences in platform preparation treatment as well as general attributes and metrics. It would be beneficial as a whole to expand flake analysis to include the platform preparation methodology in other non-Clovis and post-Clovis cultures. Data from other biface and flaked stone tools would help discern the uniqueness of Clovis technology and allow for connections to be made of possible Clovis origins as well as post-Clovis connections. Clovis blade-production flakes from the Gault Clovis collection need to be examined for the use of platform preparation traits on tablet flake striking platforms as well as other flakes related to Gault Clovis blade core production.

Finally, with regard to non-Clovis debitage, Pevny (2009) compared data of platform traits of Clovis flakes to platform traits of post-Clovis flaking technologies in Area 8 at the Gault Site. Overall, the results were inconclusive (2009:218) in that statistical testing failed to distinguish any differences, even though differences were observed (Pevny 2009:218-219).

This area warrants further research. The methodology used in this study could be modified to collect and analyze striking platform data from post-Clovis flaked stone tool industries. Platform preparation data would either draw more attention to the uniqueness of Clovis technology or highlight the similarities with other post-Clovis biface technologies, but more importantly, would contribute to a greater understanding of technological trends throughout the archaeological record.

Since both studies contribute to technological flake data from Clovis manufacturing areas at the Gault Site, future research directions, should address the need for more flake and debitage data, not only of the Gault Clovis flakes and tools, but also from other Clovis manufacturing sites or material source camps. More analysis is needed on overshot flakes. The methods and variables used in both studies can be modified and adapted to most flaked stone tool assemblages. Striking platforms seem to be the key to unlocking behavioral information that provides reliable insight of knapping behaviors used. However, no matter how much data is collected on each flake, it counts for naught if there is no research question guiding the effort. Finally, go out and bust some rocks, even basic knowledge of flintknapping is better than no experience at all.

Final Conclusion

Clovis technology represents a complex and highly developed bifacial reduction technology. While Clovis shares basic biface production similarities with other post-Clovis technologies, such as fluting, and the use of direct percussion, the data here elucidates important differences in the application of reduction techniques used by Clovis knappers .

The results of the OSF study indicate that the use of overshot flaking was a technique applied by Clovis knappers at the Gault site. It was also a decisive means of removing cortex, or square edges, or for correcting problems that occurred as a result of flintknapping, such as stacks or hinges, or was used to purge raw materials of flaws or geological occlusions. It should be noted at this point that in this sample, a relatively small percentage of overshot flakes reveal that some these flakes were failures such as catastrophic ruination of the biface.

It is clear in the data from the Clovis flake study as well as the OSF supplemental study, that debitage analysis of individual flakes can provide useable data. These data not only support current Clovis technology research, but also furthers our understanding of the flakes produced during the biface manufacturing process that is technology specific to the biface reduction sequences of Clovis at the Gault Site.

This research has contributed to a greater understanding of Clovis biface technology and reduction processes and flake removal techniques. To a certain degree, these data confirm previous observations of Clovis flakes and striking platforms. Only now, there exists comparative data on Clovis biface manufacturing technology from the Gault Site. These data not only provided comprehensive data of Clovis biface manufacturing at the Gault Site, but also explored the intentionality of overshot flaking.

The attention to preparing striking platforms before removing flakes is a strategic process where individual preparation traits were used on different flake types as required enhancing the continued production of bifaces and other tools such as spear points. Clovis knappers, therefore, were not simply repeating a learned behavior, but had an intimate knowledge of the raw toolstone materials with which they worked and operated using a set of manufacturing techniques that allowed them to produce the tools they desired.

