Testing the Atlantic Ice Hypothesis: The Blade Manufacturing of Clovis, Solutrean and the Broader Technological Aspects of Production in the Upper Palaeolithic.

Submitted by Thomas Joseph Williams, to the University of Exeter as a thesis for the degree of Doctor of Philosophy in Archaeology

October 2014

I certify that all material in this thesis 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.

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Abstract

The origins of Clovis technology and the nature and timing of the first populations to reach the Western Hemisphere is one of the most contentious issues in American archaeology. With the rejection of “Clovis-first”, many scholars consider that all colonising migrations followed a route out of Asia and across Beringia into North America. However, none of the technologies present in the far northeast of Asia or Beringia exhibit the manufacturing processes that were used in Clovis. To address this enigma, Stanford and Bradley proposed a radical alternative for the origins of Clovis. They argue that a small pioneering group of Solutreans crossed the Atlantic ice sheets of the LGM and reached the shores of North America. The basis for this argument stems from technological similarities between Clovis and the Solutrean, as well as from climatic, oceanographic, and ethnographic data. Biface manufacture is at the centre of their technological analysis, specifically comparing the reduction sequences of the distinctive Solutrean laurel leaf points and comparing them to Clovis points. This thesis tests the assumption of Stanford and Bradley that the blade manufacturing technologies of Clovis and Solutrean were “virtually identical”. By analysing the blade manufacturing processes from the Solutrean assemblage at Laugerie-Haute and the Clovis assemblage from the Gault site and comparing them to the broader technological patterns present across Eurasia between ~30,000 BP and 11,000 BP; this thesis supports the findings of Stanford and Bradley with the amendment that Clovis specifically intended to produce curved blades but did not use blades to produce projectile points. While convergence cannot be completely ruled out, there is a lack of evidence that would explain the number of similarities in the manufacturing processes. Thus it remains highly likely that interaction across the ice-edge corridor of the Atlantic may have occurred during the LGM.

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Acknowledgements

First and foremost, I want to thank my parents, Andrew and Lindsey Williams, not only for financial backing but for their love, support and encouragement, and for instilling in me the importance of exploring the world and all it has to offer. I also thank Matthew, Wendy, and Ryan, for their constant encouragement (and scribbles).

Of course, none of this would have been possible without my supervisors, Bruce Bradley and Linda Hurcombe. Bruce taught me how to break rock, draw blood, and most importantly to always challenge established paradigms, with the archaeological record as a guide. Bruce has been a constant mentor, teacher, and friend. Meanwhile, Linda helped me to stay on course by guiding me and reminding me to stay focused on producing the thesis itself, and not just the exploration of technologies. I also thank the University of Exeter and all of my fellow students.

I thank Michael Collins for his help, advice, support, and for allowing me to constantly distract him and discuss blade technology. I am indebted to Clark Wernecke and the Gault School of Archaeological Research. Mike and Clark not only provided support (one much louder than the other) and access to the collections of Gault, but they provided me with employment through the final stages of this research. I look forward to continuing the research started at the Gault project (now the Prehistory Research Project) and also want to thank Texas State University for its continued support of the project. I am forever grateful to Jill Patton, Marge and Gene Vanderbur, Margaret Grant, and Doug Eldred, not only for their backing of the Gault School, but for funding my first trip to Texas (Thank you!!). I also thank Howard and Doris Lindsey for their continual support of Gault.

For my skills as a knapper, and my understanding of stone tool technology, I not only thank Bruce, but also Bob Patten, Mike Johnson, Mike Dothager, and Bo Madsen, all of whom introduced me to the wider concepts and manufacturing processes of lithic assemblages. Tony Baker, who in one meeting, changed my entire perception of this thesis (rest in peace). I also thank Antony Whitlock, Nada Khreisheh and everyone involved in my various flint knapping adventures.

Special acknowledgement and thanks goes to Jennifer Anderson, who happily (and somewhat blindly) agreed to proof read this thesis. Her help was invaluable in constructing this thesis by reminding me that punctuation is a valuable tool in getting your point across. Wilson “Dub” Crook III provided invaluable comments, suggestions and has been a constant friend and mentor, not just in archaeology, but in understanding geology, chemistry, mineralogy, and above all, the great state of Texas.

I also thank the following people, for their friendship, questions, debates, challenges and above all for listening; Sergio Ayala, Charles Andy Speer, Liz Sefton, Jon Lohse, David Madsen, C. D. Cox, Ciprian Ardelean, Danni Davies, Dick and Deb Boisvert, Jennifer Gandy, Robert Lassen, Toni Fischer, John Clark, and Elton Prewitt.

I want to thank Laura Nightengale and the staff at Texas Archaeological Research Laboratory at the University of Texas at Austin for allowing access to the Clovis collections. Additional thanks goes to Pierre-Jean Texier, Andre Morales, and the staff of the Musée National de Préhistoire in Les Eyzies for access to the Solutrean material.

Finally, I am, and always will be, indebted to my partner (and soon to be wife), Nancy Velchoff, who should take sole responsibility for changing my initial PhD topic to the thesis that lies herein. She has been my constant guide, my biggest supporter, my sounding board, my voice of reason, and has kept me focused throughout this process; my rock. Last but not least, many thanks to CoCo (Pug super-genius) and Napoleon Bonapug and their dogged talent for comic relief.

Without the help of these peoples and institutions, none of this would have been possible.

“To sum it all up, we contend that the archaeological evidence that Clovis predecessors were immigrants from south-western Europe during the LGM is stronger and more compelling than the evidence that their ancestors were from an Asian microblade tradition that came out of north-eastern Asia at the end of the LGM.”

(Stanford & Bradley, 2012, p.247)

Chapter 1
Introduction

This thesis focuses on Clovis and Solutrean blade production, specifically the technological choices made by each culture. This tests the assumptions of Stanford and Bradley (2012) who hypothesise that a group of Solutreans brought the technology seen in Clovis to the New World. Explicitly, this thesis focuses on their argument that Clovis and Solutrean blade technologies are virtually identical (Bradley & Stanford, 2006).

The route taken by Palaeolithic groups into the New World remains one of the most contentious issues in American archaeology. One of the most widely held assumptions contends that small groups, travelling east from north-eastern Asia, crossed Beringia and spread across North America (Figure 1). Numerous authors (Wormington, 1957; Adovasio & Page, 2002; Stanford & Bradley, 2002; Meltzer, 2009; Bamforth, 2013; Ives et al., 2013; Collins et al., 2013) have commented on this first colonising wave and its expansion across the America's. One of the first anthropological articles that dealt with the origins of the First Americans was published in 1912 where it was proposed that the initial migration occurred across the Bering sea (Fewkes et al., 1912). More recently, research has suggested that some groups may have made the journey via the Pacific Ocean, travelling by watercraft and following closely to the shore (Figure 1) (Erlandson & Braje, 2011; Erlandson et al., 2011; Erlandson, 2013; Collins et al., 2013). Regardless of the route, the majority of researchers cite north-eastern Asia as the location of origin for modern humans in North America.

Recently, Stanford and Bradley (2012) examined new and existing data and proposed a radical alternative to this argument. They reason that a small group of hunters crossed the ice sheets of the Atlantic Ocean during the LGM (Figure 1). This group originated from the Solutrean culture, found in Spain and France between 25,000 and 18,000 years ago (Stanford & Bradley 2002; 2012; Bradley & Stanford 2004; 2006). Specifically, they contend that a small group of Solutreans exploited the fauna of the Atlantic Ice sheets and eventually landed on the coast of North America. This founding group of Solutreans carried with them the knowledge and skill of only a small segment of the entire Solutrean technology. This group left behind a technological tradition that evolved during the pre-Clovis period and became Clovis technology (Stanford & Bradley, 2012, p.247). Their research focuses on the specific manufacturing technology of the lithic industries from America, Europe, and Asia. Through their analyses of biface production, reduction strategies, and thinning techniques, Stanford and Bradley (2012) found that Clovis lithic technology shares more affinities with the Solutrean than with any other lithic technology found in Beringia or Asia.

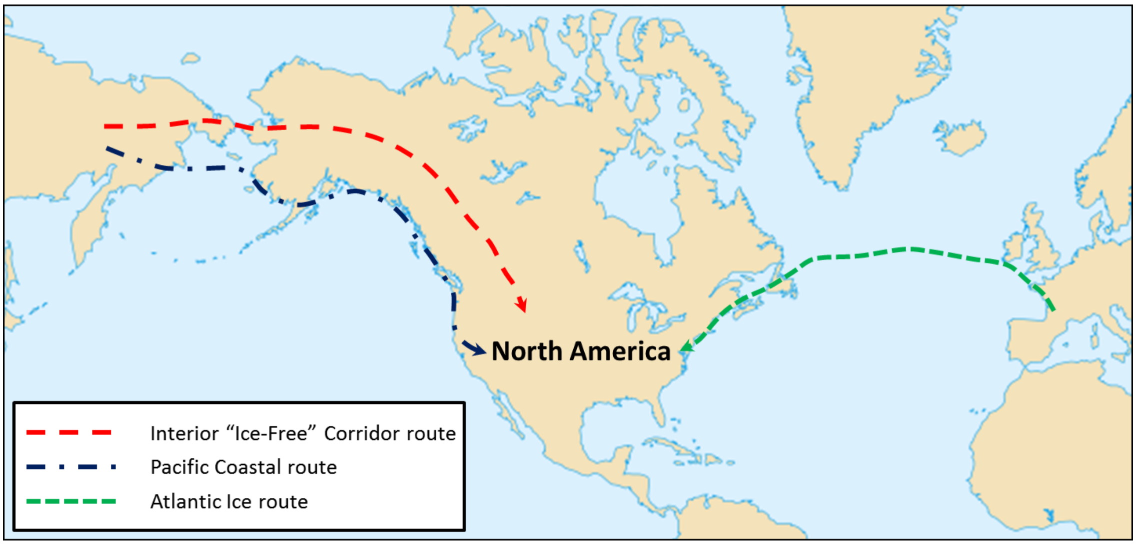

Figure 1. Possible routes into the New World

The idea that America has cultural links to Europe is not new to the study of the First Americans. Greenman (1963) proposed various connections regarding both the technology and the art associated with Upper Palaeolithic cultures in Europe and North America. While his article stimulated discussion at the time, most notably from Francois Bordes et al. (1964), Greenman's conclusions focused heavily on the overall appearance of artefacts rather than specific qualities. Bordes et al. (1964) critiqued Greenman's article, stating that his knowledge of Europe was out-dated and that there were a finite number of ways to work flint; furthermore, similarities in the environment and levels of technological and societal development had led Greenman to superficial conclusions regarding resemblances between cultures. Bordes concluded that the ancestral roots of the First Americans were not to be found in the western Old World (Bordes et al., 1964, p.321).

Stanford and Bradley (2012) applied their practical and experimental knowledge regarding the production of lithic technologies to recent archaeological discoveries in both Europe and North America. This led them back to the European origins theory. *Across Atlantic Ice* (Stanford & Bradley, 2012) is the culmination of their fifteen-year long study of the technologies and cultures of pre-Clovis, Clovis, Solutrean, western European Upper Palaeolithic and Beringia. In their conclusion, Stanford and Bradley overtly state that their work is, "…not intended as an explanation but rather a set of testable theories" (Stanford & Bradley, 2012, p.249).

While focusing on the first migrations into the Americas, Stanford and Bradley's work (2012, chap.1) highlights the importance of technology in the field of lithic analysis. Technology, with specific reference to stone tool manufacture, is an often-misused term. In archaeological literature, the word "technology" has a number of different meanings, ranging from the typological tool-kit of a culture (Clarke, 1968) to the specific reduction sequence of Mousterian industries (Bradley, 1976). The latter represents a very particular type of technology and will be used throughout this thesis, while the former represents an association of typologies with a certain culture. In this respect, typology refers to a description of the stone tools, while technology refers to the process of creating those tools.

For example, Clovis technology is already well-defined, in terms of biface and blade production (Frison & Stanford, 1982; Bradley, 1982; Frison & Bradley, 1999; Collins & Lohse, 2004; Dickens, 2005, 2008; Bradley et al., 2010; Smallwood, 2010; Jennings et al., 2010; Waters et al., 2011b; Smallwood, 2012, 2013; Jennings, 2013; Deeringer, 2014). Research in America has focused specifically on how these Palaeolithic people worked chert nodules, identifying platform production and preparation techniques, biface reduction strategies, blade core maintenance, and the importance of the spacing and sequencing of flake detachments. In-depth studies of this nature have allowed American archaeologists to recognise hallmark characteristics of a particular culture based on technology alone (e.g. Bradley 1982).

Analyses of European assemblages, including the Solutrean, lack the same clarity. European research focuses mainly on typologies, with only small references to a specific technique of the technology. The recognition of the *en éperon* technique as a characteristic of the Magdalenian assemblages of Late Upper Palaeolithic Europe is a case in point (Cheynier, 1956; Karlin, 1972; Brézillon, 1977). It is recognised as a typological criterion, rather than as a technological practice that involves the isolation and strengthening of a platform to aid detachment. Platforms that exhibit the *en éperon* technique get recorded in the literature (Barton, 1992; Jacobi, 2004), but there is little to no emphasis placed on understanding this technique. Recent studies have shifted to place more emphasis on reduction strategies (e.g. Delagnes et al. 2007), but this has not been as widely adopted as it has in America. The best evidence for manufacturing technologies comes from archaeologists such as Aubry et al. (2008), Renard (2002), and Almeida (2005), who have focused some of their research on reduction strategies.

Current methodologies for the collection of raw data from Europe and America also present challenges. Studies from both sides of the Atlantic overlook the value of platform production techniques, core maintenance, error correction, and to a lesser extent, knapping decisions. This makes it difficult to assess and characterise specific and defining technological features.

American research is more heavily weighted towards quantitative empirical data, while European research focuses more on qualitative attribute data. This is not to say that the research uses only one technique or the other; rather, research is concentrated on either one or the other. The result is that direct comparisons can be difficult to make.

These different approaches to lithic technology arguably stem from diverse methodological attitudes and the history of lithic analysis. Reduction sequences, also known as *chaîne opératoires,* are a prime example of these differences. According to Shott (2003), William Henry Holmes first introduced the concept of a lithic reduction sequence to North American archaeology. This concept was then revised by Muto (1971), Bradley (1975), and Collins (1975) who brought the idea into the forefront of American archaeology. The *chaîne opératoire* was originally described by Leroi-Gourhan (1967) in *Le geste et la parole.* Although as Shott (2003) states, the 1993 reprint introduced a wider archaeological audience to *Chaîne opératoire* as it was published in English. In an analysis of these two concepts, Tostevin (2011) concludes that while similar, the *chaîne opératoire* offers a wider anthropological context while the reduction sequence provides more epistemological rigour.

Both methods provide the lithic analyst with a framework around which raw material exploitation, lithic production, use and discard can be analysed. The inherent differences mean that researchers place more emphasis on those stages that they regard as important to furthering our understanding of the culture. This practice often leaves the minutiae of manufacture and production techniques out of the equation in favour of a more generalised approach. It is this overall view of a lithic industry that academics refer to as a technology.

As discussed above, technology is a central theme in Stanford and Bradley's (2012) research; however, they also draw on climatic, oceanographic, and ethnographic data to explain how a migration along an ice-edge corridor would be possible. They particularly reference the Solutrean culture, as they were already adapted to survive in harsh climatic conditions. Their research also considers the DNA evidence, suggesting a small-scale migration may have contributed to the existence of the X2 haplogroup, present in some modern populations across the American continent.

Despite the wealth of data, their theory has been heavily criticised by numerous authors (Fiedel, 2000; Straus, 2000a; Straus et al., 2005; Morrow, 2014; Clark, 2004; Eren et al., 2013b, 2014a). The majority of these criticisms focused on the distance of the crossing between continental Europe and North America and apparent misunderstandings of the hypothesis. Echoing Bordes' critique of Greenman in the 1960's, critics also proposed that the observed similarities identified by Stanford and Bradley were superficial, stemming from a convergence of ideas. Similarities resulting from convergence occurred because of parallel environmental conditions and the similar needs of all hunter-gatherer groups.

Hoffecker (2007) explored the idea of recursion, and argued that recursive representations are complex and wide ranging in the archaeological record, from about 0.1 mya. Similarities resulting from recursion occur because of the repetition of ideas ingrained into the human psyche. This concept along with convergence provides archaeologists with an explanation for certain phenomena observed in the archaeological record, but it has also become a standard critique without the presentation of further evidence to support either claim.

Rather than exploring similarities in assemblages or cultures with scientific protocols and systematic study, critics often take a theoretical standpoint, void of data. Theory, rather than solid evidence, is often the basis for constructing migration histories, particularly when archaeological data is lacking. It was archaeological theory, based on current understandings of the ice sheets, which led to the “Clovis-first” model. Moreover, it is this reliance on theory that formed the cornerstone for challenges to the Clovis-Solutrean connection. As with any conclusion, data must be the foundation used to support the case, either for or against. This includes any argument based on convergence.

Clarke (1968) proposed a theoretical model for the study of archaeological cultures. Using archaeological artefacts as the foundation of his model, he proposed that the construction of culture focused upon shared artefact assemblages. Furthermore, these cultures were a part of a wider societal network, which he termed the “culture group.” In this grouping, not all elements of a culture group must share the same specific type states, but there is a high level of residual affinity in type families expressing the culture group’s necessary identity (Clarke, 1968, p.300). Briefly stated, two cultures can share the same polythetic range of types, regardless of some differences in toolkits.

Clarke then established a final classification: the technocomplex. While highly theoretical, Clarke’s technocomplex suggested that cultures or culture groups could share an affinity, and even a historical root, based on observations of similar specific cultural traits. He argued that a culture group could share a polythetic complex of type families based on common factors. In essence, a technocomplex “…represents the partly independent arrival of diverse developing cultural systems at the same general equilibrium pattern, based on a similar economic strategy, in similar environments with a similar technology and a similar past trajectory” (Clarke, 1968, p.329)

This model is highly relevant to the conclusions Stanford and Bradley (2012) put forward. The hierarchical classification system provides a theoretical basis for the analysis of the Clovis and Solutrean cultures. Stanford and Bradley’s argument fits well within Clarke’s “culture group,” in that Clovis and Solutrean share an affinity based on a shared historical root, possibly in the proto-Solutrean of France and Spain. It is also possible that the observed similarities represent Clarke’s technocomplex, the independent arrival of each culture at the same pattern, based on economic strategy and technology.

Research Agenda

This thesis challenges and critically analyses Stanford and Bradley’s (2012, p.247) assertion that the archaeological evidence is “stronger and more compelling” for the route of Clovis via a migration from south-western Europe than it is from North-eastern Asia. To achieve this, the focus of this thesis is on the blade technologies and their manufacturing techniques present in both Europe and North America during the LGM. Specifically, data from the Clovis assemblage at the Gault Site, Central Texas, and the Solutrean assemblages from Laugerie-Haute, south-central France was collected and analysed.

Although Stanford and Bradley (2012, p.169) briefly discuss blade technologies, biface technologies are at the centre of their research. This imbalance is addressed by systematically analysing the technology of blade production from Northern and Eastern Europe, North America, Russia, China, Siberia, and Beringia.

In order to fully assess any connection between Clovis and Solutrean assemblages, this project focuses on Clovis and Solutrean cultural trajectories. This includes the recent discoveries of a “transitional” assemblage termed “Pre-Clovis” as well as the Solutrean to Magdalenian blade technologies, including the “transitional” assemblages of the “Badegoulian”.

This research considers Clovis and Solutrean blade technologies in the wider context of blade manufacturing across the globe, taking spatial and temporal considerations into account. This research also explores theoretical models as a means of critically assessing similarities and differences associated with Clovis and Solutrean cultures.

The technological analysis and data collection focuses on four main characteristics: platform preparation, core production and maintenance, morphological core use and blade production. As previously mentioned, lithic research largely overlooks the specific mechanics of blade manufacture. By analysing these four characteristics, this research ascertains how similar or different the characteristics of each blade technology are in terms of their reduction sequence. It also highlights specific technological choices made by prehistoric groups, as well as highlighting any similarities in reduction strategies that may exist.

The technological analysis examines the blades themselves. This includes the concepts of primary and secondary products. It also includes types such as crested blades and corner blades and the effect that the detachment of specific blade types may have on the core during production. Other debitage, such as core tablets and flakes (products that can be utilised but were not the original intention of preparing a blade core) are also considered. This thesis explores the more enigmatic features of Clovis blade production, including the highly curved nature of cached blades. By understanding the blade production technologies of these cultures in detail, this thesis tests the conclusions of Stanford and Bradley (2002; 2012; Bradley & Stanford 2004; 2006).

This thesis provides an in-depth exploration of ideas about technocomplexes, cultural trajectories, and the evolution of technology. Data from the analyses of these different approaches is used to construct an analytical framework suited for in-depth comparative studies, both for this thesis and as a model for future research.

In order to critically assess and fully understand the nature of blade technologies and how they may support or challenge the work of Stanford and Bradley it is important to outline a set of aims and objectives relevant to the goals of this research. A clear hypothesis is also imperative for any scientific study, stating the null and alternate hypothesis. The following sections outline the aims, objectives, and hypothesis of this research.

Aims

1. To assess the assertions of Stanford and Bradley (2002; 2012; Bradley & Stanford 2004; 2006) that Solutrean and Clovis blade technologies are "virtually identical".

2. To compile and analyse a comparative database on blade and core attributes from both the Solutrean (Laugerie-Haute) and Clovis (the Gault site) assemblages. With additional data concerning the Magdalenian (Laugerie-Haute) and pre-Clovis (the Gault site) blade production.

3. To identify the similarities and differences in the *chaîne opératoire(s)/reduction strategies* of blade production from the Solutrean (Laugerie-Haute) and Clovis (the Gault site) assemblages with specific reference to blade platforms, core preparation and maintenance and reduction and blade curvature.

4. To theoretically explore the reasons behind cultural similarities and differences between the Solutrean and Clovis technologies.

Objectives

1. To create a standardised methodology for the comparison of blade technologies from different regions.

2. To analyse blade platforms from the Solutrean (Laugerie-Haute) and Clovis (the Gault site) assemblages, looking specifically at platform type and preparation (*after* Tixier et al. 1983; Inizan et al. 1999; Bradley et al. 2010).

3. To study the methods of blade core preparation and reduction, specifically regarding wedge-shaped cores, and to analyse the similarities and differences in flat-backed cores against ridge-backed cores and core maintenance.

4. To critically assess blade types and the effect that each type has on the use of a core, both in terms of the product, as well as how detachment continues the use life of the core.

5. To compare and contrast each of the above aspects in order to assess the *chaîne opératoire(s)/reduction strategies* of blade manufacture in the Solutrean and Clovis technologies.

6. To analyse any indicated connections between the assemblages and explore the reasons behind any similarity or difference.

7. To use Clarke's (1968) model of culture in order to understand the varying cultural trajectories evident in each technology.

8. To explore other possible technological roots (convergence or recursion) for the blade production strategies seen in Clovis assemblages.

9. To assess the literature concerning blade production methods from Eastern Europe, Russia, China, Siberia, and Beringia and compare them to Clovis.

10. To determine how relationships between technologies may be used to indicate degrees of prehistorical relatedness.

Hypothesis

Before stating the hypothesis, it is important to outline the assumption that is made in this thesis; what is the possibility that a complex technology would simply emerge in the archaeological record without a past trajectory? More specifically, a complex technology requires an origin in an earlier cultural assemblage that exhibits some, if not all of the technological traits present in the later assemblage. Thus, the innovation of the later assemblage is rooted in the earlier assemblage. In technological terms "complex" refers to the labour-intensive production of stone tools (Shea & Sisk, 2010), including the use of flaking strategies, sequencing and spacing, platform preparation, and error correction. Furthermore, innovation is considered an intricate process which stems from inherited or learnt traditions (Petrie, 2011, p.155) which can take generations to acquire (Patten, 2005). In this respect, the innovation of a complex technology must stem from an older tradition, exhibiting a past trajectory towards the later assemblage.

Null Hypothesis: There is strong evidence to demonstrate a correlation between the blade industries of Asia and North America. This challenge's Stanford & Bradley's (2012) assertion of a connection between Clovis and Solutrean technologies, thus negating some of the work conducted. This study demonstrates that A) Clovis antecedents came from a tradition rooted in Asia and B) there is only a certain number of ways in which to produce the blades and any similarities identified in Clovis and Solutrean may simply reflect unique adaptations to environmental factors; suggesting multiple variations of a similar technology can evolve independently from one another.

Alternate Hypothesis: Major similarities in the blade technologies between the Solutrean and Clovis technologies suggest the possibility of a link between the two. This may either be an historical/cultural link, indicating that there was interaction across the ice-edge corridor of the Atlantic during the LGM; or a technological link between Clovis and the Solutrean in terms of convergence. Similarities between the *chaîne opératoire* and reduction sequences of both industries may indicate a shared knapping tradition, while the differences in formal tool types may represent the changing dynamic in the priorities of a group as it reached North America.

This thesis begins by outlining and exploring the major themes of this research. Next, Chapter 2 outlines and critically reviews the written literature concerning flint knapping, including its terminology, history and the current understanding of the technology of blade production. This is intended to provide a general overview of the technological concepts discussed within this thesis. Chapter 3 breaks down the history of the Solutrean hypothesis and its major criticisms. This is followed by Chapter 4 that assesses the Solutrean Hypothesis in its entirety. Chapter 5 provides an outline of the major and minor theoretical concepts relevant to the study of archaeological culture and technology. Chapter 6 presents a new method, in terms of a blade core taxonomy, than can be used in the interpretation of blade technologies.

Chapters 7 to 12 contain an in-depth critique of the literature for relevant archaeological cultures. These chapters focus on the history of research, the major sites and the descriptions of the technology, as well as other relevant attributes. These literature reviews cover Clovis (Chapter 7) and Pre-Clovis (8) before examining the Solutrean (9) and the LGM blade technologies of Europe (10). Finally, the literature concerning blade technology in North-eastern Asia (10) and Beringia (12) will be assessed as the two possible roots for technology in the New World.

Chapter 13 details the methodological approach of this thesis to data collection. Chapter 14 presents the results and brief analyses of the Clovis, pre-

Clovis, Solutrean, and Magdalenian data. The quantitative analysis of these industries is presented in Chapter 15 followed by a qualitative assessment and comparison of these reduction strategies in Chapter 16. A discussion focused on the similarities and differences between Clovis and Solutrean technology is presented in Chapter 17. Chapter 18 presents the findings from both the literature review and the data analysis, placing Clovis, Solutrean, and the Atlantic Ice hypothesis in the wider context, critically assessing the outcome of the research and what it contributes to our understanding of the archaeological record. Finally, concluding remarks and suggestions for further research are presented in Chapter 20.

Summary

This thesis focuses on Clovis and Solutrean blade production, specifically the technological choices made by each culture in terms of platform preparation, core production and maintenance, morphological core use and blade production. A new methodology combining analytical approaches will be used to analyse lithic technology. An assessment of the reduction sequence or *chaîne opératoire* of both cultures and a detailed analysis of the theoretical reasons behind cultural similarities supports the methodological approach. This research will make a genuine contribution to our understanding of archaeology and the study of technology, not just to the Clovis-Solutrean theory proposed by Stanford and Bradley (2012) and the peopling of the New World but also to a wider understanding of the nature of blade production.

Chapter 2

Blades, Cores and Flint Knapping: A Technological Perspective

This chapter examines the archaeological literature concerning blades, cores and technological reduction sequences pertaining to the analysis of Clovis and Solutrean technologies. Blade technologies are considered a ubiquitous feature of Upper Palaeolithic assemblages. The technology associated with producing these long, narrow flakes is a global phenomenon encompassing a wide variety of cultures. The aim of this chapter is to provide a general overview of the blade manufacturing concepts relevant to this thesis.

Blades

Traditional models of human dispersal suggest that the production of blades and associated blade tools appeared in the archaeological record with the arrival of anatomically modern humans at the beginning of the Upper Palaeolithic (Bar-Yosef & Kuhn, 1999, p.322). While this consensus remains, early authors on the subject noted that blades were not confined solely to the Upper Palaeolithic. Bordes (1968, p.27) commented that blades appeared in the Middle Palaeolithic, but suggested that some of these could be "accidental blades". Recent research on the Middle and even Lower Palaeolithic has revealed that there are a number of instances where early populations produced blades (Mcbrearty & Brooks, 2000; Villa et al., 2005; Soriano et al., 2007; Wilkins & Chazan, 2012; Shimelmitz et al., 2011). Although these blades do not strictly adhere to the notion of a blade, as defined by later periods, it is clear that these stone tools were purposefully produced.

Bordes (1961; 1968, p.27) described a blade as a flake that is more than twice as long as it is wide. This definition, as Collins (1999, p.7) discussed is used erroneously. Bordes' term specifically referred to technologies from the Lower and Middle Palaeolithic. Collins (1999, p.32) expanded this definition to include almost any flake with the same 2 to 1 proportions, and proposed the term "blade-like flake" (Figure 2).

Due to the ambiguity of the term “blade”, researchers have expanded Bordes’ original description. Whittaker (1994) describes blades as long, thin flakes that follow a ridge system developed on the surface of a core. This description is now accepted as a standard amongst Upper Palaeolithic archaeologists, who argue that there must be evidence either from the blade itself or from the assemblage that there was a clear blade-manufacturing component. Odell (2003, p.45) expanded upon this description, stating that alongside the characteristics of long, thin and a length two times greater than the width, “…a more stringent definition requires evidence for the use of a blade technique involving true cores. While Odell’s statement on the definition of a blade can be considered accurate, his term “true core” is subjective.

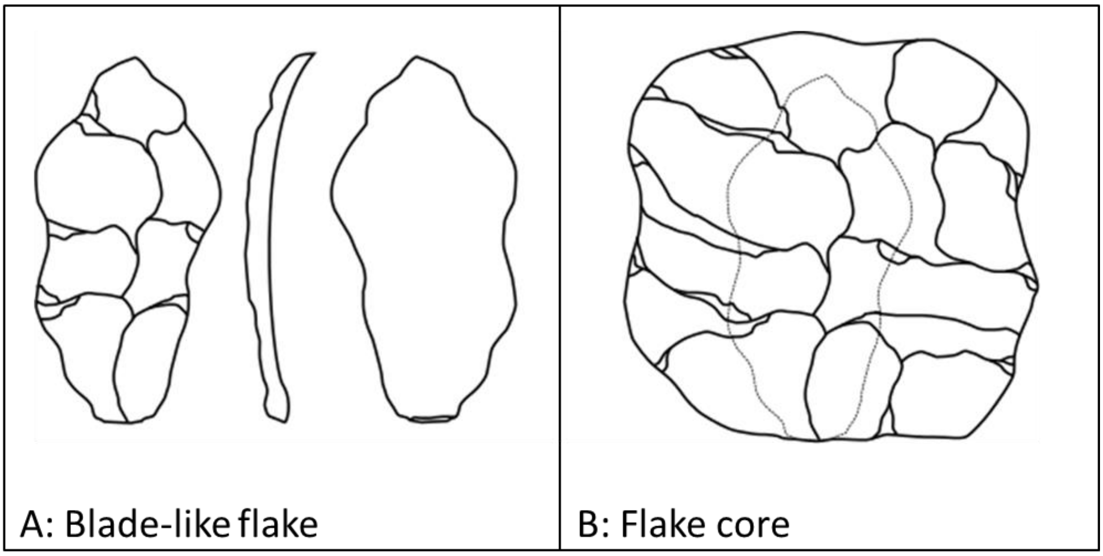

Figure 2. Hypothetical example of a blade-like flake

Bar-Yosef & Kuhn (1999, p.323) observed two definitions of the term blade. The first was the morphological description, as outlined by Bordes (see below) (Figure 2). The second definition was technical, describing blades as elongated blanks with parallel or slightly converging edges, possessing ridges running parallel to their long axes, which made them triangular or trapezoidal in cross-section (Figure 3). While Bar-Yosef & Kuhn were correct in their assessment of the two definitions of blades, this is repetitious. Therefore “a flake more than twice as long as it is wide” (Bordes, 1968, p.27) could be described as a morphological as well as a technical description, especially when considering that the description Bar-Yosef & Kuhn present still relies heavily on describing the blade morphology, rather than a technique of removal.

Butler (2005, p.35) provided one of the most comprehensive descriptions of what a blade is, describing them as:

> "A flake whose length is more than twice its width, and which has parallel edges and ridges on the dorsal side. Although many pieces may have the appearance of being a blade, only true blades that fully meet the above criteria should be recorded as such, because the blade is a specific diagnostic piece. It is possible to create proxy blades accidentally that meet the dimensional criteria but do not have parallel edges or ridges, which show that blades are being consistently produced from the same core."

This definition provides researchers with a clear framework to analyse blades. The words "consistently produced from the same core" are key to Butler's description. Blades are not haphazard products stemming from knapping coincidences; but rather, they are intentionally created by the knapper, and follow a manufacturing technology and production strategy (Figure 3). As Whittaker (1994) highlighted, each blade removal creates ridges for the subsequent removal of the next. This statement alludes to another important characteristic that defines blade manufacture: spacing. Certain characteristics of blades are reliant upon the spacing of removals along the core face.

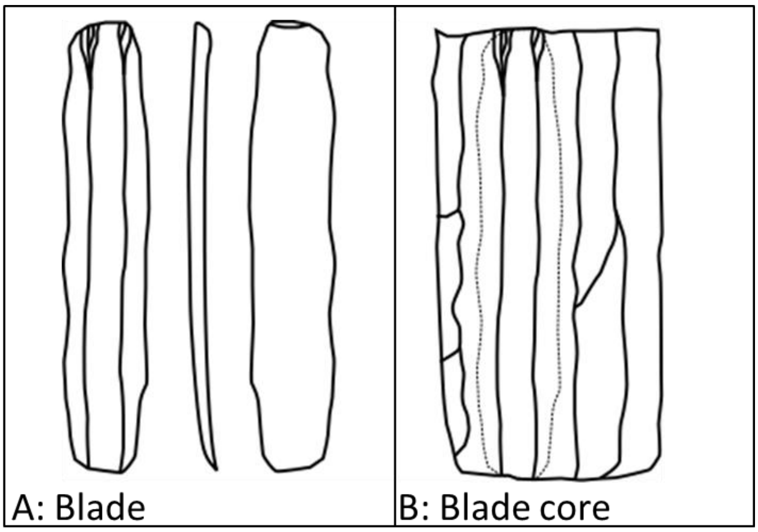

Figure 3. Hypothetical example of a blade struck from a prepared blade core

For example, the morphology of a blade is directly correlated to the morphology of its core. The blade's length, width, parallel sides and cross section are dependent upon the core's morphology. In his own definition, Crabtree (1982, p.16) highlighted the cross sections of blades, saying that they could be triangulate, sub-triangulate, or trapezoidal.

Another example is found in “true blades” (Collins, 1999; Butler, 2005). This terminology is now generally accepted, and it refers to Upper Palaeolithic blades that were detached from a core that was intentionally prepared for the purpose of consistently removing a series of long, thin, parallel sided flakes.

Some authors have developed quantitative methods for the identification and analysis of blades. Most recently, Sain and Goodyear (2012) developed a method for distinguishing between true Clovis blades and bladelike flakes at two sites in North America. While this study can be useful to the mass analysis of a site, it neglects the technological aspects of blade manufacture. The study relies on a universal definition of a blade rather than focusing on the specific technology of Clovis. Their criteria for “blade value” neglects curvature, which has been highlighted as a trait of Clovis blades (Collins, 1999; Collins & Lohse, 2004; Kilby, 2008; Bradley et al., 2010). The study neglects the two specific types of blade cores associated with Clovis blade manufacture, namely wedge-shaped cores and conical cores, as described by Collins (Collins, 1999; Collins & Lohse, 2004; Bradley et al., 2010) and disregards the preparation and morphology of a core and the fact that it directly influences platform angle, another of Sain and Goodyear’s attributes.

Three different terms have been applied to the size of blades. The first is simply the elongated flakes labelled as blades or true blades. The second term, bladelets, represents those blades that are generally considered smaller, or narrower than blades (see below). Finally the third is termed microblades. While these terms have been widely used in the archaeological literature, there is little consensus on what differentiates a blade from a bladelet or a bladelet from a microblade. Collins (1999, p.10) uses a range of between 3 and 15cm to define a blade. In contrast, Butler (2005, p.35) states that bladelets have a width of less than 12mm; but he qualifies this by adding that they are a specific blade form found in the Mesolithic. Bladelet is also often used in a relative sense, though sometimes it is unclear to what the smaller blades are being related. In some circumstances, the term “long blade” is used (Barton et al., 2003) to separate industries with bladelet traditions from those with larger blades in the assemblages; however, the term long blade can also refer to a specific archaeological culture (*see* Barton & Cunliffe 1992). Early and Late Neolithic assemblages from the Near East contain blades far in excess of Collins' 15cm definition, with blades over 25cm in length (Altinbilek-Algül et al., 2012, p.168). These large blades from the cell building sub-phase of the Pottery Neolithic phase in the Near-East are produced using a lever to apply pressure to a cylindrical or semi-cylindrical core (Altinbilek-Algül et al., 2012, p.164). This example indicates how difficult it can be to apply specific size constraints to blade technologies.

Finally, it is important to note that any technology can have flakes that could be appropriately labelled as blades. The removal of a ridge in a bifacial technology such as Folsom could be described as a blade. However this does not indicate that the Folsom culture of North America had a blade production technology. To deal with this issue, Bradley et al. (2010, p.107) proposed the use of the terms "incidental" and "intentional" blades. Incidental blades are those that occur during the flaking process, though not always intentionally. They set a length of 5cm as the mark at which incidental blades become bladelets and intentional, or true blades, become microblades. For the purposes of this research, all three terms (blades, bladelets and microblades) will be used in conjunction with the appropriate scale for each assemblage.

By studying the blade industries found in the archaeological record, such as Clovis in the United states (Collins, 1999), the Creswellian in England (Jacobi, 1991), the industries of South Africa (Soriano et al., 2007), the expedient blades along the Yellow river in China (Li et al., 2013) and the pressure blades in India (Shipton et al., 2012), it becomes clear that the defining characteristic of blade technology lies not in the blades themselves, but in the production sequence. Ultimately, a blade technology is defined by the creation of a core to facilitate the removal of such flakes. A blade technology must have both blades and cores in sufficient quantity to establish the intentional use of blade manufacturing as part of the technology. This notion was exemplified in Bradley and Giria's (1996) analysis of blade cores in the High Arctic. Here, they stated that knapping technology is complex, but can be defined on the basis of sequences of technological necessities. These necessities include the "elongated projections on the flaking surface" that maintain blade production or the prior removal of blades to create a specific flake scar pattern on the surface of a blade, such as a true blade. By identifying these necessities, the technological processes involved in manufacture can be linked to an assemblage and allows for the reconstruction of that technology. This reconstruction can inform our understanding of past cultures in anthropological terms (Bradley & Giria, 1996).

Cores

The current consensus on what defines a blade is intertwined with the core from which it is detached. The term core, at its most basic level is used to describe a stone from which flakes are removed. As such, the term is used throughout archaeological literature in all time periods where the removal of stone flakes is present. Therefore, it is important to define what criteria can be used to separate a blade core from other types of cores, for example, generic flake cores or *levallois* flake cores.

Some natural forms of stone can be used to consistently produce a series of regular blades following the morphology. In other circumstances, a piece of raw material must first be suitably prepared and a blade face setup, this is known as a precore. This precore establishes the core’s required platform (from which blade platforms can be prepared), suitable spacing and a blade face (from which the blades will be detached). This is the “true core” described by Odell (2003, p.45). The specific morphology of a blade core is dependent upon the technology.

The technique used to remove a blade, combined with the desired end product influences the shape and style of the core. Other factors from the manufacture also play vital roles in shaping the core, including traits such as blade length, width, thickness and curvature as well as processes including how the knapper keeps the core platform viable for removals, how the knapper can correct a mistake as well as how the knapper can create the desired blades. The production of a blade core, and hence blades, represents a fluid system of manufacture where the knapper negotiates the problems associated working a piece of raw material. This can also include material quality and/or knapper skill. All of these factors define the technology of blade manufacture.

Blade cores come in a variety of forms, dependant on the technology. Basic descriptions of blade cores attribute them as having single platforms, opposed platforms (2) or multiple platforms (Azoury et al., 1986). In many respects, these three types encompass the blade core types present in the archaeological record. Naviform cores (Wilke & Quintero, 1995; Barzilai &

Goring-Morris, 2013), keel cores, prismatic cores (Sanger, 1968; Sollberger & Patterson, 1976; Clark, 2012), wedge cores (Morlan, 1970; West, 1996a), conical cores (Collins, 1999), wedge-shaped cores (Bradley et al., 2010) and microblade cores (Clark, 2001; Pastoors et al., 2010) are some of the names given to blade cores identified around the world (Figure 4 illustrates a small sample of blade core types). In general, the names of each core type are indicative of a particular shape or style. Naviform, or keel cores, relate to a core shaped like a boat. Wedge and wedge-shaped cores literally mean that they are shaped like a wedge; whereas prismatic, conical, or bullet-shaped cores are pyramidal or cone shaped respectively.

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Figure 4. Blade cores: (A) Middle Stone Age Core from Kathu Pan 1, South Africa (Wilkins & Chazan, 2012); (B) Experimentally reproduced conical/bullet core similar to Mesopotamian Obsidian cores (Chabot & Pelegrin, 2012); (C) Bidirectional naviform core from Kfar HaHoresh, Near East (Barzilai & Goring-Morris, 2013); (D) Microblade core from the Osipovskaya Culture, Russian Far East (Tabarev, 2012a); (E) Macroblade core from the Pacific Northwest (Sanger, 1968).

Cores have also been described according to how blades were removed from them. In their paper on experimental replication of Corbiac blades, Bordes and Crabtree (1969) defined core types, which included unidirectional cores and bidirectional cores (Figure 5). The bidirectional cores where then subdivided into opposed cores (platforms at opposite ends from each other), opposed angular cores (where a steep angle in the middle of the core face prevented blades travelling the full length of the core) and opposed alternate cores (similar to opposed, except each platform is utilised alternately) (Bordes & Crabtree, 1969).

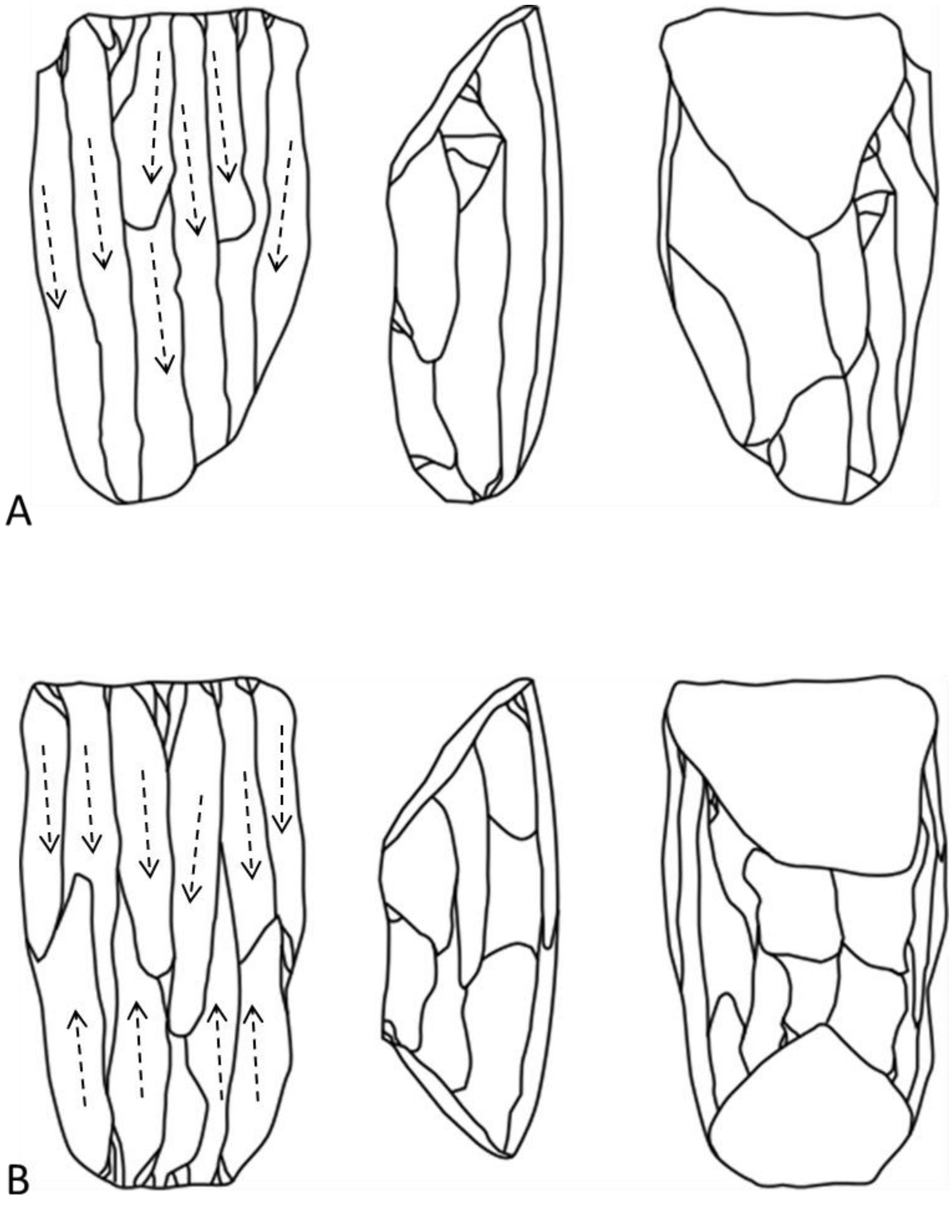

Figure 5. Illustration of unidirectional single platform (A) and bidirectional opposed platform (B) cores.

Additionally, cores have been described by how much of the core was utilised for the removal of blades. Delagnes et al. (2007) described core production as semi-tournant (only part of the core face is used), tournant (the full circumference of the core is used), frontal (where only a small section of a tabular nodule is utilised) and facial (where only one face of a tabular nodule is used).

A core's platform(s), morphology, the direction of removals and how the mass of the core is utilised all contribute to the production of blades. Ultimately the production sequence is systematic and consistent, facilitating the removal of the long, thin, parallel sided, triangular or trapezoidal cross-section flakes, or "blades". All of these factors make blade cores different from other types of cores including those where the objective may only be the removal a single flake (Eren & Bradley, 2009) or the removal of multiple large flakes as blanks for other tools (Sharon, 2009; Bradley et al., 2010, p.57).

The production sequence and the blade cores themselves play important roles in keeping the core viable and for correcting mistakes made during the manufacturing process. In order to keep a blade core viable for the removal of blades, any mistakes made during the knapping process require correction. Errors affect two areas of the core: the face and the platform.

Face maintenance and correction is required when an error occurs during the detachment of blades. For example, if the knapper strikes a blade with too much outward force, the result maybe a hinge or step termination (Whittaker, 1994). This would disrupt the parallel ridges of the core and could lead to further hinge or step terminations, likely ending the use-life of that core. Correction methods vary depending on the technology. A blade may be detached that follows one of the ridges of the hinged blade scar that removes one half of the hinge, followed by a second detachment on the opposite arris. Alternately, a blade may be detached from the same platform to dive underneath the error and detach it. Another approach may be to create a second platform on the distal end of the core and remove a blade in the opposite direction. The specific nature in which this form of error is corrected represents one aspect of the embedded technology of blade manufacturing. These methods were discussed in an analysis of blade technology at Kostenki, Avdeevo and Zaraysk (Bradley & Giria, 1998).

Core platforms may require frequent maintenance or just occasional retouch depending on the technology. Certain blade technologies may require that the platform of the blade be isolated from the core platform; this creates an acute angle between the blade platform and the core. As Whittaker (1994) states “…platform preparation is crucial”. Throughout the use of the core, the platform will decrease in angle from the removal of preparation flakes (flakes removed with the intention of creating a platform for the subsequent removal of a blade). One method may be the use of core tablet flakes to rejuvenate the core platform by removing a large mass of material, often leaving behind a deep negative bulb that creates a new platform. This concavity creates an acute angle between the core’s platform and flaking face. Core tablets can be seen in numerous blade technologies (Laughlin & Aigner, 1966; Powers & Hoffecker, 1989; Collins, 1999; Ballin et al., 2010; Borrell, 2011).

Blade Production

Blade technologies come in many forms. While certain aspects may remain the same, such as the creation of platforms or parallel ridges, there is a significant diversity. This diversity relates to the technological aspects of production, in terms of hard or soft hammer techniques, the preparation of the core and to the blade platform, how the force is applied to the platform and how the knapper holds or steadies the core for blade detachment.

Newcomer (1975) outlined a tripartite system for the description of flaked stone tools. His system, which he calls “levels of abstraction”, applied to both the similarities as well as the differences seen in blade production.

The first of Newcomer’s (1975, p.97) “levels of abstraction” is method. Method relates to the stages used in the production sequence of any particular technology. In terms of a blade technology, method relates to how a core is established followed by the sequence of blade removals and the rejuvenation techniques used in the lifeway of that core.

Mode is Newcomer’s (1975, p.98) second level and it refers to three basic flaking modes: hard hammer, soft hammer, and pressure. These traits are observable on the blades and flakes associated with a given technology. As a general rule, hard hammer flakes have larger bulbs while soft hammer flakes retain a slight lip at the apex of the platform and ventral surface. Pressure flakes may not have an observable bulb, and platforms may be concave. Newcomer (1975, p.98) views mode as a bridge between method and technique.

Technique is Newcomer’s (1975, p.98) third level and refers to the way in which force is applied to detach a flake. For example, a hard hammer may be used for direct percussion, but it may also be used against an anvil, free hand or on the knapper's thigh, cushioned with leather (Newcomer, 1975, p.98). Each technique has subtle variations in the precise mechanics of how the flake is detached and how the material must be prepared in order to facilitate the detachment.

The concepts of hard and soft hammer are still widely used in technological studies (Driscoll & García-Rojas, 2014). However they can be problematic as the generalities of bulb size and lipping are not specific indicators of the mode. To resolve this issue, Bradley (1978) identified an alternate explanation for these traits.

Pronounced bulbs and large platforms are the result of non-marginal percussion (Figure 6). This occurs when a flake is struck in from the margin of the core and the area of impact does not overlap the margin. This is equivalent to the term "internal percussion" used by Soriano et al. (2007). The second type, marginal flaking (Figure 6), is when the strike area overlaps the margin and creates more salient bulbs and small platforms. A hard hammer, such as a stone, can be used either marginally or non-marginally and so can create flakes that have the traditional "soft hammer" traits. The concepts of marginal and non-marginal flaking are recognisable traits on the platforms themselves and therefore an objective approach to technological mode.

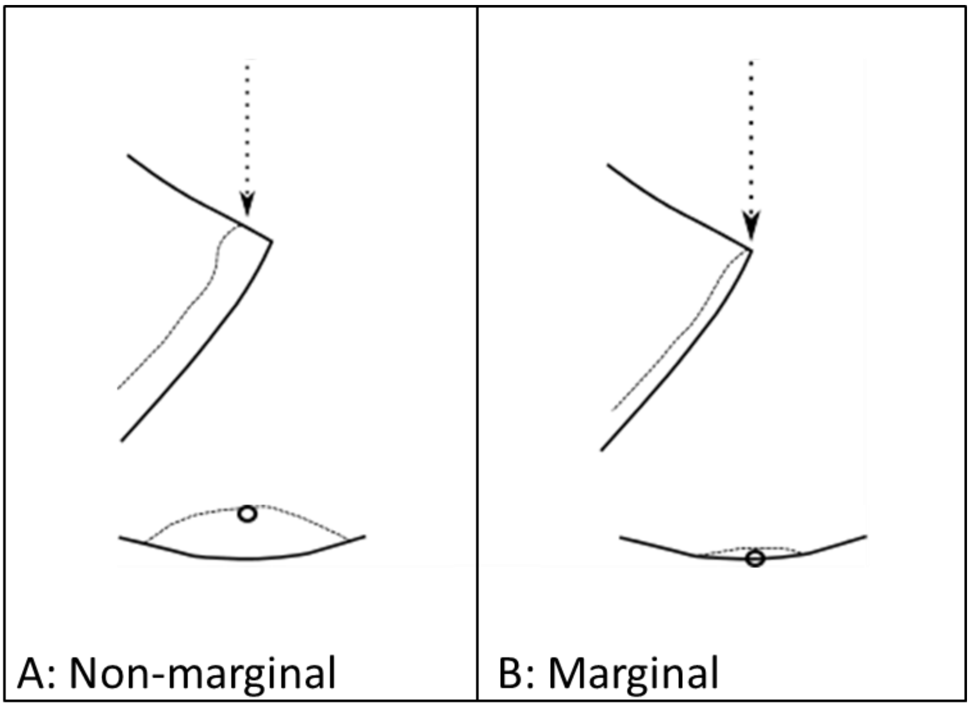

Figure 6. Non-Marginal (A) and Marginal (B) flaking, as defined by Bradley (1978)

As Newcomer (1975, p.98) explained, only level one (method) and two (modes) are generally accessible to archaeologists and modern flint knappers. Method can be interpreted through the archaeological record, particularly where manufacturing/workshop sites are carefully excavated. The stone artefacts themselves will retain attributes associated with the mode of flaking, such as relatively prominent bulbs on hard hammer (non-marginal) flakes or the fracture wings observed on pressure flaked obsidian (Takakura, 2012, p.286). Technique remains elusive to archaeologists, as this is almost invisible in the archaeological record. Any device for holding the core or lever for the removal of flakes was likely made of organic material, and as such, its survival in the archaeological record is rare. Any stone working that is conducted freehand is, for obvious reasons, completely invisible to the archaeologist. And so any diversity in the production of blades relies on the analysis and comparison of the method and mode of the industry. There are exceptions to this, in which in-situ debitage flake patterns could indicate technique (Aubry et al., 2008).

More recently, the mechanics of flake creation have been studied in depth by engineers rather than archaeologists. Baker (2003) identifies these mechanisms in his paper on flake creation. His key concept was that a core will vibrate when energy is transferred to it, via either percussion (direct/indirect) or pressure. This vibration is key to the flake releasing from the core. However this is dependent on the force exerted on the core, which must be sufficient to initiate a crack. This exertion is dependent on the strength of the platform rather than the strength of the knapper. A strong platform yields greater energy and produces a long flake (Baker, 2003). Depending on the method of detachment, the force load applied to the core will either be a static (pressure) or dynamic load (percussion). This study reveals that there are a number of fundamental scientific principles that govern the flint knapping process; specifically, that the platform is crucial to the manufacturing process, confirming Whittaker's (1994, p.223) statement.

To better understand blade technology, brief summaries of the stages of production are discussed below. These stages are intended to serve as a guide to the technological processes that may be performed during production. This section is followed by two archaeological examples that highlight the range and diversity of the archaeological record.

Stages in Blade Manufacturing Technology

Raw material selection

The size and quality of the raw material can present numerous challenges for a knapper to overcome. This is especially apparent in the manufacture of blades, where the desire for long, narrow flakes requires a surface conducive to their removal. The archaeological literature on raw material selection contains numerous descriptions of raw material size and shape (Bordes & Crabtree, 1969; Bordes et al., 1969; Barton & Cunliffe, 1992; Wilke & Quintero, 1995; Doelman, 2009; Shimelmitz et al., 2011; Wilkins & Chazan, 2012). The specific terminology used can be highly subjective due to the type of raw material and the nature of the formation processes which can be complex and dependant on the numerous factors including but not limited to ocean depth, pressure, and existing bedrock morphology.

The availability of material and the material's size, shape and flaking quality not only influence raw material selection, but also influence the reductive process. Furthermore, the intended final product can also be a major influence. Raw material may require a certain amount of flexibility within the knapping process. The key is that the material selected can be shaped as is appropriate for the technology. For example, a reduction strategy that requires acute platform angles may require trimming the initial raw material to create the appropriate angle. A recent article by Eren et al. (2014) concluded that while raw material plays a role in the reduction process, it cannot be assumed that it definitively influences artefact morphology.

Initial Reduction

After the selection of raw material, several technological steps need to be accomplished, depending on the complexity or manufacturing necessities of the technology. A platform needs to be established on the core along with an associated blade face. This stage may be influenced by the raw material. A correct angle may exist between two planes of the core which also has a natural "ridge" along a convexity to guide the removal of an initial blade. Some cores may not exhibit an appropriate convex morphology. This may be corrected via the creation of a crest along the intended blade face. A crest can be created by either bifacially or unifacially flaking along one face or edge which creates a ridge consisting of two series of negative bulbs (Whittaker, 1994; Inizan et al., 1999). Depending on the core morphology and the technology, the next step involved either the creation of a blade face, or the establishment of a platform. This may be achieved directly through the removal of an initial blade as this blade establishes the ridges for the continued removal of blades.

The technological steps undertaken during this initial phase shape the core during the entire reduction sequence and are retained throughout the reduction process.

Curvature and morphology

Inizan et al. (1999) discussed the importance of the morphology of the blade core itself to the repeated production of blades. Specifically, Inizan et al. (1999) identified certain requirements in the morphology of a blade core, including the need for transverse (cintrage) and longitudinal (carénage) convexity that are crucial to repeated blade production. A longitudinal convexity can be used if a slight distal curve is required, and this can be achieved through the creation of a second platform on the opposite end of the core to the primary striking platform. This opposed platform can be used for correcting errors on the core such as hinges but always serves as a subsidiary platform. Transverse convexity is also essential as blade production is impossible once the blade face becomes too flat. If these two morphological traits are not controlled throughout the blade production sequence, knapping errors (usually in the form of hinging) will increase and ultimately lead to the core being discarded. Aubry et al. (1998) noted the increased error rate in Solutrean blade cores from Les Maitreaux that exhibited little control over this convexity.

Blade production

Once the core platform and blade face have been established, blade production can begin. The technological aspects of this stage may include the creation of blade platforms, the detachment of blades (marginal or non-marginal) as well as maintenance and error correction (see below).

After blade production has been established the remaining technological steps overlap depending on the requirements of the technology and the nature of the reductive strategy. A technology may require constant correction to maintain the correct technological attributes of production. This may include constant platform preparation and core maintenance, as in Clovis technology (Collins, 1999). Conversely, a core may be heavily prepared in the initial stages to allow for the continual production of large quantities of blades (Clark, 1987).

If the aim is to produce regular blades systematically, each removal may be placed at a specific location in order to maintain the spacing of scars on the core. As the production progresses, a series of blades is produced. Each removal is not necessarily done for the sole purpose of producing a blade. In certain circumstances it may have been necessary for the knapper to remove a blade that is thicker or thinner (depending on the technology) than required. This removal may serve to re-align the spacing of a core, remove an error or to set up a platform opposite to the core face for the removal of a platform preparation flake. In Bradley and Giria's (1996) analysis of blade manufacturing, they describe the use of corner blades as a method of rejuvenating the core face for the continued production of blades. Furthermore, in their assessment of blade production at Kostenki 1/1, Bradley and Giria (1998) identify corner blades as a way of maintaining transverse curvature to the blade face which can result in errors.

Historically, blade production has been described in terms of specific stages; however, due to the nature of production it is more informative to assess the technological effects of blade removals. In this respect, blades can be viewed as either manufacturing blades or production blades.

Manufacturing blades are removed as a means of continuing the production of blades. These blades may remove an error or open up more of the core volume. Alternatively, these blades may be used to establish spacing for the production of true blades. Production blades refer to the intentional product of the technology. The removal of these blades may reduce the mass of the core as well as flatten the blade face thereby necessitating rejuvenation.

In many technologies, these two types may overlap as the manufacturing blades may also serve as tools, thus representing production blades. In essence, this distinction is a matter of intention, and thus analysis of the archaeological record is required to determine this. In later pressure blade industries, such as those found in Mesoamerica, production blades occur at a higher ratio to manufacturing blades than in early blade industries from the Middle Stone Age in Africa. This ratio of manufacturing blades to production blades can provide archaeologists with a quantitative method for understanding blade production as an assemblage can be interpreted based on the presence of one or both of these types.

Platform preparation and core platform maintenance

Platform preparation may be necessary for the removal of each individual blade. Core platform maintenance may be required if these preparation scars alter the platform. As blades are produced, mass is reduced from the core platform. This process can alter the core striking angle and may require maintenance to re-establish the desired angle.

Depending on the technology, a knapper may create individual platforms for each blade removal while simultaneously keeping the core platform viable for subsequent removals. This routine preparation and maintenance keeps a core viable throughout the entire reduction strategy. Other technologies may utilise a single core platform without individual platform preparation, with platform reduction (via the removal of a core tablet) as a preparation option.

Core Maintenance

An essential part of flint knapping is correcting mistakes. The type of mistake influences how it may be corrected; and, there are numerous ways in which a knapper may correct mistakes.

For example, hinge errors may be corrected using numerous methods. As mentioned, a hinge may be removed using two blade detachments, one on each side of the hinge, removing half of the hinge at a time. An alternative method involves the knapper utilising the end opposite the main platform, by preparing a new platform and removing a blade (or flake) in the opposite direction removing the hinge. Hinges may also be struck using indirect percussion by placing a punch on the hinge itself. These are not the only method of hinge removal possible, and the exact method used may be dependent on numerous factors, including but not limited to raw material, core morphology, and the specific technology.

Core maintenance is another key aspect of blade production. Core maintenance can occur at any stage of manufacture and for any number of reasons. These reasons can include loss of the correct platform, errors in the knapping process, faults in the raw material or the removal of flakes to facilitate the correct core support. Maintenance strategies, including error correction techniques and platform, are often imbedded in a given technology and vary significantly from culture to culture.

As discussed, maintaining transverse and longitudinal convexity to the blade face of the core is also essential to continued production. A straight face on a core is more likely to yield hinge or step fractures. In some technologies, this convexity requires little to no maintenance. If the convexity is lost, it can be re-established by the removal of a plunging blade. This may require preparation in the form of partial or full cresting. In some pressure blade industries, an almost straight face can be used, providing that the angle between platform and blade face is suitable for pressure blade detachments.

Core abandonment

There are numerous reasons as to why cores were discarded. An error may have been too large to correct, the platform angle may have been lost, or the core becomes too small to produce the desired blades. Discard is specific to each technology and the reasons behind abandonment are not always apparent from the archaeological record.

Examples of blade technologies

Upper Palaeolithic Blade Technology

Any discussion on the timing and nature of the arrival of modern humans into Europe and the rest of the world must also include the arrival and production of blade technologies. Bar-Yosef and Kuhn (1999) state, blade manufacturing is a key component of Upper Palaeolithic technology and ubiquitous across much of the world. Blade technology was not an entirely new concept as early blade manufacturing industries were present in Africa, at sites such as Rose Cottage Cave (Soriano et al., 2007) and Kathu Pan 1 (Wilkins & Chazan, 2012). Blades have also been recovered from Qesem Cave, Israel outside of Africa dating to around 400 – 200 ka BP (Barkai et al., 2006; Shimelmitz et al., 2011). In their analysis of blade production, Bar-Yosef and Kuhn (1999) note the presence of pre-Upper Palaeolithic blade sites as well as Early Upper Palaeolithic sites. Three clusters of pre-Upper Palaeolithic sites can be identified, one in South Africa, one in the Middle East and one in Northern

Europe (Bar-Yosef & Kuhn, 1999, fig.1). This pattern continues into the Early Upper Palaeolithic (Bar-Yosef & Kuhn, 1999, fig.2).

These pre-Upper Palaeolithic industries share some commonalities with the traditions of the Upper Palaeolithic, including the use of both unidirectional and bidirectional cores. The dating from Kathu Pan 1 (500 ka BP) and Qesem Cave (400 ka BP) reveals that the invention of blade production has deep roots in human evolution and that at least two waves of the technology left South Africa into the Middle East and Europe. The first occurring around 500-400 ka BP, with the second occurring post ca. 80,000 BP. This hypothesis remains conjecture and requires a more detailed technological analysis of the specific manufacturing processes and reductive strategies before any full assessment can be undertaken. As Stanford and Bradley (2012, p.150) state in their hypothesis, independent invention and reinvention are key to understanding cultural relationships. This includes the development and spread of blade technology.

While archaeologists recognise blade industries in many different areas across time, there remains a lack of technical literature on the specific manufacturing methods and modes. This lack of data forces archaeologists to use typological comparisons of stone tool industries, which can often lead to conclusions based on false assumptions such as identifying technological continuation from one period to another based solely on the typology of the finished tools.

Presented below are two very different studies of the technology of manufacture. The first study involves an assemblage from Qesem Cave, Israel, an Acheulo-Yarbrudian cultural complex with a deep (7.5m) stratigraphic sequence dating between 400 and 200 kya, or the later part of the Lower Palaeolithic. This assemblage contains one of the oldest blade industries in the world (Shimelmitz et al., 2011). The second case study involves the replication of Mesoamerican polyhedral blades, based on the collections as well as written accounts from early explorers who witnessed the production first hand (Crabtree, 1986). These two industries were selected for demonstration purposes because they reflect the broad spectrum of blade production. Detailed descriptions of the literature concerning studies of Clovis and Solutrean blade production are presented in later chapters.

Qesem Cave, Israel (400-200 kyr)

The knapping sequence at Qesem Cave has been carefully reconstructed through the detailed analysis of 19,167 artefacts (Shimelmitz et al., 2011). While the knapping sequence at Qesem Cave has only been described at a basic level, it demonstrates a very early technique for the systematic production of blades.

Flint slabs (tabular nodules) were specifically chosen for the production of blades at Qesem Cave. These nodules followed a concept known as *débitage frontal* (*see* Delagnes et al. 2007)*,* where blades were struck from the thin edge of a core rather than a wider face. These nodules remain relatively similar in shape as the series of blade removals progressed (Shimelmitz et al., 2011)(Figure 7). As Shimelmitz et al. (2011) describe, one of the main concepts behind this technology was that reduction took advantage of the natural shape of the raw material and did not include any core pre-shaping.

Blade removals proceeded following the natural topography of the core, utilizing a core platform to blade face angle of between 70°-80°. Detachments were made using a hard hammerstone (Shimelmitz et al., 2011) and non-marginal strikes (*see* Bradley 1978). All removals were described as overpassing (overshot) (Figure 7), because the flake travelled across the entire surface of the blade face to remove the opposite end (Shimelmitz et al., 2011). This type of overshot technology is different from the overshot technology described on Clovis bifaces (Callahan, 1979; Frison & Bradley, 1999; Bradley et al., 2010; Waters et al., 2011b). In Clovis biface manufacture an overshot flake removes a portion of the opposite margin as a method of thinning, the action described by Shimelmitz et al. (2011) is used to remove errors from the blade face and rejuvenate the core.

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Figure 7. Blade Technology from Qesem Cave Israel: A-D Blade cores; E Primary Element Blade; F-I Naturally Backed Knives; J-K Blade overshots. After Shimelmitz et al. (2011).

The initial blade removal was either a cortical blade or, less frequently, a crested blade. However these cores were not bifacially worked to the same degree as some later Upper Palaeolithic blade technologies and are referred to as primary element blades (Shimelmitz et al., 2011). The next removal was from the opposite edge on the face of the core, where a second cortical or crested blade was removed. The final blade in the sequence removed the central arris created by the first two removals, which often retained a small portion of cortex down the central channel of the blade (Shimelmitz et al., 2011). All subsequent removals repeated this same sequence of detaching corner blades to set up a centre blade.

Shimelmitz et al. (2011) described the first removal in this three-blade sequence as a primary blade (Figure 7). The second, due to the angle between blade face and cortical edge, was referred to as a naturally backed knife (Figure 7); and, the final interior detachments were labelled as blades.

Occasionally, maintenance of the platform was performed by faceting. There is evidence of the occasional removal of a core tablet but it was only used to a minor extent. Blade face maintenance was also required, but as the author's note, due to the full-length removals (overshot) that were intended to remove the entire surface, very few hinge and step terminations were created. Where maintenance of the core was required, knappers either used deeper strikes to remove overshot blades or occasionally worked the core from the opposite end. However due to the low frequency of second platform use, it would appear that this was only used for correcting and maintaining the core (Shimelmitz et al., 2011). It appears that the primary reason for core discard at Qesem Cave was exhaustion. This was demonstrated by the mean lengths of the discarded cores, which was only slightly shorter than the blades themselves (Shimelmitz et al., 2011).

The blade production sequence at Qesem Cave illustrates the early origins of blade manufacture, before the expansion and dispersal of Upper Palaeolithic "true blade" technologies associated with anatomically modern humans (Mellars, 2006).

In his book "Peoples of the Flute," Bob Patten (2005) discusses the manufacture of stone tools as a process, similar to that of the modern production line. To a certain extent, the industry at Qesem Cave can be viewed as an early blade production line, following the basic principles of blade manufacture discussed above.

Mesoamerican Polyhedral blade cores

Crabtree was one of the first mainstream, modern flint knappers, and certainly the first to bring flint knapping to the attention of modern archaeologists (Clark, 2012). In his article on "Mesoamerican polyhedral cores and prismatic blades", Crabtree (1986) used his own experiments alongside the historic written accounts of Torquemada, Sellers, Catlin, Joly, and Hernandez to replicate the blade technology distinct to central America. He describes five different types of precore forms that were established for the removal of pressure blades as documented in Mesoamerica. These were described simply as cores with one ridge, two ridges, three ridges, four ridges, and finally cores with more than four ridges (Crabtree, 1986).

According to Crabtree (1986), the first step in the Mesoamerican knapping sequence involved selecting a suitable nodule of raw material with a flat surface. The initial preparation was then conducted by percussion. A blow was struck at a right angle to the flat surface, close to the edge. This removed the cortex and set up the initial platform. The cobble was then rotated so that a second flake could be removed, intersecting with the first removal to produce a corner. This corner became the ridge used for the first prismatic blade. If this initial ridge was straight, then it was ready to be removed; however, if there were any irregularities, they had to be removed by percussion flaking prior to blade detachment. This process was completed by either unifacially or bifacially removing flakes from the ridge to straighten it. The platform was then prepared by grinding, which created a rough edge for the pressure tool (in this case, a crutch). Finally, the blade was removed (Crabtree, 1986). Figure 8 illustrates two techniques used by Crabtree in his experiments, indirect percussion and pressure.

Setting up two, three, four or more ridged cores followed a similar procedure. One method for creating a two-ridge core involved removing a second flake at a right angle perpendicular to the first flake, creating two ridges on the core. The other option for creating a two ridge core involved creating a rough biface by percussion to make two bifacial ridges on opposite sides of the core (Crabtree, 1986). To create a three-ridge core, a triangular cross-section is created by removing two large flakes at right angles from the centre of the core creating a form similar to the prow of a boat. A flake should then be removed from the centre, in line with the previous two flake scars, setting up a triangular core ready to be worked (Crabtree, 1986). To create a core with four ridges, a cube was created. This was achieved by removing flakes from a flat surface; the bulb of one flake will leave a flat surface for the removal of additional flakes until the core becomes square (Crabtree, 1986).

Once the initial precore was shaped, the platform could then be prepared. This was conducted by flaking the platform. Flaked platforms required the removal of small flakes from around the intended blade platform to create a 'seat' for the pressure tool. As Crabtree (1986) explained, this method had distinct disadvantages for the knapper, as the platform would require rejuvenation after each detachment sequence. Rejuvenation, in the form of a core tablet flake, was also challenging to the knapper as the flake must remove the entire surface and leave a negative bulb. The other disadvantage of this technique was that it shortened the length of the core and therefore the length of the next series of blades (Crabtree, 1986).

Crabtree (1986) also discussed recovering the core from any miscalculated removals. As the proximal end of the core reduces in size, it could be easy to incorrectly position the tip of the crutch, removing a blade that was too wide and too thick. In order to overcome this, the tool should be placed closer to the edge and more outward pressure should be applied. However there was a risk of removing the distal end if too much pressure is applied.

Hinge or step fractures may be removed from the face of the core by placing the tip of the tool onto the hinge/step and applying pressure to remove a second blade. Again, this method was not without risk, as any anomaly left on the surface of the core may hinder the next removal (Crabtree, 1986). An alternate method for removing these hinges was to set up a platform on the distal end of the core opposite the error and detach a flake long enough to remove the hinge (Crabtree, 1986). The knapper could then continue to produce blades until exhausting the core.

This image has been removed by the author of this thesis for copyright reasons

Figure 8. Experimental obsidian blade cores using indirect percussion (A) and pressure (B); indirect pressure blades (C) struck from core A; Pressure blades struck from core B. After Crabtree (1986)

Discussion

These examples can be considered at opposite ends of a broad spectrum, they demonstrate the variability that can exist in blade manufacturing processes. These two industries demonstrate the embedded technological processes or necessities that can be found within a manufacturing technology. These embedded technologies can be used for comparative purposes, if similarities are found within the manufacturing process. Bordes stated that there are a finite number of ways to break rocks (Bordes et al., 1964). While this statement is technically true (as it follows the mechanics and physics of fracture) (*see* Baker 2003), it discounts the variability resulting from precore shaping, maintenance, production and correction. These processes highlight the complexities found in a complete embedded technology.

Summary

Alongside technology, innovation is critical in addressing the relationships between cultures. The data for these relationships resides not simply in an analysis of the number of platforms, the direction of removals and the morphological utilisation of the core, but also in the specific nature of platform preparation and maintenance, blade face maintenance and error recovery. The taxonomy discussed in Chapter 6 provides a unified system under which blade technology can be assessed; however, it is the fine detail that provides the strongest evidence for historical relationships. An example of this is the formation of a bifacial precore. Depending on the size of the raw material, these cores can be used to create a range of blade lengths, from macroblades to microblades. A core used to produce macroblades may exhibit different end products than a core intended to produce microblades. However if the same bifacial core shaping is conducted in both instances, it may indicate a cultural connection. If both reductive strategies start production via the same specific removal of two lateral margins, then rotate the core to utilise these blade scars as core platforms, there may be a connection between the technologies. It may be said that the younger assemblage has its technological roots in the older assemblage, whether that is from macro to micro or vice versa.

The difficulty with any analysis of production lies in the archaeological record itself. The vast majority of cores recovered are discarded after being exhausted during the manufacturing process. It is often difficult to make any assessment of precore shaping or of core maintenance on the evidence of these discarded cores alone. Because analysts tend to focus on cores and not include the ‘debitage’, technology largely remains at the fringes of any discussion about culture while the end products become the focus. This practice has also led to a rise in misconceptions regarding blade technology and the principal methods of manufacture.

In their discussion on the importance of blade technology, Bar-Yosef and Kuhn (1999) use a brief description of blade manufacturing outlined by Clark

(1987, p.268) regarding the production rates of Mesoamerican blade cores. In any discussion of Upper Palaeolithic blade production, the technology and/or reduction strategies of Mesoamerica bear little to no resemblance to those used during the Upper Palaeolithic. Clark (1987, p.268) states that 10-20 blades can be struck from a single core. The majority of Upper Palaeolithic cores are unlikely to have produced this number of blades. While the difficulties in assessing reduction processes have led to a lack of technological understanding, they do not preclude analyses of certain technological aspects. Discarded cores will, in many cases, retain aspects of platform use and maintenance as well as other possible pieces of evidence, including error correction techniques and core shaping. The blades provide evidence for directionality of removals, core shaping, and blade platform preparation. Associated debitage from the assemblage may also yield diagnostic production flakes such as core tablets, indicating the need for rejuvenation during the manufacturing sequence.

Chapter 3

The Solutrean-Clovis Hypothesis: A short history and critique

Often referred to as the search for the “First Americans,” the timing, nature and route of the first human populations into the American continents has been the subject of heated debate in recent years. With the “Clovis-first” model (Wormington, 1957; Fladmark, 1979) no longer widely accepted (Waters & Stafford 2013), numerous authors have proposed new hypotheses and theories on the arrival of modern humans into America, and more specifically, the origins of Clovis (Boldurian & Cotter, 1999; Fiedel, 2000; Adovasio & Page, 2002; Meltzer, 2009; Erlandson, 2013).

The Clovis-first Model

The “Clovis-first” model was based on early twentieth century geologic data, which demonstrated that an “ice-free corridor” existed between the Laurentide and Cordilleran ice sheets. Although the exact date of this opening was never agreed upon (Fladmark, 1979), archaeologists saw this corridor as the migration route from Asia into North America. The roots of this model can be found in the texts of Spanish cleric, José de Acosta (1604). He proposed that ancient hunters followed game herds over a land bridge from north-eastern Asia into north-western North America. He reasoned that the abundance of wild animals were unlikely to have embarked on an ocean voyage or to have been carried by the sea (Acosta, 1604, p.61). However de Acosta remained vague on the precise ancestral homeland.

In his writing on the physical appearance of the Native population, Brerewood (1622) discusses the physical appearance of the Native Americans, and described their origins as “North-east Asia, the Tartars’ homeland” (Brerewood, 1622).

Thomas Jefferson (1788, p.108) reasoned that a voyage via the sea was “…practicable, even to the imperfect navigation of ancient times”. Furthermore, Jefferson commented on the resemblance between the “…Indians of America and the Eastern inhabitants of Asia” and conjectured that the former were derived from the latter (1788, p.108). Finally, Jefferson (1788, p.108) also remarked on the discoveries of Captain Cook, who proved that "…if the continents of Asia and America be separated at all, it is only by a narrow strait".

These three concepts; the arrival of both humans and animals, the resemblance of the native populations to those of Asia, and the narrow strait between America and Asia, became the foundation for the "Clovis-first" paradigm.

This theory suffered from a complete lack of any physical evidence; and yet, it pervaded archaeological thought and research until the late twentieth century. Fiedel (2000) states that it is this theory that "…has been assumed by most serious scholars". This statement represents a basic dichotomy in American archaeology between 'serious scholars' and assumptions, which should only be used and clearly stated in relation to hypothesis construction and not in the application of theory.

Following the discovery of Folsom artefacts embedded in the bones of extinct bison, an older point type was identified, named Clovis after their discovery near the town of Clovis, New Mexico (Cotter, 1937). Described as fluted projectile points for the diagnostic basal flake, archaeologists began to interpret these Clovis points as the earliest known culture. With the advent of radiocarbon dating in the 1950s, sites such as the Lehner Clovis site began to yield results of 13,251 ± 548 and 13,072 ± 166 calBP (Fiedel, 2000) which fit with the geologic date for the ice-free corridor of 13,400 calBP (Fiedel, 2000), cementing the "Clovis-first" model and the origins of Clovis out of Asia.

With the theory accepted, researchers began to look for the origins of Clovis technology in Beringia and Asia. Numerous field projects and excavations were conducted, including those at Dyuktai Cave in Siberia along with Ilnuk and Onion Portage, both in Alaska (West, 1996a). These assemblages, with earliest dates around 13,110 calBP (Hoffecker, 1996a), led archaeologists to connect Siberian and Alaskan lithic industries based on their shared tool types, namely the biface and blade industries. This line of evidence was constructed solely from the appearance of the tool types present in the two areas. Later, it was used again to support the theory that Clovis originated in Asia (Goebel et al., 1991; West, 1996a; Hoffecker, 1996a; Fiedel, 2000; Straus, 2000a).

This model was challenged with the discovery of numerous sites that pre-dated the earliest known development of Clovis in North America. Monte Verde (Dillehay, 1989, 1997), Meadowcroft Rockshelter (Adovasio et al., 1978; Adovasio & Carlisle, 1982; Adovasio et al., 1990, 1999; Adovasio & Page, 2002), Cactus Hill (McAvoy & McAvoy, 1997; Macphail & McAvoy, 2008) and Taima-Taima (Bryan et al., 1978) were just some of the sites that produced lithic material that came from good contexts, dating before the arrival of Clovis (Figure 9). These sites have been assessed and reassessed in literature concerning the first Americans (Dillehay, 2000; Fiedel, 2000; Adovasio & Page, 2002; Meltzer, 2009; Stanford & Bradley, 2012). This evidence, combined with a more complete understanding of the glacial coverage of North America and the exact timing of the “ice-free corridor” (Gowan, 2013; Dixon, 2013; Ives et al., 2013), sealed the fate on this theory that persisted for four hundred years.

Figure 9. Location map of Clovis & Older than Clovis sites from North and South America. Adapted from Collins et al. 2013.

Beyond Clovis-first

While the Clovis first model is no longer widely accepted as a valid theory (Waters & Stafford, 2013), many archaeologists still view Asia as the route of all migrations into the American continents. This notion is exemplified in the work of Goebel et al. (1991, p.49) who state that, "…while no archaeologist has yet confirmed the existence of an Alaskan or Siberian antecedent of the Clovis Culture, there is no doubt that the first Paleoindians entered the New World via Beringia". In the twenty two years since Goebel et al. made this statement, there remains no evidence for a viable antecedent for Clovis in the archaeological record from either Alaska or north-east Asia.

The work of Goebel et al. (1991) focuses on the typological toolkits from two major sites in Alaska: Walker Road and Dry Creek. They argue that both assemblages share a number of typological similarities to Clovis, including blade and flake retouching, end and side scrapers, cobble tools, bifaces and projectile points (Goebel et al., 1991, p.70). They then argue that there are two possible models explaining the first peopling of the Americas. The first model assumes a late entry by the Nenana Culture at around 13,000–12,000 BP, based on the age, lithic technology and geographic extent. The second model assumes that both Nenana and Clovis stem from the same, older culture; both industries representing a different branch. The Walker Road site dates to 13,736 ± 177 calBP, while the Dry Creek 1 component is dated to 13,025 ± 140 calBP (Goebel et al., 1991, p.52). These dates fit closely to the known dates of the Clovis occupation in North America, which Collins (2002) dated to between 12,900 calBP and 12,550 calBP; and more recently, Waters and Stafford (2007) dated to 13,000 calBP and 12,700 calBP.

The most recent dates for fluted projectile points now place the oldest manifestations of the culture at 13,430 ± 135 calBP and 13,475 ± 134 calBP (both from Sloth Hole, Florida) and the youngest sites date to c.12,300 calBP and 12,100 calBP (from Charlie Lake Cave, British Columbia and northwest Alaska respectively) (Stanford & Bradley, 2012). The Dry Creek 1 site sits within the known Clovis dates, while the Walker Road site is considered to be contemporaneous with Clovis (Shott, 2013). These two models are based solely on typological attributes, many of which are elements commonly found in a wide variety of lithic industries from the Upper Palaeolithic around the world (Grayson & Cole, 1998; Barton et al., 2003; Doelman, 2009; Banks et al., 2011; Shipton et al., 2012; Angevin & Surmely, 2013). Despite the claims of Goebel et al. (1991, p.75) for technological similarities, typology is not technology.

More recently Goebel, Waters and O'Rourke (2008) have suggested an even earlier entry model, this one around 15,000 BP. They argue that the dating, from sites like Monte Verde, Schaefer and Hebior, point to the colonisation of America immediately after the deglaciation of the Pacific Coastal corridor. They also state that the genetic evidence supports this date of entry. This hypothesis relies on rapid expansion, from west to east. An re-analysis of the Waters and Stafford (2007) dates by Hamilton and Buchanan (2007) argued for a spatial patterning of the dates from the oldest in the Northwest to the youngest in the South and East. An examination of the dates reveals that while a handful of older dates can be found towards the northwest of the United States, and the youngest dates are found in the far northeast of America, most of the dates cluster around the Great Plains region with no apparent patterning. As such it is likely that the patterns found by Hamilton and Buchanan (2007) are a product of a statistical pattern, and not a real world pattern. Furthermore, archaeological data from sites like Meadowcroft Rockshelter, Cactus Hill and Page-Ladson show expansion also spread across North America from east to west (Stanford & Bradley, 2012).

In a recent article, Shott (2013) re-analysed a number of papers that have been used to demonstrate the arrival of humans into North America via Asia. He concluded that there is still little data from which to draw any meaningful conclusions; however, Shott (2013) maintained that, "…almost certainly the Americas were colonised from Siberia; almost certainly Clovis' ancestors subsequently radiated across the Americas". This echoes the statement of Goebel et al*.* (1991), with still little evidence forthcoming.

Greenman (1963) was one of the first researchers to seriously consider a connection between Europe and America. Greenman (1963) explored the typological similarities between Newfoundland and Spain and France, focusing particularly on the Solutrean and Magdalenian cultures. Greenman's (1963) argument was based on similarities between the art and watercraft of the Beothuk and the art found in Europe during the LGM. This was combined with the appearance of the stone tools found in America, particularly the now discredited Sandia points (Thompson et al., 2008; Thompson & Haynes, 2012) in New Mexico. This hypothesis was widely criticised for relying solely on typological attributes, one commentator even challenged Greenman to prove his theory by crossing the Atlantic (Bordes et al., 1964). Bordes (Bordes et al., 1964) suggested that any similarities in the assemblages came from the similarities of the environment and from the fact that you can only work flint in so many different ways.

These so called “trait-parallels” (typologies) proposed by Greenman failed to stand up to scrutiny, as no other forms of archaeological data supported any of these claims. It is ironic that Greenman was dismissed for his reliance on “trait-parallels;” because supporters of the “Clovis-first” model, and indeed more recent research, continue to rely on “trait-parallels” or typologies between Siberia, Alaska and North America (*see* Goebel et al. 1991; Goebel et al. 2008; Fiedel 2000).

In Greenman’s (1963) conclusion, he criticised the fixation that current anthropologists had on the Bering Strait as the only possible migration route. He suggested that while he did not claim a European route was the only one, or indeed the first, there was no evidence to support a crossing from the Bering Straits down into North America. He backed up his statement with a conclusion drawn by Rainey (1953) who argued that the Strait presented one of the most formidable barriers anywhere in the world.

One of the first authors to seriously address the issue of lithic technology was Jelinek. In his study of early technologies in the New World, Jelinek (1971) notes the striking resemblance between the “Llano Complex” (Clovis) and the Solutrean assemblages of Europe. The lanceolate, bifacially flaked, projectile points with concave bases were the most obvious correlation; but Jelinek (1971) also listed the blade industries, with small endscrapers, gravers, and a scarcity of burins as similarities in these two cultures. It is interesting to note that Smith (1963) had identified one fluted point in Solutrean context. However with the chronological gap between the two industries alongside the use of pressure flaking and shouldered points in the Solutrean, Jelinek (1971) suggested that this represented a convergent development which grew out of two fundamentally similar traditions.

Greenman and Jelinek where not the only authors who discussed the similarities between the New World and the European Old World. Cotter’s master’s thesis (1935) also highlighted these similarities, which he later revisited in a co-authored book with Boldurian (Boldurian & Cotter, 1999).

Neither work presented an actual link between the two cultures, citing the chronological gap and the Atlantic Ocean as the two main factors affecting such a connection.

The Solutrean-Clovis hypothesis

Stanford and Bradley (Stanford & Bradley 2002; 2012; Bradley & Stanford 2004; 2006) reconsidered a connection between the Solutrean and Clovis cultures due to a lack of forthcoming evidence from Asia and the growing body of pre-Clovis evidence in eastern North America. This hypothesis stems from a connection between Europe and America, an idea that was nothing new to the archaeological community. However Stanford and Bradley's approach took a new perspective to the study of the first Americans, examining technological characteristics rather than just typological ones.

The Solutrean-Clovis hypothesis was first presented to the archaeological community at the Clovis and Beyond Conference in Santa Fe, New Mexico in 1999 and stemmed from Stanford's long established claims that, "…there has to be a pre-Clovis" (Hall, 2000). This proposal was first published as a chapter in the edited volume, "The First Americans" (Stanford & Bradley, 2002). This chapter began by acknowledging that the origins of Clovis remain a mystery and that despite decades of research there remains no technologically similar assemblages in east Asia (Stanford & Bradley, 2002). Their work also negated any hypotheses based on a Pacific coastal route, as regardless of the route and means of migration; the technological markers that should indicate a progenitor of Clovis were simply not present. Stanford and Bradley (2002) also suggested that the ice-free corridor was not open until 11,000 calBP and may have been uninhabitable for a long period afterwards. This point is contested by Straus et al. (2005) who argue that there is no evidence that the route was impassable. Stanford and Bradley (2012) presented the latest advancements in their Solutrean-Clovis hypothesis in their book, *Across Atlantic Ice* (see chapter 4). Other hypotheses, including the Pacific coastal route and earlier land migrations (i.e. prior to the LGM) continued to be considered in light of the failure of the "Clovis-first" model (*see* Erlandson et al. 1987; Erlandson & Braje 2011; Erlandson 2013).

In the conference proceedings, Hall's (2000) write-up of Stanford's talk discusses how, after repeated attempts to find the origins of Clovis in Alaska and then in Russia, he and Bradley started to look at the specific characteristics of Clovis technology and where else this technology was found. The answer, as Stanford stated was also found in Iberia, belonging to the Solutrean culture. Stanford and Bradley's argument was based on an assessment of technologically specific characteristics that were shared between the two cultures including, the use of exotic material, pressure flaking, controlled overshot flaking, specific platform preparation techniques (described as very wide, very well set up and, very heavily ground) and caching behaviour (Hall, 2000).

The final question that this hypothesis sought to answer was how exactly the Solutreans made a transatlantic journey. Stanford and Bradley's argument was based on a seasonal ice connection that spanned the 1,400 miles between Europe and the eastern seaboard of North America during much of the LGM (Hall, 2000).

Stanford and Bradley's hypothesis was criticised before any formal results or analyses were published. Straus (2000b) argued that due to the deep time separating the Solutrean from Clovis, the former was an "impossible" candidate for the latter. The argument was based on current dating, which placed Clovis 5,000 years after the end of the Solutrean culture. Figure 10 highlights this age gap while providing an overview of the major sites discussed and their relevant ages. This also highlights the pericontemporaneous nature of the Beringian and Clovis assemblages. Finally, it is also important to note that the dates from the Chesapeake Bay area are older than the dates for the Solutrean period. This is a major criticism of the hypothesis and is discussed below (O'Brien et al., 2014a).