Appendix 1 - Flake and Platform Data Collection Form

			FLAKE CONDITION						DESCRIPTION																													
CATALOG			FLAKE CONDITION						PLATFORM TRAITS																PLATFORM METRICS (mm)		FLAKE STAGE & TYPE (These can be combined)								FLAKE METRICS (mm)			
			Flake Status		Flake Termination				Platform Status					Platform Shape				Platform Preparation									Flake Stage			Flake Type								
Entity	LOT #	Spec. #	Complete	Incomplete	Feathered	Overshot	Hinged	Broken / Step	Remnant (prt'l)	Shat/Crushed	Lipped	Plain	Cortical	Straight	Concave	Convex	Dihedral	Grinding EDGE	Grinding OBV	Grinding REV	Faceted	Reduced	Released	Isolated	PF LENGTH	PF DEPTH	Early	Middle	Late	Biface Shaping	Biface Thinning	End Th/Chan Flk	Other	Indeterminate	FLAKE LENGTH	FLAKE WIDTH	FLAKE THICKNES	NOTES

Codes: Lipping: (N) Normal (M) Minor (H/E) Heavy/Extreme (0) None Any Traits not Marked are considered Absent

C Cortical (P) Plain Flake Types and Stages can be Combined (BFS) Biface Shaping (BFT) Biface Thinning (BFST) Biface Shaping/Thinning

Figure 92—Flake and Platform Data Collection Form

Appendix 2 – Clovis Biface Flake

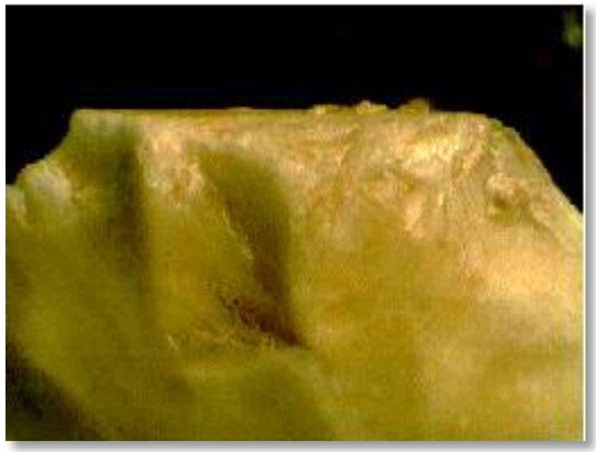

Figure 93 — Example of a 'straight' platform on a Clovis biface thinning flake image is of the dorsal/obverse side of a striking platform that has been ground, faceted, and isolated (UT-4509-58). The photo was taken with Amscope MD400 20X.

Figure 94—Microscopic Photo of 'heavily ground' Clovis platform. (Photo taken with AmScope MD400 20X magnification)(Spec# UT-4470-8).

Figure 95 — Heavy lipping on a Clovis flake (UT-4384-4). The platform length measures 18.2 mm.

Appendix 3 – Terms and Terminology

Term	Definition
Biface Shaping Flakes	These flakes can be as wide as long, or wider than long, but usually remove very primarily from the edge of the biface in order to shape the piece. These are not necessarily a useful means of thinning (Inizan, *et al.*1999:44).
Biface Thinning Flakes	The dorsal flake scars can be complex (Kooyman 2000:59) situated in a crossed or overlapping patterns, or can be opposed or multidirectional. Flake body varies in size and thickness and occurs throughout the reduction stage.
Broken/Step Flake	A step flakes usually terminates at a right angle. Step flakes here are considered broken or 'incomplete'.
Complete Flake	A whole flake retaining most normal flake attributes
Concave Platform	Striking platform is curved downward
Convex Platform	Striking platform is slightly curved upward.
Cortical Platform	The striking platform retains all or portion of the original surface, or subcortex of the parent material
Early Phase Flakes	A flake group that usually exhibits traits that can be associated to early biface reduction. Flakes should have at least three (3) previous flake removals on the dorsal side and may retain plain, simple, or complex platforms.
End Thinning/ Channel Flake	A longitudinal thinning flake
Entity	A Univ. of Texas @ Austin two-letter modifier assigned to specific lot numbers in the Gault Site collection.
Faceted	Platform Preparation Trait -- faceting reduces the platform on the ventral/strike-side of platform.