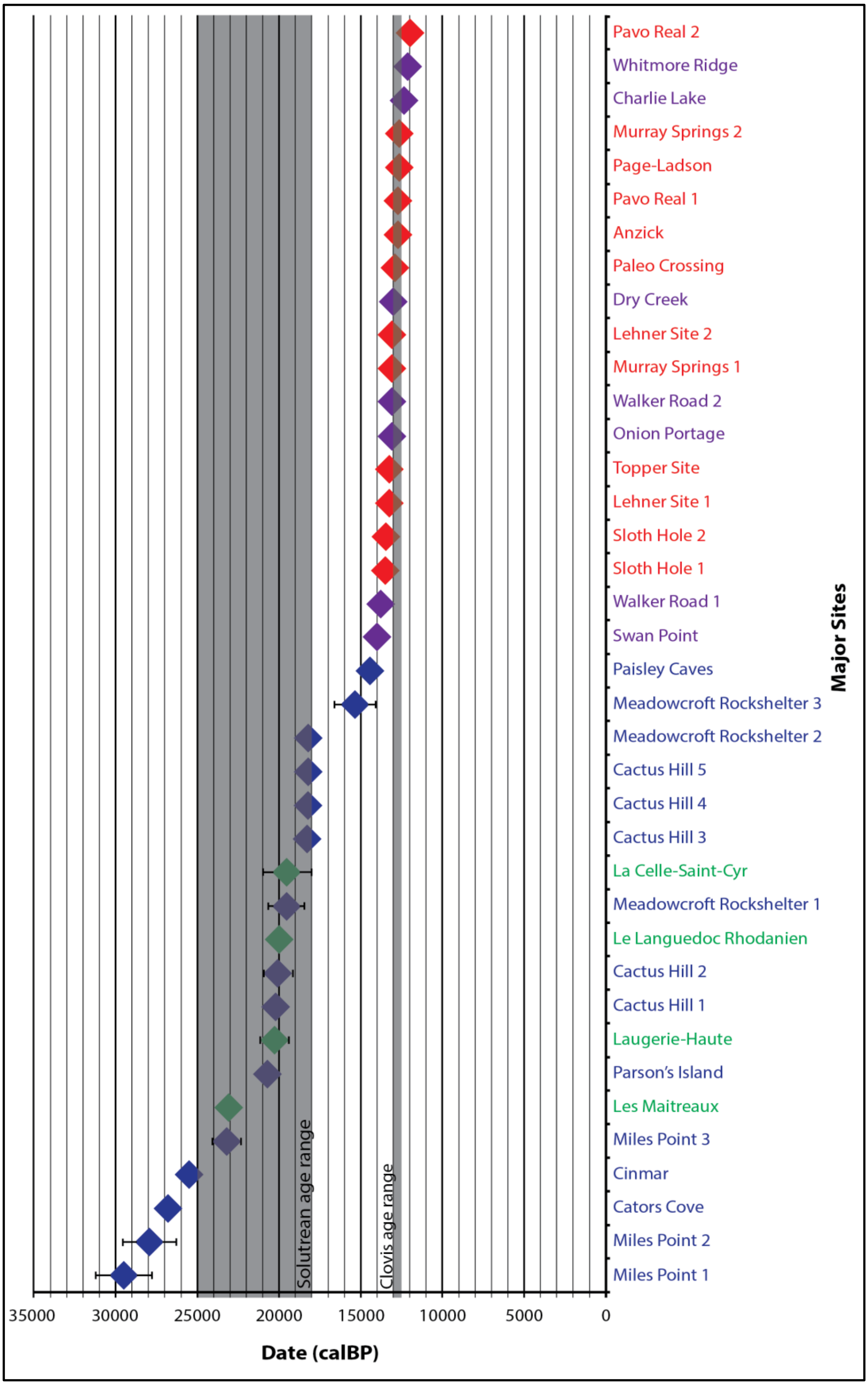

Figure 10. Annotated timeline indicating the ages (calBP) of the major sites discussed for older than Clovis (blue), Solutrean (green), Beringian assemblages (purple) and Clovis (red). The age range for the Solutrean (including the earliest established Solutrean dates) and Clovis assemblages is also shown.

Despite the unusual approach of criticising a hypothesis before it was published, Straus' (2000b) critique was highly perceptive. He broke down Solutrean chronology by region: France (20,500 to 18,500 calBP), Cantabrian Spain (20,500 to 17,000 calBP) and Portugal (21,000 to 16,500 calBP) (Straus, 2000a). When these dates were compared to carefully dated Clovis sites, which ranged from 13,000 calBP to 12,700 calBP, Straus (2000b) argued that the 5,000 year, 200 generations, gap was insurmountable. Additionally, differences in technologies, a lack of evidence for deep-sea fishing, and marine mammal hunting capabilities were cited as proof that it was impossible for any migrations to have taken place (Straus, 2000a).

Straus (2000b) also concluded that from the analysis of Solutrean technology, the groups of artefacts found in association with the Solutrean (e.g. laurel leaves, stemmed points, basally concave points, shouldered points, endscrapers, perforators, knives and burins) were not consistent with the bifacial points and blade technologies of Clovis. Straus (2000b) conceded that bone points and spear throwers were a part of both technological toolkits; however, the similarities were simply a function of converging solutions to similar problems. Again, this argument is based solely on typological categories of artefacts, ignoring the technological markers discussed by Stanford at the Santa Fe conference (Hall, 2000).

While Straus' (2000b) approach is not completely unsupported, it did not address the fundamental arguments of Stanford and Bradleys' work. This is not surprising considering that Straus (2000b), himself, admitted the material that he critiqued was taken from third party sources since there were no publications on the source material at the time. However, his critique set a precedent for most future criticisms of the Clovis-Solutrean hypothesis, including relying on typology not technology (Straus et al., 2005), and focusing on singular features of the hypothesis as a means of disregarding the entire body of work (Eren et al., 2013b).

Stanford and Bradley (Stanford & Bradley 2002; 2012; Bradley & Stanford 2004; 2006) focused specifically on highly controlled flaking techniques (including intentional overshot flaking), blade technology, which they described as "closer to Clovis than any other European Technology" and "virtually identical", and the bone, antler and ivory technologies. Alongside this, they considered incised stones and use of exotic raw materials to construct their hypothesis (Stanford & Bradley, 2002). In this respect, their article dealt specifically with technology, rather than just typology as used by Greenman (1963).

The chronological gap between the Solutrean and the Clovis was the first major criticism of the hypothesis that was addressed. It was addressed by examining the existing data from Meadowcroft Rockshelter and Cactus Hill (Stanford & Bradley, 2002). Meadowcroft Rockshelter in Pennsylvania contains deeply stratified cultural deposits that pre-date the Clovis period (Adovasio et al., 1978; Adovasio & Carlisle, 1982). Dating suggests that the shelter could be as old as 18,200 calBP (15,000 ^{14}C BP) (Adovasio et al., 1990). Haynes (1980) questioned these dates, arguing that samples were contaminated by coal residues in the groundwater; however a micromorphological analysis of the sediments found no evidence of groundwater contamination (Goldberg & Arpin, 1999). Stanford and Bradley (2002) also rebut this point, stating that none of this intense scrutiny has been applied to sites with charcoal dating in Alaska, where contamination and soil mixing are major problems. At Cactus Hill in Virginia, radiocarbon dates on white pine charcoal from one of the hearth features belonging to the earliest occupation of the site were between 18,200 and 20,200 calBP (15,000 and 17,000 ^{14}C BP). The eastern United States has the highest variability in fluted point types coupled with a significant number of archaeological sites (Stanford & Bradley, 2002). These technologies were very similar to the technology of the Solutrean with bifacial weapon tips that exhibited basal thinning (although not the typical Clovis fluting) as well as the similarities in the blade and blade core technologies (Stanford & Bradley, 2002).

The second major criticism to be addressed by Stanford and Bradley (2002; Bradley & Stanford 2004) was the issue of the geographical distance between Europe and North America. They argue that the pleniglacial seacoast along the European Coast would have been a resource-rich habitat for hunting and fishing. Further, sea temperatures would have been sufficient to support Atlantic cod, seals, and Great auks.

The third major criticism that Stanford and Bradley (2002; Bradley & Stanford 2004) addressed was the question of boats and maritime technology and capability. They cite Adovasio et al. (1996) who found that plant-fibre technology in the form of cordage, netting and textiles were being produced in Central Europe by 25,000 BP, suggesting that it is a reasonable assumption that the Solutreans were not only aware of this technology, but used it. They also address the issue of boats, stating that watercraft technology was in use at least 30,000 years before the Solutrean Period, and that the lack of direct evidence is not evidence that it was a technology outside the capabilities of the Solutrean craftsmen (Stanford & Bradley, 2002). Instead, this situation is similar to Australian archaeological assemblages, where there is also no direct evidence for maritime crossings, but other forms of evidence indicate exactly that (Stanford & Bradley, 2002).

The last consideration addressed by Stanford and Bradley (2002) was the route. Their proposed route along the Atlantic ice was made possible due to the fluctuating seasonal conditions present and the knowledge of the Solutrean groups, given their long history of habitation along the coast (approximately two thousand years). This habitation indicated the possibility that seasonal trips out onto the ice were frequently undertaken, and ultimately pushed farther and farther along the ice front. As the venture continued, the Solutreans exploited marine resources, both on the ice and in the sea, until a small group landed in the New World. These early pioneers likely took stories of the rich picking in the seas around New England back to their homeland, sparking more trips across the Atlantic ice (Stanford & Bradley, 2002).

In their conclusion, Stanford and Bradley (2002) acknowledge the data was not complete and stated that their intention was to spur debate and create opportunities for more research and encourage the academic community to think outside the present paradigms.

The 2002 book chapter was later published in a substantially modified version in World Archaeology (Bradley & Stanford, 2004). The article included more specific details about the lack of evidence forthcoming from Asia or Alaska and the technological capabilities of the Solutrean culture, which not only showed similarities but would have also made an Atlantic ice crossing viable.

In a 2004 book chapter in “The Settlement of the American Continents,” Geoffrey A. Clark (2004, p.104) “deconstructs” the North Atlantic connection based on three main problems: the chronological gap, the North Atlantic itself and Stanford and Bradley’s conception of what a Solutrean assemblage was. The chapter fails to make a single reference to the chapter published by Stanford and Bradley (2002). Further, like the early article by Straus, Clark’s (2004) paper makes numerous false assumptions pertaining to the precise data that was actually used to construct the Solutrean-Clovis hypothesis. Clark's chapter also covers many of the same arguments presented by Straus (2000b).

Clark's (2004, p.106) first critique focused on several conceptual problems relating to the study and definition of archaeological groups and cultures as defined between North American and European archaeologists. He argues that the concepts of a "culture" are constructed around different frameworks and that we have to recognise the implicit bias, preconceptions and assumptions when it comes to defining what constitutes a specific culture. Presumably, these traits are a reflection of the archaeological tradition in which the researcher was taught although Clark does not establish this, but instead reflects on how often the two are conflated, particularly by Stanford and Bradley (Clark, 2004, p.106). Clark (2004, p.106) proceeded by addressing the concept of culture. He explains that the formal similarities between Clovis and Solutrean are, "...explained entirely and parsimoniously by functional requirements and technological convergence"; however, he offers no evidence to support this view.

Clark's argument like Straus' was based on a typological perspective, discussing biface tool concepts as one complete "package" that is known and utilised by various groups across space and time. This was not the perspective that Stanford and Bradley used in their 2002 chapter, nor was it in their 2004 article or in *Across Atlantic Ice* (Stanford & Bradley, 2012). Instead, their focus was based on the technological traditions and methods of manufacture (Stanford & Bradley 2002; 2012; Bradley & Stanford 2004; 2006), not simply on what type of tool occurs in the archaeological record. Clark (2004, p.106) sees this typological assessment of culture as a European perspective, although numerous North American archaeologists have used exactly the same perspectives in their own research (*see* Turner & Hester 1999).

If neither Solutrean nor Clovis populations were identity conscious, then both groups operated in a fluid and constantly changing paradigm which was renegotiable (Clark, 2004, p.108). Referring back to Bordes argument that stone can only be worked in a few ways (Bordes et al., 1964), Clark also argues that there must be a certain level of equifinality in the archaeological record (Clark, 2004, p.108).

Clark's (2004, p.109) argument asserted that cultures should not be defined by typology alone. "…that the assumption that there are tool making traditions and that these are passed on through generations and are archaeologically visible are essentially a history projected back into the Pleistocene and hence, similarities can be explained without reference to typologically based stone tool traditions and the preconceptions, biases, and assumptions upon which these are based". This argument must also be used as a criticism for any hypothesis asserting connections between Asia, Alaska and North America. There is simply not enough evidence to conclude that, based on typology alone, Clovis origins can be found in Asia. While heavily weighted against Stanford and Bradley, Clark's work must be applied equally to all aspects of the first Americans.

In his conclusions, Clark (2004, p.112) states that the hypothesis is difficult to sustain under these conceptual arguments based on a post-hoc, accommodative argument (developed after an analysis has been completed), and assumptions about these cultures based on typology is problematic and should be subjected to critical scrutiny. This conclusion overtly states the inherent contradiction within Clark's work, as the current Asian route is based on exactly the same factors that he uses to "deconstruct" the Atlantic hypothesis, yet levels no criticisms towards this body of research.

Finally, it seems counter-intuitive to suggest that it is wrong to develop post-hoc accommodative arguments. Scientific progress is achieved through observations, generating a hypothesis, then gathering data, and publishing those findings for others to critique and to test. Nevertheless, post-hoc accommodative arguments have a long history of development in archaeology; while this approach is not condoned it has to be recognised. Stanford stated in his presentation during the 1999 Clovis and Beyond conference that their hypothesis arose out of a lack of evidence (their observations of a lack of Clovis looking material in Asia/Siberia and commonalities seen in the Solutrean technologies of Europe) from the continued exploration of Alaska, Beringia and Asia (Hall, 2000). While their hypothesis was not clearly formulated, it is an incorrect supposition by Clark to assume they are just placing a theory on to the data. It is negligent of Clark to critique a hypothesis without referencing the 2002 work by Stanford and Bradley. Clark offers little in his conclusion about what the alternative should be, but to start with theory first, before any data collection, which would be the logical opposite to Clark's post-hoc accommodative model pushes archaeology beyond any reasonable scientific process. It is interesting that Clark later published in a conference book on science in archaeology lamenting the state of science in American archaeology (Clark, 2007).

Straus, Meltzer and Goebel published the first response to an article on the Clovis-Solutrean hypothesis in 2005. Straus et al. (2005) stated their 'belief' that there were far more reasonable and parsimonious alternatives for the "few" formal similarities that existed between Clovis and Solutrean technologies. They began their discussion by assuming, for the sake of argument, that the hypothesis is correct. They state the following about the Solutreans:

> "…their landfall would have reverberated for centuries, and, indeed, millennia afterward through their material culture, not to mention in their genes and languages, in so far as those can be detected among descendant populations." (2005, p.509)

Moreover, Straus et al. (2005) contend that:

> "For this colonizing Solutrean group would have carried with them the full code for reproducing their culture. Every tool and artefact they and their descendants produced would have been determined by this knowledge. To be sure, new forms and technologies would have been invented over time, but in the early centuries and millennia of settlement, their roots in Solutrean Europe would be deep and unmistakable. Thus we should not see just one or a few similarities between the artifacts of America and Europe; we should see scores of them. We should see similarities not just in functional items (e.g. end scrapers), but also in the kind of culturally distinctive technologies and stylistic attributes humans use to mark who they are and the peoples to whom they belong (e.g. forms and manufacturing strategies of projectile points, which can be elaborated in culturally distinctive ways, beyond their minimal functional requirements). And we should not just see an instant abandonment of forms and attributes characteristic of the material culture they brought with them, but instead a series of evolutionary changes in the material culture occurring in different forms at different times, as old forms were adapted to new situations. All of this is in contrast to a situation in which two assemblages are historically unrelated." *(2005, p.509)*

While this assumption is correct in its logic, and Stanford and Bradley agree with this statement (Bradley pers. comms. 2013), it should be applied in the same manner to all arguments for a Clovis antecedent. Thus, the aforementioned statement on colonizing populations can be rephrased to fit any colonizing population. According to Bradley:

> "For this colonizing **Asian** [sic, emphasis his] group would have carried with them the full code for reproducing their culture. Every tool and artefact they and their descendants produced would have been determined by this knowledge. To be sure, new forms and technologies would have been invented over time, but in the early centuries and millennia of settlement, their roots in **Palaeolithic Siberia** [sic, emphasis his] would be deep and unmistakable. Thus we should not see just one or a few similarities between the artifacts of America and **Asia.**" [Sic, emphasis his] (Pers. Comms. 2013)

This appears to be the same standard set by Clark (2004), whereby the critical arguments against the Clovis-Solutrean hypothesis need not be applied to the study of an Asian or Pacific coastal route. Despite numerous claims that there is no doubt Clovis came from Asia (Goebel et al., 1991) any solid evidence is still missing. This claim is reiterated by Straus et al. (2005) in their rebuttal of the hypothesis, again without presenting any solid data.

Straus et al. (2005) argue that the technological arguments presented by Stanford and Bradley (2004) are subjective assertions that are empirically unsubstantiated. They contend that even with a cursory glance at any bifacial assemblage, overshot flake scars can be found across temporal and spatial industries; and so, they are not exclusive to Solutrean or Clovis (Straus et al., 2005). This, coupled with the fact that overshot flaking only appears on certain Clovis specimens (approximately 12% in their assessment), was interpreted by Straus et al. (2005) as indicative of the fact that not all Clovis technology involved the use of overshot flaking, and that not all overshot flaking was Clovis or Solutrean. They did concede that subsequent flaking and edge trimming might have removed traces of overshot flaking. While this argument is valid, it does not address the argument that Stanford and Bradley (2002; Bradley & Stanford 2004) presented in either of their two previous publications.

Bradley and Stanford (2004) argued that overshot flaking was a specific and intentional action used by Clovis and Solutrean knappers at certain times during the manufacturing process; they never claimed that only Clovis and Solutrean industries featured overshot flaking, or that all of Clovis technology involved overshot flaking. In this respect Straus et al. (2005) appear to be interpreting the hypothesis as they perceive it, rather than addressing actual claims of the hypothesis itself.

The blade technologies from each culture were also assessed by Straus et al. (2005), who note that Stanford and Bradley are not specific about their claims for an almost identical technology. They discuss the fact the long blades are only found in specific areas in the United States, and that the Cantabrian region of Spain is conversely limited to only a few specimens that could be described as long blades. Microblades, or small blades, have been recovered from Clovis sites and these were used to indicate a connection to Asia (Straus et al., 2005, p.512). Again, Straus et al. (2005) seem to have misinterpreted the explanations given by Stanford and Bradley (2002), who refer to similar methods of precore shaping, setting up the core face and blade detachment techniques.

The arguments that Straus et al. (2005) make concerning the lack of other technological characteristics, such as burins, echoing previous statements by Straus (2000b) and Clark (2004) also reflects assumptions made by the authors. This argument appears to stem from the understanding the Solutrean groups moved their entire technology and social systems across the Atlantic. This is problematic as Stanford and Bradley (*see* Stanford & Bradley 2002; Bradley & Stanford 2004) never made this claim and demonstrates the misunderstanding by Straus (2000b) and Clark (2004). Straus et al. (2005) also discuss the lack of heat-treating in Clovis technology, a point that Bradley and Stanford also discussed. This argument raises further questions about flint knapping and production, specifically concerning issues around whether or not prehistoric knappers heat treated chert for technological reasons, cultural reasons or a mixture of the two. High-quality chert usually does not require heat-treating. Thus, it is unclear whether an industry would heat treat material unnecessarily.

Despite some of their apparent misinterpretations of Stanford and Bradley's hypothesis, Straus et al. (2005) raise a number of relevant issues regarding art and the use of marine resources. Referencing Cannon and Meltzer (2004), Straus et al. (2005) refer to a lack of any evidence of faunal species that inhabited landscapes close to water resources or marine resources. They identify only two sites (Aubrey and Minisink) with faunal remains linked to wet environments (Straus et al., 2005). This implies that a new colonizing wave of people into North America abandoned the coastal environments with which they were familiar.

This proposition raises obvious questions about the nature of the pre-Clovis material; and, Straus et al. (2005) state that the chronological gap requires pre-Clovis material. As with all the arguments presented and discussed above, this critique must be applied to any route coming from Asia and Siberia into Beringia and North America. For example, the Pacific coastal route would also require marine adaptations; and, while shell middens have been found, they date to the post-Clovis period (Erlandson et al., 2011).

Straus et al. (2005) conclude their critique by reviewing the existing evidence from Beringia including, the Nenana, Tanana, Ushki and Siberian Upper Paleolithic. They assert that both bifacial and blade technologies (although, not the typical large cores associated with Clovis) were found in the assemblages from the Beringia (Straus et al., 2005). They also highlight two sites which feature overshot flaking: Ust'-Kova (located along the Angara River in Irkutsk Oblast, Russia) and Berelekh (located along the Berelekh River, a tributary of the Indigirka River, Sakha, Russia) (Goebel 2004). However Bradley and Stanford's (2006) examination of the overshot illustrations provided by Goebel (2004) revealed that they do not exhibit any form of overshot flaking on the bifaces. Further, in Goebel's (2004, p.341) Berelekh example, the dating is highly suspect, as the samples cannot be unequivocally tied to the assemblage. This example might feature an overshot scar, but it has been obscured by the removal of other flakes. If the point in question was re-sharpened, the flake would appear to be overshot as it extends across the midline. There is also a basic misunderstanding of overshot flaking which can lead to general "across the midline" thinning flakes (see chapter 4) to be misidentified as overshot flakes.

Neither example can be used to identify overshot flaking as an intentional biface reduction technique in Palaeolithic Russia. With regards to the blade and bifacial technology, Straus et al. (2005) revert to the premise of identifying similarities based upon typology alone (e.g. the production of both blades and bifaces). This line of evidence is exactly what they argue against at the crux of the Atlantic Ice hypothesis.

Bradley and Stanford's (2006) reply to Straus et al. confirmed some of their claims, including the acknowledgement of the need for a deeper discussion and analysis of pre-Clovis materials; however, they also suggest that Straus et al. fail to recognise that the sites they present post-date pre-Clovis when reporting on the Beringian material (Bradley & Stanford, 2006). The two main areas that Bradley and Stanford (2006) focus on in their reply is the understanding of technology, in terms of flaked stone tools, and the notion that all things Solutrean should be reflected in Clovis assemblages.

Bradley and Stanford (2006) recognise the fact that vast amounts of archaeological data may be buried on the sea floor beneath the Atlantic Ocean on both continents, but they argue that the same issue confronts every theory concerning the first peopling of the Americas. They contend that the arguments made by Straus et al. should also be applied to sites from Asia, Siberia and Beringia. The example they use is the Page-Ladsen site which is heavily criticised by Straus et al. (2005), but the artefact associations with the dating are no worse than those claimed for Berelekh (Bradley & Stanford, 2006). They also address the issue of distance, as this is often cited as a flaw in the theory (Straus, 2000a; Clark, 2004; Straus et al., 2005). Estimated measurements of distance are presented by Bradley and Stanford (2006) for Isturitz to Cactus Hill (from Europe) and Dyuktai to Cactus Hill (from Beringia). By their estimations, the journey from Dyuktai to Cactus Hill is approximately 64% longer than the crossing from Europe; and, it would cover a substantially longer stretch of ocean ice-front (Bradley & Stanford, 2006).

Another major factor of the Clovis-Solutrean hypothesis is the ocean voyage and the extent of the North Atlantic ice sheets (Stanford & Bradley 2002; 2012; Bradley & Stanford 2004; 2006). In a review of the North Atlantic conditions during the LGM, Westley and Dix (2008) concluded that there were a number of obstacles to the hypothesis which should be recognised. They concluded that, based on new data, the extent of the ice sheets, along with the timing of its maximum extent, may not have occurred precisely during the Solutrean period in Europe, this coupled with winds and weather patterns that were against the direction of migrations and a less productive sea environment than Stanford and Bradley claim suggests that any Atlantic ice crossing was impossible (Westley & Dix, 2008, p.94).

Additionally, Bradley and Stanford (2006) state that several criticisms are based on an understanding of flaked stone tool that is too simplistic, repeating the issue of typology versus technology. The Straus et al. (2005) article, like the previous articles by Clark (2004) and Straus (2000b) presented arguments based on the typological assessment of the Solutrean and Clovis cultures.

Thus, Bradley and Stanford (2006) reiterate the fact that only Clovis and Solutrean incorporated overshot flaking into their production repertoire. They take this work further by conducting a study of biface illustrations, (*see* Kozlowski 1990; Bouzouggar et al. 2002), concluding that only around 1.7% of all bifaces retain overshot flake scars (Bradley & Stanford, 2006). An analysis of a further five publications (Bordes, 1961; Heinzelin de Braucourt, 1962; Lumley, 1976; Singer & Wymer, 1982; Wymer, 1982) reveals that around 17 out of 338 bifaces illustrated have overshot flaking (approximately 5%). When this data is added to Bradley and Stanford's data, 23 overshot flake scars can be identified from 712 bifaces across both the Middle and Upper Palaeolithic (approximately 3%). This strengthens the argument that while overshot flaking does occur during other periods and other methods of manufacture (a point that Bradley and Stanford never disputed), there was not a systematic use of this flaking method. Only in Clovis and Solutrean assemblages is it identified as a purposeful and intentional flake removal technique.

Bradley and Stanford (2006) then study both Clovis and Solutrean bifaces and conclude that overshot flaking is far more common, ranging from 6% to 42% for Clovis and Solutrean assemblages. This is confirmed for Clovis by an analysis conducted at the Gault site in Texas, where approximately 40% of all Clovis bifaces retain one or multiple overshot flake scars (Velchoff pers. comms. 2013).

Bradley and Stanford (2006) also confronted the misunderstandings or misinterpretations of the data with respect to the blade assemblages. Bradley and Stanford (2006) contend that the small blades (bladelets) present in Clovis and pre-Clovis assemblages do not stem from the same tradition of manufacture and technology present in Asia due to the differences in core shaping, preparation and flaking techniques (Bradley & Stanford, 2006). Finally, Bradley and Stanford (2006) present a cluster analysis based on several key technological attributes that confirms the many similarities that exist between Clovis and Solutrean, which simply do not exist in Beringian material.

Stanford and Bradley's (2012) book, "Across Atlantic Ice", represents the combined data and analyses regarding the Clovis-Solutrean hypothesis. Its publication renewed interest in the transatlantic connection, both positive and negative; and, this acclaim was not just received from the archaeological community, but also from a wider academic and public audience. This is demonstrated by the number of reviews published on the book, from the Journal of Field Archaeology to the Washington Times (Kopper, 2012; Shea, 2012; Runnels, 2012; Curry, 2012; Balter, 2012; Lepper, 2013a, 2013b; Bamforth, 2013; Dennell, 2013).

Eren et al. (2013) published an article claiming that overshot flaking was a manufacturing mistake. Their refutation to Stanford and Bradley's book was based on the experimental replications of Clovis bifaces by two of the authors. In their opinions, this evidence discredited the entirety of the Clovis-Solutrean hypothesis. However it reveals another apparent misunderstanding or misinterpretation of Stanford and Bradley's hypothesis and the claims therein.

The main argument that Eren et al. (2013) present is that overshot flaking was not the most effective means of thinning a biface, and represents a difficult technique that was not the most optimally effective technique. Furthermore, the lack of overshot flakes in Clovis sites indicates that all overshot flakes must be mistakes, thereby discrediting Stanford and Bradley's hypothesis (Eren et al. 2013). The majority of these arguments, as discussed by Lohse et al. (2014), are constructed from a misinterpretation of the evidence presented by Stanford and Bradley, who never claimed overshot flaking to be the only technological similarity or that it was optimally effective at thinning a biface. Like previous articles (Straus, 2000b; Clark, 2004; Straus et al., 2005) the paper by Eren et al. (2013) skewed the logic presented by Stanford and Bradley and reduced the entire hypothesis down to a singular principle and then based an entire research project on dismissing this principle. In a reply to Lohse et al. (2014), Eren et al. (2014) argue that there experimentation using overshot flaking provides unequivocal, empirical data. The major issue with their experiments remains the fact that rather than reducing a piece of raw material, they selected preformed bifaces and ignore the use of overshot flaking as a method of square-edge removal as discussed by Bradley et al. (2010). This does not rule their data invalid, but by focusing only on one aspect, it cannot be used to refute the entire hypothesis.

The most recent criticism of the hypothesis was presented by O'Brien et al. (2014a). While they provide many of the same unsubstantiated criticisms of technology presented in previous critiques, they raise a valid assessment of the older than Clovis dates reported from the Eastern seaboard associated with the bi-pointed laurel leafs (O'Brien et al., 2014a). O'Brien et al. (2014a) argue that the dates from the Chesapeake region are older than those reported for the Solutrean and so cannot be the ancestral root of the technology. In a response to this challenge, Stanford and Bradley (2014) present an updated chronology for the region indicating that the archaeological finds are from the stratigraphic levels that do not predate the Solutrean and that some of the dates (Figure 10) relate to sedimentary dates and not specifically to the artifacts. While this update does address some of these issues, Figure 10 highlights the fact that the older dates still provide a timeframe that extends backward beyond the Solutrean period. This issue remains unresolved and while it may be due to the provenance of the artifacts and the use of OSL dating on the geological sediments, further archaeological testing is required to establish their associated age.

Further analysis of this dating is presented in chapter 8. O'Brien et al. (2014a) also criticise Stanford and Bradley for using cluster analysis as it is only informative regarding overall similarity and not historical relatedness. This ignores the issue that this same method was used by Goebel et al. (1991) to make the same claims about Beringia. They argue instead for the use of cladistics, phylogenetics, and parsimony trees (O'Brien et al., 2014a). While this method of analysis is increasingly being used in archaeological analysis (O'Brien et al., 2001; Buchanan & Collard, 2008) it has been critiqued for placing undue emphasis on data exploration in phylogenetic inference (Grant & Kluge, 2003). This methodology places undue emphasis on formal groups while hiding other groups which effectively misconstrues the data (Grant & Kluge, 2003). Farris (2014) also argues that this analysis can create misdirection as homology (the shared similarities or traits) does not equate to synapomorphy (a shared trait inferred to have been present in the most recent common ancestor). Thus, the method proposed by O'Brien et al. (2014a) has the same issues with regard to historical relatedness that the cluster analysis used by Stanford and Bradley (2012) has.

In a final response, O'Brien et al. (2014b) argue that the hypothetical possibilities presented by Stanford and Bradley should not be construed as facts in need of disproving and that "…there is no evidence that supports the Solutrean 'solution'". The major issue here is that, as a hypothesis, it should be critically assessed, and while O'Brien et al. (2014) do raise a valid critique, they do not address the revised dates provided by Stanford and Bradley (2014).

Furthermore, while O’Brien et al. (2014) cite recent DNA evidence (*see* Rasmussen et al. 2014) concerning the Anzick burial, they ignore the fact that the dating for this possibly Clovis burial occurs towards the end of the Clovis period, and that along with the technology, Beringia still remains a presumed entry route into the New World, with no data to support this theory.

Summary

Hall claims that the hypothesis presented by Stanford at the Clovis and Beyond Conference was profound (Hall, 2000, p.3). It has ignited a renewed effort to identify the first Americans. The hypothesis has also highlighted numerous issues within American archaeology. Many researchers in North America appear fixated on outdated and unsubstantiated paradigms. Ironically, Straus et al. (2005) recount the case of Alfred Wegener in the introduction of their article. Wegener proposed the theory of continental drift, an “outrageous” claim that was ignored for forty years until new evidence proved its accuracy.

Thus it becomes clear that only by a systematic analysis of the hypothesis itself can any progress be made toward acceptance, modification, refinement or rejection. This thesis analyses one aspect of the Solutrean-Clovis hypothesis, the blade manufacturing technology. As an isolated body of research, the similarities and differences in the blade technologies of the Clovis and the Solutrean cannot provide archaeologists with the whole truth. But, it may be used within a larger framework of analytical studies to assess the validity of the hypothesis.

Chapter 4
Across Atlantic Ice: The Data

The previous chapter discussed the history of the Clovis-Solutrean hypothesis as well as its major criticisms. This chapter focuses on the observations and data that are presented by Stanford and Bradley (2012), and specifically the blade and blade core manufacturing data. It also synthesises the remaining data and its applicability to this research. It is important to note that the Clovis-Solutrean hypothesis pertains specifically to the origins of Clovis in North America and not to all peopling of the Americas.

Constructing the Solutrean-Clovis hypothesis

Stanford and Bradley (2012) begin by outlining some of the basic assumptions in their hypothesis. According to Kuhn (1962, p.44), science is the inspection of paradigms, aided by assumptions. The first assumption made by Stanford and Bradley (2012, p.149) is that the more complex a process of production between two assemblages, the higher the likelihood that they are historically related. What is the probability that two assemblages originate from a common point, a common ancestral culture. In flaked stone technology, a greater level of generalised similarities increases the likelihood of independent invention. Conversely, a more complex process is less likely to have been developed independently, particularly as more choices become available (Stanford & Bradley, 2012, p.150). This assumption focuses on how independent invention can be assessed. Complex biface thinning appears around 25,000 years ago; therefore, archaeologists must determine if biface thinning was a product of invention, importation or just a resurgence of older ideas (Stanford & Bradley, 2012, p.150).

Stanford and Bradley's (2012, p.150) rationale for identifying the correct process of origination is based solely on identifying characteristics within the archaeological record. For example, if there was local invention or innovation, then there should be a developmental sequence in the assemblage that indicates its invention. If the technology was imported to the region, then there should be evidence of an earlier example elsewhere, which was then brought into the region. Finally, if it represents resurgence, then it would be necessary to trace the culture back through time and space, documenting each technological process.

Stanford and Bradley's (2012, p.150) second assumption is that stone tools were produced for the same basic suite of requirements by people world-wide; and that, if a new tool was required, knappers would first operate within their normal flaking traditions to create it. This view was supported by the work of Patten (2005), who argued that technological innovation and invention was the result of a consensus by the population. Any new ideas must fit within the existing technological paradigm (Patten, 2005). Stanford and Bradley (2012, p.150) argue that the theory of processual archaeology contributes little to the understanding of stone tool technology. Independent invention of the same technology is possible as a shared adaptive response to similar conditions, such as environmental change or raw material availability (Stanford & Bradley, 2012, p.151). In essence this processual argument encapsulates the arguments for convergence. The counter-argument to this is that people would have imposed their traditions on a new situation first, before radically altering anything (Stanford & Bradley, 2012, p.151). This concurs with the ideas presented by Patten (2005).

The major problem with the processualist view lies in demonstrating that the technological adaptation represents an inherent change within one group of people and their technology alone within a specific region. More often, external factors contribute to technological change. An example of this can be found in the transition from small blades to long blades during the Late Upper Palaeolithic in Britain, where the first half of the period (approximately 13,000 BP to 12,000 BP) is defined by small retouched bladelets, known as Cheddar points (Garrod, 1926; Jacobi, 1991, 2004); while the second half of the period, during and after the Younger Dryas, was dominated by long blades (Barton & Cunliffe, 1992; Conneller, 2007). These environmental changes may have been the catalyst for this technological change; however, more recent research on this period has revealed that earlier technologies represent a culture group strongly associated with the Magdalenian of France, while later technologies were dominated by culture groups moving westward from Germany and the Federmesser culture (Conneller, 2007; Jacobi & Higham, 2009).

With their assumptions outlined, Stanford and Bradley (2012, p.152) state their opinion that Clovis stone tool technology is distinctive, highly-developed and complex; and as such, it must have an antecedent with a significant history. The statement concerning Clovis as a complex technology is supported by other studies of Clovis technology (Collins, 1999; Kilby, 2008; Boldurian & Hoffman, 2009; Bradley et al., 2010; Smallwood, 2010; Jennings et al., 2010; Waters et al., 2011b). Stanford and Bradley (2012, p.152) then outline the three technologies present during the LGM that chronologically could represent an ancestor to Clovis.

The first stone tool tradition considered was from Beringia. Assemblages there consisted of inset blades and thick bifacial technology. The second is the blade technologies of Asia, and the final possibility is the thinned bifaces and blade technologies of south-western Europe (Stanford & Bradley, 2012, p.152).

While the focus of this research is on the blade technologies of Clovis and Solutrean, the concepts within the bifacial reduction strategies are key to understanding the technologies present during the LGM. The most important is the concept of biface flaking strategies, where flakes are purposefully removed from a biface with the specific aim of achieving a particular outcome. These individual strategies (outlined below) have been well documented in the literature (Smith, 1966; Callahan, 1979; Bradley, 1982; Bradley et al., 2010; Stanford & Bradley, 2012).

As noted in chapter two, there is a difference between typology (description) and technology (process). The definitions outlined below are based more on typological descriptions (in this case flake pattern) than on the technological processes that define a technology. The following assessment of these reduction strategies is based on determining each biface’s width to thickness ratio; the higher the ratio, the thinner the biface. Bifaces can generally be proportionally flaked, thinned or thickened (Figure 11). Each strategy requires specific techniques and produces bifaces with significantly different width to thickness ratios. For proportional flaking, flakes are removed that only slightly cross the longitudinal midline of the biface and result in width to thickness ratios of between 3:1 and 4:1.

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Figure 11. Flaking patterns in biface reduction. From Stanford and Bradley (2012, p.27)

For thinning, flakes are removed that cross the thickest area of the biface, or in some cases, dive just over the edge of the opposite margin. Figure 12 illustrates flaking patterns as described by Stanford and Bradley (2012, p.26). This process can be achieved via three main types of flaking (Figure 12);

diving flaking, full-face flaking and overshot or outré passé. In diving flaking, a flake is removed with the intention of stepping or hinging near the midline of the biface, a flake is then removed from the opposite margin to remove this step or hinge. The creation of this hinge near the midline, if accomplished in the same location on both faces, means that the finished biface may be thinner in the middle than it is along the margins. Full-face flaking involves removing flakes that travel across the midline, but stop just short of the opposite margin. In overshot or outré passé flaking, a flake is driven across the biface to remove a portion of the opposite margin. To be considered a thinning process the resulting width to thickness ratios must be greater than 4:1.

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Figure 12. Flaking patterns identified by Stanford and Bradley. Proportional flaking – flaking just past the midline (1); full face thinning flaking (2); overshot flaking (3); to or just before the midline flaking (4); alternatively 4 could also be used in diving flaking which thins the central axis. After Stanford and Bradley (2012, p.27)

Finally, for intentional thickening, flakes are removed only to the point of maximum thickness of the biface and no further. As this technique requires flakes to stop at or before a set point, this process can often be as difficult a technique to master as any of the thinning techniques (Stanford & Bradley, 2012, p.26).

This description is not the only technological assessment of bifacial flaking technologies (*see* Smith 1966; Callahan 1979; Bradley 1982; Bradley et al. 2010; Stanford & Bradley 2012; Smallwood 2012; Jennings 2013; Eren et al. 2013), but this specific concept is the one presented by Stanford and Bradley (2012, p.152) when they discuss the thick bifacial technology of Beringia and the thinned bifaces of Europe.

Quantitative Analysis

Stanford and Bradley (2012) performed both quantitative and qualitative comparisons of their data. For the qualitative analysis, two statistical tests were conducted. The first test was a dynamic systems analysis and the second was a cluster analysis. Before beginning these analyses, Stanford and Bradley (2012, p.152) noted the limitations of the available data, namely sites with small sample sizes, sites with poor preservation and, in some cases, sites with poor excavation strategies. Crucially, Stanford and Bradley (2012) are not overtly clear on exactly what assemblages were used in the analysis of these industries. This raises issues with repeatability in the analysis and would require the disclosure of a complete list of data.

In both forms of analysis, the technological traits present in each assemblage were identified, and their presence or absence for each technology was recorded. Dynamic systems analysis was then used to assess the corresponding traits between two production systems. In this type of analysis, the characteristics at the top represent the beginning of the sequence and those at the bottom represent the end of the sequence. For complex bifacial thinning it is interesting to note the some of the more complex techniques are conducted towards the middle and end of the sequence. Stanford and Bradley (2012, p.155) conclude that correspondences at the top of this system may be fortuitous; however, those that remain similar nearer the bottom of the chart represent an increasing likelihood that the two systems are historically related.

For this analysis, Stanford and Bradley (2012, p.155) compared the following primary flaking attributes: material, modification, method, technique, platform preparation, sequencing and spacing. Method, technique, basal treatment and finishing were then grouped together in the secondary flaking attributes. Stanford and Bradley (2012, p.155) found that the primary and secondary flaking attributes were aligned from top (primary) to bottom (secondary), and hence from simplest to most complex. A Dynamic systems analysis chart (Figure 13) was then used to compare the following reduction strategies: Beringian to Clovis, Beringian to Solutrean and Clovis to Solutrean.

The results from this analysis clearly show similarities between Solutrean and Clovis biface manufacturing (Stanford & Bradley, 2012, p.156). Ten out of the eleven attributes (91%) were identical in their comparison of Clovis to Solutrean, while only five (45%) matched for both Beringian-Clovis and Beringian-Solutrean comparisons. The one attribute not shared between Clovis and Solutrean was the basal treatment, where Solutrean technology indicates lateral thinning and Clovis technology indicates basal fluting (Stanford & Bradley, 2012, p.157). Additionally, Stanford and Bradley (2012, p.157) discussed a slight difference in the final stages of flaking, where Solutrean bifaces show a tendency for diving flaking. This analysis was only conducted for the bifacial technologies present in each industry.

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Figure 13. Dynamic systems analysis performed by Stanford and Bradley (2012, p.156)

Recently, Darmark (2012, p.262) discussed the apparent development of pressure flaking that occurred around 20,000 BP, in both the Solutrean and the Dyuktai. Her reasoning for this contemporaneous appearance is the apparent time span between humans reaching Eurasia and establishing their own technology, which is unlike European bifacial technology, and the independent invention and subsequent development of pressure flaking (Darmark, 2012, p.262). This proposal raises an interesting point that was not considered by Stanford and Bradley in their dynamic systems analysis. In the secondary flaking group, all three cultures shared the complex technique of bifacial pressure flaking (Stanford & Bradley, 2012, p.156). However if this was an independent invention, then while this attribute is a commonality, it may not share the same technological historical roots in terms of the overall flaking repertoire. So, any perceived connection would be based solely on two unrelated events that independently produced the same technique. This is an important points as it applies equally to both the Beringian and Solutrean systems outlined by Stanford and Bradley (2012, p.156).

The second stage of the qualitative analysis was a cluster analysis. In this approach, Stanford and Bradley (2012, p.159) analysed a range of both typological and technological characteristics to complete two cluster analysis dendrograms. The first cluster analysis dendrogram of typology placed the fluted point traditions (e.g. Clovis of North America) with the Middle French Solutrean, Late Dyuktai, Late French Solutrean and North Spanish Solutrean (Figure 14). The analysis also placed pre-Clovis with Ushki/Early Dyuktai, Mesa/Sluiceway, Nenana and Denali (Stanford & Bradley, 2012, fig.6.3). These results came as a surprise to Stanford and Bradley as pre-Clovis grouped with the Beringian material, but concluded that small sample sizes and the reliance on typologies skewed the data. They further reasoned that the results could also come from similar functions or a pre-Clovis contribution to Beringian technologies. They point to the lack of association between the Late Dyuktai and the Denali as another indicator of the flaws with using only typological criteria for this analysis (Stanford & Bradley, 2012, p.159).

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Figure 14. Typological cluster dendrogram. After Stanford and Bradley (2012, p.160)

The second cluster analysis dendrogram focused specifically on flaking technology (Figure 15). In this analysis, fluted point traditions clustered to the Middle and Late French Solutrean and to the Northern Spanish Solutrean, while a second cluster included Nenana, Mesa/Sluiceway, Ushki/Early Dyuktai, Denali, Late Dyuktai (Stanford & Bradley, 2012, p.161). The Early French Solutrean as well as the French Magdalenian and Gravettian formed a second level cluster with the Beringian material, while only pre-Clovis relates at this level to the Solutrean and Clovis material. Stanford and Bradley (2012, p.161) interpret this as three distinct technological traditions. The first is present in Beringia, while the other two existed in Europe. More importantly it is one of the European traditions, the group that includes the Middle and Late French Solutrean and the Northern Spanish Solutrean that has a western expansion that includes North America. The final point is that the second European group, that consists solely of Upper Palaeolithic blade traditions (Early French Solutrean, French Magdalenian and Gravettian) has more in common with the Beringian material, which they conclude is the probable result of a common ancestral technology (Stanford & Bradley, 2012, p.161).

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Figure 15. Technological cluster dendrogram. After Stanford and Bradley (2012, p.160)

Kajiwara (2008) drew a connection between the microblade reduction strategies present in Europe and how these industries, which included the Aurignacian of Europe, were ancestral to the techniques in East Eurasia. It is this possible common ancestry to which Stanford and Bradley allude (2012, p.161). This research indicated that a blade manufacturing tradition, following similar core preparation and flaking practices, spread across large areas of the world. It is probable that this dispersal was coupled with the spread of modern humans (Mellars, 2006). Alongside this, Otte and Noiret (2002) argued that the Solutrean Period could be subdivided into two phases, the first was described as the Proto-/Early Solutrean, and was connected to the Gravettian of the northern plains in France and Belgium. The second phase of the Solutrean was described as the Middle/Later Solutrean, representing a later stage in population migrations, with the technology moving from North Africa through Spain and into France (Otte & Noiret, 2002). This was later expanded by Renard (2011); although, her interpretation of the data indicated local level adaptations that integrated both Gravettian and Solutrean technological traits. These ideas correspond with many of the interpretations presented by Stanford and Bradley concerning distinct cultural traditions.

Qualitative Analysis

The next stage of analysis conducted by Stanford and Bradley focused on the qualitative cultural comparisons between Clovis and Solutrean. This included both a typological and technological assessment of the tools as well as other archaeological components found at Solutrean and Clovis sites. The first data analysed by Stanford and Bradley is that of the stone tool types:

*Endscrapers (*Figure 16*):* Stanford and Bradley (2012, p.162) focus on the production techniques of three types of endscrapers that are seen only in Clovis, pre-Clovis and Solutrean assemblages. The first type of endscraper was produced by unifacial percussion or pressure flaking that extends up and over much of the dorsal surface. Stanford and Bradley (2012, p.164) argue that these types of endscrapers are not seen in other contemporary assemblages that include bifacial manufacture and pressure flaking. Spurred scrapers (intentionally created using pressure flaking) and micro scrapers (less than 3cm long) are also present in Clovis and Solutrean assemblages, yet absent from Beringian and other Upper Palaeolithic assemblages (Stanford & Bradley, 2012, p.164).

*Gravers (*Figure 16*):* Both Clovis and Solutrean assemblages contain gravers (small sharp projections on thin flakes or blades), while Dyuktai and Denali collections do not (Stanford & Bradley, 2012, p.164).

*Plane face points (Pointe à face plane) (*Figure 16*):* These points are unifacially flaked blades, and are considered to be a hallmark of the Early Solutrean. Stanford and Bradley identified two from the New World, one from the Johnson Site in Tennessee and one from Rum Island in the Santa Fe River, Florida (Stanford & Bradley, 2012, p.165).

*Indented base points (*Figure 16*):* Usually small and bifacial, these points were common in Spain and some parts of France. Similar points, featuring both percussion and pressure flaking, were discovered in American pre-Clovis contexts at Cactus Hill, Miles Point, Jefferson Island, Page-Ladson and Suwannee (Stanford & Bradley, 2012, p.165). Further, Stanford and Bradley (2012, p.166) identify the Johnson site as a location where there is a continuous chronological, typological and technological continuum, from the earliest points (bearing a striking resemblance to those in Southern France and Northern Spain) to the fluting technology (found in eastern North America).

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Figure 16. Comparisons of Solutrean pre-Clovis and Clovis lithic tools: (a) Solutrean end scraper made on a blade; (b) Clovis end scraper made on a blade; (c) Southeast Early Paleo-American (proto-Clovis) end scraper made on a blade; (d) Solutrean spurred end scraper; (e) Clovis spurred end scraper; (f) Solutrean microscraper; (g) Early Southeast proto-Clovis microscraper; (h) Clovis microscraper; (i) Clovis graver; (j) Solutrean graver; (k) Solutrean retouched blade; (l) Solutrean plane face point; (m) Southeast Early proto-Clovis plane face point, obverse and reverse; (n) Southeast Early Paleo-American plane face point; (o) Solutrean indented base point; (p–r) Early Mid-Atlantic Paleo-American indented base points; (s) Early Southeast Proto-Clovis steeply retouched blades. After Stanford and Bradley (2012, p.163)

Laurel leaf bifaces: Recovered from the Mid-Atlantic region of North America, the geological context of laurel leaf bifaces indicates a chronological overlap with the Solutrean period, namely the laurel leaf bifaces found in France and Northern Spain (Stanford & Bradley, 2012, p.166). These bifaces were manufactured using a high degree of control in percussion flaking, including thinning flake removals and controlled overshot removals (Stanford & Bradley, 2012, p.166). Figure 17 illustrates the similarities in the technological reduction while Figure 18 illustrates the specimens found in the Mid-Atlantic region of North America.

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Figure 17. Bifacial Technology from Clovis (A) and Solutrean (B). After Stanford and Bradley (2012, p.157).

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Figure 18. Mid-Atlantic Bifaces from Virginia, North America. Adapted from Collins et al. 2013.

*Blade Technology (*Figure 19*)*: As Stanford and Bradley (2012, p.167) discuss, their research focused mainly on the bifacial technologies. However, the blade technologies of Europe, North America and Asia/Beringia are also discussed. Stanford and Bradley (2012, p.167) outline two main approaches to blade manufacture, which they identified from the assemblages in their study. The first was the use of natural, unmodified stones or flakes, which were directly utilised for blade removals. The second was conducted by shaping a piece of raw material into a suitable form, namely a precore, and then producing blades.

The first method was seen in the northern Spanish Solutrean, as well as in the pre-Clovis sites of Cactus Hill, Miles Point, Meadowcroft and Oyster Cove. It was also seen in a handful of Clovis sites and some Beringian assemblages (Stanford & Bradley, 2012, p.167). The second method is further subdivided into cores that utilise a single core face and cores that are shaped similar to a thick biface. It is this second type that Stanford and Bradley (2012, p.167) identify as the most widespread during the early and late Upper Palaeolithic. Many of these cores still retain a bifacial edge on the back of the core (opposite the blade face). In fact, Solutrean precores are prepared with only a single bifacial ridge (if any), and the backs of the cores are usually flat, either due to flaking or when they were left unmodified (Stanford & Bradley, 2012, p.168).

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Figure 19. Bladelet and blade cores: (a) Solutrean bladelet core; (b-d) pre-Clovis bladelet cores; (e) face and top view of Solutrean polyhedral blade core; (f) face and top view of Clovis polyhedral blade core; (g) face and side view of Solutrean wedge-shaped blade core; (h) face and side view of Clovis wedge-shaped blade core. After Stanford and Bradley (2012, p.168).

In their hypothesis, Stanford and Bradley (2012, p.168) identify two distinct types of blade production strategies that were shared by Solutrean, pre-Clovis and Clovis knappers: conical cores and wedge–shaped cores. Conical cores had a single platform, with unidirectional removals utilising the full circumference of the precore (Collins, 1999; Stanford & Bradley, 2012). Wedge-shaped cores were different from conical cores due to the flat back and acute angle between the single platform and blade face. These cores were most frequently unidirectional; however, an opposite platform was utilised for error correction in a number of cores (Collins, 1999; Stanford & Bradley, 2012).

These cores were identified by Stanford and Bradley (2004) as strikingly similar and types that are not seen in other blade assemblages in Europe or Beringia.

Blades, bladelets and backed blades: The size of blades seen in Clovis and Solutrean assemblages fall within the same size range of pre-Clovis specimens from the Chesapeake Bay area (Stanford & Bradley, 2012, p.169). All of these specimens are larger than those from Beringia, which is predominantly a microblade technology. Backed blades have also been recovered from several Clovis sites; the Gault site in Texas, the Bostrom Site in Missouri, and the Paleo-Crossing site in Ohio. There is also a backed blade with pressure retouch flake scars and a bevelled truncated edge from Jefferson Island (Stanford & Bradley, 2012, p.169).

These similarities identified by Stanford and Bradley focus heavily on typology. The exception to this is the discussion on biface technology and manufacturing. Blade manufacturing technology is only briefly discussed. The tool types discussed (endscrapers and gravers) and the finished point styles (Pointe à face plane and indented base points) represent changes towards the latter stages of production or, in the case of endscrapers and gravers, during retouch. This raises the possibility that these similarities, although shared, are merely an example of convergence. This is a point alluded to by Straus (2000b) and Straus et al. (2005); that these traits are not only found in Clovis and Solutrean technologies but are present in numerous industries. Stanford and Bradley (2012, p.149) contend that the number of overlapping similarities highlight the possibility of a connection. This point remains problematic as the generalities of types do not explain the manufacturing sequence used to produce them. Furthermore, some of these comparisons are based on very small sample sizes and raises the possibility of coincidental design.

Stanford and Bradley (2012, p.170) also draw a connection between Clovis and Solutrean based on the selection and treatment of raw material. The use of exotic raw material, which is often non-local and from far distances, may reflect group mobility; however, Stanford and Bradley (2012, p.170) argue that in the Clovis and Solutrean assemblages, the selection of exotic material goes beyond just mobility. Both traditions have evidence for the exploitation of quartz crystal; and, while this characteristic may have arisen independently, its absence from other early industries is striking (Stanford & Bradley, 2012, p.170).

Raw materials were often heated to improve their flaking quality (Crabtree & Butler, 1964). The process is complex and different raw material sources often require different approaches and temperatures to improve their flaking (Speer, 2010). Mistakes can result in the destruction of the stone. In Europe, the first appearance of heat treating occurred in the Solutrean, and this characteristic treatment was also recognised in Clovis sites (Stanford and Bradley 2012). However, it remains largely unreported or under recognised from the majority of technologies, and so no certain conclusions can be drawn (Stanford & Bradley, 2012, p.171). Flenniken (1987) does note the presence of heat treatment in Dyuktai assemblages, identifying this process on microblade precores.

The next stage of the qualitative analysis conducted by Stanford and Bradley (2012, p.171) concerns the use of bone, antler and ivory. Despite the rarity of all of these artefacts from all Late Pleistocene assemblages due to preservation issues, a number of artefacts have survived and are discussed below.

Sagaies (Figure 20*,* A-D*):* These are the most abundant point type, made on bone, antler or ivory. Sagaies are rods that taper to a point with a bevel at the other end. These rods have been found throughout the Gravettian, Solutrean and Magdalenian. Stanford and Bradley (2012, p.171) note that virtually identical sagaies have been recovered from fluted point sites, particularly in western North America, where the pH of soils are neutral to basic, allowing for better preservation. Sagaies were also found in Florida, made from mammoth bone which places them certainly during or before the fluted point period (Stanford & Bradley, 2012, p.171). One of the artefacts from Florida features a “zig-zag” pattern etched into the bone, which is identical to a sagaie found in France (Stanford & Bradley, 2012, p.171). Similar to sagaies, artefacts with rounded tips have been found in both North American and European assemblages possibly representing foreshafts (Stanford & Bradley, 2012, p.171).

*Bone shafts and perforated antlers (*Figure 20, H-I*):* One of the artefacts found at the Murray Springs site in Arizona was a mammoth bone shaft wrench, which was very similar to perforated antlers found in Upper Palaeolithic sites in France (Stanford & Bradley, 2012, p.172). These artefacts, while not unique to the Solutrean, are noticeably absent from Palaeolithic assemblages in Beringia (Stanford & Bradley, 2012, p.172).

Eyed bone needles (Figure 20*, E-G):* Stanford and Bradley (2012, p.174) draw a connection between the eyed needles found in the Solutrean and those from Folsom contexts in North America, which is largely due to preservation. The exception to this is from Sloth Hole in Florida (Hemmings et al., 2004) where two purported unperforated ivory needle fragments were recovered (Stanford & Bradley, 2012, p.174).

*Atlatl hooks (*Figure 20, J-K*):* There was no evidence for the use of atlatls by Siberian Palaeolithic people, but atlatl hooks do exist in the Solutrean archaeological record as well as several ivory hooks found along the Santa Fe river in Florida (Stanford & Bradley, 2012, p.175).

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Figure 20. Bone artefacts: Sagaie A-D; (A) Solutrean; (B) Clovis; (C) Clovis with zigzag design; (D) Solutrean with zigzag design. (E) bone needle from Idaho; (F) Solutrean eyed needle; (G) Folsom bone needle from Colorado; (H) Solutrean notched pendant; (I) Folsom notched disk; (J) front and side view of bone Solutrean atlatl hook; (K) front and side view of bone atlatl hook from Florida. After Stanford and Bradley (2012, pp. 172-174)

Following the analysis of the tool kits from Solutrean and Clovis assemblages, Stanford and Bradley (2012, p.175) consider a number of cultural behaviours, which appear to link them historically. The first of these is the artistic expression, visible in both Solutrean and Clovis periods. While there are no examples of elaborate cave paintings in North America, there are a number of examples of portable art. These items, either on bone disks or small limestone clasts, usually feature geometric designs. Numerous incised stones have been recovered from the Gault site in Central Texas that are markedly similar to those from Polesni, Italy (Stanford & Bradley, 2012, p.175). Stanford and Bradley (2012, p.177) also identified similarities in artefacts of personal adornment, namely the stone beads and pendants identified in Solutrean sites and the beads recovered from Blackwater Draw, New Mexico and Shawnee Minisink, Pennsylvania.

Both Clovis and Solutrean archaeological records feature caches of bifaces. These are often large and extremely well made bifaces, frequently including concentrations of red ochre (Stanford & Bradley, 2012, p.177). This type of behaviour has been found at only one site in Beringia, the Tumular Site. Stanford and Bradley (2012, p.177) note these cached bifaces appear to have more in common with microblade core preforms than with the large well-made bifaces cached during the Clovis and Solutrean Periods. A recent report by Tabarev (2012) identified the presence of biface caches in Sakhalin, but there is no apparent continuation of this behaviour into Eastern Siberia and Alaska.

There is no evidence for any form of formal, humanly made shelters during the Solutrean period; the vast majority of sites are in natural shelters. In the Early Magdalenian, there are examples of purposefully laid cobble floors. Stanford and Bradley (2012, p.179) suggest that a stone floor excavated at the Gault site is highly reminiscent of these European features. The Beringian archaeological record also contains some examples of shelters or structures, but these features take the form of shallow circular depressions, often with a fire pit in or near the centre (Stanford & Bradley, 2012, p.178).

Stanford and Bradley (2012, p.179) also discuss the construction of hearths as another feature that is similar in Clovis and Solutrean assemblages. Unlined hearths are frequently excavated from Paleoindian sites; and, many Solutrean sites feature stone lined hearths, excepting the lower Solutrean levels at La Riera Cave, which also produced indented base projectile points as well as exotic cherts, seal bones, and major deposits of limpet shells and fish remains (Stanford & Bradley, 2012, p.179).

The final assessment regarding the similarities between Clovis and Solutrean cultures lies within their mortuary practices, specifically the lack of evidence for these practices. Throughout the Palaeolithic of Europe, Siberia, and later North America, there is evidence of various mortuary practices. Though it is difficult to use a lack of evidence as evidence itself (Stanford & Bradley, 2012, p.180), it does imply that both cultures used a mortuary practice that is archaeologically invisible. As discussed, this is problematic as shared archaeological invisibility does not equate to a shared tradition of mortuary practice.

As with the lithic technology, some of the similarities raised by Stanford and Bradley (2012) are based on only a handful of artefacts. While quantity does not necessarily equate to significance, the relatively small numbers do not rule out the possibility of independent experimentation within a technological tradition. In this scenario, traditions do not have to share a common route. While the number of similarities can be considered unusual, they do not provide definitive proof to the hypothesis, but rather add weight to the possibility of a connection.

Addressing the critiques

The hypothesis as it is set out by Stanford and Bradley, also addresses several lines of evidence that seemingly run contradictory to their conclusions. Solutrean tool types absent from pre-Clovis and Clovis assemblages, including shouldered points, willow leaf points and stemmed and corner-notched points. Stanford and Bradley (2012, p.181) argue that these points may have dropped out of the cultural inventory. The other explanation for this lies in the fact that not all Solutrean assemblages contain these types of points, the group that travelled to the New World may have left before the advent of these technologies (Stanford & Bradley, 2012, p.181) or from a group or groups that also did not have them. The innovation of fluting appears to have its roots firmly in North America, with sites such as the Johnson site possibly indicating experimentation with this technique (Stanford & Bradley, 2012, pp.181, 174). In addition, backed blades are not a universal trait of Solutrean assemblages. These backed blades may have been part of a number of items other than composite projectile points and may have been hafted or slotted individually into bone knives (Stanford & Bradley, 2012, p.182).

Inset composite technology has not been identified in Clovis assemblages although it is present in both Palaeolithic Europe and western Beringia (Stanford & Bradley, 2012, p.182). The two final classes of tool evidence that are inconsistent are burins and adzes. Burins are rare in Clovis sites, with only three examples recovered from pre-Clovis sites, yet this type of tool is present in both Solutrean (rare) and Beringian assemblages (Stanford & Bradley, 2012, p.182). Finally, adzes are a recognised feature of Clovis lithic technology; however there are no identified examples of this type in the Solutrean. Stanford and Bradley (2012, p.182) suggest that this may be due to the submerged landscape off the coast of northern Spain and western France, where sources of wood, and thereby adzes may have been more likely.

Both of the above points are based primarily on hypothetical reasoning (dropping from the cultural inventory and submerged landscapes). While this does not invalidate the hypothesis, they both require further archaeological testing before they can be considered valid.

The final issue that Stanford and Bradley (2012) address is the apparent chronological gap between the Solutrean and Clovis periods, often stated as a 5,000 year discrepancy by detractors of the hypothesis (Straus, 2000a; Clark, 2004; Straus et al., 2005). While this gap is apparent with the current Clovis and Solutrean dates, Stanford and Bradley (2012, p.183) argue that this is addressed by the emerging pre-Clovis evidence. Radiocarbon dates for the Cinmar mammoth indicates that the Solutrean-style laurel leaf biface may be up to 25,490 ± 394 calBP (22,760±90 ^{14}C BP) but at least 14,600 years old (Stanford et al., 2014). The Miles Point site dates to around 23,177 ± 838 calBP (20,970 ± 620 ^{14}C BP). Pre-Clovis occupation of Cactus Hill dates to around 18,230 ± 263 calBP (16,940 ± 50 ^{14}C BP) and at Page-Ladson (~12,651 calBP/ 12,388 ^{14}C BP) there is a continuation of the blade technology (Stanford & Bradley, 2012, p.183). These dates, in Stanford and Bradley's words means "the chronological gap has been closed" (Stanford & Bradley, 2012, p.184).

This highlights the requirement for a Clovis ancestor present in North America between the Solutrean and Clovis periods. For the Solutrean hypothesis to remain valid, this chronological gap must be closed. Despite the data presented by Stanford and Bradley (2012), the evidence from "pre-" or older than Clovis sites remains complicated and relatively small. If a founding group of Solutreans left behind their technological traditions, these should be present in the older than Clovis assemblages to provide a root for the development of Clovis.

Summary

Stanford and Bradley's hypothesis is the result of a detailed analysis of the possible historical roots of the Clovis culture, namely the Solutrean. Given the high number of corresponding flake, stone and bone tool forms and technologies a historical connection is feasible (Stanford & Bradley, 2012, p.184). They concede that the Nenana complex shows the strongest similarities to pre-Clovis, but the dating of this complex shows that it was contemporaneous with Clovis, and significantly younger than the pre-Clovis sites of the Mid-Atlantic region (Stanford & Bradley, 2012, p.184). Alternatively, Haynes (2002) argued that fluted point traditions simply sprang out of an Asian technology without any transitional phases, Stanford and Bradley (2012, p.185) reject this argument on the basis that complex technologies require developmental antecedents and this is also asserted by Straus et al. (2005).

According to Patten (2005), societies and cultures only adapt and change their technology through careful experimentation and development. As such, Stanford and Bradley (2012, p.185) suggest that the problem with identifying Clovis ancestors lies not in the lack of a candidate, but simply in its location. Thus, if Solutrean assemblages were found in north-eastern Asia, no one would question their hypothesis. Instead, critics question the idea that highly skilled groups of people could travel across the ice front of the North Atlantic Ocean and arrive in the New World, relying on their knowledge of the oceans and ice edges and the resources of marine fauna available. It is from a group of maritime explorers that Clovis and the complexities of its lithic technology originate (Stanford & Bradley, 2012). This thesis focuses on testing the assertions made by Stanford and Bradley concerning the blade technologies based on the similarities between Clovis and Solutrean, as well as the differences between Clovis and Beringia.

Chapter 5

Theoretical Models of Culture

There are numerous archaeological and anthropological theories that can be used when interpreting Stanford and Bradley's (2012) Solutrean-Clovis hypothesis, specifically their proposed model of migration. According to Bradley, it is not acceptable to simply claim convergence; convergence must be substantiated (Bruce Bradley, pers. comms, 2013). Archaeologists must always first look to the evidence before they apply theory to its understanding.

This chapter looks at the two main theories that can be applied to the North Atlantic migration hypothesis. The first is the hierarchical cultural model (Clarke, 1968). The second is recursion, which states that there are a finite number of ways to work stone, and that similarities will undoubtedly occur (Hoffecker, 2007). This is similar to a comment made by Bordes (Bordes, 1968).

Archaeological Culture

Cultural theory and the concepts of archaeological cultures has been pushed from the forefront of modern archaeology; however, they are still employed by prehistorians throughout the world (Roberts & VanderLinden, 2011, p.1). Furthermore, the identification of archaeological cultures constitutes a recognition of the relationships between material culture through time and space (Roberts & VanderLinden, 2011, p.3) and even a single technology can provide a dataset with the ability to broaden our understanding of the archaeological record (Roberts & VanderLinden, 2011, p.12). Clarke's (1968) model provides a framework around which the archaeological record can be interpreted following a systematic and hierarchical method.

Clarke's (1968) approach was one of the first to give a detailed and coherent expression to what has been defined as "systems theory" or numerical taxonomy (Renfrew & Bahn, 2006, p.260). Put simply, this approach viewed cultures as a functioning whole composed of interrelated parts. In this "system" groups will interact with external and internal pressures, such as the environment (Renfrew & Bahn, 2006, p.259). This approach has been viewed negatively by 'post-processual' archaeologists who note that the role of an individual is overlooked (Renfrew & Bahn, 2006, p.260). This includes the root of societal growth, change, and innovation which some argue starts at a micro, individual, level (Renfrew & Bahn, 2006, p.263). Advocates countered this by arguing that these factors can be incorporated into the approach and that the shortfalls occur in its application rather than in the method (Renfrew & Bahn, 2006, p.260).

The application of this numerical taxonomy has been revived due to the development of statistical analysis which is considered a requirement for the application of this approach (Read, 2007). Kohler (2012, p.114) argues that with the advancements in computation this approach offers a "…completely open, rapidly evolving, and non-dogmatic set of approaches". Primarily, statistical application takes the form of cluster analysis or cladistics (O'Brien & Lyman, 2000, p.194) and have been applied to a variety of lithic industries (O'Brien et al., 2001; Buchanan & Collard, 2008; Lycett, 2009; Lycett & von Cramon-Taubadel, 2013).

In a recent critique of the Solutrean hypothesis, O'Brien et al. argue for the use of cladistics, phylogenetics, and parsimony trees (O'Brien et al., 2014a). While cladistics have not been used in this thesis due to issues with its application (*see* Grant & Kluge 2003; Farris 2014), cluster analysis techniques have been applied (chapter 15).

In this thesis, Clarke's (1968) original approach is used to explore the possible relationships between Clovis and Solutrean technology at a theoretical level as well as with the use of statistics. This is due to the development of numerical taxonomy and systems analysis which have focused more on its application than on the specific methodology and its development by Clarke (O'Brien & Lyman, 2000, p.265). Furthermore, Clarke's (1968) approach is considered not only as one of the most influential texts on this form of analysis, but also still relevant to systems analysis (O'Brien & Lyman, 2000; Renfrew & Bahn, 2006; Kohler, 2012).

While this is by no means the only attempt to relate material culture to cultural theory (Binford 1965; Hodder & Orton 1976; Fotiadis & Hodder 1995; Hodder 2001) the hierarchical nature of the model and its application provides deeper interpretive scope for the assessment of the Solutrean hypothesis.

Clarke's hierarchical cultural model

Clarke's (1968) work in *Analytical Archaeology* was a major step in creating and describing a strict rank or hierarchy to the archaeological world. His methodology starts with a simple attribute analysis to define artefacts. He then groups artefacts by types. From this analysis, he defines assemblage-specific groups, which become cultures. It is this last point that is most important to this thesis, because these cultures become groups and the linkage of groups indicates a technocomplex.

Clarke defines an assemblage as "…an associated set of contemporary artefact-types" (Clarke, 1968, p.245). Artefact-types typically represent specific attributes, such as a specific type of lithic projectile point, endscrapers on blades, or pottery styles. By studying each assemblage within its own temporal and spatial context, archaeologists can define a culture. Further, by allowing for variation and oscillation in both the natural and humanly constructed world, it is possible to create these cultures based on these shared affinities between artefact types in assemblages that share temporal and spatial stratigraphic constraints.

Clarke proposed four criterion by which a group of assemblages could be described as a culture, these are summarised as:

1. The component assemblages must share a large number of specific artefact-types with one another, although each assemblage need not contain all types in the shared set (Clarke, 1968, p.246).
2. The artefact-types represented in the assemblages comprise a comprehensive selection of types from most of the material spheres of cultural activity (Clarke, 1968, p.246).
3. The same specific artefact-types occur together repeatedly in those component assemblages, albeit in varying combinations (Clarke, 1968, p.246).
4. Finally, the component assemblages must come from a limited, defined and continuous geographical area and period of time (Clarke, 1968, p.246).

Breaking these characteristics down, the first criterion states each assemblage that makes up the culture shares the same range of artefact-types and even if some assemblages lack certain types, they can still make up a component part of that culture. These component assemblages must also represent the same selection of material types (criterion 2). This is not simply a choice between, for example, flint and clay, but the material spheres of weapon assemblages or pottery assemblages. This is the more ambiguous social activity that is implied by the artefact-types in each component assemblage of the culture. Criterion 3 is very similar to criterion 1, although it stipulates that these artefact-types are repeated, in varying combinations, across all assemblages. Arguably the most important aspect is the fourth criterion, which states that all assemblages must come from a "*limited, defined and continuous geographical area and period of time*". It is within this definition that Clarke (1968, p.248) saw many misuses and even abuses of the term "culture", and it was these, which he aimed to eradicate in constructing such a hierarchy system.

According to Clarke (1968, p.299), cultures can also be linked to an entity above that of a culture, a culture group. The culture group represents a larger entity than a culture; however it also represents a lower level of affinity. The culture group provides less specific information regarding cultural attributes; but it provides more general information about a culture group, such as the implied socio-economic or technological activities conducted by the component cultures.

Clarke (1968, p.299) placed his archaeological culture at the peak of his system, containing the largest amount of information and content about an assemblage attributing it to a culture with general and specific characteristics, "*a material culture subsystem of a specific sociocultural system*". The culture group thus represents a larger entity than a culture; however it also represents a lower level of affinity. Specifically, a culture group covers a larger geographical area and contains a larger population, but shares less complexity in social organisation, which Clarke (1968, p.300) refers to as, "…a low level affinity." Low-level affinities share approximately 30% or less of their cultural attributes; however, these cultures are united in terms of shared sets of specific type states. Conversely, high level affinities, those sharing approximately 60% or more, unite the group though shared type families (Clarke, 1968, p.300). This means that cultures can be grouped with low-level similarities in specific artefacts, providing that they have greater than 60% similarities between the type families. In this description Clarke is using the term “family” to denote a family of artefact-types. Therefore, cultures can be linked to an entity above that of a culture, a culture group, which provides less information regarding the specific cultural attributes, but provides a level of affinity regarding the type of families and hence the implied socio-economic or technological activities conducted by the component cultures.

The final tier in Clarke’s hierarchy is the technocomplex. The technocomplex attempts to create a single entity out of component culture groups that provide a level of affinity only across artefact families. Clarke (1968, p.330) himself stated that his definition was only an “*attempt to define the technocomplex”*:

> *“A group of cultures characterised by assemblages sharing a polythetic range but differing specific types of the same general families of artefact-types, shared as a widely diffused and interlinked response to common factors in environment, economy and technology”* (Clarke, 1968, p.330)

Clarke (1968, p.330) describes technocomplexes as having a negligible level of affinity (<5%), uniting the group in terms of shared specific types but a residual medium level of affinity (30-60%) uniting the groups in terms of shared type families. This suggests that although the same specific types or states of artefacts such as endscrapers, burins or projectile points may not be shared between the component cultures, they will share differing specific types from a common set of artefact-type families. For example, a blade technology alongside a biface technology may not produce the same specific types of blade tools or biface tools, but because they share these two technological elements they may form part of the same technocomplex.

Clarke (1968, p.331) qualifies these similarities by suggesting the component groups will also share the same general patterns in economic strategy, similar environments and a similar technology. Despite the possibility of a partly independent arrival of these cultural systems, they will have a shared and similar past trajectory. A technocomplex may have huge space-time dimensions but provide a simple outline of prehistoric trajectories, a cluster of successive bundles of the cultural system. In this system, technocomplexes can transform through space and time, providing the same shared affinity (30-60 percent) of type families (Clarke, 1968, p.330).

Environmental change may also shift the nature of the technocomplex, provided the shared affinity remains intact. One example of this shared affinity is the projectile points of the Clovis and Folsom in North America. The shared family of projectile point remains intact, while the specific manufacture of that technology changes along with its desired end-use (e.g. Clovis hunted mammoth and other big game, while Folsom almost exclusively hunted bison).

Clarke (1968, p.323) also states that these technocomplexes can represent a convergence of ideas or strategies. However, Clarke (1968, p.323) defines convergence as, "…the acculturating of a culture group with increasing inter-group communication and diffusion condensing into a single large-culture". In other words, cultures are linked through gradual meeting and communication over time until they become one large associated group. In this respect, a technocomplex can be seen as the equivalent of an archaeological cultural paradigm, in which culture groups operate under the same general system of responses to the conditions imposed upon them. According to Clarke (1968, p.333), these technocomplexes are not static entities but provide a "…strategic blend of components of old and tried efficacy which form a skeletal framework within which many different individual formats may be accommodated". This blend of components exists regardless of time or space but is dependent upon similarities in environment, economy and technology as well as past trajectories.

Finally, it is important to note that the past and future trajectories of these cultures are not necessarily predetermined by the technocomplex. Groups may share a past trajectory, or one may have been incorporated into the other via convergence, and neither of these scenarios would indicate that the cultures would follow the same future path. Time and space constraints may alter the group beyond the framework of the technocomplex.

By constructing this hierarchy within archaeological assemblages and cultures, Clarke aimed to provide a system of informative labels that would explain similarities in the archaeological record. This system was also seen as a method of correcting and ending the misuse and abuse of terminology, which led to uninformative or misleading assumptions of cultures and created misunderstandings and false conclusions about the archaeological record.

One of the main criticisms of this model was that it created a biological model from archaeological taxonomy (Gamble, 2008). It is functional, systematic and adaptable, but relied heavily on the simple identification of artefact-types. As Gamble (2008) states, if taxonomy was the sole task of archaeologists, we would be merely “stamp collecting”.

Clarke’s model referred only to artefact types (i.e. hunting tool, storage equipment). His model did not delve any deeper into the assemblages. Moreover, it ignored other evidence available to archaeologists from the record, such as specific manufacturing techniques. For example, if two cultures had a bifacial technology, but their initial core preparation techniques were widely different (i.e. one technology arriving at thinned bifaces, and the other purposefully thickening along the mid-line), then these two cultures cannot be connected via a technocomplex, let alone a culture group. Though it may be correct to say that the type families are the same, labelling them as such is misleading and damaging to understanding and interpreting the archaeological record.

The same can be said when it comes to the identification of hunting practices. It is misleading to group a culture practicing large scale game drives, then scavenges from the remains with another that actively encounters prey in the environment, based solely on the shared affinity of the hunting equipment present. This same argument can be made across the varied spheres of human invention. If methods differ, it is uninformative and misleading to group the assemblages and cultures together, ultimately damaging the information and content of the archaeological record that Clarke himself was trying to avoid.

If archaeologists are aware of these limitations, then it is possible to use Clarke’s model to identify and reasonably construct cultures, culture groups and technocomplexes. As such, future use of Clarke’s theory should incorporate not just simple typologies, but a broad spectrum of human behaviour in terms of social, economic and technological responses.

For example, Group A’s primary technology was a bifacial projectile point. These points were produced on preforms made on flakes from a core nodule, using organic direct percussion. Each preform had flake scars that run to the mid-line of the flake and no further. Platforms for the removal of shaping and thinning flakes were prepared by faceting, isolating and heavily grinding. The final stages of production were conducted using antler pressure flaking.

These projectile points were then hafted and used as part of a bow and arrow technology to hunt individual game animals. Group A may also have bone harpoon technology and bones from the assemblage indicate a mixed seasonal diet of marine and terrestrial fauna.

If Group A is compared to another group, Group B, then a number of different outcomes could be hypothesised depending on the nature of Group B and the associated spatial and chronological proximity. If Group B contains the same tool types, the same knapping sequence but different seasonal fauna, then it is likely to represent the same group and the same culture exploiting the landscape in a seasonal occupational system of resource gathering. By contrast, if Group B utilises a much wider and larger point, more suited to hafting on a spear shaft, but the mechanics of manufacture are largely the same and bone is no longer used as a harpoon but as a spear point alongside a diet dominated by terrestrial fauna. It is reasonable to deduce that these groups represent a culture group, where similar type families are present and the technology has a shared affinity in the production of points, but geographical and environmental factors have likely influenced and altered some of the major characteristics of the culture.

Finally, if these two groups were compared to a culture in a different geographical area, of a slightly younger age, where the knapping sequence is the same and the production of a bifacial projectile point is still present, but different faunal species are hunted and clay is used to create pottery. Clarke's original model would label the cultural connection as representing a technocomplex, where families are the same and the environmental response may be shared but there is no definitive or direct link between the two cultures archaeologically. The cultures share the same past trajectory but at some point diverged, with certain elements, in this case the manufacturing technology remaining constant, while responses to external factors changed.

Although this model is somewhat uncomplicated, care must still be taken when examining and exploring every facet of each culture. It can be a useful tool in studying and understanding past cultures, particularly cultural relationships, trajectories and historical relatedness. Two seemingly separate cultures may in fact share the same historical trajectory from a single past culture, but time and space has separated them, creating either a culture group or technocomplex depending on the evidence. It would still be far too simplistic to suggest that just because two cultures can be ascribed to the same technocomplex that they are therefore branches of the same culture.

Representation and Recursion

In his article on representation and recursion, Hoffecker (2007) assessed how cognition and physical and environmental constraints can play a major role in human technology and creativity and how cultural remains may represent choices based on a finite number of ways in which expression can be projected.

The material remains of past societies are unique to humans due to the ability to project thoughts or mental projections into a wide variety of media outside the confines of the brain (Hoffecker, 2007). These external representations are often complex and feature a hierarchical structure with embedded components and all exhibit the property of recursion (Hoffecker, 2007).

Recursion at its most basic level is the process of repeating items in a similar or exact way. Hoffecker (2007) suggests that recursion is the capacity for generating a potentially infinite array of varying combinations, and then explains that, in linguistics, it can mean the creation of a potentially infinite range of expressions from only a finite set of elements.

As Hoffecker (2007) states, humans can generate a wide variety of recursive representations, and the archaeological record is filled with examples of recursion that can only be recognised through comparative analysis. V. Gordon Childe (1973, p.124) expressed this as "…refashioning what already is".

Hoffecker (2007) refers to the large bifaces of the Acheulean as one of the first examples of representation and recursion, where the products reflect an imposition of a "mental template" onto a piece of stone. The finished product does not resemble the original blank; and, this form is imposed on nodules and large flakes of various sizes and shapes. The prepared core techniques associated with the Middle Palaeolithic are parts of a more complex technological system where three or four elements comprise the tools and weapons (e.g. a handle/shaft, a binding material or adhesive and a stone flake/blade or point). The variation seen in the Middle Stone Age also represents a pattern of recursion, where a combination of elements reflects a recombination of design elements to produce a number of different shapes (Hoffecker, 2007).

The Upper Palaeolithic technologies are highly recursive and exhibit a pattern of variability, innovation and accumulated knowledge. Stone projectile points are a good example of this where different specimens or assemblages from different stratigraphic levels or different sites illustrate recursive conceptual design. While these points all share the basic requirements for a point (hafting element and sharp tip), the form is free to vary in a wide array of possible combinations (Hoffecker, 2007).

Recursion, in this form, suggests that the variability in the stone tool traditions is a product of the society, the culture and the people within each group. In essence, recursion represents an adaptive strategy in the development of stone tools. This adaptive response can be connected to the idea of convergence in the archaeological record, where similarities in form represent common, shared and selective pressures that produce similar form in tool types.

In his article on stone tools, style and social identity, Barton (1997) argues that selective control creates similar typologies in size, shape and retouch configurations. Therefore any similarities in the composition of artefacts or their associated assemblages are most likely to be a result of selection favouring one form over another, convergence in similar contexts, and not related to any common descent (Barton, 1997). To back up his argument, Barton (1997) identified three examples where a specialised blade industry developed: the complex societies of south-west Asia (Rosen, 1983), the Mesoamerican prismatic blades (Clark, 1987), and the blade industries of the Indus valley (Biagi & Cremaschi, 1991).

While these three industries appear to share some commonalities, the connections are only based on typological analysis of morphologically similar blade industries (i.e. “true” blades with parallel sides and trapezoidal cross sections). The technological aspects of each industry are not the same. Preparation and pre-core formation retain specific attributes unique to each industry. These three industries are a clear demonstration of François Bordes (1964) claim “…you cannot work flint in 36 different ways”. There are only a finite number of ways that chert can be worked in order to produce tools. This is where recursion, or recursive representation, repeats itself in the archaeological record.

Combining Theory and Reality

It is essential that any theory used as an explanative model for the archaeological record be constructed around evidence first. It would be a major misuse of science and a complete misrepresentation of the facts to simply pin evidence onto a theoretical model.

It is not acceptable in any form of science for theory to be used first and foremost as a substitute for evidence, and even more unacceptable to merely use theory as a method of critique. Data must be collected, analysed and evaluated, then these datasets compared between cultures. Following this, further assessments of external factors that may have affected or influenced any connection, must be fully explored.

The theoretical models above are presented here as possible explanations for the technological similarities presented by Stanford and Bradley (2012). They are not the only models of culture that may be applied, but they are relevant to understanding the data presented for a possible migration of Solutrean peoples to North America. These theories are considered in the final analysis and discussion on blade technologies.

Chapter 6

Taxonomy of Blade Technologies

One of the major obstacles in the comparison of technologies is that of nomenclature. This fact is prevalent throughout the study of blade technologies where numerous terms, such as bullet core, polyhedral core, and conical core have been used to describe similar blade technologies, whereas terms like wedge-shaped core have come to represent two different types of blade technology. This is particularly important to the study of the first Americans where the term wedge-shaped has been used to describe both the microblade technologies of Asia (Morlan, 1970), and Clovis blade cores (Collins, 1999).

As described in Chapter 2, blade, and blade core technology is the result of a number of attributes that make blade industries unique from other flake or bifacial technologies. In order to address the issues in the nomenclature of current literature and to create a unified system for the analysis of blade industries through time and space, it is necessary to create a system of classification that highlights both the similarities and differences in blade technologies.

While this system is not intended to cover all aspects of technology, it represents the basic fundamental criterion of blade technologies which, if used as a benchmark for analysis, can be used to conduct more detailed analysis not only of individual assemblages but also allow for comparisons between industries.

Constructing the taxonomy

As discussed previously, blade production relies on the creation of a core. After initial shaping and possibly precore formation of the raw material, a core is produced with the intention of detaching a series of blades for use as tools, either in their own right, or as blanks for further development. While there is a certain degree of variation in all blade technologies, there are three main attributes of a blade core that can be used for comparative purposes. First, all blade cores will have a platform, to facilitate the removal of blades. Second, the core itself will be used in a certain way for the removal of blades, also described as the “Morphological Use”. Finally the direction in which each individual blade is removed, or débitage direction, is included. These three attributes can be used to construct a model taxonomy that encompasses all forms of blade manufacture. The specifics of each type are described below.

Core Platforms

There are five types of core platforms that were used in the production of blade manufacture. All of these terms are frequently referred to in the literature (Tixier, 1963; Bordes & Crabtree, 1969; Crabtree, 1986; Bergman, 1987; Inizan et al., 1999; Shimelmitz et al., 2011). As the creation of a platform on a core is essential to the consistent removal of blades, platform type will be the first level of the taxonomy.

Type I – Single Platform, Plain (Figure 21)

Type I cores will have a single platform for the removal of blades. The platform itself will remain unworked for the duration of blade removals. Core tablet flakes may have been removed from the top of the platform if the striking angle was lost, but no faceting of the platform was conducted during the detachment of any blades. Single platform, plain cores may have required a number of flake detachments during pre-core production in order to produce a plain platform.

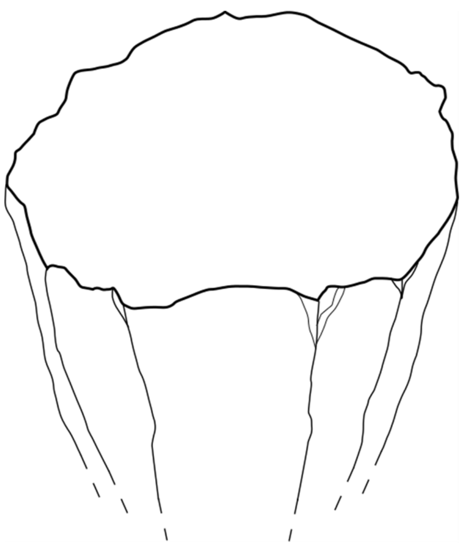


Figure 21. Type I

Type II – Single Platform, Faceted (Figure 22)

The second type of blade core is similar to the first with the exception that the platform itself will be worked during the removal of blades. Preparation flakes were frequently removed from the top of the core to set up each subsequent blade removal. As blade production progressed, it may have been necessary to rejuvenate the platform by removing a core tablet flake, but small preparation flakes continued to be detached for each blade removal.

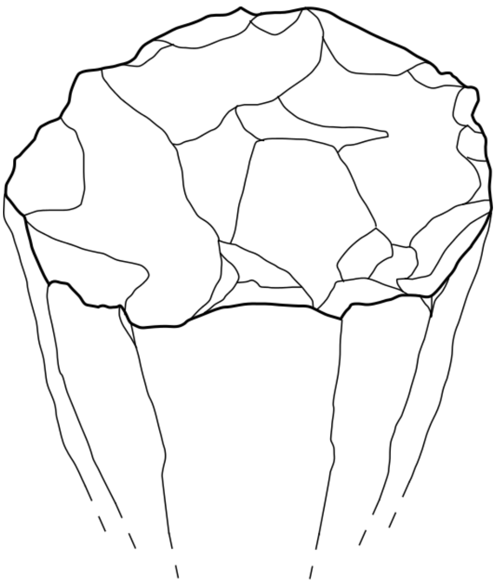


Figure 22. Type II

Type III – Double Platform, Plain (Figure 23)

The third type of core has two plain platforms. The most common configuration for this type of core was two opposing platforms (one at either end of the core). The advantage of a second, opposing platform was that any errors or corrections required to the blade face were achieved through detachments from the opposite end.

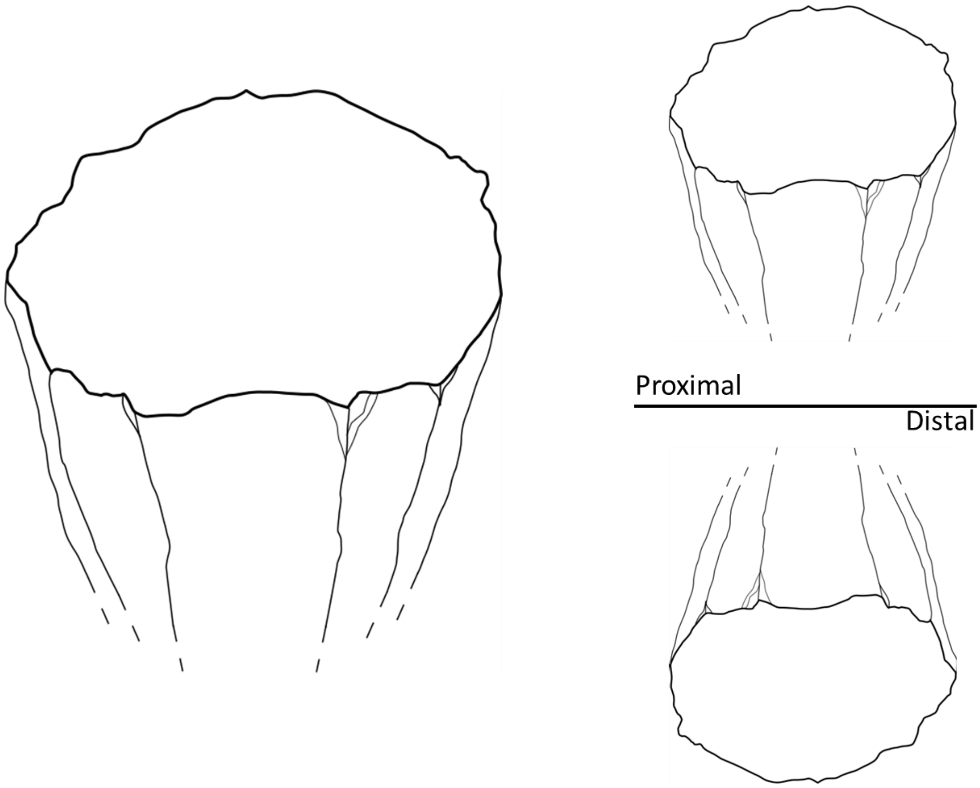


Figure 23. Type III

Type IV – Double Platform, Faceted (Figure 24)

Type IV cores are similar to Type III cores, but like Type II cores, the platforms are faceted. The majority of these cores were set up with opposing platforms and had the same advantage in blade core maintenance as Type III cores. These platforms may have required rejuvenation of either part or the whole platform periodically. The disadvantage of this style of core was that the length of the core could be lost from both ends, dramatically shortening the blades during each sequence of removals.