	The platform may exhibit two or more flake scars that can be parallel, radiate or transect previous flake scars.
Feathered Termination	A whole flake that terminates successfully at a low angle
Flake Length	Longest measurement of flake
Flake Thickness	Metric measurement of thickest portion of flake.
Flake Width	Widest measurement of flake
Grinding (present on PF edge)	The platform has detectable grinding by observation or feels across the top or margin edge.
Grinding/Obverse	The platform has detectable grinding on the “dorsal” non-strike/flake removal side of the platform.
Grinding/Reverse	The platform exhibits grinding on “ventral” strike-side of flake.
Hinged	A flake termination where the distal end exhibits a rounding or rolling termination (Sollberger 1994). Hinged flakes are recorded as a complete flake in this study.
Incomplete	A broken flake, with missing or indiscernible termination
Indeterminate	Flakes that cannot be placed within a specific group.
Isolated	Platform preparation trait -- isolating of a platform usually indicates careful preparation and the striking platform will retain the appearance of being separated or projected
Late Phase Flakes	These flakes may have less preparation traits but may exhibit numerous (5+) dorsal flake scars, and may be small and/or relatively thin.
Lipped Platform	Small protrusion on the ventral side of the flake usually created from soft hammer or antler

	percussors. Can be observed as normal (present), minor, or heavy/extreme.
Lot #	Permanent curation control number
Middle Phase Flakes	Flakes will usually exhibit highly complex platform preparation traits, but the dorsal side should have four (4-5) dorsal flake scars and may retain some cortex (Fig. 95).
Other Flake Type	These flakes cannot be placed within a specific flake group
Overshot Termination	(*aka* Outré Passé) is plunging flake that can be inferred as a termination or a morphological flake-type. This flake type is also considered a flake removal technique used in Clovis biface technology
Plain Platform	Platform has no preparation
Platform Depth	Metric depth of platform
Platform Length	Metric length of platform
Reduced	Platform Preparation Trait -- reducing removes material overhangs from the dorsal/obverse side of the platform and may exhibit two or more flakes scars on the ventral side of the platform.
Released	Platform preparation Trait -- releasing a platform is intended to weaken the area around the platform by removing small flakes that often create small or truncated scars on the *Reverse* (strike-side) of flake
Remnant (partial platform)	A flake striking platform that has sustained damage but may retain recordable preparation traits.
Shattered/Crushed	Further quantifies the severity of remnant platforms.
Spec #	Specimen number
Straight Platform	Shape of platform is straight with no convexities or concavities can be plain or retain complex preparation traits.

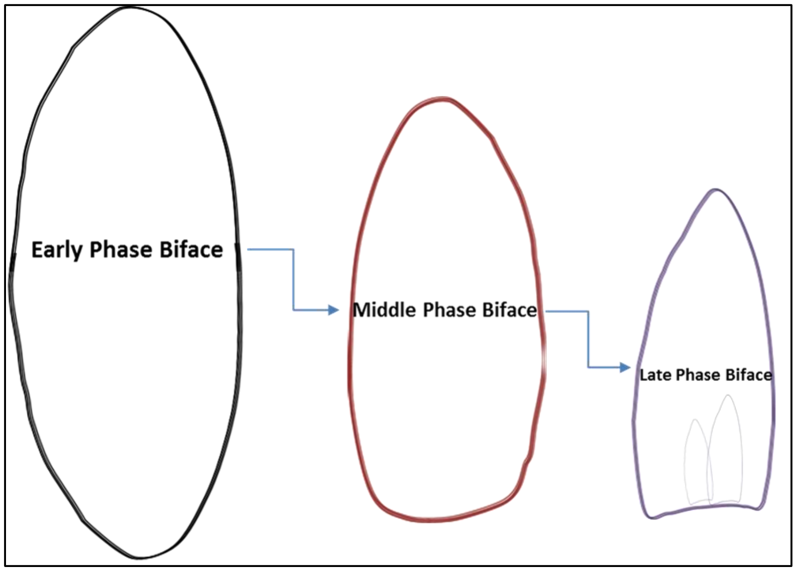

Figure 96-- General Schematic of early, middle, and late Clovis biface reduction phases used in this research

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