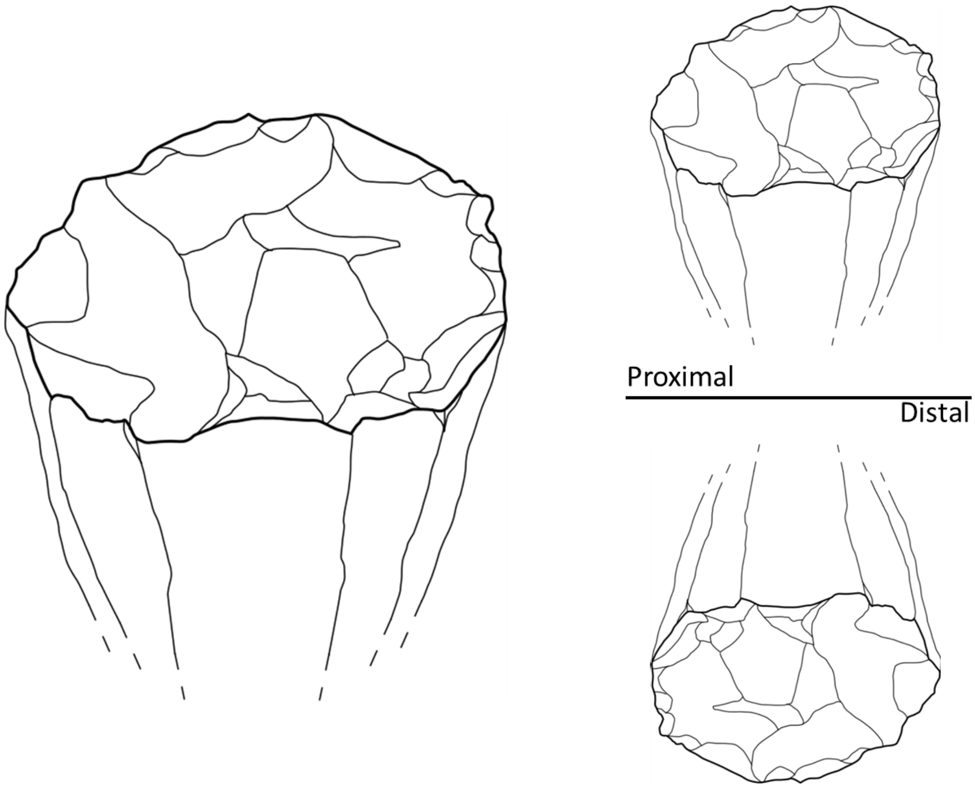


Figure 24. Type IV

Type V – Multi-platform Cores

Type V cores have multiple striking areas used as a platform for the removal of blades; these cores tended to be less organised in sequencing and consistency. Type I – IV cores may have been modified into Type V cores with the loss of the blade face due to an unrecoverable error.

Type VI – Expedient Cores

The final category of core is the expedient core. These cores can potentially have one, two or multiple platforms; what separates these cores was the fact that there was no specific strategy of spacing the blade removals for consistent detachments. These cores exhibit little to no platform preparation and the blade removals followed natural ridges with an occasional removal of a second blade from the initial face. Expedient cores would exhibit little to no initial pre-core development.

Morphological Use

The second major attribute of a blade core is the amount and portion of the surface used as the blade face. This aspect of blade manufacturing technology is constrained by a number of aspects of the technology and the intended final product. Access to raw material and its shape, size and condition will have an effect on how the core is shaped and how the blade removals proceed. This category is adopted from Delagnes et al. (2007) and the principle methods of débitage (removal). Morphological use is the second level of this taxonomy.

A – Facial Flaking (Figure 25)

Facially Flaked cores are worked only on one face of the core. These cores were formed to use one face of the raw material for the detachment of blades. This face will have been the widest face of the initial core. The back of the core may have remained unworked or may have been flaked in a specific way (flat-backed or bifacially) to allow for further maintenance and working of the core during blade removal.

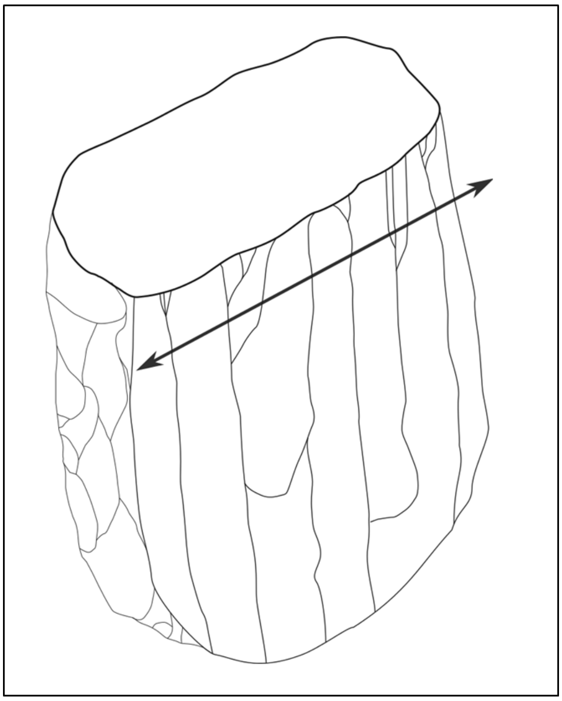


Figure 25. Facial Flaking

B – Frontal Flaking (Figure 26)

Frontal Flaked cores are similar to Facially Flaked cores (A), but rather than utilising the broad face for detachments, Frontally Flaked cores use the thinnest part of the core. In some aspects, this technique may have preserved more of the raw material and produced a higher yield of smaller blades than if a similar core was used facially.

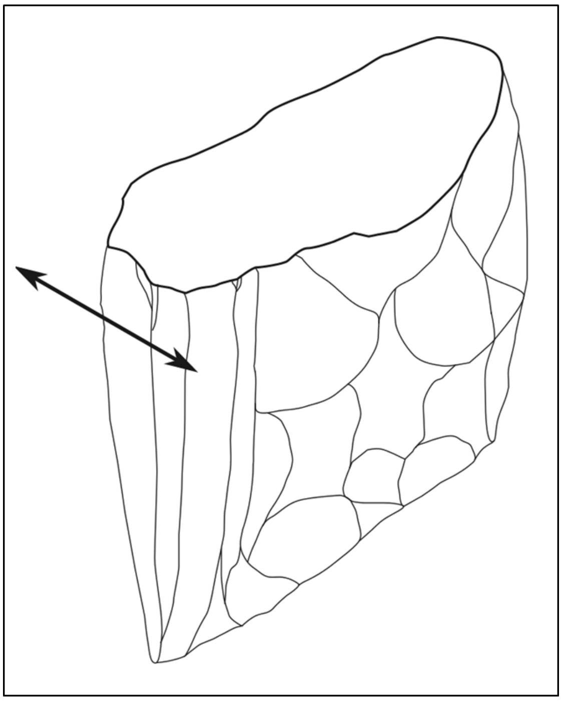


Figure 26. Frontal Flaking

C – Full Circumference Flaking (Tournant) (Figure 27)

These cores are shaped specifically to allow for the entire circumference of the core to be utilised for the production of blades. These cores tended to have a conical or polyhedral appearance. In this respect, they were shaped using a different method to cores types A and B above.

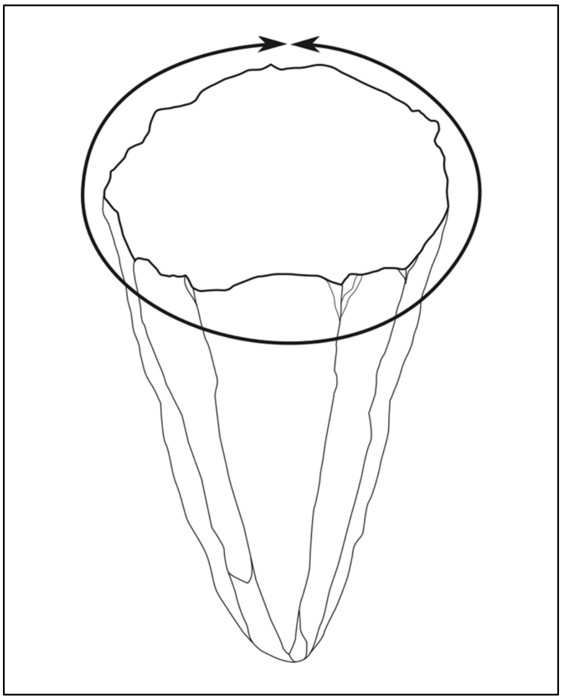


Figure 27. Full circumference flaking

D – Semi-Circumference Flaking (Semi-Tournant) (Figure 28)

Semi-Circumferential flaked cores utilise only a portion of the full circumference for the removal of blades. The blade face and platform would retain a circular appearance while the unworked side of the core may have retained the remainder of the full circumference, or it may have been flattened. Semi-Circumference Flaking may also have allowed the core to be held in a support or device to facilitate blade detachment.

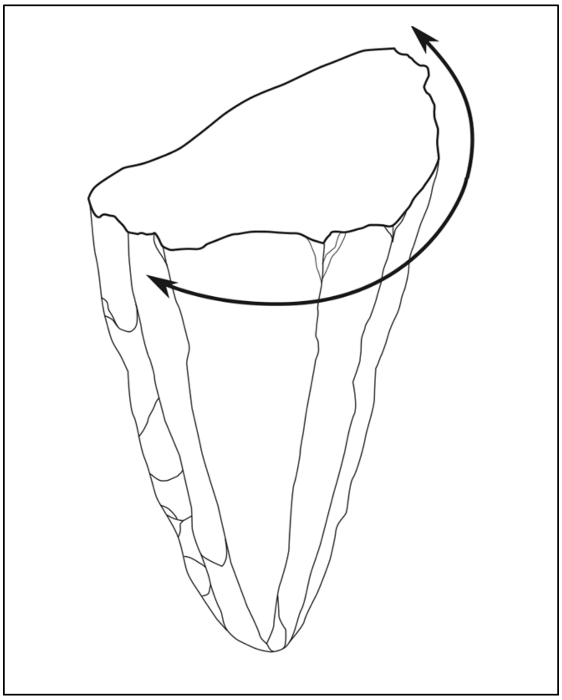


Figure 28. Semi-circumference flaking

Flaking trajectory (direction of blade removals)

The direction in which blades are removed is the final aspect of blade technology. This attribute reveals evidence for how, once the core has been prepared, it is used for the systematic production of blades. Depending on how the blades are detached, the life of the core can be established and this may help in understanding why and when the core was ultimately discarded. This is the third level of this taxonomy.

1 – Unidirectional (Figure 29)

Unidirectional cores are those where blades are removed only in one direction, from the platform across the blade production face. The advantage of this technique was that blade length could be retained across a large number of removals.

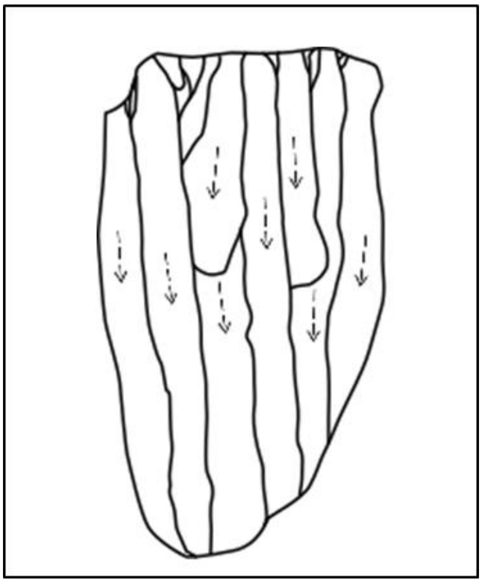


Figure 29. Unidirectional core

2 – Bi-Directionally Opposed (Figure 30)

When blades are removed from a core with two striking platforms (Type’s III & IV above) with the detachments being of roughly equal length; the core can be described as bi-directionally opposed.

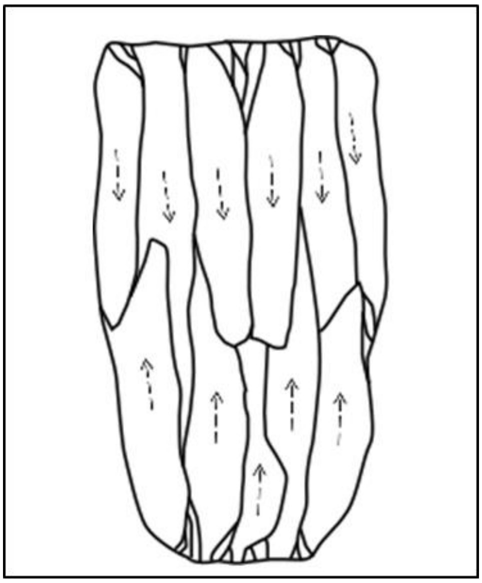


Figure 30. Bi-directionally opposed core

3 – Bi-Directionally Alternate (Figure 31)

Bi-Directionally Alternate cores are similar to Bi-Directionally Opposed cores; however, the scars left on the blade face will show a clear pattern of alternate use between the two platforms. A blade or series of blades was detached from one platform, the core was then rotated and the second platform was used to remove another blade, or series of blades, following the arris from the previous blade. These removals would be roughly equal in length.

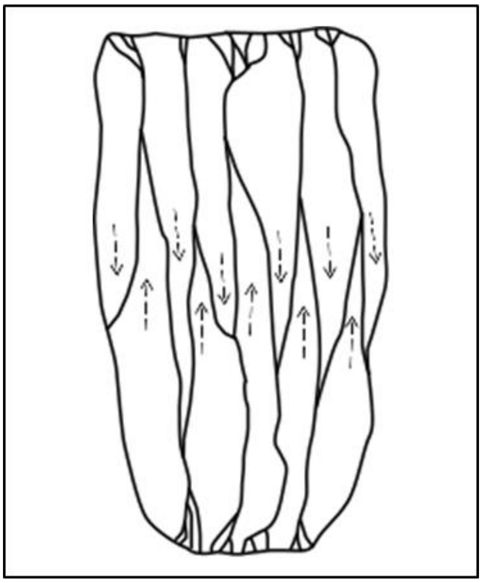


Figure 31. Bi-directionally alternate core

4 – Bi-Directionally Angular (Figure 32)

Bi-Directionally Angular cores have a series of blade removals from one or two platforms that meet at an angle. In this respect the core can be described as pyramidal, where two platforms were created on opposite faces of the core with the blade removals travelling the length of the face from both platforms, leaving an angle between them.

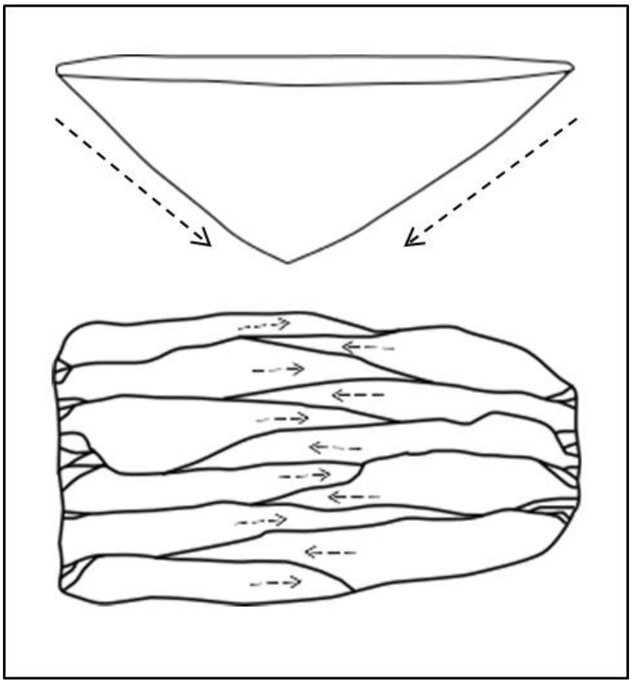


Figure 32. Bi-directionally angular core

5 – Asymmetrical (Figure 33)

Asymmetrical blade removals will show a heavy reliance on one platform over the other. This technique may have been the result of the creation of a second platform in order to maintain the flaking face or to correct an error on the blade face of a core. Scar lengths on asymmetrical cores would usually be significantly shorter from the opposing platform.

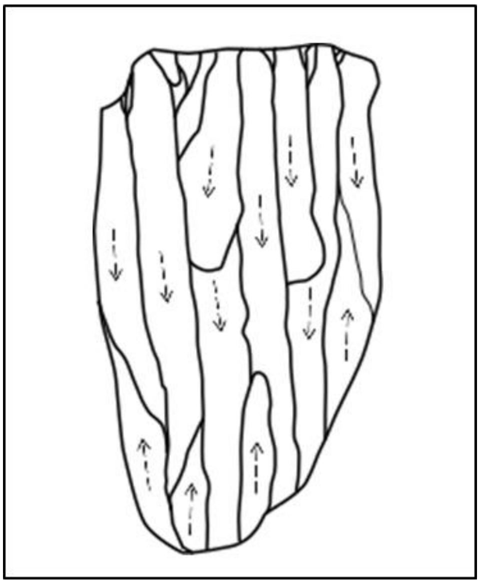


Figure 33. Asymmetrical core

6 – Multidirectional (Figure 34)

These cores will retain blade scars on a number of different faces of the core. Generally, these cores will fit into either the Type V or VI category above. However, it is possible that a well-prepared core may have been handed to a novice knapper and so the core retains evidence of ordered sequential removals before the multidirectional flaking.

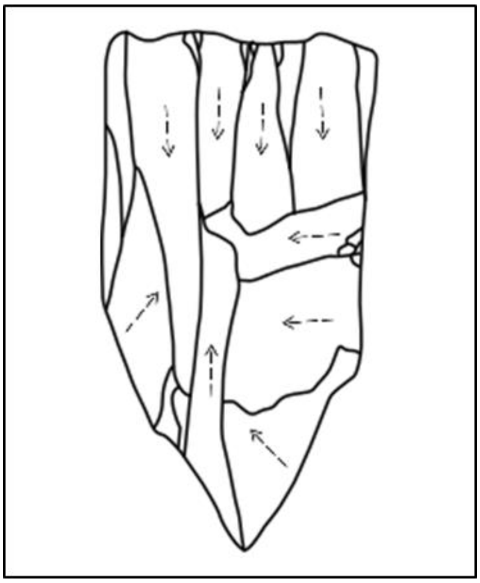


Figure 34. Multi-directional core

Using the Taxonomy

The principal purpose of this taxonomy is that it can be used to describe blade manufacture from regions and cultures across the globe. In illustration, the taxonomy should be written as follows; Type II A-1. In this example, cores would have one, faceted platform using one face of the nodule with blades detached in one direction only (unidirectional). A Type IV D-3 would be a core with two faceted platforms with semi-circumferential core flaking bi-directionally, with a series of blade detachments alternating between each platform. Figure 35 summarises the taxonomy for reference.

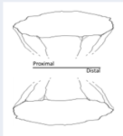
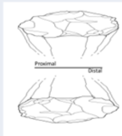
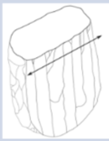
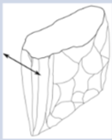
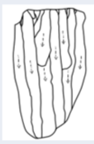
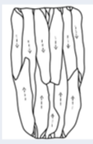
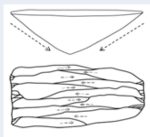
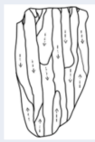
Type					
Type I *Single platform – plain*	Type II *Single platform – faceted*	Type III *Double platform – plain*	Type IV *Double platform – faceted*	Type V *Multi-platform*	Type VI *Expedient*
					
Morphological use					
	A *Facial*	B *Frontal*	C *Full Circumference*	D *Semi-Circumference*	
					
Flake Trajectory					
1 *Unidirectional*	2 *Bi-directionally opposed*	3 *Bi-directionally alternate*	4 *Bi-directionally Angular*	5 *Asymmetrically opposed*	6 *Multidirectional*
					

Figure 35. Core taxonomy

The use of this taxonomy is not intended to be applied solely as a method for understanding blade technology. It is important in any research on technology that other factors are analysed. The method, and strategies of removals must also be understood, alongside the mode, or flaking technique used (percussion or pressure, hard hammer or soft hammer). Sequencing and spacing are also important factors alongside the maintenance, rejuvenation, and error correction attributes. Discard or core abandonment should additionally be interpreted before a more complete picture of technology can be understood.

What this taxonomy does allow for is a greater understanding of blade technology in a wider global context. In one region, technology may stay the same across numerous archaeological cultures, or we may see the progressive development within one culture from Type I to Type III cores with bi-directional removals. This approach allows one to compare technologies across regions to understand how they spread both spatially and temporally.

As outlined in Chapter 2, there are a number of challenges faced by knappers when working stone and there are numerous methods in which these can be met. Some of these methods will have an impact on the appearance of the core and so it is important for each core to be studied for an assemblage in order to establish the basic form utilised for that specific technology. An assemblage may, overall, consist of Type II A-1 cores. Not all cores in this assemblage may be placed in this category; there may be some Type IV A-5 cores, where the knapper has created and used a second platform for the removal of smaller blades to correct errors on the blade face of the core. There may even be Type IV A-6 where removals have become multidirectional. This latter trait may be due to lack of skill as opposed to planned development (*see* Lohse 2010).

The difference between Type V and VI is another important aspect of this taxonomy. While certain cores may have multiple platforms, the removal from those platforms may adhere to the second and third level of this taxonomy, so a Type V A-1 core may exist. It may be impossible to assign any further levels to the Type VI expedient cores as, by their very nature, the use of the raw material is expedient and therefore formal blade manufacturing strategies may be lacking. It is possible in any assemblage to find some Type VI cores, particularly at manufacturing sites. If a culture is restricted to only Type VI cores it would be necessary to explore the reasons why and establish if this technology can be classified as a blade technology. Figure 36 highlights six examples of cores using this taxonomy. It is also possible that a core exhibits a plain and faceted platform. Again, this would require further analysis to explore the possible reasons behind this.

Finally, it should also be recognised that not all of the possible combinations with this taxonomy can exist. A Type III C-2/3/4/5 core would not retain the correct angles to allow for the continued and successful detachment of blades. Equally, a Type IV C-2/3/4/5 core would be highly unlikely due to the angle between the platform and core blade face. It is possible that the preparation of a Type IV C-2/3/4/5 could establish the correct angle, but the investment required to keep this type of core viable may outweigh the benefits.

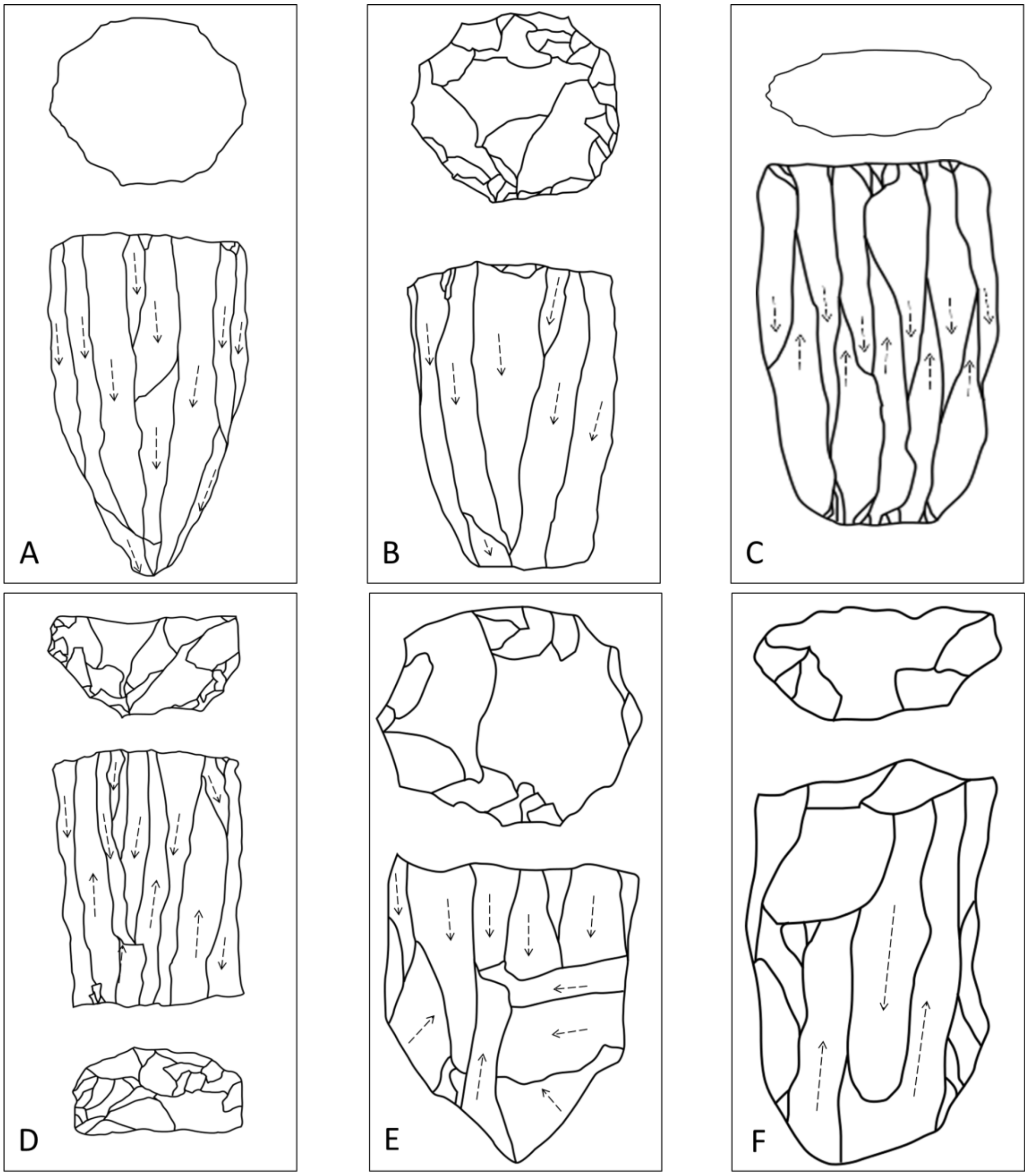


Figure 36. Illustrations of core types; Type I C-1 (A); Type 2 C-5 (B); Type I B-4 (C); Type IV D-3 (D); Type V A-6 (E); Type VI

Examples of Applying the Taxonomy

Qesem Cave

Returning to the examples from Chapter 2, the blade technology present at Qesem Cave (Shimelmitz et al., 2011) would be described as Type I B-1 (single plain platform, with unidirectional frontal flaking) with cores (Figure 37). One platform, using the thinnest end of these tabular cores is used, with blades being removed in one direction, although facial flaking is also identified. Shimelmitz et al. (2011) also discussed the occasional use of an opposing platform for the correction of errors. Therefore this technology also has some Type III B-5 (double plain platforms, with asymmetrically opposed frontal flaking) cores, but it is clear from analysing the entire assemblage that the Type I B-1 cores are the standard form. It should be noted that Type III B-5 is a variation on the Type I B-1 cores.

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Figure 37. Qesem Cave cores; Type I B-1 (A); Type 1 A-1 (B); Type III B-1. After (Shimelmitz et al., 2011)

Mesoamerican Polyhedral cores

In Crabtree's (1986) paper on replicating obsidian blades from Mesoamerica, there was more variety in the types of cores used. Type I and II cores were discussed with either C or D category of use alongside the direction of removals of either the 1^{st} or 2^{nd} type. In this respect, there are eight permutations within this technology, ranging from Type I C-1 (single plain platform, with unidirectional full circumferential flaking) (see Figure 38) to Type II D-2 (single faceted platform, with bi-directionally opposed semi-circumferential frontal flaking). This variability may reflect differences in raw material availability, or it may reflect a certain degree of flexibility in the manufacture, or even a desire for different types of blades that require different types of cores.

If this technology was to be compared to another, it would be important to understand whether or not all permutations were in fact utilised by that culture. If eight permutations were possible yet one industry refrained from using 3 of those permutations while another industry had all eight represented, it would be important to understand what factors affected this.

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Figure 38. Type I C-1 core from Crabtree's experiments (1986)

Evolution, Adaptation, and Technological Relationships

Patten (2005) asserts the idea that technology does not just occur, or change 'overnight', and that innovation and technological change represents a systematic process where small attributes of the particular manufacturing sequence or design are changed only when it is perceived by the group to give an advantage over the current method. These "process steps" (Patten, 2005) are usually an expansion of prior knowledge, and old methods are not abandoned until the new one is tried and tested. The consequence of this is that technology tends to mature slowly and only minute changes in the technology occur over minor timeframes; bigger changes are therefore representative of the culmination of small adaptations to the technology and are only viewed from a larger generational perspective.

Consistent with this is the idea that a group would rarely change all three aspects of blade technology outlined above, at least not within a narrow time span. As Petrie (2011) states, innovation is an inherently complex phenomenon. However, through time, there could be significant technological shifts. Analysis of these shifts requires the analysis of both the small-scale and the large-scale processes (Petrie, 2011). The establishment of a second, opposing platform may appear and become the dominant core type as it provides the knapper with an in-built system for maintenance and correction. This step may have started on only a handful of cores and represent a very marginal technological aspect at first. As the use of technology progressed, either the culture or the following culture recognised the advantages (or perceived advantages) that a second platform had. Slowly this second platform may have been incorporated into the style until it became the dominant core type.

A technology may also drift, and changes can occur for apparently "random" reasons. Raw material has been cited as a possible reason for technological change, although a recent article by Eren (2014) questioned how influential raw material is to the reduction process. Finally, technology can change for non-utilitarian reasons, and identifying these changes within a single population/group/culture can present challenges to any investigation.

Using this new methodology, the spread and evolution of blade technologies can be assessed on both an intra- and inter- regional scale. The technological evolution and adaptation of blade technologies in one specific region can be analysed. Beyond this the dispersal, evolution, and adaptations of blade manufacturing can be assessed across wider geographic regions without the often, confusing nomenclature and analytical approaches hindering research.

Human and technological dispersion can be analysed in greater detail by describing the basic elements of blade manufacture through time and space and how each element is altered or changed. The progression from single to double platforms in one region followed by the dispersal of that technology into its neighbouring region with the evolution of bi-directional flaking allows archaeologists to combine research efforts to understanding the nature of technology and would allow for more detailed evaluations as to the reasons behind some of these changes. Furthermore, it provides a framework around which technological origins can be assessed. A technology may be related to a preceding culture based on the blade technology, even if separated geographically.

Understanding the broad patterning of technology also allows archaeologists to assess regions where a new manufacturing technology appears. This may indicate the influx of new people into the region bringing their own technological skills and manufacturing techniques. Finally, it must also be stressed that simply because two cultures share the same core types, it does not inherently imply a relationship. Raw material constraints combined with technological requirements may lead to an overlap in technology separated by space, time, or both. What is important is that archaeologists understand the full nature of the technology. Even if typologically speaking, cores appear the same, where the same types of rejuvenation flakes were removed, did the technology utilise the same method of error correction or the same mode of removal (hard or soft hammer percussion or pressure flaking)? These questions require further analytical study and only then can the full picture of blade technology and its dispersal be understood.

This model taxonomy enhances nomenclature with a universal code that can be used to categorise any blade industry. By describing blade technology in this manner, research into the dispersal of technologies can be more effectively presented and understood by the wider community as well as allowing for a greater understanding of blade manufacturing techniques in prehistory.

Chapter 7
Clovis Blade Technology

The following chapters assess the current literature on those blade technologies relevant to this thesis. Blade technology remains poorly understood in terms of the actual technological approach and methods of manufacture (i.e. the process). While numerous investigations have been conducted into blade manufacture (Bordes & Crabtree, 1969; Crabtree, 1986; Bradley et al., 1995; Bradley & Giria, 1996, 1998; Collins, 1999; Renard, 2002; Delagnes et al., 2007; Renard, 2011; Shimelmitz et al., 2011; Boëda et al., 2013) this knowledge is only occasionally applied to the archaeological record in any great detail. Where this level of detail is lacking, interpretations are based upon the evidence presented in the publications, including any illustrations.

The first two chapters (including the current chapter) focus on the archaeological record of the United States, assessing both Clovis and pre-Clovis blade manufacturing. The next two chapters analyse the blade industries from western Europe, focusing specifically on the Solutrean of France and Spain (chapter 9) and then a discussion on the Aurignacian, Gravettian, Badegoulian and Magdalenian of western Europe (chapter 10). Chapters 11 and 12 focus on the Beringian and Asian archaeological data, respectively. Figure 39 illustrates the major North American sites discussed in text including three of the main Beringian sites discussed in chapter 12.

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Figure 39. Location of major North American sites discussed in the text

A history of Clovis research

As previously mentioned (chapter 3), Clovis was traditionally assumed to be the first culture in North America (Waters & Stafford, 2013). Clovis blades were first identified from Blackwater Draw, New Mexico (Figure 40). Blackwater Draw, frequently referred to as Blackwater Locality no.1 was first investigated in 1932 after A. W. Anderson of Clovis, New Mexico brought the site to the attention of E.B. Howard, then of the University Museum in Philadelphia. Since this discovery, numerous archaeological excavations have been undertaken at this locality, including research by the University of Pennsylvania, Texas Memorial Museum and the Museum of New Mexico (Hester et al., 1972). Blackwater Draw has become the Clovis type site (Hester et al., 1972; Boldurian & Cotter, 1999; Haynes et al., 1999) and from the artefacts recovered, archaeologists were able to construct a Clovis toolkit. This toolkit consisted of fluted projectile points (named Clovis after the local town) (Figure 41), scrapers, knives, gravers, and other flake and blade tools, hammerstones, choppers and a variety of bone artefacts, including bone awls and bone points

(Hester et al., 1972; Boldurian & Cotter, 1999). The site of Blackwater Draw consists of an extinct river bed which lies in the headwaters of the Brazos River (Hester et al., 1972). Geologic analysis of the site concluded that prior to human populations reaching the area; the stream was cut by the Pecos River which limited the water supply to local runoff and created a series of small shallow ponds (Hester et al., 1972). It is these ponds that attracted a wide variety of fauna, including turtles, snakes, mammoth, bison, horse, camel, deer, and antelope (Hester et al., 1972; Meltzer, 2009).

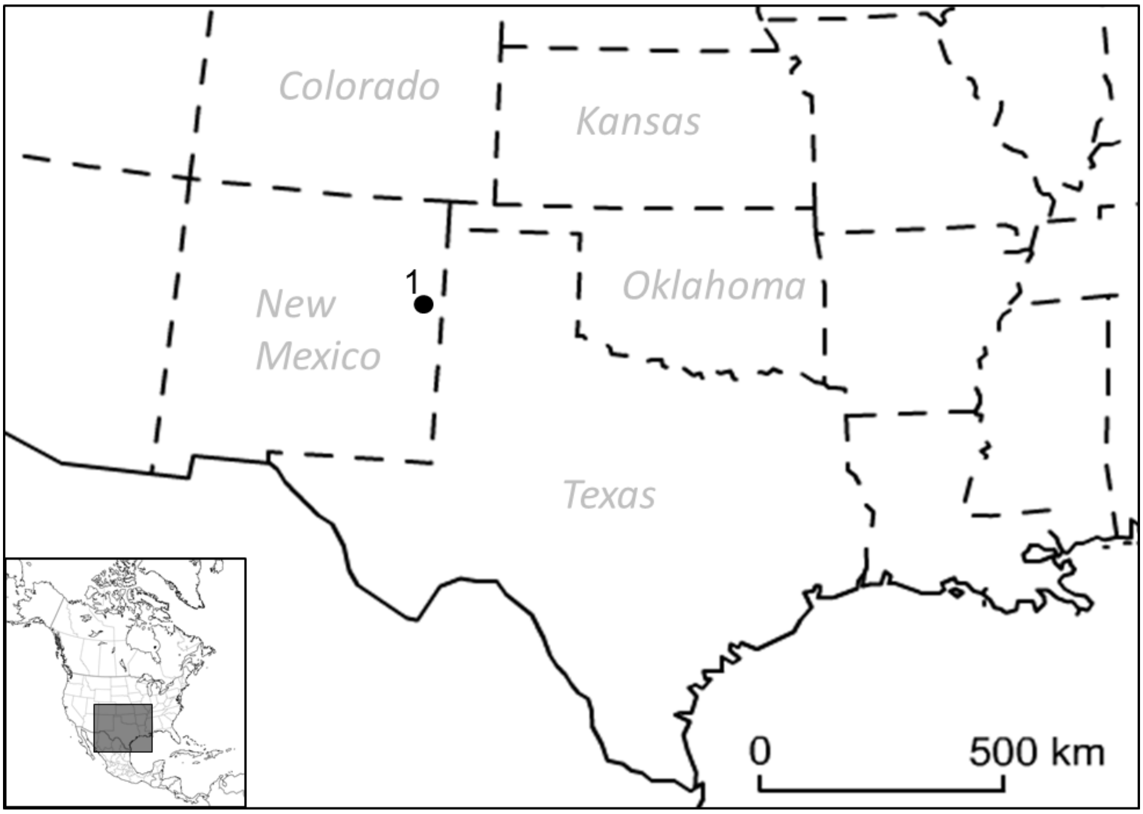

Figure 40. Location of Blackwater Draw (1)

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Figure 41. Clovis points recovered from Blackwater Draw. After Boldurian and Cotter (1999, p.17)

Evidence from the Clovis deposits indicates that bison were the most abundant species (Meltzer, 2009, p.268). Despite this, it appears that the mammoth remains were the focus of the Clovis activity, which included numerous flaked stone artefacts found around mammoth remains and a bevelled bone rod found in association with a mammoth ulna (Cotter, 1937; Boldurian & Cotter, 1999).

Further gravel quarrying operations in 1962 recovered a total of 17 blades. These blades (Figure 42 Figure 43) were identified as Clovis by Green (1963) based on the location of the find, in a contact between basin fill and caliche bedrock, and on similar implements recovered from the Lehner site (Haury et al. 1959a). It is these blades that have defined the characteristics that are now associated with Clovis blades, this definition stems from Green's assessment of the blades as long, thin, curved, prismatic blades removed from flint nodules (Green, 1963).

Clovis blade technology

Green (1963) noted from the blades themselves that they represented a formalised concept of manufacturing technique, one in which the end product fulfilled the purpose of intentional production. Green (1963) also noted the lack of retouch on the blades themselves, but rather numerous small flake scars which resulted from use, another indication that the blades were struck for use directly from a core. Due to the angle of the striking platforms, Green (1963) concluded that the blades were detached using indirect percussion, with the striking platform providing the footing for the punch.

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Figure 42. Original photographs of the Blackwater Draw Blades. After Green (1963)

As discussed above, Green (1963) also draws on similarities between these blades and two fragments recovered from the Lehner site. The blades from the Lehner site were identified as scrapers and were tentatively associated with the 17 blades from Blackwater draw based on the high degree of curvature exhibited. Similarities between these curved scrapers recovered from the Lehner site and other sites were made by Haury et al. (1959b) who noted similar artefacts in the pre-ceramic horizons in the California desert, and southern Arizona. Green (1963) also discusses an interpretation by Haury who noted similarities between these specimens and similar unifacially retouched scrapers from the El Jobo site in Venezuela (Cruxent & Rouse, 1956; Haury et al., 1959). As Green (1963) states, these resemblances are extremely remote.

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Figure 43. Curved blades from Blackwater Draw. After Collins (1999, fig.3.14)

Green (1963) concludes his analysis of the Blackwater Draw blades by briefly mentioning the parallels between the Upper Palaeolithic of the Old World and the newly discovered Paleoindian complexes, but he concludes that due to the quality of the evidence it would be difficult to answer any questions on the earliest Americans without distortion or exaggeration (Green, 1963). However, Green (1963) concludes that, based on the evidence from western North America, there appears to be little correlation between the “crude” industries from the Pacific side of the continent and the highly developed blade technology present at the Paleoindian sites further south. Green (1963) proposes two migrations present in the New World, with an older population connected to this complex blade technology and a later industry as seen in the sites from the pacific.

The early discoveries of Clovis were dominated by points recovered in association with mammoth remains and, as Collins (2002) states, it is these finds which gave rise to the notion of Clovis as specialised mammoth hunters who continually moved across North America. These kill sites dominated early theories’ concerning the technology of Clovis, and it was not until the 1960s, 1970s and later that evidence for Clovis camp sites began to mount. Green’s (1963) study of Clovis blades firmly established blade technology as a staple in the Clovis lithic toolkit. However, the phenomenon of blade manufacture remained largely unrecognised and under researched with a few exceptions (Haynes, 1966; Hester et al., 1972; Stanford, 1991). This factor, combined with the over representation of kill sites in Clovis research has led many researchers to conclude that all Clovis blades fit the definition outlined by Green.

Collins (1999) addressed the issue of recognition in his book on Clovis Blade Technology. The analysis of Clovis blades was based primarily on the wealth of data relating to Clovis blades from Texas, and specifically on the discovery of the Keven Davis Cache, located in Navarro County, Texas (Collins, 1999) (Figure 44). The blades discovered from the Keven Davis cache were almost identical to those recovered from Blackwater Draw in 1962, being long, thin and heavily curved. However, at the time of writing, the majority of Clovis cores were identified as conical cores; these polyhedral cores consisted of one multi-faceted platform with unidirectional removals from around the entire circumference of the core (Type II C-1). This presented a major issue for the study of Clovis blade technology, as Green (1963) concluded that the only evidence for blade cores in the vicinity of Blackwater Draw were the conical cores collected from surface locations across Texas (*see* Kelly 1992; Chandler 1992; Collins & Headrick 1992; Chandler 1999; Birmingham & Bluhm 2003; Calame 2006). However, these cores retain long, straight blade scars and so, as Green (1963) states, could not have been the same technology that produced the Clovis blades. This final point still requires careful reconstruction to determine if this is the case, although the early stage blade cores from Pavo Real indicate the removal of straight blades from conical cores (Collins et al., 2003).

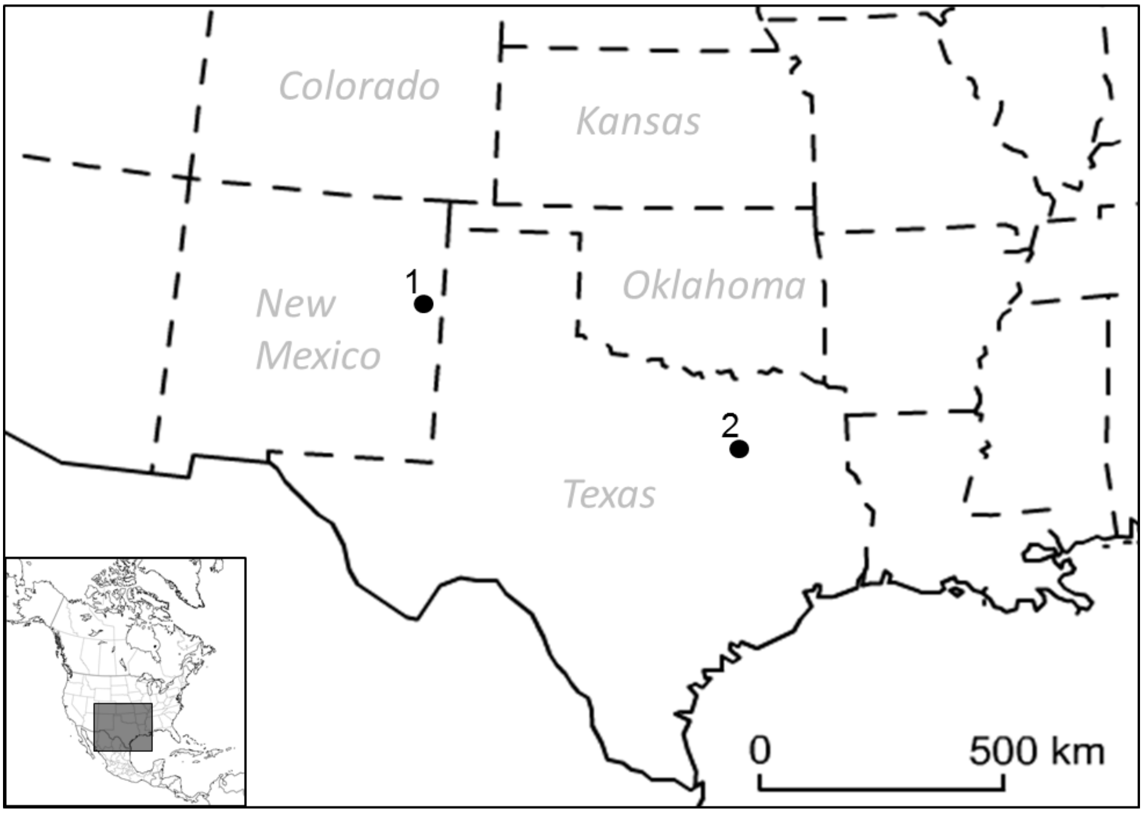

Figure 44. Location of Keven Davis Cache (2) in relation to Blackwater Draw (1)

Collins (1999) recognised the occurrence of both conical shaped cores (Type II C-1) and wedge-shaped cores (Type II A-1: single faceted platform, with unidirectional facial flaking), but due to the abundance of conical cores, the manufacturing methods he presented were largely based on these cores, although he notes that in experimental replication, Glenn Goode produced blades more typical of Clovis on the wedge-shaped cores (Collins, 1999, p.27). This dichotomy, between the heavily curved blades (Figure 45) found in Clovis caches and the straight faced conical cores was addressed in the postscript (Collins, 1999, p.185). In this postscript, Collins (1999, p.185) presented data from the Gault site, Central Texas, where excavations had recovered 13 blade cores, with only one of those being conical, with the rest being wedge-shaped cores, of the type that was used by Goode to produce heavily curved blades (Collins, 1999, p.186). The publication of Clovis Blade Technology (Collins, 1999), Kincaid Rockshelter (Collins et al., 1989), the Pavo Real monograph (Collins et al., 2003) and Clovis Technology (Bradley et al., 2010) marked a turning point in the full recognition of Clovis blade technology.

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Figure 45. Keven Davis Blades. After Collins (1999)

Clovis Sites

Before presenting an in-depth analysis of the manufacturing sequence of Clovis blades as discussed by numerous authors (Collins, 1999; Collins & Lohse, 2004; Boldurian & Hoffman, 2009; Sain & Goodyear, 2012; Dickens, 2005, 2008; Bradley et al., 2010; Waters et al., 2011b), it is important to assess the archaeological record in terms of those sites that have yielded evidence for Clovis blade manufacture.

As previously mentioned, the majority of early Clovis blade artefacts came from kill sites. As discoveries continued, Clovis blades were also identified in caches (Kilby, 2008), and from camp sites and workshops, such as the Gault Site, Texas (Collins, 2002). Each site type can provide archaeologists with evidence that can be used in the interpretation of a culture as a whole. With Clovis blade technology, the blades recovered from kill sites provide evidence for the functions that blades served there. The cached blades provided Clovis archaeologists with an indication of what type of blade traits were most common and even desirable during Clovis. Finally, the camp sites and workshop sites provide the most detail on the specific manufacturing processes that were used by Clovis knappers.

As discussed above, the site of Blackwater Draw, which is both a kill site and a cache site, defined Clovis blade technology. However, as Stanford (1991) notes, blades and blade cores have been recovered from numerous sites, although appear to be most common in the southeast and southern plains of North America. In terms of manufacturing technology, the Gault site, Central Texas represents the largest collection of recovered Clovis artefacts from any excavation (Collins, 1999; Collins & Lohse, 2004; Bradley et al., 2010; Waters et al., 2011b). A list of Clovis sites which contain recovered blade components is listed in Table 1. This table is not a comprehensive list but provides an indication of the types of sites and locations where blade technology has been recovered.

Table 1. List of Clovis sites that contain blade components

Site Name	State	Publications	Site Type
Blackwater Draw	New Mexico	(Green, 1963; Boldurian & Cotter, 1999; Hester et al., 1972)	Kill & Cache
Gault Site	Texas	(Collins, 1999; Collins & Lohse, 2004; Bradley et al., 2010; Waters et al., 2011b)	Workshop
Carson-Conn-Short	Tennessee	(Stanford et al., 2006)	Workshop
Pavo Real	Texas	(Collins et al., 2003)	Workshop
Kincaid Rockshelter	Texas	(Collins et al., 1989)	Camp
Murray Springs	Arizona	(Agenbroad & Huckell, 2007)	Camp
Shawnee Minisink	Pennsylvania	(McNett et al., 1977)	Camp
Williamson Site	Virginia	(Green, 1963; McAvoy & McAvoy, 2003)	Cache
Adams Site	Kentucky	(Gramly & Yahnig, 2013)	Workshop
Ledford Site	Kentucky	(Gramly & Yahnig, 2013)	Workshop
Aubrey Site	Texas	(Ferring, 2001)	Workshop
Wilson-Leonard	Texas	(Prilliman & Bousman, 1998)	Workshop
Topper Site	South Carolina	(Steffy & Goodyear, 2006; Sain, 2010; Sain & Goodyear, 2012)	Workshop
Agate Basin	Wyoming/Dakota	(Frison & Stanford, 1982)	Kill
McFaddin Beach	Texas	Various unpublished collections	Surface collection
Keven Davis	Texas	(Collins, 1999)	Cache
Anadarko	Oklahoma	(Kilby, 2008)	Cache
Anzick	Wyoming	(Kilby, 2008)	Cache
Busse	Kansas	(Kilby, 2008)	Cache
Crook County	Wyoming	(Kilby, 2008)	Cache
East Wenatchee	Washington	(Kilby, 2008)	Cache
Fenn	Wyoming/Utah	(Kilby, 2008)	Cache
Sailor-Helton	Kansas	(Kilby, 2008)	Cache
Phil Stratton Site	Kentucky	(Gramly, 2013)	Workshop
Paleo-Crossing	Ohio	(Eren & Redmond, 2011; Miller, 2013)	Camp

Of the sites mentioned in the table, this thesis will focus on the blade components from the Gault Site, Carson-Conn-Short, Pavo Real, Murray Springs, the Topper site, and Paleo Crossing, as well as a brief analysis of the Clovis caches, including East Wenatchee and the Sailor-Helton cache. Although these sites represent only a small portion of the total number of sites with blade technologies, they are representative of the range of Clovis blades and blade cores.

The Gault site

The Edwards Plateau, located in Central Texas is one of the largest sources of chert in North America (Banks, 1990). The rich beds of chert, ranging from 0.6cm thick to almost 15cm thick (Banks, 1990) and the high quality nature of the material has attracted human populations throughout the prehistoric and historic periods.

The Gault site (Figure 46) is situated in the Balcones Ecotone, a transitional zone between the upland areas of the Edwards Plateau, and the lowland Black Prairie region of the Gulf Coastal plains (Collins, 2002) (Figure 47). The site itself is almost 800m long by 200m wide and up until the 1990s the site was a prime target for looters and collectors (Collins, 2002). In 1998 the new owners of the property discovered the partial remains of a mammoth (one ulna and a nearly complete lower mandible of an adolescent mammoth) (Wernecke pers. comms. 2013). A field crew from the Texas Archaeological Research Laboratory under the supervision of Collins and Lundelius recovered these specimens along with the associated Clovis artefacts, which included four blade cores and a number of blades (Wernecke pers. comms. 2013).

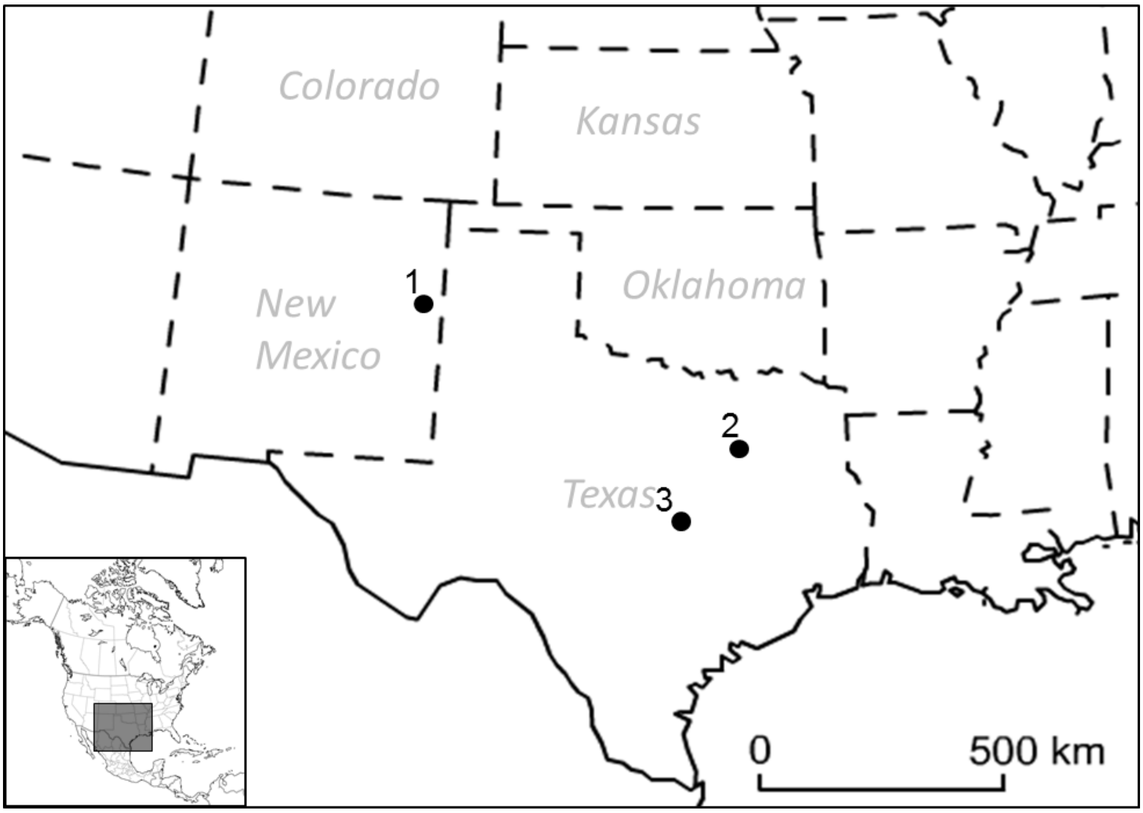

Figure 46. Location of the Gault site (3); Keven Davis cache (2); Blackwater Draw (1)

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Figure 47. Location of the Gault site with the major ecotonal regions shown. Courtesy of the Gault School of Archaeological Research

Following this excavation, negotiations began with the landowners, eventually agreeing on a three-year lease. Excavations were conducted between 1999 and 2002 relying heavily on professional, volunteer and avocational groups (Wernecke pers. comms. 2013). In 2002, the last year of the lease, test pits were dug in Area 15 of the site, with the goal of reaching bedrock, as these excavations continued, archaeological material, in the form of manmade debitage was discovered at elevations below the known Clovis deposits (Wernecke pers. comms. 2013). This discovery led to renewed negotiations with the landowners and eventually the land was purchased and subsequently donated to the Archaeological Conservancy (Wernecke pers. comms. 2013). Excavations began in Area 15 of the Gault site and were completed in the summer of 2013 (Wernecke pers. comms. 2013).

It is estimated that roughly 600,000 Clovis age artefacts have been recovered from the Gault site, which would account for around 60% of all Clovis artefacts recovered from across North America (Wernecke pers. comms. 2013). Current dating of the Clovis deposits using optically-stimulated luminescence (OSL) places the Clovis occupation of the site between ~13,250 ± 760 and ~12,387 ± 569 BP (Collins pers. comms. 2013). It was not possible to conduct radiocarbon dating at the site due to the poor preservation of organic matter (Collins pers. comms. 2013). OSL dating yields higher margins of error than radiocarbon dating, but these dates do correspond with those outlined by Collins (2002) and Waters and Stafford's (2007a) reappraisal.

With such a wealth of information recovered in-situ from the Clovis deposits at the Gault site, no other site has contributed more to an understanding of Clovis technology, and specifically Clovis blade technology. In 2010 a monograph on Clovis Technology was published with the majority of data coming from the Gault site (Bradley et al., 2010). Following this publication, in 2011, Texas A&M University published a monograph on the excavations conducted at the Gault site during the 2000-2001 excavation seasons which included in-depth analysis of the biface and blade technologies (Waters et al., 2011b). Clovis blade technology (Figure 48) from the Gault site had already been discussed in detail by Collins and Lohse (2004) in an edited volume on the first Americans.

The Gault site in Central Texas has generated significant numbers of artefacts relating to Clovis blade manufacture, which also includes distinctive blade core debitage (Collins & Lohse, 2004; Bradley et al., 2010). The existing knowledge of Clovis blade technology and manufacturing methods stem largely from analysis of this site and are discussed in detail below. However, Clovis blades have been recorded from numerous sites across North America.

Figure 48. Clovis Blade cores; Wedge-shaped (A-C); Conical (D-G); and Clovis Blades (H-L)

Pavo Real

The Pavo Real site (Figure 49) in South-Central Texas was first identified during the planned expansion of a rural two-lane road on the outskirts of San Antonio, Texas (Collins et al., 2003). Rescue excavations at the site recovered a Clovis workshop which contained numerous blade cores, blades and blade core preparation flakes, some of which refit (Collins et al., 2003). The site itself lies between the same transitional ecotone as the Gault site (Collins, 2002) although lying further to the south along the Balcones escarpment (Collins et al., 2003). The Edwards plateau is also a karstic region which includes many sinkholes, caves, caverns, and springs and the limestone hosts an extensive reservoir known as the Edwards Aquifer (Collins et al., 2003). As discussed above, the Edwards Plateau is a rich resource of flaking raw material and high quality chert outcrops are located at Pavo Real.

The intact Clovis component at Pavo Real dated between 12,690 ± 700 calBP and 11,940 ± 680 calBP (Collins et al., 2003) placing it closer to the end of the Clovis period based on reported Clovis ages by Collins (2002) and Waters and Stafford (2007a). When these dates are compared to the Clovis levels at the Gault site, it would appear that there is some overlap in occupation times with Pavo Real having a slightly younger occupation.

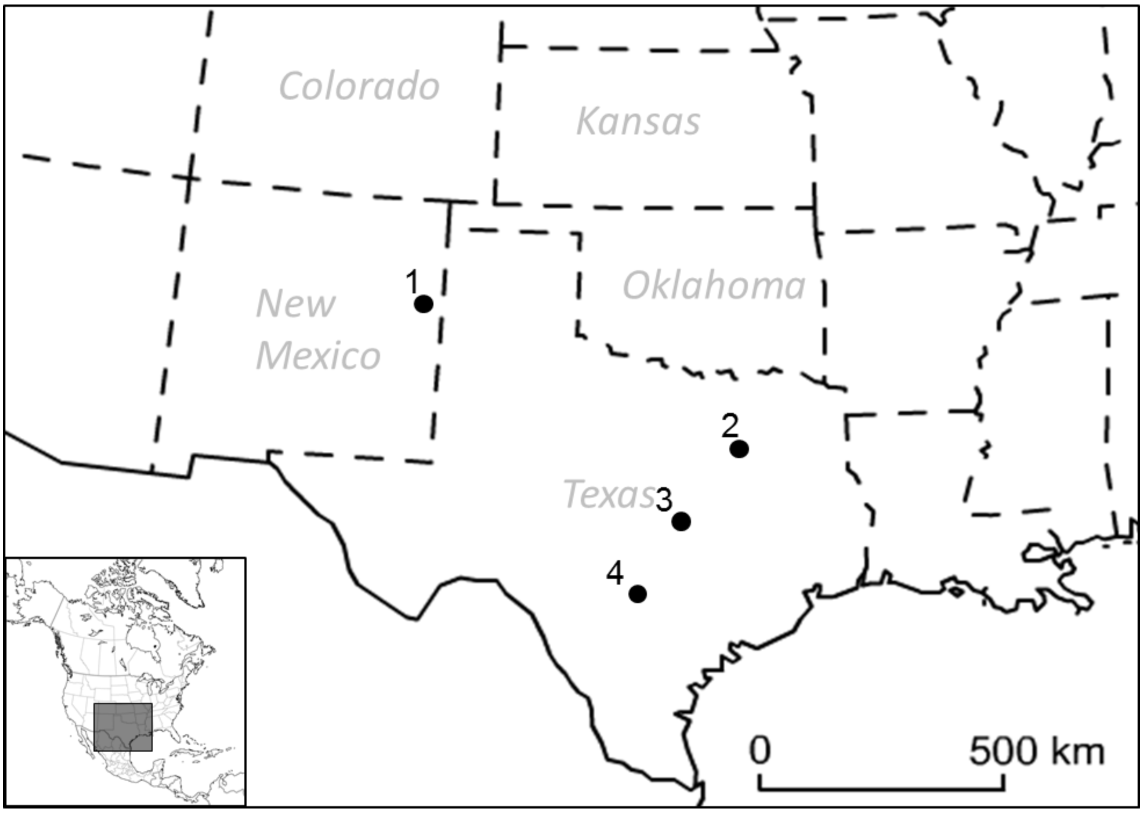

Figure 49. Location of Pavo Real (4); the Gault site (3); Keven Davis cache (2); Blackwater Draw (1)

The blade component at Pavo Real consisted of fourteen blade cores (Collins et al., 2003), of these, eight were classified as conical cores (Type II C-1) and six were described as wedge-shaped cores (Type II A-1). Along with these cores, 28 core tablet and platform preparation flakes were recovered, six error recovery blades and 132 blades (which includes 4 blade-like flakes) (Collins et al., 2003). A further 16 blades were also identified as tools, 11 blades were unifacially retouched and 5 exhibited endscraper retouch (Collins et al., 2003).

During post-excavation analysis 17 refit groups were identified, 4 of which were blade core refits (Collins et al., 2003). From these refit groups it is possible to identify certain methods used during the manufacturing process, which is discussed in detail below.

Refit Group 1 was described as a wedge-shaped core that was abandoned early in its reductive life with a multi-faceted platform and three blade scars on the core face (Collins et al., 2003). Platform preparation appears to have occurred on two blade removals, one negative bulb remains on the core face and the flake scar terminated due to a flaw in the material (Collins et al., 2003). A total of eight flakes were removed from this core, and when refitted the core was described as a blocky cortical piece (Collins et al., 2003).

The second refit group (Figure 47) from the study was an abandoned conical core with 12 removals; four core tablets, two platform preparation flakes, and six blade fragments (Collins et al., 2003). The core platform was multifaceted with two core tablet scars and a small number of platform preparation scars, the face of the core retains scars of three removals (Collins et al., 2003). Artefacts from this refit were recovered from over two meters away (Collins et al., 2003).

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Figure 50. Refit group 2 from Pavo Real. After Collins et al. (2003)

Refit group 5 comprises of a conical blade core, six core tablets, and one blade. The six core tablets refit onto the platform of the core sequentially with a final preparation flake removed before the blade was detached (Collins et al., 2003). This sequence of removals means that no negative bulbs from previous blade removals can be identified on the individual core piece. It is unclear whether this core was worked with the intention of being used later or if it was abandoned at this point (Collins et al., 2003).

A small blade fragment, which refits onto the face of an exhausted multifaceted platform conical blade core (Type II C-1) comprises Refit group 6 (Collins et al., 2003).

These 4 refits from Pavo Real contribute to a greater understanding of Clovis blade manufacturing technique, including the use of core tablet removals and platform preparation flakes. One of the interesting features of the assemblage is the lack of negative bulb scars on the face of the conical cores, suggesting, as refit group 5 indicates, that numerous rejuvenation episodes occurred during manufacture. Many of the platforms that remain on the cores were multifaceted, which may indicate that for each blade removal the core platform was prepared in a specific way to facilitate removal.

Pavo Real and the Gault site are not the only two sites along the Balcones Escarpment in Texas with stratified Clovis deposits that contain evidence for blade manufacture. Along with the surface finds from across Texas, there are several sites located along the Edwards Plateau which contain Clovis blades, blade cores and blade manufacturing debris. A blade core was recovered from Kincaid Rockshelter (Collins et al., 1989) and retouched blades were recovered from a rescue excavation on the outskirts of Austin, the Wilson-Leonard site (Prilliman & Bousman, 1998). A blade core was also recovered from close to a chert outcrop of the Edwards Plateau close to the Gault site, identified as site 41BL55 (Nightengale pers. comms. 2013).

While Clovis blade manufacturing sites are numerous across North America, the sites in Texas have contributed to the current understanding of Clovis blade manufacture. This fact is largely due to the number of well excavated workshop and camp localities, alongside the early recognition of blades by Green (1963) in New Mexico and later the detailed analysis of Clovis blades by Collins (1999). Subsequently, Clovis blade technology is defined by many of the characteristics and traits associated with these artefacts. While numerous other Clovis sites share all of these traits, it is important to note that the evidence for Clovis blade manufacture is not always well documented.

Murray Springs

In 1966 archaeologists were exploring and mapping the late Quaternary deposits in tributaries downstream of Lehner site (Figure 51) in the San Pedro Valley, Arizona when mammoth bones were identified in stratigraphy directly below a layer of black organic clay (Haynes, 2007, p.6). Excavations were conducted at the Murray Springs site (Figure 51) between 1966 and 1971, unearthing a wide variety of Clovis age artefacts and associated faunal remains, including mammoth, bison, camels, horse, and Dire wolf (Hemmings, 2007, p.94). Dating of the site indicates a range of between 13,093 ± 196 calBP (11,190 ± 180 ^{14}C BP) and 12,596 ± 223 calBP (10,710 ± 160 ^{14}C BP) (Waters & Stafford, 2007b). Evidence for Clovis blade use and manufacturing were recovered from area 3, 4, 6, and 7 of the site (Huckell, 2007, p.205). Area 3 was identified as a mammoth kill location (Hemmings, 2007, p.96) with a utilised blade fragment found in-situ (Huckell, 2007, p.205). Area 4 contained the remains of multiple bison kills (Hemmings, 2007, p.114) and one in-situ retouched blade (Huckell, 2007, p.205). Area 6 and 7 were identified as a hunting camp. From this locality, two complete blades, and six blade fragments were recovered, along with two cores identified as blade cores (Agenbroad & Huckell, 2007, p.160)

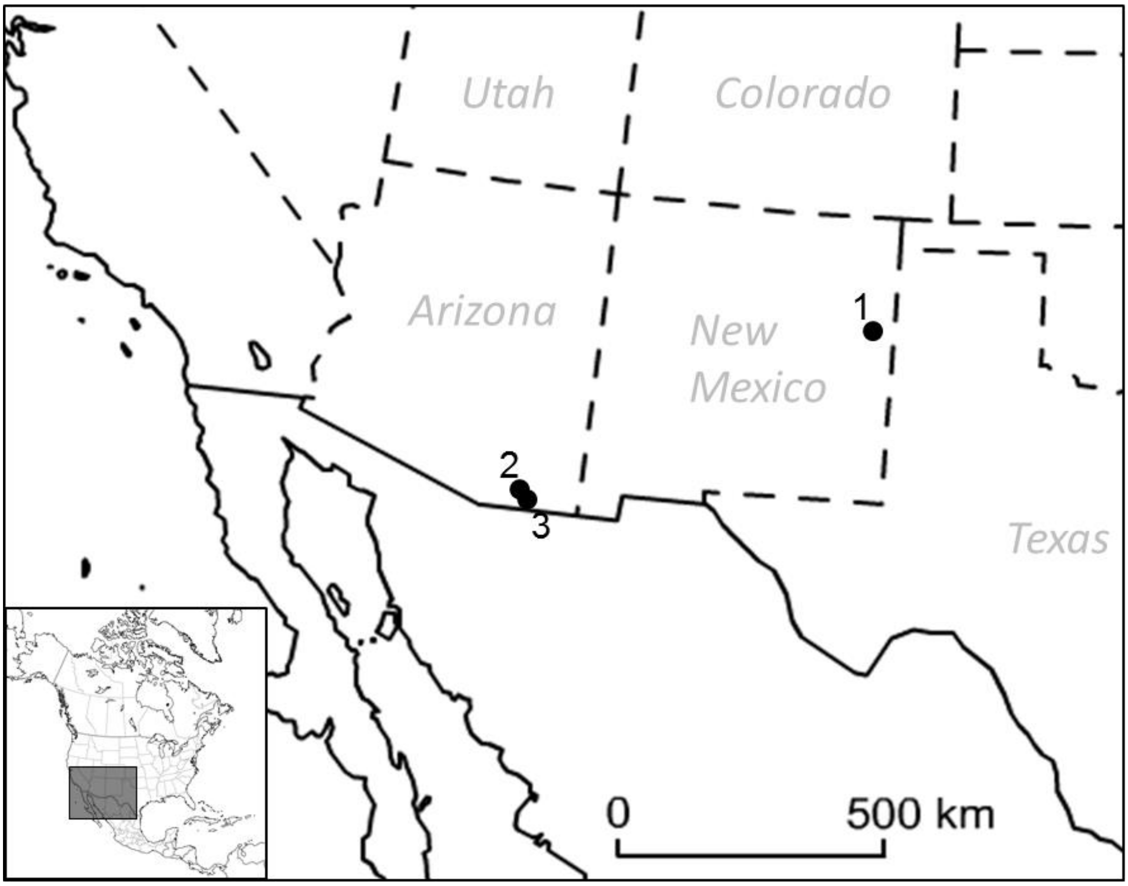

Figure 51. Location of Murray Springs (2) and the Lehner Site (3) in relation to Blackwater Draw (1)

Three of the recovered blades are described as being intentionally retouched, one of the blades has endscraper retouch and a pair of notches, this blade was broken into five pieces in antiquity (Agenbroad & Huckell, 2007, p.160). A second endscraper was recovered from Area 6 which was triangular in cross section, the central ridge of this piece retained a series of flake removals (crested blade) that were struck in order to straighten the ridge prior to detachment (Agenbroad & Huckell, 2007, p.161). This technique was common in blade removal practices, as flake detachments follow the guiding ridges on the core face (*see Chapter 2)*. The third blade was retouched with deep scars on the dorsal surface which removed a portion of the central ridge in an attempt to thin the blade (Agenbroad & Huckell, 2007, p.161). Three blades were utilised with two specimens exhibiting use damage along both lateral edges, the third specimen was reported as broken to a specific length possibly for hafting (Agenbroad & Huckell, 2007, p.161). Two distal fragments were also recovered, one which appears to have broken due to a material flaw, while the other retains no evidence for retouch or use (Agenbroad & Huckell, 2007, p.161).

The two cores recovered from Murray Springs were found in area 7 and described as fragments (Agenbroad & Huckell, 2007, p.162). One of these fragmentary blade cores retained a single, plain platform. From this platform, two large flakes were detached leaving deep negative bulbs of percussion visible on the core (Agenbroad & Huckell, 2007, p.162). Nineteen fragments that refit together have been identified as another core. The core is described as retaining a bifacial margin and it appears to have been intentionally burnt (Agenbroad & Huckell, 2007, p.162) although no evidence is provided by the authors to support their claims of intentionality. From the reconstruction of this core, Agenbroad and Huckell (2007, p.162) suggest the possibility of this core as a blade core. In his assessment of the Clovis component from Murray Springs, Huckell (2007, p.205) argues that there is positive evidence for Clovis blade technology. Evidence for this is provided in the form of the tools and cores recovered. The blades show positive indications of use at the site, while Huckell (2007, p.205) suggests that the cores indicate an "on-the-spot" manufacturing scenario and were made from locally available material. Huckell (2007, p.206) states that all but two of the blades can be termed typical, which he describes as true blades produced from prepared cores and not simply fortuitous blade-like flakes. Of the blades that retain striking platforms, Huckell (2007, p.206) identifies all but one of them as being prepared in a "bifacial fashion" and heavily ground, the only exception is one blade that retains a plain platform. Three of the more complete specimens display marked curvature (Huckell, 2007, p.206). Huckell (2007, p.208) also notes the presence of ridge preparation (as described above) on the blade from Murray Springs and similar removals from one of the Blackwater Draw blades. When analysed as a whole, Huckell (2007, p.209) proposes that, while the nature of the burnt core makes any analysis difficult, the blade assemblage represents an on-the-spot preparation and shaping of one or more cores and not simply flakes removed from bifacial manufacturing.

The Murray Springs blade assemblage (Figure 52) appears to be very similar in character to the blade assemblage recovered from the Gault site (Collins, 1999; Collins & Lohse, 2004; Bradley et al., 2010) and Pavo Real (Collins et al., 2003). Although the data from the excavated cores reveals little about the specific nature of manufacture, Huckell's conclusion of "on-the-spot" manufacturing implies an expedient use of blades at the site. The single, plain platform core may support this conclusion, with the removal of the blade-like flakes; however, the burnt core may represent a core that was carried to the site from a different location. The bifacial ridge would indicate the formation of a precore similar to those from Central Texas, but as Huckell discusses, its fragmentary nature makes any solid conclusions difficult.

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Figure 52. Murray Springs Blades. After Huckell (2007)

Carson-Conn-Short

The assemblage recovered from the Carson-Conn-Short site in Tennessee includes numerous specimens of blades and blade cores that share all the traits associated with Clovis blade manufacture. The Clovis horizons from the site yielded 226 blade cores and 1956 blades (Stanford et al., 2006). The site itself lies in western Tennessee close to Kentucky Lake.

Very little research has been published on this vast collection from the Carson-Conn-Short site. Stanford et al. (2006) presented a preliminary analysis of a small reference collection housed at the Smithsonian but included only minor details about the site. The collection contained two wedge-shaped cores (Type II A-1) and three cores which were described as sub-conical, Stanford et al. (2006) state that these terms are taken directly from Collins' 1999 publication. They discuss a number of the core preparation techniques identified on the cores. The material is described as local cobbles which were shaped into a precore with the establishment of a platform before blade production (Stanford et al., 2006). They discuss the removal of horizontal or oblique flakes which were removed in order to regularise the vertical edge to ensure successful removals of long blades (Stanford et al., 2006).

These removals were similar to those outlined by Bradley et al. (2010, p.44) who describes core maintenance and error correction. In this monograph, Bradley et al. (2010, p.44) describe the removal of flakes from the flat back of the core towards the core blade face from the distal edge of the core in order to reduce blade curvature. Neither Bradley et al. (2010), nor Stanford et al. (2006) discuss the technological purpose in any great detail behind the detachment of flakes from the back of the core across the lateral faces to the front of the core. Figure 53 illustrates two of the cores recovered from the site. Stanford et al. (2006) also discuss the removal of corner blades, which retain cortex on one side of the dorsal face, as sequential removals from either face of the core. It is interesting to note that that Stanford et al. (2006) define the overall shape of the cores as "D" shaped (or a horse's hoof), where the back remains flat, or cortical and only one face is used for the removal of blades. The platform of the core was prepared by the removal of centripetal flakes from the dorsal surface of the core (Stanford et al., 2006). Stanford et al. (2006) also identify negative bulbs on the core face indicating the core was discarded after a final stage of small blade removals. Occasionally, cores were discarded after diving blades truncated the core (Stanford et al., 2006).

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Figure 53. Clovis Blade Cores from Carson-Conn-Short. After Stanford et al. (2006)

In terms of blades from the Carson-Conn-Short site, the largest is a cortical blade (Stanford et al., 2006), which is expected as cortical blades are often the first blades removed during the precore shaping and when establishing a blade face for subsequent removals (*see Chapter 2)*. The blade was 188 mm long (Stanford et al., 2006), which is a good indicator of the original size of the nodule. Stanford et al. (2006) state that all primary blades were strongly curved, as opposed to the secondary blades which were described as relatively flat. In cross section all blades are triangular or trapezoidal and the flake scar pattern from the cores and from the blades indicate a unidirectional removal technique (Stanford et al., 2006). One of the interesting features of this small sample of the Carson-Conn-Short assemblage is the modification of one of the wedge-shaped cores into what Stanford et al. (2006) describe as a possible tool. Small bladelet flakes were struck from the posterior surface to form an acute edge on the core (Stanford et al., 2006). This edge is crushed and Stanford et al. (2006) suggests that the core was subsequently used as an adze.

As discussed above, Collins (1999) originally identified two types of cores associated with Clovis deposits, wedge-shaped cores (Type II A-1) and conical cores (Type II C-1). The sub-conical cores described in Stanford et al. (2006) appear to retain some flaking on both lateral margins that runs perpendicular to the blade face. These cores are classified as Type II D-1 (single faceted platform, with unidirectional semi-circumferential flaking) as the blade removals are described as from both the anterior face and sides. As discussed in chapter 6, the taxonomy provides archaeologists with a method for analysing blades from a technological perspective. Within Clovis technology, either of these Type II D-1 cores possibly represents a variation on the Type II C-1, with either material flaws or knapping errors forcing the knapper to alter the shaping of the core. Likewise, a Type II A-1 core may have been modified with continual corner blade removals, which widened the core face around to the lateral edges of the core thus creating a Type II D-1 core. This raises the possibility that during precore shaping, Clovis knappers would select either a facial or full circumferential flaking style of core depending on either the raw material shape or desired end product.

The Topper site

The Topper site is located in South Carolina along the Savannah River (Steffy & Goodyear, 2006). Excavations at the site began in 1998 and Clovis deposits have been recovered throughout the river terrace sequence from the current hill top down to the river banks (Steffy & Goodyear, 2006). Dating on the Clovis layer indicated an age of 13,200 calBP (Smallwood, 2010). Both blades and cores were recovered from this site, although, like the Murray Springs Site, Steffy and Goodyear (2006) described the cores from Topper as “informal” in their assessment of the macro blades. Steffy and Goodyear (2006) state that the cores present in the Topper assemblage have three or four parallel blades struck from one or more faces resembling a horse's hoof. It is noteworthy that Steffy and Goodyear describe these cores in this manner, the same term that Stanford et al. (2006) assign to the cores identified at the Carson-Conn-Short site.

While Stanford et al. (2006) identify these cores as essentially formal cores, Steffy and Goodyear (2006) class them as informal (based on description of formal cores as polyhedral cores). Steffy and Goodyear (2006) present no further argument regarding their classification of these cores.

While the majority of blade cores so far detailed from Clovis sites were unidirectional with single platforms, Bradley et al. (2010, p.44) note that Clovis knappers would occasionally utilise a second platform. This second platform was used for error recovery or as a method to establish a second core face when a failure ended the use life of the current blade face. Due to this, and without any illustrations of the core from the Topper site, it is difficult to assess whether or not these cores were as "informal" as Steffy and Goodyear claim.

The macro blades discussed by Steffy and Goodyear (2006) were described as straight, rather than heavily curved and blade scars on the dorsal surface indicate unidirectional removals. In this brief analysis of the blade technology identified at Topper, Steffy and Goodyear (2006) also note the wide platforms on the blades as well as heavy grinding, although they attribute this grinding to failure during detachment, which seems an unusual conclusion given the data presented by Collins (1999) on the intentional use of grinding on Clovis platforms.

In a more detailed analysis of the Clovis blades from Topper, Sain (2010) studied 257 blades from the Clovis contexts at the site, 139 of which were complete specimens. In this article, Sain (2010) describes the Topper blades as straight, with wide, thick platforms, diffuse bulbs of percussion, and triangular or trapezoidal in cross section. Sain (2010) identifies sporadic retouch occurring across the blades and describes this as being unifacial along either lateral margin or struck into the dorsal surface from either end (proximal or distal). Following on from the initial assessment of blade technology at Topper by Steffy and Goodyear (2006) Sain identifies 22 blade cores (presumably recovered after 2006). This includes 2 examples of conical cores, 19 wedge-shaped cores and 1 which is described as cylindrical (Sain, 2010). The cores which were studied were again described as resembling a horse's hoof, and Sain (2010) states that the cores were rotated with additional removals resulting in a wedge-shaped core. However, there is no further detail in this technological assessment of the Topper cores and so it is difficult to assess if the platforms were worked or not, there is also no explanation as to why one of the cores is described as cylindrical, as opposed to conical. Sain (2010) attributes the occurrence of the shorter, less curved blades from the Topper assemblage as an indication of raw material constraints, namely the small size of the raw material available to the Clovis knappers.

The conclusion drawn by Sain (2010) based on his analysis was that regional variances may be the reason for the differences. The issue of regional variation is difficult to assess from the analysis that is presented for the Topper blades, but it raises an interesting question concerning Clovis. As stated above, Clovis blades have been defined by the early discoveries and exhibit two specific traits; long and heavily curved. As Clovis technology is identified from more sites in North America it is worth considering amending the original definition.

The long, heavily curved blades are found mainly in cached contexts, whereas blades from the Gault site, Pavo Real, Carson-Conn-Short and Topper appear to be more varied including, straighter, shorter blades. This may indicate that Clovis knappers placed special importance on these long, heavily curved blades. This is in contrast to the blades recovered from workshop localities where blades may have served a purely functional role. This is supported by microwear analysis of Clovis blades from the Gault site which indicated a number of different activities were conducted, including hide cutting, butchery, and grass cutting (Shoberg, 2010). In this assessment, activities were differentiated on the basis of blade thickness. The thick "robust" blades were used for heavy duty butchering and scraping, and the thin "delicate" blades for precise manufacturing of wood and bone (Shoberg, 2010, p.156).

The site of Paleo Crossing, located in Medina County, Ohio, is a multi-component locality that includes a blade assemblage (Eren & Redmond, 2011). Radiocarbon dates from the site indicated an occupation around 12,907 ± 106 calBP (10,980 ± 75 ^{14}C BP) (Miller, 2013). One blade core was recovered from the site which had a final flake removal detached from the opposite end of the core to the previous blade detachments (Eren & Redmond, 2011). In an assessment of this blade component, Eren and Redmond (2011) concluded that while the blades were shorter than those from the Gault Site, there were no statistically significant differences in blade thickness, platform angle, platform width, platform depth, and index of curvature and concluded that these blades were Clovis. Microwear analysis from one of these blades indicated it was used for cutting plant material (Miller, 2013).

Clovis cache sites

Kilby (2008) identified all of the Clovis caches which contained evidence for blade manufacture. Only two examples of blade cores have been identified from a Clovis cache, the Anadarko cache (Hammatt, 1970), and while these retain blade scars, the illustrations show no evidence for any specific platform and lack any indication of negative bulbs and so positive identification on the specific nature of these blade cores remains difficult. Unfortunately the entire cache is currently missing (Kilby, 2008; Kilby & Huckell, 2013). With no unequivocal examples of blade cores in any Clovis cache, it would appear that no special emphasis was placed on caching blade cores in these locations.

Turning to the question of whether or not the long, heavily curved blades were regarded as something beyond purely functional, it is important to assess how heavily curved the blades were within Clovis caches. The Green cache (Green, 1963), Keven Davis cache (Collins, 1999), along with the JS, Pelland, Franey, and Sailor-Helton cache (Kilby & Huckell, 2013) are all considered as blade caches. The Green and Keven Davis cache, are discussed above as featuring heavily curved blades, in Kilby's analysis of the Clovis caches he discusses the curvature of blades from Franey and Bussy. The Franey blades, consisting of 35 blades (Kilby & Huckell, 2013) range from long, thin, heavily curved blades to shorter and less curved blades (Kilby, 2008). The blades from Pelland are similar in curvature to those of the Green and Keven Davies specimens, although Collins has questioned whether this cache is Clovis in age (Collins pers. comms. 2013). In Kilby's (2008) discussion on the Sailor-Helton cache he describes the blades as representing a range of curvatures, although provides no empirical data for this range.

With a range of length and blade curvature present in these cache assemblages, it is clear that long, heavily curved blades are not the sole aspect of blade production that is preserved by the behaviour of caching, but from its heavy presence; curvature should not be discounted as a purely functional aspect of Clovis blade manufacturing. Numerous possibilities may be proffered as to why these heavily curved blades appear in Clovis assemblages; however the focus of this thesis is on the process that produced them, rather than the functional or even symbolic purposes of these blades.

Clovis blade manufacturing and reduction sequences

Concerning the production sequence of Clovis blade manufacture, Bradley et al. (2010) present the most detailed breakdown of the knapping sequences used by Clovis knappers. This work is a more detailed, Clovis specific study of blade manufacture than was presented in Collins' (1999) "idealised" *Chaîne opératoire.*

Dickens (2005) studied the blades recovered from the Gault site during the 2001 – 2002 Texas A&M University field schools for his doctoral thesis. The majority of his findings supported the early work of Collins (1999), but Dickens (2005, p.234) identified specific core platform traits used during the production of conical blade cores. Dickens (2005, p.234) ascertained that platform rejuvenation was often undertaken by flaking from the blade face, into the platform itself, as a method for correcting surface irregularities. This technique produced sequent flakes, which retain deep bulbs and "V" shaped profiles and were detached to facilitate the correct striking angle for blade removals (Dickens, 2005, p.235) (Figure 54). Dickens (2005, p.235; 2008) also states that these removals often led to the need to remove bigger flakes, as the continued removal of sequent flakes led to deeper core platforms with numerous "knots", steps and hinges that may have ended the use life of the core platform.

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Figure 54. Blade core sequent flakes. After Dickens (2008)

Boldurian and Hoffman (2009) conducted a series of experiments, in order to determine the mode of the manufacturing technique (Newcomer, 1975) used by Clovis knappers. In these experiments, Boldurian and Hoffman (2009) knapped three different cores, from different material using different techniques, including soft hammer indirect percussion and soft hammer direct percussion. During these experiments, Boldurian and Hoffman (2009) recognised the importance of a specific trait of these heavily curved Clovis blades which had been largely under-recognised in the existing literature; the point of maximum curvature.

The point of maximum curvature is calculated simply by measuring from the blade platform along the ventral surface to the deepest point, thus the place of maximum curvature. This can then be calculated as a percent, where 50% would be curved in the middle, a 25% curve or 75% curve would indicate curvature closer to the proximal or distal ends respectively. Boldurian and Hoffman (2009) recognised this measurement as a key attribute in order to assess mode of manufacture. Using this trait, Boldurian and Hoffman (2009) suggested that direct percussion with a soft hammer billet gripped loosely in the hand with a semi-rest produced blades resembling Clovis. While curved blades could be produced using a number of techniques, it was the soft hammer, direct percussion techniques that yielded the highest number of Clovis-like blades, supporting the views of Collins (1999, p.31) and the experimental results of Goode.

Collins' (1999) seminal work on Clovis blades was updated in the 2010 publication on Clovis Technology (Bradley et al., 2010). Bradley et al. (2010, p.3) provided a detailed evaluation of the manufacturing process based on the results of the analysis on the Clovis blades and blade cores recovered primarily from the Gault site.

The manufacturing process was broken down by conical core production and then wedge-shaped core production. The acquisition of raw material was the first step in any reductive strategy, and the form in which the raw material comes is important to any manufacturing process. Raw material shape was identified as either irregular, rounded nodules, or as beds (Collins, 1999, p.17). Those pieces eroded or quarried from the bedrock, were identified as blocky, while the stream or river-rolled pieces were identified as cobbles (Collins, 1999, p.17). Each individual piece of raw material presented its own unique challenges, with some pieces more conducive to early blade removals than others (Collins, 1999, p.17). Before Clovis detached any blades, the core had to have three prerequisites; An initial guiding ridge, a platform, and a suitably acute angle between the core platform and blade face (Bradley et al., 2010, p.27). It seems likely that not all Clovis blade cores were first shaped via the creation of a precore to facilitate removals, if these three prerequisites existed in the natural morphology. Furthermore, expedient cores, where long, thin flakes were struck sequentially from the face of a nodule were also present as part of the Clovis Blade toolkit (Collins & Lohse, 2004; Lohse, 2010). If these three prerequisites were not present, initial Clovis core working took the form of precore shaping. The reduction strategies for both conical and wedge-shaped cores as presented by Bradley et al. (2010) are summarised in detail below.

Conical Cores (Type II C-1)

Precore Production

Bradley et al. (2010, p.27) state that Clovis knappers would select material that retained a flat edge on one end of the core, preferably with a 70-80 degree angle to another core face. The removal of a prominence along one of the core faces would create two guiding ridges for subsequent removals. From the archaeological record, they identify the elongated rounded eminences on cobbles, nodules, and the corners of flat blocky pieces as ideal starting points (Bradley et al., 2010, p.27). Analysis of blades indicates that only a small minority retained cortex. The primary core platform was orientated close to a right angle so as to allow for removals around the entire circumference of the core (Bradley et al. 2010, p.28). This angle would require the preparation of individual blade platforms for each blade removal throughout the reductive process (Bradley et al. 2010, p.28).

Platform Preparation

The next stage in the manufacturing process identified by Bradley et al. (2010, p.29) was the preparation of the core platform. Clovis knappers would have modified the core platform for each removal in order to produce an acute angle to facilitate detachment (Bradley et al. 2010, p.29). The evidence of this is shown in the flake scars on the platforms. These removals were detached from the blade face itself with the force directed almost straight into the core which frequently hinged or stepped (Bradley et al. 2010, p.29). This technique produced deep bulbs, thus creating the acute angle (Bradley et al. 2010, p.29). The sequent flakes as described by Dickens (2005; 2008) were the result of this process.

The platform created from these removals would then be trimmed, ground and released in order to detach a blade (Bradley et al. 2010, p.30). The remnant of a blade detachment left a typically shallow negative bulb and would leave an overhang. Any overhang of material between the core platform and blade face would be removed by reduction (Bradley et al. 2010, p.30). This repeated removal of platform preparation flakes resulted in deeply dimpled core platforms, which often left them with a heavy stack of hinges and steps at the centre (Bradley et al. 2010, p.32).

Blade Production

Blade production from conical cores continued in this fashion, with each individual platform created, prepared and detached from around the entire circumference of the core (Bradley et al. 2010, p.32). Due to the lack of any evidence supporting the intentionally “roughening” of a platform to prevent the slippage of a pressure tool, Bradley et al. (2010, p.32) concluded that blade removals were conducted using direct soft hammer percussion.

Bradley et al. (2010, p.32) also state that each blade removal was interspersed with a diverse range of tasks, from maintaining the overall core platform to preparing each individual blade platform and even recovering from errors during blade detachments.

Core Platform Maintenance

As Bradley et al. (2010, p.32) discussed, the nature by which the core platform was flaked in order to establish an acute angle for blade detachments frequently resulted in a stack at the centre. Due to this style of flaking, Clovis knappers had to pay considerable attention to maintaining the overall core platform (Bradley et al. 2010, p.33). These stacks would quickly become prominent features on the core platform and once it began to interfere with continued blade removal, Clovis knappers took steps to correct this (Bradley et al. 2010, p.33).

Core tablet flakes were used at this point and, if successful, would remove the entire core platform, reducing the height of the core, and therefore the subsequent length of blade detachments (Bradley et al. 2010, p.33). These thick core tablet flakes would leave a deep negative bulb on the platform, thus renewing the acute angle between the core platform and blade face in the area of the negative bulb. This method of removal was discussed after the finds from Pavo Real, Central Texas, revealed that numerous core tablet flakes were removed (Collins et al., 2003).

Bradley et al. (2010, p.35) notes this technique as a possible explanation for the peculiarity of Clovis conical blade cores that exhibit no negative bulbs on the blade face, due to the removal of these bulbs via core tablet flakes. This was a distinctive attribute of Clovis blade manufacture and one that was created via this continual sequence of core tablet and platform preparation flakes (Bradley et al. 2010, p.37).

Flaking Surface Maintenance

Bradley et al. (2010, p.37) identifies flaking surface maintenance (henceforth termed blade face) as another important aspect of managing and controlling the effective use life of a Clovis conical core. For a blade removal to be successful, Bradley et al. (2010, p.37) identified the need for an elongated guiding prominence that is minimally convex. During blade production, numerous problems may arise, some in the form of knapping errors while others are features of the core that create difficulties for continual removals (Bradley et al. 2010, p.37).

In order to correct these complications, Clovis knappers frequently had to sacrifice core mass in order to establish functionality (Bradley et al. 2010, p.37). Bradley et al. (2010, p.38) suggest that excessive curvature in blades was reduced by the use of an opposite platform, while a lack of curvature can be countered via the removal of flakes at either or both ends of the prominence. If blades became too broad and flat, it may be necessary for a Clovis knapper to remove a series of blades from elsewhere along the core platform-blade face interface and continue this sequence around the core re-establishing the correct spacing and length in the troublesome area (Bradley et al. 2010, p.38).

Wedge-shaped Cores (Type II A-1)

Wedge-shaped cores differ from conical cores as only one face of the core was utilised for blade production, with the opposite core face usually flat (Stanford & Bradley, 2012). As Bradley et al. (2010, p.38) state, while this process is less complex than conical cores, it encompasses wider variations in form and strategy.

Precore Production and Core Preparation

Bradley et al. (2010, p.38) determined that wedge-shaped core production was more opportunistic in the early phases of preparation. It was rare to see complex precore formation and blade detachments were frequently focused around pre-existing natural raw material forms (Bradley et al. 2010, p.38). Well-rounded, flattish cortical nodules of chert were selected and then a flake was struck off one end in order to produce a platform. This platform was orientated at an acute angle to a cortical edge that featured a rounded, elongated ridge (Bradley et al. 2010, p.38).

One key feature of these cores was the flattened backs of these cores. These flat backs were obtained by transverse flaking across the face of the core opposite the cores blade face. While this was recognised by Bradley et al. (2010), they only discuss it briefly in relation to maintenance.

Using the face of a core, the first initial blade would be entirely cortical and due to the morphology of the cobble, strongly curved (Bradley et al. 2010, p.38). Due to the initial flake, an acute angle would be maintained on the core after this initial blade detachment. The next sequence of blade removals would be side blades. Bradley et al. (2010, p.38) described two types of side blade, the first retained cortex to one side of the guiding blade ridge, with a blade scar, or scars opposite.

The second type of side blade exhibited numerous flake scars perpendicular to the removal trajectory in the place of the cortical side. This is indicative of where cortex was removed in order to form a guiding ridge by flaking from the flat back towards the blade face of the core (Bradley et al. 2010, p.38). The technological importance of these blades lies in their detachment, by creating another guiding ridge and effectively opening up the face of the core for subsequent removals. Centre blades follow on from the removal of corner blades, detaching a blade that follows one of the ridges without any cortex removed.

The individual blade platform preparation is similar to the platform preparation identified on Clovis bifaces (Bradley et al. 2010, p.38). Bradley et al. (2010, p.40) also describe a more complex approach to wedge-shaped core production, which knappers may have employed. Large thick bifaces may have been flaked from the raw material. These would have served the same purpose and been reduced following the same technique. Bradley et al. (2010, p.40) only identifies one example of a large biface from the Gault site which had a series of blade removals from one edge of the core.

Platform Production and Maintenance

The next stage was the repeated readjustment of the core platform in order to maintain its viability for subsequent removals (Bradley et al. 2010, p.40). Core preparation was achieved in a similar manner to conical cores with the exception that no core tablet flakes were removed (Bradley et al. 2010, p.40). As blade detachments continued, the angle between the core platform and blade face would become less acute, the solution employed by Clovis knappers was to strike a large flake from the platform, rejuvenating the platform by establishing an acute edge (Bradley et al. 2010, p.42). The archaeological record from the Gault site indicates that these flakes were frequently struck from the corner of the core, producing an acute edge in the centre of the blade face (Bradley et al. 2010, p.42). Individual blade platform preparation was conducted for each removal following the same techniques used on conical cores (Bradley et al. 2010, p.42).

Core Face Maintenance

As production from a wedge-shaped core continued, additional shaping may have been required to the distal end, the back of the core, or both (Bradley et al. 2010, p.44). Trimming the distal end of a core would reduce blade curvature and may be the sole purpose of this technique. The trimming was produced by the removal of flakes from the flattened back of the core towards the distal end (Bradley et al. 2010, p.44). Bradley et al. (2010, p.44) also describes occurrences on Clovis wedge-shaped cores where this distal trimming goes further and establishes a blade face that intersects another blade face, and results in the detachment of straighter blades. This technique resulted in Type IV A-4 (double faceted platforms, with bi-directionally angular facial flaking) cores. Like the Type II D-1 cores described above, Type IV A-4 cores were most likely an example of variation on a central theme and indicate the complex reductive strategies employed by Clovis knappers. The wedge-shaped cores themselves, overall, have blade scars, which were more curved than those on conical cores. Bradley et al. (2010, p.44) notes that this may reflect the removal of a deeply plunging (and so curving) blade that significantly reduced the length of the blade core frequently resulting in core discard.

Commonalities between Conical and Wedge-shaped reduction

Bradley et al. (2010, p.44) observed a number of behavioural traits that were shared in both reductive processes. As mentioned above, similarities exist in the preparation of the blade platforms, and in the maintenance of the core platform. They also note an interesting similarity, which is based on Tony Baker's dynamic loading model (Baker, 2004; Bradley et al., 2010, p.27). This model predicts that cores are constrained by their length and width. In this model, cores are similar to a cantilever beam under rapid dynamic loading, and this model accounts for 79% of the variability in core length. In analysis, Baker (2004) assumed that all cores were exhausted, and plotted the maximum length against the square root of the width multiplied by the thickness. Baker (2004) concluded that cores become unsuitable for blade detachments as they become too flexible and so likely to produce undesirable results. The implications of this model are that both types of Clovis core are discarded once the core becomes too flexible.

Knapping errors and corrections

Several types of errors can occur during the reduction of both types of Clovis blade core. Material flaws, step or hinge fractures, platform collapse and diving blades are all reported (Bradley et al., 2010, p.45). Bradley et al. (2010, p.45) state that, in the case of platform collapse, recovery was possible by reversing the direction of blade removals. An alternative on conical cores was available by simply rotating the core and removing flakes from along a different portion of the blade face (Bradley et al., 2010, p.45). In the event of a larger failure, core tablet flakes could be removed from conical cores (Bradley et al., 2010, p.45). For hinge and step fractures, a wider range of options available for recovery, although there are several cores from the Gault site which appear to have simply been abandoned at this point. In certain circumstances, it was possible to drive a second blade from the same platform (Bradley et al. 2010, p.46).

Alternatively, the Clovis knapper may establish a platform on the opposite (distal) edge of the core and strike a blade that removes the step or hinge from the opposite direction (Bradley et al. 2010, p.46). They also note that on rare occasions, flakes were driven laterally across the face of the core (Bradley et al. 2010, p.46). Diving errors, where a blade removed a large portion of the distal edge, were considered as fatal. Although they conclude that while their blade production may have ended, there is evidence that these cores were recycled into other tools, such as hammerstones, choppers, or even training pieces (Bradley et al., 2010, p.45; Lohse, 2010).

Summary

This in-depth deconstruction of the reduction sequence employed by Clovis knappers remains one of the preeminent examples of a technological analysis of Clovis blade production. In this respect, Clovis blade technology is one of only a handful of blade technologies that has been deconstructed in such detail. The reasons for this are varied, but as discussed in Chapter 2, there is still a misconception of typology as technology. Only a small number of blade assemblages have been studied in such detail. This includes the Solutrean (Chapter 9) and some technologies found across Eurasia (Chapter 12). A further assessment of Clovis blade production is presented in the discussion.

Chapter 8

Blade Technologies older than Clovis

Blades and blade cores have only been recovered from a handful of older than Clovis sites in North America. Due to the sparse nature of these assemblages, and the diversity of technologies represented in the pre-Clovis record, very little information has been published on the blade technology recovered from deposits stratigraphically below Clovis, or from those deposits which date to before 13,000 BP.

This chapter examines eight sites with evidence for blade technologies older than Clovis before briefly discussing basic characteristics of these early technologies. The presence of blades and the specific nature of the technological reduction strategies employed are becoming increasingly important to the study of the earliest North Americans and the origins of Clovis. As Collins et al. (2013, p.522) state there appear to be seven early cultural patterns in North America before Clovis. Of these seven, four are of particular importance to the Solutrean-Clovis hypothesis. These four patterns are:

1. Pattern 1: one site and 11 localities in New England where large, thin, bi-pointed bifaces have been found (Collins et al., 2013, p.522)

2. Pattern 2: four sites along the Atlantic seaboard manifesting thin bifaces with or without blades is the second relevant cultural pattern identified (Collins et al., 2013, p.522).

3. Pattern 5: two sites located on the Southern Plains periphery with cultural material below Clovis (Collins et al. 2013, p.523).

4. Pattern 6: numerous sites and complexes distributed near the Pacific margin from Beringia to southern South America. These

sites all share the presence of thick, narrow projectile points and bifaces, but lack macro blades (Collins et al. 2013, p.523).

Of these four cultural patterns, three are relevant to the study of blade technology. Patterns 2, 5, and 6 all contain evidence for blade manufacture. The data from patterns 2 and 5 is discussed below. Pattern 6 concerning the Pacific margin is discussed in chapter 12. Figure 55 presents the major sites that Collins et al. (2013) use for identifying patterns 2 and 5.

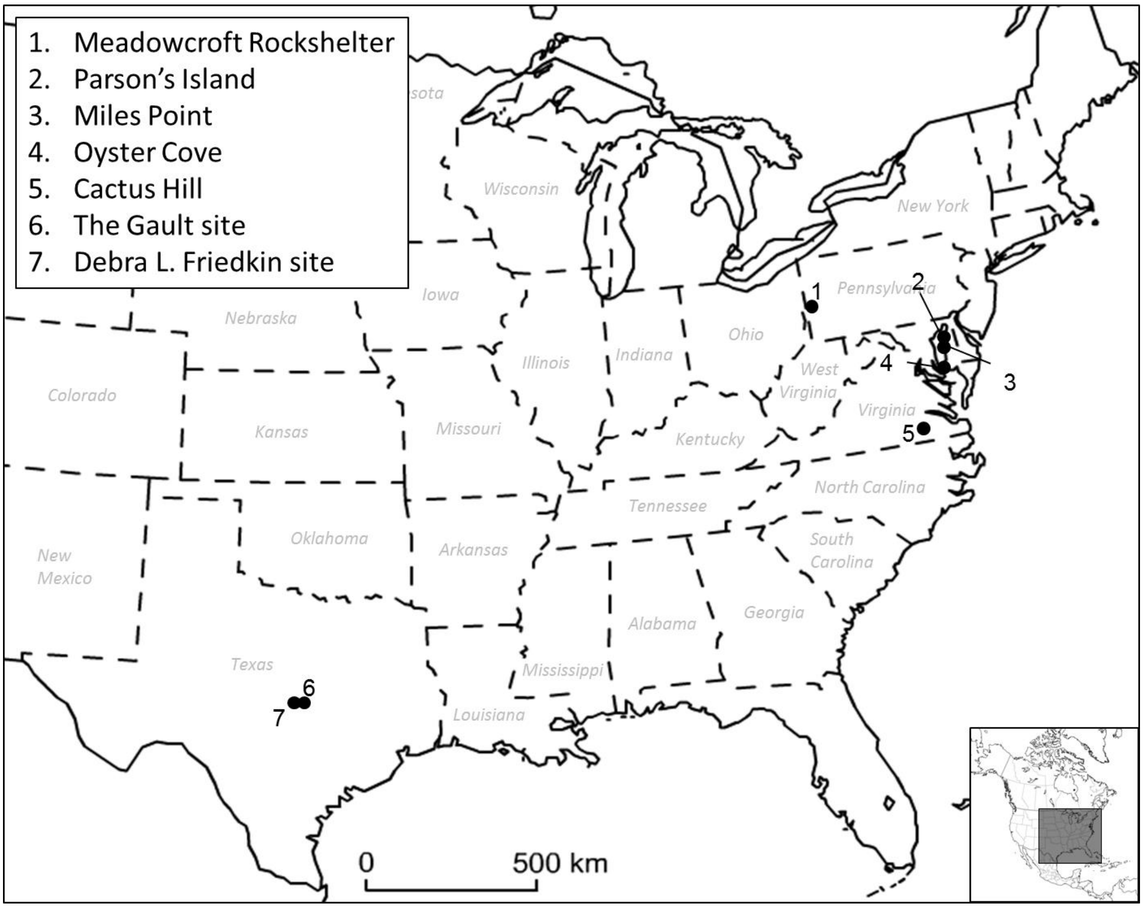

Figure 55. Location of the major sites discussed in this chapter

Older than Clovis sites

Collins et al. (2013, p.526) identified Cactus Hill, Virginia; Meadowcroft, Pennsylvania; Oyster Cove, Maryland; and Miles Point, Maryland, as the four sites which feature blade technology on the Atlantic Seaboard. They also identify the site of Cators Cove, Maryland as another early site from which evidence for serial prismatic blade production was recovered (Collins et al. 2013, p.526). Alongside these sites, evidence for blade technology stratigraphically below Clovis deposits has been recovered from the Johnson site, Tennessee (Barker & Broster, 1996), The Debra L. Friedkin site (Waters et al., 2011a) and the Gault site (Collins, 2013) both in Central Texas. These two sites are from pattern five in Collins et al. (2013, p.528) research. It is important to note that the Debra L. Friedkin site lies along Buttermilk Creek and is located downstream from the Gault site, although no formal analysis has yet been conducted into how the two sites relate to each other or if they are actually different areas of the same site.

Cactus Hill

Cactus Hill, Virginia, is a multicomponent stratified site located along the Nottoway River (McAvoy & McAvoy, 1997). The site is in a sand dune approximately 1.8m thick and as Goodyear (2005, p.107) notes, due to careful excavation, a well-documented and dated archaeological sequence has been established. Excavations during 1993 recovered three quartzite prismatic blades along with seven quartzite flakes and two fluted points in a hearth feature approximately 7cm below Clovis deposits (McAvoy & McAvoy, 1997, p.103) (Figure 56). Radiocarbon dating of the white pine wood charcoal from this unit produced a date of 18,279 ± 242 calBP (15,070 ± 70 ^{14}C BP) (Feathers et al., 2006). In 1996, further excavations revealed another hearth feature with a cluster of quartzite prismatic blades dating to 20,054 ± 885 calBP (16,670 ± 730 ^{14}C BP) (Feathers et al., 2006).

The blades recovered from the Cactus Hill site are described as prismatic blades and manufactured out of quartzite (McAvoy & McAvoy, 1997, p.103). One of the blades is curved in profile (Goodyear, 2005, fig.6; Collins et al., 2013, fig.30.4). The polyhedral cores recovered from the site feature single, plain platforms with blade removals from the entire circumference of the core, indicating Type I C-1 (single plain platform, with unidirectional full circumferential flaking) cores.

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Figure 56. Blades (A-D) and blade cores (E-F) recovered from Cactus Hill. After Collins et al. (2013)

Meadowcroft Rockshelter

The site of Meadowcroft Rockshelter is located 48km southwest of Pittsburgh, Pennsylvania. It lies within the Cross Creek drainage, a tributary of the Ohio River and is one of the longest standing cases for human presence before Clovis (Adovasio et al., 1978; Adovasio & Carlisle, 1982; Adovasio et al., 1990; Goodyear, 2005; Stanford & Bradley, 2012; Collins, 2013). The assemblage recovered from lithostratigraphic unit IIA of the site, contained enough material for the assemblage to be classified as the Miller Complex (Adovasio et al., 1978). The Miller point, as discussed by Stanford and Bradley (2012, p.165) is from this unit. The dating of the site has been the subject of continued controversy however, as Goodyear (2005) notes; the six radiocarbon dates reported by Adovasio et al. (1999) provide an unquestionable associated range for the artefacts recovered. This range is from 19,550 ± 1111 calBP (16,175 ± 975 ^{14}C BP) to 15,354 ± 1268 calBP (12,800 ± 870 ^{14}C BP) (Adovasio et al., 1999, fig.1).

The blades from Meadowcroft are relatively small (compared to Clovis) blades which are triangular to trapezoidal in cross section and blade detachments appear to have been unidirectional (Adovasio et al., 1999, fig.2; Adovasio & Page, 2002, p.156) (Figure 57). A cylindrical polyhedral core (Figure 57) was also recovered from the nearby Krajacic site in the Cross Creek drainage. The dates for this site range from 16,000 to 11,300 calBP (Adovasio et al., 1999, p.426). In an assessment of the blade industry from Meadowcroft, the technology was described as Eurasiatic, and Upper Palaeolithic in "flavour" from the small blades and prepared cores (Adovasio et al., 1999, p.418). More specifically, they connects it to material from North China dating to 30,000 BP (Adovasio & Page, 2002, p.157); however, they provide no further evidence in support of this claim.

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Figure 57. Blades (A-C) from Meadowcroft and blade cores (D-F) from Krajacic site. After Adovasio et al. (1999)

In Sollberger and Patterson's (1976) experiments on the replication of prismatic blades, they noted similarities between the blade from Meadowcroft with the Paleoindian blades of Clovis, and concluded that Paleoindian blades were exclusively struck using direct percussion, implying the same is true of the Meadowcroft blades. They also concluded that pressure and indirect percussion were introduced in the later, post-Pleistocene period (Sollberger & Patterson, 1976).

Delmarva Peninsula sites

The sites of Miles Point, Oyster Cove and Cators Cove are located on or close to the Delmarva peninsula in the Chesapeake Bay in Maryland and analyses have revealed significant correlations between the cultural artefacts recovered and the corresponding stratigraphic units (Lowery et al., 2010). Specifically, these artefacts were found just below a pedological break between the Tilghman soil and the Miles Point loess. A total of 22 radiocarbon dates from the Tilghman Soil have provided dates ranging from ~32,000 calBP (30,288 – 29,297 calBC(2σ)) to ~21,000 calBP (19,118 – 18,164 calBC(2σ)) (Stanford & Bradley, 2014). Each site has also been dated individually. The Miles Point site yielded two dates of 27,940 ± 1636 BP and 29,485 ± 1720 BP (Lowery et al., 2010). Cators Cove has been recently dated to between 26,770 BP and 26,170 BP (Collins et al., 2013). Oyster Cove remains the oldest of these sites with a radiocarbon date of approximately ~30,500 BP (28,514 –27,616 calBC) (Stanford & Bradley, 2014). Stanford and Bradley (2014) suggest that as the dates from Oyster Cove were derived from bulk sediment analysis the date is probably too old.

All three of these sites have yielded prismatic blades. At the Miles Point site, two cores have been identified (Lowery, 2007; Lowery et al., 2010; Collins et al., 2013) (Figure 58). Lowery (2007) describes one of the cores as bi-polar, and is manufactured from a quartzite cobble. The core itself retains a cortical back and has the shape and appearance of an expedient blade core (Type VI). The second core identified from Miles Point had a prepared platform, with unidirectional removals along both the face and sides with a bifacial back (Type II C-1).

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Figure 58. Miles Point Blade cores; Polyhedral core (A); Bi-polar core (B). After Lowery et al. (2010)

More recently, another site has been identified around Chesapeake Bay. The site of Parson's Island (Figure 59) lies just north of Miles Point and exhibits the same stratigraphic horizons as Miles Point. A single side blade (Figure 60) has been recovered from this site along with numerous bifacial points. Specifically, two bi-pointed laurel leaf bifaces were found in-situ at the base of the 4Ab1 palaeosol with an associated date of ~20,700 calBP (18,990 – 18,478 calBC) (Stanford & Bradley, 2014). The blade was recovered from the foreshore, and has been associated with the 4Ab1 palaeosol on the basis that no other stone tool cultural horizon is present at the site (Collins pers. comms 2014). This blade exhibits two blade scars that terminate at 90° to the blade and would have created an arris for the detachment of the blade. Thus it is likely these flakes are the result of some form of precore preparation with flaking from the back towards the front. The cortex along one edge indicates that this blade is possibly from an earlier stage of manufacture. There is unifacial percussion retouch along the whole length of the blade on the non-cortical side (Bradley pers. comms 2014).

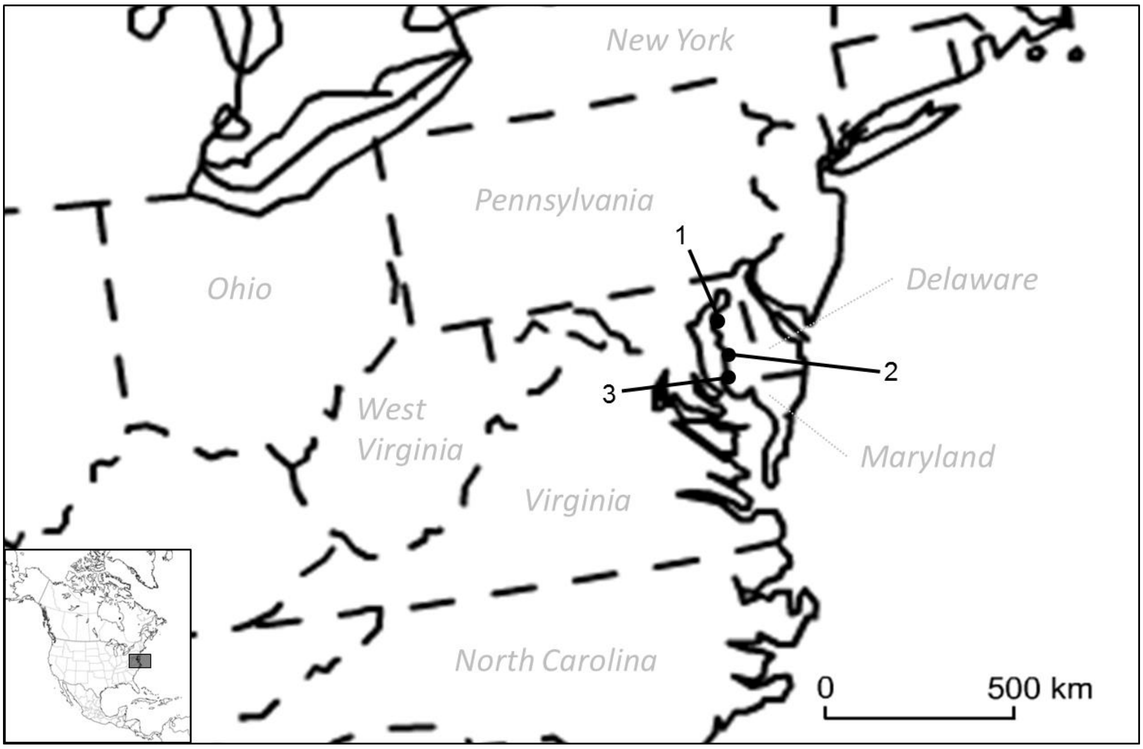

Figure 59. Location of Parson's Island (1); Miles Point (2); and Oyster Cove (3) in Chesapeake Bay

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Figure 60. Blade from Parson's Island. Image courtesy of Bruce Bradley

The evidence for specific blade technologies, as discussed above, is sparse and varied. The cores from Cactus Hill and one of the cores from Miles Point do not appear to have been shaped in any way as a precore before blade detachment began. The platforms on the Cactus Hill cores do retain flake scars that indicate the removal of a core tablet flake; however, it is impossible to determine whether this was due to some form of precore shaping or a product of core platform maintenance. In both cases, the raw material constraints of quartzite and size of the raw material may have played a role in the knapper's decision. The Miles Point core with a small platform and unworked cortical back has the traits of expedient use.

In contrast, the Meadowcroft and the second Miles Point core show evidence for some form of precore shaping. This evidence comes from the flaking preparation on the platforms and the series of blade removals. The Miles Point core in particular has a bifacial ridge on the back of the core which would indicate some form of precore shaping preparation. Unfortunately, with a lack of any detailed publications concerning the specific nature of the technology of manufacture, many of the specific details remain unknown and so are difficult to assess.

As outlined above, alongside this group of sites, three additional sites have been reported to contain evidence for blade technologies older than Clovis. The Johnson Site in Tennessee has been widely reported to contain blades (Barker & Broster, 1996; Stanford & Bradley, 2012; Collins et al., 2013). However aside from these reports, no specific information has been published on these artefacts.

Debra L. Friedkin site

As mentioned, the Debra L. Friedkin site, Texas is located approximately 250m downstream of the Gault site in a small valley of Buttermilk Creek which is incised into the chert-bearing Edwards limestone (Waters et al., 2011a). The assemblage recovered during excavation was named the Buttermilk Creek complex and OSL dating from the site yielded a maximum age of 16,170 ± 1030 BP (Waters et al., 2011a). Waters et al. (2011) detailed the nature of the assemblage (Figure 58), which included 5 blade fragments, 14 bladelets and 2 possible bladelet cores. No further detail has been published on this technology.

Figure 61. Blade fragments from Debra L. Friedkin. After Waters et al. (2011)

The Gault Site

The Gault site is located at the headwaters of Buttermilk Creek (the location of which is discussed in the previous chapter). Excavations at Area 15 of the Gault site yielded blades, blade fragments and 3 blade cores in deposits below Clovis (Collins et al., 2013; Collins, 2013; Velchoff et al., 2014). The majority of the blade assemblage was recovered from the northeast corner of the excavation within an area containing a possible geologic disturbance (Collins pers. comms. 2014). However, to date there has been no detailed stratigraphic work completed that would address whether or not the disturbance is a cut and fill feature from the upper Clovis layers, or if the stratigraphy of the “Older than Clovis” deposits are intact (Collins pers. comms. 2014). Blades and one blade core have been recovered from the area outside of this geologic disturbance indicating that the blade assemblage is not restricted to this area. This adds weight to the inference that these artefacts are a component part of the “Older than Clovis” assemblage.

Collins’ (2013) initial assessment of this blade technology indicates that it was very similar to that of Clovis. Of the three cores recovered (Figure 62), two were described as wedge-shaped, while the third retains features of both wedge-shaped and conical core production (Collins, 2013). The blades (Figure 63) associated with these deposits were used in an unmodified state as well as one endscraper on a blade which has hafting notches similar to those identified in Clovis (Collins, 2013). This evidence indicates that a specific blade reduction technique continued into the Clovis period, while, as Collins (2013) reports, the bifacial technology does not appear to follow this trend.

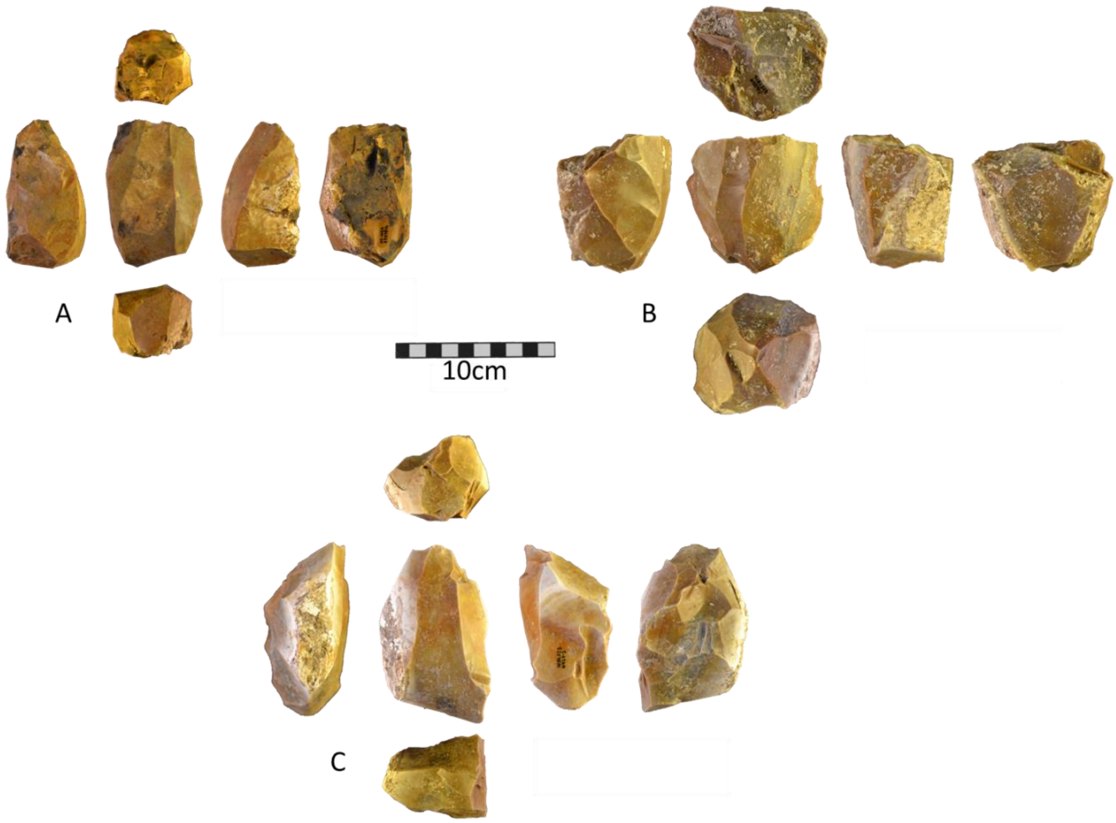

Figure 62. Older than Clovis blade cores from the Gault Site. A-C wedge-shaped; B conical

Figure 63. Older than Clovis blades from the Gault Site.

Summary

While the 7 cultural patterns presented by Collins et al. (2013) provide a solid framework for the macro-regional assessment of technologies older than Clovis, analysis of the blade manufacture technologies may be used to subdivide the Atlantic seaboard into two groups. One is a predominantly expedient based technology, while another technology utilises precore and maintenance techniques similar to a range of Upper Palaeolithic blade technologies. However, this would require further research in order to determine if this is a division in groups or cultures or an adaptive response to raw material constraints or functional and time constraints.

With the exception of the Gault site, there is no evidence that supports the direct continuation of the Clovis blade industry from any early sites so far recorded anywhere in North America. It is possible that numerous blade technologies were present. The possible technological roots of these industries will be examined in more detail in the discussion.

Chapter 9

Solutrean Blade Technology

Many North American researchers have commented on the similarities between Clovis blades and blade cores and Upper Palaeolithic industries of the Old World (Green, 1963; Collins, 1999; Adovasio & Page, 2002; Goodyear, 2005; Bradley et al., 2010). One major problem with drawing any similarities is that the term “Upper Palaeolithic” has become too generalised a term for the range of blade technologies present in the archaeological record of the Old World. Another problem with any similarity, as discussed in Chapters 2 and 3, is that the identification of blades in an assemblage cannot be used as the basis for any macro-scale analysis of the ancestors of that culture. This is because, while blades can indeed only be struck in a handful of ways (Bordes et al., 1964; Sollberger & Patterson, 1976), blade production represents a plethora of techniques specific to each industry. Furthermore, while two industries may appear generally similar, the precise nature of the technology may distinguish them.

This fact is certainly the case for archaeological assemblages in the Upper Palaeolithic of Europe, where despite the “ubiquity of blades” (Bar-Yosef & Kuhn, 1999), manufacturing processes were distinct and complex. This is not to say that the mechanisms of manufacture are entirely different. In fact, the cores used in the manufacture of Aurignacian blades share some commonalities with the cores utilised for Solutrean blade production. To fully explore these similarities and differences, it is important to assess Solutrean blade technology in the context of Europe. Thus, this chapter focuses on the literature that detail Solutrean blade manufacturing and reduction technologies. The origins of the Solutrean culture are also analysed. The subsequent chapter briefly explores some of the other blade technologies of Northern Europe.

Unlike Clovis, few authors have specifically deconstructed the reduction sequence of Solutrean blade manufacture. According to Stanford and Bradley (2002; 2012; Bradley & Stanford 2004; 2006) this is likely because the Solutrean period does not have a single, dominant toolkit across all regions in which it is found. Alongside this, the development of the Solutrean chronology has been questioned regarding different ancestors of the Lower Solutrean and the Middle and Upper Solutrean (Otte & Noiret, 2002). In this respect, it is difficult to view the development of Solutrean technology within one continuous evolutionary model.

Solutrean origins

Philip E. L. Smith (1962) was one of the first authors to fully document and describe the Solutrean archaeological culture, first in his doctoral thesis and then in a book (Smith, 1966). Smith (1962, p.1) synthesised the disparate works of earlier researchers, such as de Mortillet, Breuil, Peyrony, Pericot, and de Sonneville-Bordes, who had documented the Solutrean from the individual regions of Europe. He then assessed the Solutrean culture as a whole.

Smith (1962, p.163) recognised regional disparities and set about to document the Solutrean accordingly, starting with an analysis of the Solutrean levels at Laugerie-Haute. He then preceded with an analysis of the Southwest, central west, central east, the Pyrenees, the Mediterranean and the Solutrean of Belgium and England (Smith, 1962).

The explanation for this regional diversity may lie in the origins of the Solutrean itself. In their assessment of the origins of the Solutrean, Otte and Noiret (2002), argued that the Solutrean period should be divided into two clearly distinct elements. The first element combines the “proto-Solutrean” and Lower Solutrean, which they link to the Gravettian of the northern plains (mainly Northern France and Belgium) (Otte & Noiret, 2002). It is based on both shared typological and technological elements found in these regions and similarities between unifacially retouched blades of the Gravettian, specifically those from La Grotte de Spy, and Maisières-Canal in Belgium, and the “proto-Solutrean” from Saint-Pierre-lès-Elbeuf (Otte & Noiret, 2002).

Otte and Noiret’s (2002) second element combines the Middle and Upper Solutrean, which they argue originated in Spain. Their argument is based on the typological similarities between the assemblages recovered from Mugharet el’Alyia, Morocco and Parpalló Cave, Spain (Otte & Noiret, 2002). The assemblage at Mugharet el’Alyia was recovered from layer six of the excavation and assigned to the final Aterian phase (Debénath et al., 1986), which was dated to between 35,000 and 60,000 BP (Wrinn & Rink, 2003). The assemblage from Parpalló Cave (Figure 64) was dated to approximately 22,000 and 21,000 BP (Bofinger & Davidson, 1977).

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Figure 64. Parpalló Cave assemblage. After Otte and Noiret (2002)

One final piece of evidence that Otte and Noiret (2002) use in their analysis is the depictions of aurochsen in cave paintings. One such painting from La Grotte de la Pileta, Andalusia, Southern Spain dated to around 24,043 ± 471 calBP (20,130 ± 350 ^{14}C BP). A similar aurochs was found painted in La Grotte de la Tête-du-Lion in Bidon, Ardèche, in south central France, dated to 23,574 ± 931 calBP (19,700 ± 800 ^{14}C BP) (Otte & Noiret, 2002). Otte and Noiret (2002) conclude that the late arrivals that brought with them the typology and technology that formed the Middle and Late Solutrean were likely assimilated into the existing culture that had moved southward from the northern plains (Otte & Noiret, 2002).

In a re-evaluation of the origins of the Solutrean, Renard (2011) argued that there was a strong technological tradition that spread across the entire Solutrean range, both geographically and chronologically; however, there was also a distinct social phenomena, with distinct regionalisation of projectile point types, which occurred mainly in the Upper Solutrean. Renard (2011) concluded that there was likely a long-term unity of technical practice during the Solutrean.
Renard (2011) began by discussing the site of Vale Comprido in Portugal, which had an industry located stratigraphically between the Final Gravettian and the Middle Solutrean that has been referred to as a “proto-Solutrean” industry.

This industry was first identified and analysed by Zilhão and Aubry (1995). It was characterised by two distinct manufacturing sequences. The first produced the elongated, convergent blanks for the fabrication of Vale Comprido points (Figure 65) (basally thinned points) (Renard, 2011). The second produced bladelets from carinated cores (alternatively described as ridge or keel cores) (Renard, 2011). Renard (2011) also notes the presence of another blade production technique, manufactured using soft hammer percussion, which she affiliates with the Final Gravettian.

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Figure 65. Vale Comprido Points from Portugal. After Renard (2011)

Additionally, a single stratigraphic layer with evidence for human occupation was dated to the "proto-Solutrean" period at the site of Marseillon, Aquitaine, France. Dates from the Solutrean layers at Marseillon indicate an age range of 21,000 to 19,000 BP (Teyssandier et al., 2006). Thus the "proto-Solutrean" predates 21,000 BP. Unlike the other two major "proto-Solutrean" sites in France (Laugerie-Haute and Abri Casserole), there is no risk of inter-level intrusions contaminating the evidence (Renard, 2011). The main lithic reduction sequence at Marseillon was characterised by the use of triangular blade blanks, which were basally thinned via "direct retouch" along the morphological axis of the piece, like Vale Comprido points (Renard, 2011). In this instance, the term "direct retouch" applies to the use of percussion to basally thin the blade. Thus, this is not retouching the piece but a thinning stage associated with the final working of the blade. Renard (2011) further breaks down the manufacture of Vale Comprido points by identifying the thinning of the base as starting from the plain platform and travelling along the central ridge, occasionally accompanied by direct retouch along one of the edges. Blanks selected for Vale Comprido points at Marseillon were generally thick, wide and straight in profile; and, they were always detached using direct hard hammer (Renard, 2011). In addition to Vale Comprido points, Renard (2011) notes the presence of a generalised toolkit at Marseillon, consisting of endscrapers, laterally retouched blades and retouched flakes.

Renard (2011) describes the manufacturing technique for Vale Comprido points as similar to the concept of levallois flakes. The widest face of the core, with low convexities, was exploited for removals. The removals were detached from a single platform and the triangular geometry of the Vale Comprido points was maintained through the removal of oblique core edge removals (Renard, 2011). The blades were then detached using non-marginal hard hammer percussion, thus retaining thick platforms (Renard, 2011). Thus, Marseillon fills the gap between the "proto-Solutrean," identified in Portugal, and the "proto-Solutrean" sites of Laugerie-Haute and Abri Casserole in France.

The Lower Solutrean has long been regarded as the first stage of the development of Solutrean technology (Renard, 2011). This period was characterised by the emergence of the pointe à face plane, or blades with unifacial retouch. Smith (1962, p.138) argued that this term was too simplistic and could be ascribed to many different industries. However, many of these points also had slight retouch on the ventral face and so Smith (1962, p.138) retained the use of pointe à face plane as a type unique to the Solutrean period. Renard (2011) further noted that these points were thinned using flat, covering pressure flaking (alternately described as deep or invasive pressure flaking), which she described as Solutrean retouch.

Lower Solutrean technology as a whole was defined by the exclusive intention to produce blades and bladelets. However, individual blade and bladelet production sequences involved different degrees of techno-economic investment (Renard, 2011). Essentially, blade production ranges from expedient creation of cores with no precore shaping to specific precore manufacturing and blade removal strategies. Within this range of reduction strategies, two forms of blanks were desired by the Solutrean knappers, both of which were designed for the production of elongated blades. The first type included blades with parallel edges, while the second type included blades that converge at the distal tip (Renard, 2011). Blades with parallel edges, true blades, were used as blanks for the majority of the "domestic" tools associated with the Lower Solutrean; while, the convergent blades were more often selected for the fabrication of pointe à face plane, or those which were systematically retouched (Renard, 2011). The cores used to produce these blades were similar to those of the "proto-Solutrean"; however, they differ from them in their more systematic approach to production, using soft hammer percussion and the use of two opposing platforms (Renard, 2011).

Renard (2011) also refutes the findings of Smith (1966) who considered the Lower Solutrean to be lacking bladelet technology. Based on more recent excavations, Renard (2011) concluded that small curved bladelets were a secondary feature of the Lower Solutrean industries. Renard (2011) found that the majority of these bladelets were manufactured on smaller carinated cores; and, the use of retouch to form a backed blade appeared to be less dominant in the Lower Solutrean with natural or unretouched edges more frequent.

Based on the analysis of the technological traits of the "proto-Solutrean" and the Lower Solutrean, Renard (2011) argued that there was a clear affiliation between the two. This conclusion was based on the similarities in the production schemes of Vale Comprido points and *pointes à face plane*, namely the intentional production of bladelets from carinated cores and the mechanism through which Vale Comprido points become *pointes à face plane* (Renard, 2011). Two blades cores are illustrated in Figure 66 that demonstrate the similarities between proto- and lower Solutrean. Renard (2011) highlights this last point as important for drawing a connection between the "proto-Solutrean" and Lower Solutrean periods. These two technologies of point production may share similarities in the intention to produce blade blanks, but each was distinct in their detachment. Vale Comprido points were struck non-marginally with hard hammer; while, pointe à face plane blanks were struck marginally with soft hammer percussion (Renard, 2011). There was also a distinction in technological investment. The bulk of investment in the manufacture of *pointes* *à face plane* points focused on the production stage in order to predetermine the morphology of the blanks. This is in contrast to the production of Vale Comprido points where there is a high degree of technical investment in the basal thinning of the blank. This is designed to remove the platform and/or the bulb of percussion through inverse, low-angled “retouch” (thinning) (Renard, 2011). In Renard’s (2011) synopsis of this, she argues that this presents a clear link and hence an evolutionary mechanism for the Solutrean, rooted in the earlier industries of the “proto-Solutrean”.

Figure 66. Proto-Solutrean (A) and Lower Solutrean (B) blade cores. After Renard (2011)

Vale Comprido points and the “proto-Solutrean” have been dated to between 25,500 and 24,500 calBP (Renard, 2011). Dating for the Lower Solutrean is more problematic, but dates from Laugerie-Haute and Les Peyrugues indicate a range of 24,800 and 24,400 calBP (Renard, 2011). In her conclusion, Renard (2011) states that there is a clear indication of technological continuation during the Solutrean period which has its roots in the “proto-Solutrean”. She also notes that there is evidence for local evolutionary models as seen in the stylistic similarities in the mobiliary art at Parpalló (Renard, 2011).

This final statement, concerning local evolutionary models is most prevalent in the Upper Solutrean, where distinct point styles have been identified in different regional contexts (Renard, 2011). This indicates that regionally distinct societies developed specific point types while maintaining social relations with other groups; attested to by the diffusion of technological ideas over long distances (Renard, 2011).

Renard's (2011) model contradicts the proposition of Otte and Noiret (2002) that the origin of the Solutrean has two different, regionally diverse ancestors. Unlike Otte and Noiret (2002), who based their analysis solely on typological similarities, Renard (2011) identified specific technological traits that not only evolved from an earlier industry, but were maintained throughout the Solutrean period. More importantly, these technological characteristics remained constant while the specific end products, namely the projectile points changed in style, particularly during the Upper Solutrean. It is this last conclusion drawn by Renard that may explain the diversity discussed above.

These two papers on the origins of the Solutrean are not the only possible explanations. Bradley et al. (1995) suggest that the bifacial traditions may have stemmed from the Szeletian and Streletskyan bifacial technologies, while Roche (1964) connects the Solutrean of Portugal with the Blattspitzen tradition. However, Renard (2011) and Otte and Noiret (2002) highlight an existing dichotomy in archaeological studies that remain part of the ongoing debate on cultural ancestors. This dichotomy is between typology and technology; which is highlighted in Chapters 3 and 4, specifically concerning the ancestors of Clovis. Typology and the descriptions of a lithic industry are valid in any initial analysis of both ancestral and descendent cultural connections. This validity is seen in the cultural theories developed by Clarke (1968), who drew both inter- and intra-cultural connections based on shared typologies. However, these typological descriptions can also create misrepresentations of facts.

One such example of this occurs in Otte and Noiret (2002). In their analysis of Gravettian blades, they found that the retouch present on the blades appeared generally similar, yet contained subtle differences in technological approach. The retouch on the dorsal surface is sporadic, abrupt and minimally invasive; while the retouch on the pointe à face plane is regular, low-angled, flat and invasive, with frequent retouch on both the ventral and dorsal surfaces. Technologically, the first type of retouch is used to shape the final piece and create a usable edge. The second type of retouch, defined as Solutrean retouch, shapes and thins the blank, resulting in a specific point style.

One of the difficulties in assessing Solutrean blade technology resides in the tendency of researchers to rely purely on typological classifications of assemblages rather than focus on manufacturing technology. Furthermore, cores are seldom illustrated, as is the case in Smith's (1966) work. As detailed in the following chapters, this propensity is not restricted solely to the Solutrean. The following discussion focuses on the limited technological aspects that are detailed in the literature.

Solutrean sites

Laugerie-Haute

Laugerie-Haute (Figure 67) is located northwest of the town of Les Eyzies, in the Dordogne region of south-central France. It lies beneath a rockshelter carved into the limestone, close to the Vézère River and the flint outcrops of the region. Laugerie-Haute is one of the most important Solutrean sites due to the recovery of artefacts from all of the Solutrean periods: the "proto-Solutrean," the Lower Solutrean, the Middle Solutrean and the Upper Solutrean (Smith, 1962, p.163). Excavations at this site began prior to World War I, after the site became state land due to the discovery of "proto-Magdalenian" levels (Smith, 1962, p.164).

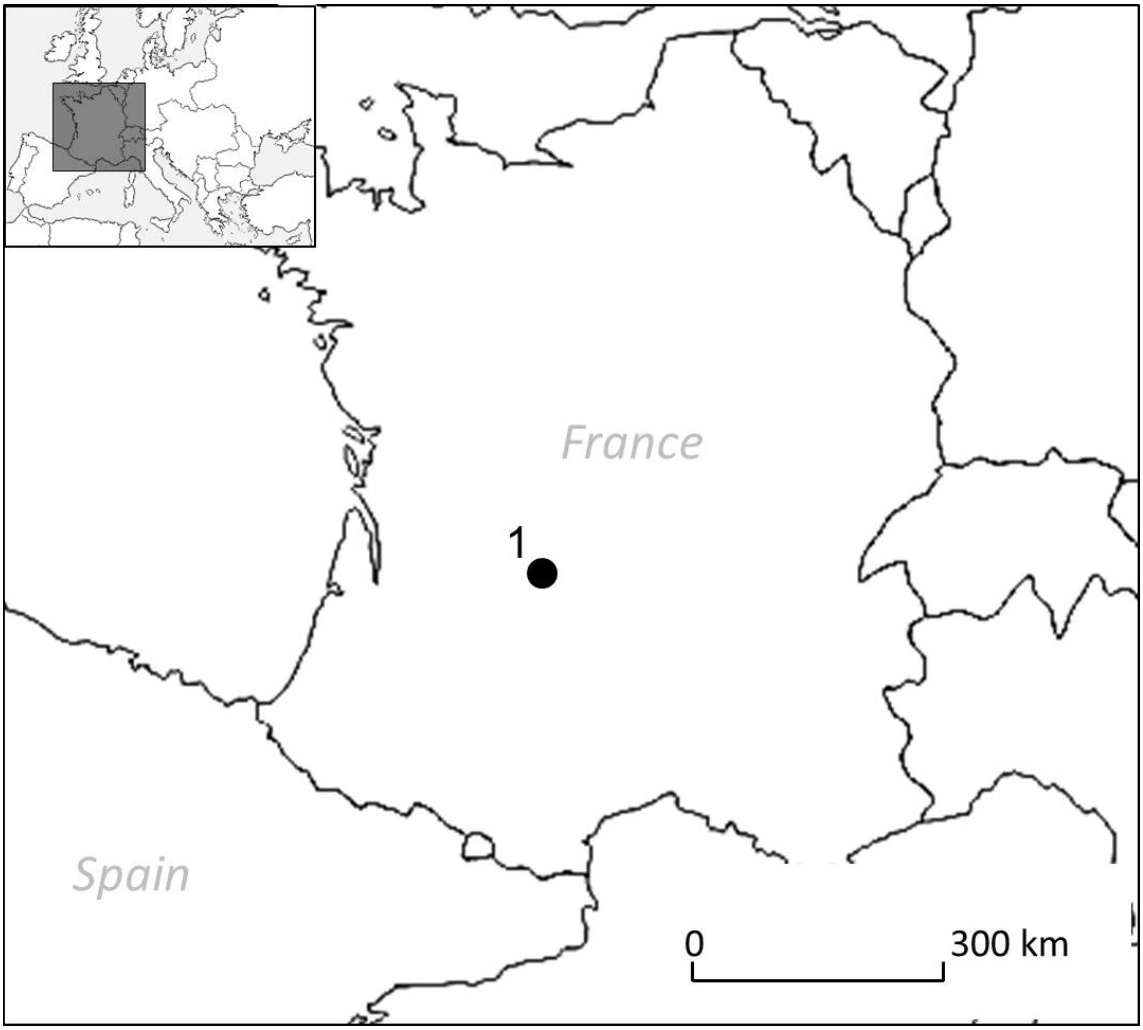

Figure 67. Location of Laugerie-Haute (1)

The site was excavated in “gross” levels, to document existing periods rather than individual occupations (Smith, 1962, p.164). Later, the excavations of François Bordes in 1957, 1958, and 1959 corrected this and established a precise stratigraphic record of the site, documenting the frequencies and changes in artefact distributions (Smith, 1962, p.164).

The site of Laugerie-Haute consists of two localities: Laugerie-Haute Ouest and Laugerie-Haute Est. Dating from Laugerie-Haute Est indicates that the earliest Solutrean occupations date to ~26,000 (Delpech, 2012) while Renard (2002) suggests that there was a growth in the Solutrean occupation of the site between 21,000 BP and 19,500 BP. The stratigraphic units containing cultural materials from Laugerie-Haute Ouest were broken down into their corresponding periods during excavation. These cultural layers have since been questioned and this is discussed below. The “proto-Solutrean” from Laugerie-Haute Ouest consists of level six from the early excavations; however, there was much debate about the materials, and de Sonneville-Bordes classified it as Aurignacian V (Sonneville-bordes, 1966). Smith (1962, p.173) concluded that there were a number of "proto-Solutrean" artefacts in this layer, including *pointes à face plane*, *pointes à cran* (shouldered points), endscrapers, burins and unretouched blades. He also drew attention to two laurel leaf fragments recorded from this layer by de Sonneville-Bordes (Smith, 1962, p.173). The *pointes à face plane* described by Smith (1962, p.173) includes the removal of the bulb with extensive flat retouch.

The Lower Solutrean levels at Laugerie-Haute Ouest consist of layers 12 a – d and layer 11a (Smith, 1962, p.175). From these layers, Smith (1962, p.177) described the recovery of "finer" *pointes à face plane* as well as endscrapers with low, thin fronts, more like the typical Solutrean endscrapers found in later levels. There are also a few burins, generally on breaks, sidescrapers and some notched and denticulate pieces (Smith, 1962, p.177). Smith (1962, p.181) also noted the presence of bladelets, with some backing on these bladelets, along with several fragments of blades which retain notches-under-breaks. Several organic tools were recovered from these layers including two possible awls and a fragment of a sagaie, alongside which, a small piece of ivory was discovered with faint incised lines (Smith, 1962, p.186). The Lower Solutrean levels also contained several composite tools, including scraper/burins, truncated blade/scrapers and burin/truncated blades (Smith, 1962, p.188). Figure 68 illustrates some of the tools on blades recovered from Laugerie-Haute Ouest.

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Figure 68. Tools on blades from Laugerie-Haute separated by period. After Smith (1966)

The Middle Solutrean was contained within layers 11 and 10 and possibly layers 9 and 8 (Smith, 1962, p.193). The major difference between the Lower and Middle Solutrean levels were the introduction and development of bifaces and laurel leaf points (Smith, 1962, p.193). Smith (1962, p.193) defined a number of these early laurel leaf points as lesser quality in terms of manufacturing with no real explosion in the use of Solutrean retouch. The rest of the assemblage was very similar to the Lower Solutrean period, including the presence of *pointes à cran*. Smith (1962, p.196) notes a decline in burins while perforators and becs increase in number. Eleven small, yellow jasper micro-scrapers were recovered from layer 10. Smith (1962, p.198) identified these as being produced on blades. Despite some of the lesser quality laurel leaf points, Smith (1962, p.201) also noted the presence of finer laurel leaf points from layer 10, including the flat, thin, and very fine flakes typical of Solutrean flaking. Inversely proportional to this rise in the number of laurel leaf points is the decline in *pointes à face plane*. Smith (1962, p.206) also noted the cores from this layer, describing two as prismatic and one as a pyramidal core.

The final layers of the site which contained the Upper Solutrean artefacts were described as lacking *pointes à face plane*, while endscrapers persist in continuing frequency (Smith, 1962, p.209). Only three burins were recovered from excavations, and Smith (1962, p.210) noted that about a third of the debitage is distinctive of Solutrean-style flaking. The cores recovered were prismatic, and two of them had double striking platforms (Smith, 1962, p.215); although, whether or not these are opposed platforms is not described. Laurel leaf points were the most distinctive artefacts found during the Upper Solutrean, including one with flaking described as parallel, controlled percussion (Smith, 1962, p.218).

The eastern side of this locality, Laugerie-Haute Est, contains no evidence for a "proto-Solutrean" assemblage (Smith, 1962, p.236). However, the artefact assemblages for the Lower, Middle, and Upper Solutrean at Laugerie-Haute Est parallel that of the Laugerie-Haute Ouest (although Smith notes a number of anomalies in some of the earlier levels, including a Mousterian point with flat retouch on the bulbar face) (Smith, 1962, p.241). This description could also indicate the presence of a Vale Comprido point, which has similar traits to that of a Mousterian point. Given the comparisons between these points and the *pointes à face plane* and their technological associations (Renard 2011), it seems more likely that this piece is a Vale Comprido point.

Demars (1995a; 1995b) re-evaluated the early analysis of the Solutrean levels from Laugerie-Haute Ouest and Est, concluding that the layers were not as clear-cut as Smith described. Instead, Demars (1995a; 1995b) argued that there was a "proto-Solutrean," an Early Solutrean, and an evolved Solutrean. The "proto-Solutrean" is defined from Laugerie-Haute Est and the Lower Solutrean is characterised by the *pointes à face plane* from Laugerie-Haute Ouest (Demars, 1995a). The laurel leaf points and *pointes à face plane* assemblages of Laugerie-Haute Est defines the Middle Solutrean period; while, the disappearance of *pointes à face plane* characterises the Upper Solutrean layers at Laugerie-Haute Ouest (Demars, 1995a). Demars (1995b) concluded that occupations at Laugerie-Haute were limited, not only chronologically, but spatially; and, these occupations moved up and down the length of the rockshelter (Demars, 1995a).

In his analysis of the tool types and technology, Demars (1995a) also stated that Solutrean does not refer to a culture, but a technological tradition. This tradition abandoned the ways of the Aurignacian and Gravettian, which still existed in Eastern Europe, and adapted to survival during the ice age.

A statistical evaluation of the layers at Laugerie-Haute Ouest and Est was conducted in 1997. The conclusion from this research was that three distinct periods exist: the "proto-Solutrean," the Lower Solutrean and the Upper Solutrean (Bosselin & Djindjian, 1997). These three periods were also placed in chronological sequence according to dates from individual layers of both localities at Laugerie-Haute. The "proto-Solutrean" was dated to between 22,000 and 21,000 BP (Bosselin & Djindjian, 1997). The dates acquired for the Lower Solutrean place this industry between 21,000 BP and 20,000 BP. The Upper Solutrean period lasted from 20,000 BP to 19,500 BP (Bosselin & Djindjian, 1997).

The most recent analysis of both sites from Laugerie-Haute focused on the biostratigraphy and the faunal remains associated in each location. Delpech (2012) analysed the remains of horse, red deer, bovines, and mammoth and compared the increasing horse population and decreasing faunal diversity between Laugerie-Haute Ouest and Est. In general, both locations indicate the increase in horse remains, while the diversity of fauna, including red deer, ibex, and bovines decreases (Delpech, 2012). However, the units in which this is identified do not correlate stratigraphically between Ouest and Est. The levels at Laugerie-Haute Ouest appear to have been deposited by solifluction (Delpech, 2012). As such, Delpech (2012) suggests that the Solutrean levels from Laugerie-Haute Ouest should be regarded as a single deposit. The levels from Laugerie-Haute Est were found to be intact and representative of the original distinctions between the Lower, Middle, and Upper Solutrean. While this interpretation contributes to a greater understanding of the sites of Laugerie-Haute, it does not completely invalidate the previous findings of Smith (1962), Demars (1995a, 1995b), and Bosselin and Djindjian (1997). These researchers note the similarities in the assemblages between Ouest and Est and their interpretations are based on an examination of both the Ouest and Est assemblages. Furthermore, Delpech (2012) indicates that this is solely a biostratigraphic analysis and requires further archaeostratigraphic assessment.

Thus, despite constant revisions to the stratigraphic and chronological interpretations of the Solutrean layers at Laugerie-Haute, there remains a consensus regarding interpretations of the technology. The first manifestations of Solutrean technologies can be seen in the production of distinct blades and cores and in the manufacture of *pointes à face plane*. As the Solutrean period progressed, laurel leaf points became increasingly abundant and the manufacture of *pointes à face plane* declined. This sequence at Laugerie-Haute is not representative of the entire Solutrean period.

In a synopsis of research into the Solutrean of Vasco-Cantabria, Spain, Straus (2000a) highlighted the major issues faced by analyses of the technological and reductive strategies of the Solutrean. He discussed numerous point styles and the various sites from which they were recovered, including the *pointes à cran* from La Riera and the stemmed, finely made points from Parpalló Cave (Straus, 2000b). He also noted the presence of concave-based points from El Mirón Cave (Straus, 2000b), a site which also contained *pointes à cran* (Straus & Gonzalez Morales, 2009). According to Straus (2000a), the ongoing debate concerning the Solutrean lies in the over-diversification of projectile point types.

As discussed above, *pointes à face plane* have been documented at Laugerie-Haute (Smith, 1962), as well as Abri Casserole (Smith, 1962), Marseillon (Renard, 2011) and La Celle-Saint-Cyr (Renard, 2002) to name only a few. Laurel leaf points have been recovered from numerous sites, including Laugerie-Haute (Smith, 1962), Les Maitreaux (Aubry et al., 1998), and Combe Sauniére (Geneste & Plisson, 1986), which also had both *pointes à face plane* and *pointes à cran*. The maximum northern extent of the Solutrean is Saint-Sulpice-de-Favières, which contains laurel leaf points (Sacchi et al., 1996). The *pointes à cran* have also been recovered from Spanish sites, including La Riera (Straus & Clark, 1986) and El Mirón (Straus & Gonzalez Morales, 2009). These sites, and others in this area of Spain and the western Pryenean region of France (Schmidt, 2013), also include numerous concave base points. Figure 69 illustrates the major Solutrean sites discussed here.

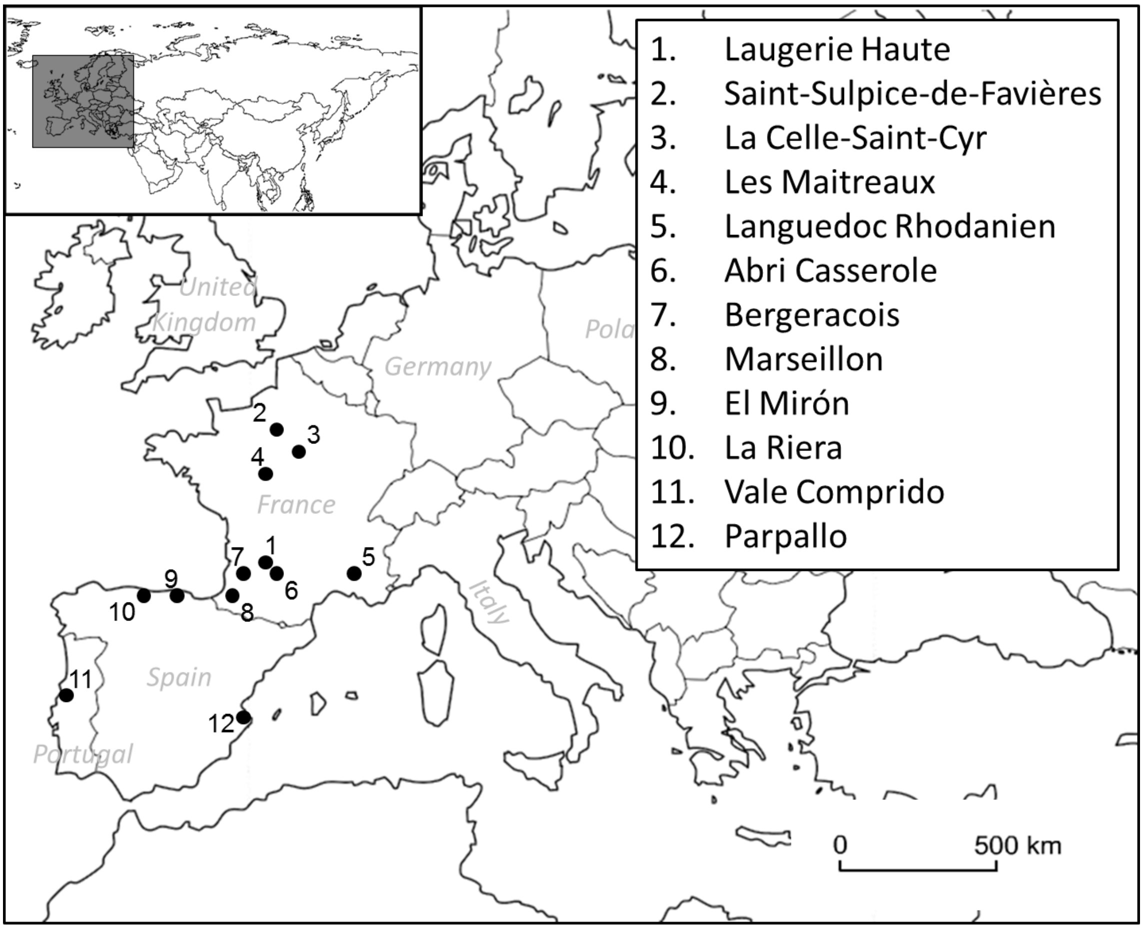

Figure 69. Location of major sites discussed in text

Few papers have explored the manufacturing and reduction process of these point styles in great detail, with the primary focus often being on a description of the typological characteristics. However, this is not always the case, and in an analysis of materials from La Celle-Saint-Cyr, Renard (2002) analysed the reductive processes used during the Lower Solutrean. Blade production during the Solutrean period was also analysed from the archaeological assemblages recovered from Les Maitreaux (Aubry et al., 1998; Almeida, 2005), Bergeracois (Morand-monteil et al., 1997), as well as from a regional study of the Rhone River, Languedoc (Bazile & Boccaccio, 2007). Furthermore, Schmidt (2013) discussed concave base points and concluded that these concave base points were made on large blades, although did not include any evidence for the type of core used.

La Celle-Saint-Cyr

La Celle-Saint-Cyr site lies on the left bank of the Yonne River, approximately 25km southeast of Sens (Renard, 2002). This is one of numerous Solutrean sites located in the southern portion of the Paris basin. The assemblage recovered from La Celle-Saint-Cyr dated to between 21,000 and 18,000 BP (Renard, 2002). The blade cores recovered from this site yielded information about the production of the *pointes à face plane*. These cores (Figure 70) were large, producing blades that were approximately 15cm in length and were detached unidirectionally (Renard, 2002). While not directly stated in the text, the detailed illustrations of these cores (Renard, 2002, fig.6) (Figure 66) show a prepared platform and preparation of the core back by the removal of flakes perpendicular to the blade face. Flakes were also struck from the back of the core towards the face, which Renard (2002) interpreted as a method for controlling both the shape of the blade face and for facilitating the detachment of convergent blades.

Renard (2002) described a second type of core. These cores had two directly opposed platforms at an acute angle to the blade face. One such core is depicted with shaping of a flat back similar to the large cores described above, while one core featured a cortical back with the establishment of two platforms struck from the blade face towards the back of the core (Renard, 2002, fig.8). Renard (2002) described a discoidal core that bears resemblance to bifacial working; however, one face of the core retains distinctive opposed blade removals.

Renard (2002) analysed the blade platforms themselves, describing the use of *en éperon*, or spurred platforms. These were platforms that were raised above the core platform to form a point, or isolated peak, to facilitate removal (Barton, 1990; Inizan et al., 1999). Renard's (2002) assessment of these cores and blades led her to conclude that the blades were detached using soft hammer percussion; however, the initial shaping of the core was conducted using hard hammer percussion. This was evident by the plain platforms, deep bulbs on the flake scars and the back face of the core and the smaller, wider and occasionally punctiform platforms associated with the blades (Renard, 2002). While this analysis falls short of documenting the full reduction sequence, the cores are of the Type II A-1 (single faceted platform, with unidirectional facial flaking) category and Type IV A-2 (double faceted platforms, with bi-directionally opposed facial flaking). Both of these types include flat backs, shaped perpendicular to the blade face, and acute angled core platforms.

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Figure 70. Blade cores from La Celle-Saint-Cyr. After Renard (2002)

Les Maitreaux

The open-air manufacturing site of Les Maitreaux has been one of the most important sites regarding information on the reduction strategies of the Solutrean. This information was gathered through the experimental replication of laurel leaf points from the site, based on an archaeological analysis of the debitage, much of which refit (Aubry et al., 1998; Almeida, 2005; Aubry et al., 2008). The site of Les Maitreaux is located at the northern edge of the Massif Central and lies along a small tributary of the Claise River (Aubry et al., 1998). The Claise River cuts through the Turonien Limestone formation in the area which bears large, high quality flint nodules (Aubry et al., 2008). As Almeida (2005) notes, the only available date in this region for the Solutrean is from layer 8d at L'Abri Fritsch of 23,062 ± 345 (19,280 ± 230 ^{14}C BP).

In an analysis of the blade production at Les Maitreaux, Aubry et al. (1998) identified the use of blocky slabs from the flint outcrops as the blanks for core production. After the blanks were selected, two opposed platforms were manufactured while retaining the cortical sides of the slab. Initial blade removals were not usually crested, but followed the natural ridges of the core if cortex had to be removed (Aubry et al., 1998). The back of the cores remained predominantly cortical throughout the reduction process (Aubry et al., 1998). Blades were struck from the core bi-directionally from each platform, and the blade face maintained a convexity (Aubry et al., 1998). As blade detachment continued, this convexity often flattened out, which Aubry et al. (1998) suggested was the reason for increased knapping errors at this stage. The striking platforms of the blades were also carefully maintained, and the edges were often ground or blunted in order to remove micro-spurs that could hinder the detachment of blades (Aubry et al., 1998). These cores are Type IV A-2, and retain a cortical back throughout production. Aubry et al. (1998) note the presence of both blades and bladelets from this assemblage.

Bergeracois, Creysse

A Solutrean assemblage was identified in a field just outside of Creysse, near Bergerac (Morand-monteil et al., 1997). The field lies atop a plateau in an area where recent silt deposits overlay the quaternary deposits. The assemblage was found in primary context in several small concentrations (Morand-monteil et al., 1997). Two groups of blades were described from the site; the first group consisted of blades with approximate dimensions of about 15cm long by more than 2 cm wide. The second group consisted of blades shorter than 10cm that were narrower and thinner than the first group (Morand-monteil et al., 1997). The assemblage contained two core types used in Solutrean blade production, but also included crested blades and core tablets (Morand-monteil et al., 1997).

The cores were produced on blocky nodules, consisting of two core platforms set opposed across the blade face (Morand-monteil et al., 1997). Much of the blade manufacture follows the form and morphology of the original nodule (Morand-monteil et al., 1997) and these cores were described as classic Solutrean blade cores. Morand-monteil et al. (1997) identified the back of one core as being shaped by the creation of a crested blade for the initial removal; and, the back of another core as being shaped by one or two lateral ridges. This may indicate the use of both crested and flat back cores during blade production; however, singular examples may also be outliers. The blades from the larger cores were straight, whereas the smaller blade removals were more convex or curved in nature (Morand-monteil et al., 1997).

Morand-monteil et al. (1997) concluded that the reduction sequence in the Solutrean differed from that of the Aurignacian. Specifically, they identified the need for flat blades in order to produce blanks suitable for the manufacture of *pointes à face plane* and *pointes à cran* (Morand-monteil et al., 1997). In the Solutrean reduction sequence, frequent core tablets were removed to rejuvenate platforms, and blade platforms were plain or faceted (Morand-monteil et al., 1997). Detachments were generally made using marginal soft hammer percussion, although the authors do note the presence of plain platforms at an obtuse angle to the trajectory of the blade removal, which they suggested indicated the use of indirect percussion (Morand-monteil et al., 1997). A number of partially crested blades were also recovered from the site (Morand-monteil et al., 1997). These partial crests may be attributed to either central cresting of a core during preparation, or corner cresting to keep the core viable during production; however no distinction is made as to where in the sequence these blades belong.

Le Languedoc Rhodanien

Solutrean assemblages were found in the region of le Languedoc Rhodanien, situated in the department of Gard in southern Ardeche (Bazile & Boccaccio, 2007). These assemblages have been dated to approximately 20,000 BP. However, there is no particularly strong development of Solutrean-style retouch (Bazile & Boccaccio, 2007). Bazile and Boccaccio (2007) discuss three types of Solutrean-aged cores present in this area. The first type of core had two opposed platforms and a wide blade face for the primary production of *pointes à face plane* and the secondary production of endscrapers (Bazile & Boccaccio, 2007). The second type of core included the same features as the first core type; however, the blade face was narrower and used for the removal of *pointes à cran* blanks, with secondary products including endscrapers and bladelets, possibly for inset or composite tools (Bazile & Boccaccio, 2007).

Bazile and Boccaccio (2007) provide no further explanation of these cores, and it is unclear whether these distinct types of core differed in the use of a facial flaking in the first type as opposed to frontal flaking in the second type. The final core type described by Bazile and Boccaccio (2007) was a more expedient core type that retained cortex around the sides and back of the core. While this article describes these three distinctive core types, there is no further discussion. The first type appears to be a Type IV A-2 (double faceted platforms, with bi-directionally opposed facial flaking) (Figure 71A) (although there is no description of the core platform), while the second type appears to be a Type III B-2 (double plain platforms, with bi-directionally opposed frontal flaking) (Figure 71B-C), and the final type seems to be a Type VI: expedient category.

Thus, there is no single source that details the entire Solutrean reduction process. However, from the various analyses presented above, it is possible to establish some of the basic traits of blade manufacture. The following discussion includes the work of Stanford and Bradley (2012) as they present a general overview of Solutrean blade technology.

Figure 71. Blade cores from La Languedoc Rhodanien; A Type IV A-2; B-C Type III A-2. After Bazile and Boccaccio (2007)

Solutrean Reduction Sequence

Core Types and Raw Material

Blocky material was the preferred type of raw material selected for the production of blades; however, there is some indication of cobble use, detailed in the cortical backs present on the cores from La Celle-Saint-Cyr (Renard, 2002) and le Languedoc Rhodanien (Bazile & Boccaccio, 2007). Type IV A-2 (double faceted platforms, with bi-directionally opposed facial flaking) cores were the most prevalent for the entire period; however, Type II A-1 (single faceted platforms, with unidirectional facial flaking) cores appear more frequently in the Lower Solutrean. Stanford and Bradley (2012, p.135) also discuss the use of natural ridges or the production of precores on medium to large pieces of flint, as opposed to the bifacial precores used in other Upper Palaeolithic technologies. In the production of bidirectional cores, one platform was usually preferred over the other (Stanford & Bradley, 2012, p.137); however Almeida (2005) indicates that both platforms were used alternately to produce a series of blades.

Precore Production and Core preparation

Little evidence is provided on the precore production of these cores. Where available, natural ridges were utilised for initial removals; and if natural ridges were not available, then crests would be created to facilitate the removal of blades. It remains unclear whether the core platforms were established prior to blade detachment. The shaping of these cores remains largely unknown; however, the number of cores described as retaining a cortical back suggests that the bifacial shaping technique, seen in other industries, was not present in the Solutrean. Stanford and Bradley (2012, p.135) indicate that there were three main core types utilised in the Solutrean period. One method was the use of two opposed platforms or bidirectional cores (Type IV A-2) used to produce straight blanks for the production of tools, including *pointes à cran* (2012, p.135). Another type of core was a unidirectional core with a single blade face (Type II A-1) for the production of, not necessarily straight, blades (2012, p.135). The final core type was a single platform core that utilised the entire circumference of the core for blade production (Type II C-1: single faceted platforms, with unidirectional full circumferential flaking) creating a conical shaped core (Stanford & Bradley, 2012, p.135). Stanford and Bradley (2012, p.135) also discuss the use of natural ridges or the production of precores on medium to large pieces of flint, as opposed to the bifacial precores used in other Upper Palaeolithic technologies. This is supported by the evidence presented from the sites discussed above. Additionally, the use of flaking to flatten the back of the core indicates a further form of preparation.

Platform Production and Maintenance

In the Lower Solutrean, platforms were established on one end of the core. As the technology developed into the Middle and Upper periods, platforms were more frequently created as two, opposed platforms. The presence of core tablets indicates that it was necessary to maintain the core platform during manufacture for the continued production of blades and for the viability of the core. Core platforms were rejuvenated via the removal of core tablet flakes (Stanford & Bradley, 2012, p.135).

Blade Production

Each blade platform was prepared, and the data indicates that blade platforms were prepared individually prior to removal. Furthermore, there is data concerning the evolution from plain hard hammer platforms to faceted soft hammer platforms. The majority of removals during the Solutrean appear to be marginal soft hammer percussion, although the use of indirect percussion was cited at Bergeracois (Morand-monteil et al., 1997). Blades were removed from the opposed platforms, and refitting analysis conducted by Almeida (2005) indicated the presence of the alternating use of each platform to produce a series of blades. Blades were predominantly straight; however, smaller bladelets were documented with some curvature resulting from the morphology of the core. Stanford and Bradley (2012, p.136) note the careful attention paid to the production of each blade by the careful flaking and grinding of the striking surface, producing nipple shaped, or *en éperon*-style platforms. Blade production began with the removal of initial blades that were either crested or followed the natural morphology of the core (Almeida, 2005), before continuing by removing corner blades to open up the face of the core for continued removals (Stanford & Bradley, 2012, p.136). Following these removals, centre blades were removed, and production continued in this manner (Stanford & Bradley, 2012, p.136).

Core Face Maintenance

No techniques or methods were specifically outlined for any further core face maintenance, and the removal or correction of errors during the manufacturing sequence remains unexplained. Renard (2002) notes the use of flaking from the back of the core towards the face, which was interpreted as a method for controlling both the shape of the blade. This production technique may also have been used for the production of corner blades or to correct errors.

Stanford and Bradley (2012, p.137) discuss the flat back nature of the Solutrean cores as a small but significant difference between the cores of the Solutrean and the ridged back cores of the Gravettian and later Magdalenian. This difference is important as it is indicative of core maintenance, and differences in approaches to blade production may have cultural and traditional significance (Stanford & Bradley, 2012, p.137). Finally, Stanford and Bradley (2012, p.137) also discuss the use of 'flat retouch' and indicate that this appears to be more related to shaping and thinning rather than retouching.

Summary

The description of Solutrean blade production described by Stanford and Bradley has numerous details in common with the descriptions presented in the literature review. This validates many of the conclusions reached by Stanford and Bradley concerning the Solutrean, and the details provided by Stanford and Bradley also help to elaborate on the reduction sequences outlined by the other authors.

Chronologically, the "proto-Solutrean" has been dated to between 25,500 and 24,500 calBP (Renard, 2011). Dating for the Lower Solutrean at Laugerie-Haute and Les Peyrugues indicated a range of 24,800 and 24,400 calBP (Renard, 2011). The Solutrean also appears to undergo a period of expansion or growth between 21,000 BP and 18,000 BP (Bosselin & Djindjian, 1997; Renard, 2002; Bazile & Boccaccio, 2007).

As stated above, Solutrean blade production differs from the industries that preceded and followed it. While all were concerned with the production of blades, Upper Palaeolithic traditions, particularly in Europe, differ in a number of important ways concerning the actual reduction strategies and sequences. In summary, Solutrean technology mainly utilised blocky or natural pieces of raw material to remove blades rather than using a fully bifacial precore production method. Cores were shaped as blades were produced and platforms prepared carefully and frequently maintained. Individual blades were carefully prepared prior to removal. These blades were detached in order to produce blanks for the production of specific tool types.

Chapter 10

Upper Palaeolithic Blade Technologies of Europe Other Than Solutrean

In her assessment of the origins of the Solutrean, Renard (2011) draws a technological connection between the proto-Solutrean in Portugal to the Lower Solutrean industries of France and Spain (see previous chapter). These proto-Solutrean assemblages are rooted in late Gravettian assemblages and technology (Renard, 2011). This places the blade production of the Solutrean broadly in a technological continuum. This chapter addresses the existing literature on the technological industries and places the Solutrean within the wider context of the European Upper Palaeolithic.

The Aurignacian Period

In an assessment of European blade technologies, Bar-Yosef and Kuhn (1999) identify the Near East and Levantine as a possible location for the expansion of blade technologies out of Africa. This theory is also proposed in a recent assessment of Western Asian blade traditions (Boëda et al., 2013). Boëda et al. (2013) identify the Mediterranean and the Middle East as the starting point for the dispersal of Upper Palaeolithic blade technologies out of Africa. A study of early Aurignacian human fossils indicated the presence of Aurignacian industries across much of Europe, including Eastern Europe and into the Middle East (Churchill & Smith, 2000). This dispersal was also analysed by Mellars (2006) who identifies the origins of the Aurignacian in the Middle East and its progression through Eastern Europe and into France and Spain.

Kuhn (2002) discusses the microlithisation of blades during the proto-Aurignacian. This period has typically been identified as a large flake and blade industry; however, Kuhn (2002) states that the Dufour blades are manufactured from a different technique to blade production. Dufour blades (Figure 72) were small bladelets often described as twisted in profile. After detachment from a core these bladelets were further reduced using either inverse or alternating retouch. These bladelets are considered a type fossil of the Aurignacian.

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Figure 72. Dufour blades. After Bordes (2006)

These tools have been recovered from the proto-Aurignacian along with cores originally identified as carinated scrapers (Kuhn, 2002). The debate remains on going as to whether these scrapers were purposefully created as cores, scrapers or both (Churchill & Smith, 2000; Chazan, 2001a; Kuhn, 2002).

The cores themselves were small with a single platform and the use of one blade face with frontal unidirectional flaking (Type I B-1). Blade removals were usually expedient with little to no precore shaping. Where shaping was evident these cores retain a bifacial edge. The angle between platform and blade face was acute (Mellars, 2006).

During the Aurignacian period, carinated scrapers (Figure 73) continued to be produced. Alongside these cores, small conical cores have also been recovered that exhibit plain platforms with full circumferential unidirectional flaking (Type I C-1). These appear to be the result of continual blade detachment from around the edge of the core rather than a true reduction strategy. Churchill and Smith (2000) note the use of both unidirectional and bidirectional opposed cores for the production of blades.

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Figure 73. Carinated Scrapers. After Mellars (2006)

In a technological evaluation of carinated scrapers as cores, Chazan (2010) discusses the use of a flake as the core for producing bladelets, including Dufour blades. The process of reduction was standardised with no form of preparation prior to detachment. Blades were detached from one side of the core across the face and then back using a semi-circumferential unidirectional method along one face (Type I D-1). Figure 74 illustrates a schematic of Aurignacian blade production as defined by Chazan (2010).

In his assessment of microblade technologies in the Upper Palaeolithic, Straus (2002) identified the use of small blades in the Aurignacian, Gravettian, Magdalenian and later Mesolithic period. While Straus (2002) discusses the Solutrean, he does not make a case for the use of microblades in either France or Northern Spain.

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Figure 74. Schematic of Aurignacian bladelet production. After Chazan (2010)

For the Aurignacian in general, core platforms were plain; however, core tablets with deep bulbs were removed as a method of re-establishing the angle between core platform and blade face (Chazan, 2010). This is in contrast to the production of individual blade preparation flakes creating small negative bulbs as is seen in the core platforms and core tablets of the Solutrean or Clovis (Stanford & Bradley, 2012, p.135).

As Stanford and Bradley (2012, p.117) note, there are on-going debates concerning the precise nature of the Aurignacian Period, which has been dated to around 33,000 and 27,000 BP. Aurignacian technology was dominated by bladelet production on small flakes. Macro blades were produced; however, production was more expedient in approach, with minimal precore shaping. Many of the cores appear unorganised in terms of spacing and consistency. Blade detachments occur more frequently on the most suitable ridge, rather than constantly maintaining the blade face for intentional blade products (Bordes, 2006, fig.7). However, according to Stanford and Bradley (2012, p.117), Aurignacian technology consisted primarily of full bifacial edge trimming, which formed a guiding ridge that was retained throughout manufacture. The dominant tool forms during this period were backed blades with abrupt retouch.

The sites of Hayonim Cave in Israel (Chazan, 2001b) and La Ferrassie, Dordogne, France (Chazan, 2001a) (Figure 75) both have Aurignacian assemblages that contain the distinctive Dufour blades. While Hayonim Cave is outside the area of study for this chapter, its inclusion here attests to the spread of the Aurignacian out of the Middle East. Chazan (2001a; 2001b), in his assessment of these sites, concluded the reduction strategy was the same, indicating the widespread nature of this technology. Chazan (2001a) also identified that, from the assemblage at Hayonim Cave, the only viable candidates for cores were the carinated scrapers (Type I B-1/Type I D-1). The assemblages from La Ferrassie (Chazan, 2001a) and Hayonim Cave (Chazan, 2001b) also feature burins which are a common component of Aurignacian assemblages (Bordes, 2006; Chazan, 2010).

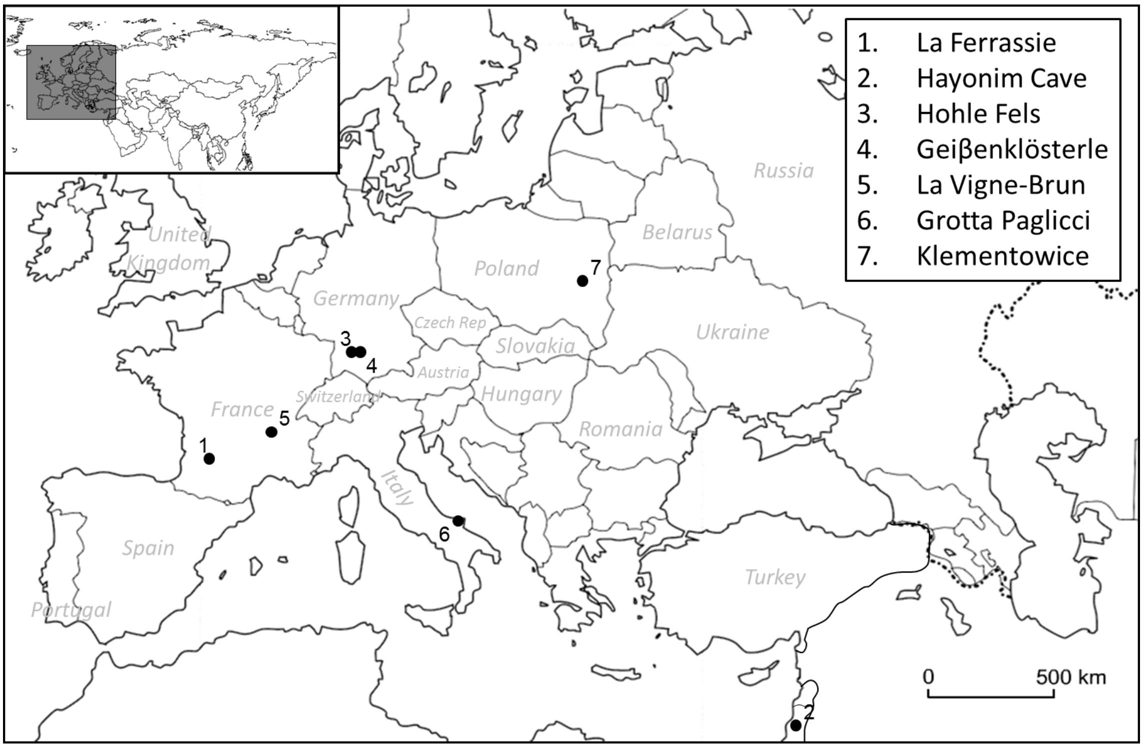

Figure 75. Major sites discussed in text including La Ferrassie (1), and Hayonim Cave (2)

In Jean-Guillaume Bordes' (2006) re-evaluation of the Aurignacian, he identified the use of both carinated scrapers, and in later Aurignacian levels, nosed scrapers as the primary core type for the production of blanks for tools. Bordes (2006) also states that both blade and bladelet technologies were present in the Aurignacian and that each involved a different reduction strategy.

The blades produced during the Early Aurignacian were detached from expedient style cores with minimal precore shaping, the formation of crests was uncommon in this industry and the blades were wide, thick, and slightly curved (Bordes, 2006). Core tablets were removed to re-establish the core platform, and the blade platforms themselves were faceted or spurred (Bordes, 2006). These cores were discarded once the core size fell below 8-10cm (Bordes, 2006). For this early period, the bladelets were produced on the cores outlined above; in essence these cores were simply large flakes. Bordes (2006) also notes that there was very little difference between the production sequence in the Early Aurignacian and the later periods. However, change occurred in the form of the increasing production of bladelets over blades, which declined in production during the Later Aurignacian (Bordes, 2006).

The Gravettian

The Gravettian dates to between 27,000 and 20,000 BP (Stanford & Bradley 2012, p.117). Blade production remained basically the same, but there is a preference for bidirectional, opposed platform cores (Stanford & Bradley, 2012, p.119). Backing on blades was abrupt and burins continued to be produced. Small blades were also a common feature along with truncated blades (Stanford & Bradley 2012, p.119).

Blade production during the Gravettian, as stated by Stanford and Bradley (2012, p.117), represents a continuation of the Aurignacian. The major difference they highlighted was that of a typological change in the development of end products with macro blades again becoming one of the dominant blanks for tool production (Stanford & Bradley 2012, p.117).

Ten major Gravettian sites have been discovered and/or excavated along the Danube Corridor in south-western Germany dating to after 29,000 BP (Floss & Kieselbach, 2004). The site of Steinacker, located on the eastern flank of the Rhine River contained approximately 400 cores manufactured from the local material situated close to the site (Floss & Kieselbach, 2004). The same types of cores have also been recovered from the sites of Hohle Fels (Figure 76) (Floss & Kieselbach, 2004) and Geiβenklösterle (Figure 76) (Moreau, 2010) in the same locality. In their analysis of these cores, Floss and Kieselbach (2004) note the same continuity in production methods with one exception. In the Gravettian, crest production becomes more frequent with blades becoming more regular, longer, and narrower. These cores have one platform or two opposed platforms and feature one or two removal surfaces along the frontal edges of the core with either unidirectional of bi-directionally opposed flaking (Type II B-1 or Type IV B-2) (Floss & Kieselbach, 2004).

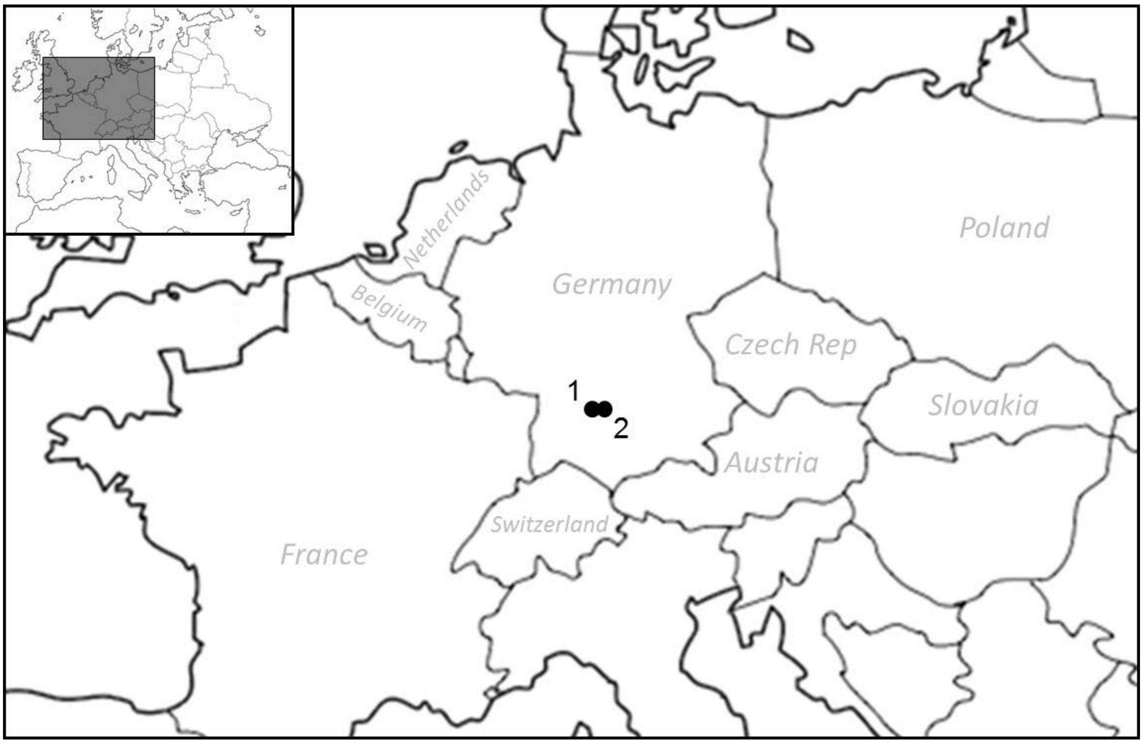

Figure 76. Location of Hohle Fels (1) and Geiβenklösterle (2)

Hohle Fels is a cave site situated on the eastern edge of the Ach River within the Danube Corridor (Floss & Kieselbach, 2004). The cave lies within the Jurassic limestone formations in the area and provided an excellent source of high quality raw material to the caves occupants (Floss & Kieselbach, 2004). The cores (Figure 77) recovered from Hohle Fels retain cortex throughout the manufacture process as indicated by the remnants of cortically backed cores and the high percentage of blades with cortex (Floss & Kieselbach, 2004). The cores show minimal evidence for precore shaping, the main concern of the knapper appeared to be on the blade face, rather than on any other part of the core, as was evident in the retention of cortex on the cores (Floss & Kieselbach, 2004, fig.7). Cresting was the only form of preparation identified. It is interesting to note that in one example illustrated from Hohle Fels, core platform maintenance was undertaken via the removal of a flake from the corner of the striking platform (Floss & Kieselbach, 2004, fig.7). Floss and Kieselback (2004) also note the continued use of bladelet production although do not specify the nature of the bladelet cores in any detail.

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Figure 77. Blades (A-F) and cores (G-I) from Hohle Fels. After Floss and Kieselbach (2004)

The site of Geiβenklösterle Cave is located close to Hohle Fels along the Ach River (Moreau, 2010). The assemblage from the cave includes Gravettian blade cores, blades and bladelets. Moreau's (2010) analysis of the industry at Geiβenklösterle including the 85 recovered cores notes the use of flakes as the blank from which blade cores were produced. The knapping process and technical features of the blade and bladelet production at Geiβenklösterle remained constant. From the procurement of raw material, the initial preparation of the core was characterised by a low investment following the detachment of the initial blade. A unidirectional approach was maintained exploiting one surface of the core, described as frontal (Moreau, 2010). Blades were removed from the flank of the core when maintenance of the cores' convexity was required. Partial crests were also formed along ridges to facilitate blade production (Moreau, 2010). From the illustration of these cores (Moreau, 2010, fig.5,6) (Figure 78) it is also apparent that a second opposed platform was utilised, this may have been used to correct errors along the blade face by detaching a blade underneath the error. The frontal trajectory described by Moreau (2010) indicates the removal of blades from the margins of a flake, rather than along the dorsal or ventral surface (Type II B-1).

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Figure 78. Bladelets (A-G); blades (H-Q); and cores (R-T) from Geiβenklösterle. After Moreau (2010)

This production technique was also present at the site of La Vigne-Brun (Digan, 2008) (Figure 79). Located in the eastern Massif Central 5km upstream from Roanne, France in the Loire river valley, the site of La Vigne-Brun contained an Early Gravettian deposit with over 13,000 artefacts recovered during excavation (Digan, 2008). The major difference between this assemblage in France and those described above from Germany is the higher proportion of bladelets manufactured. Dating of this material indicated a range between 29,000 and 27,000 BP (Digan, 2008).

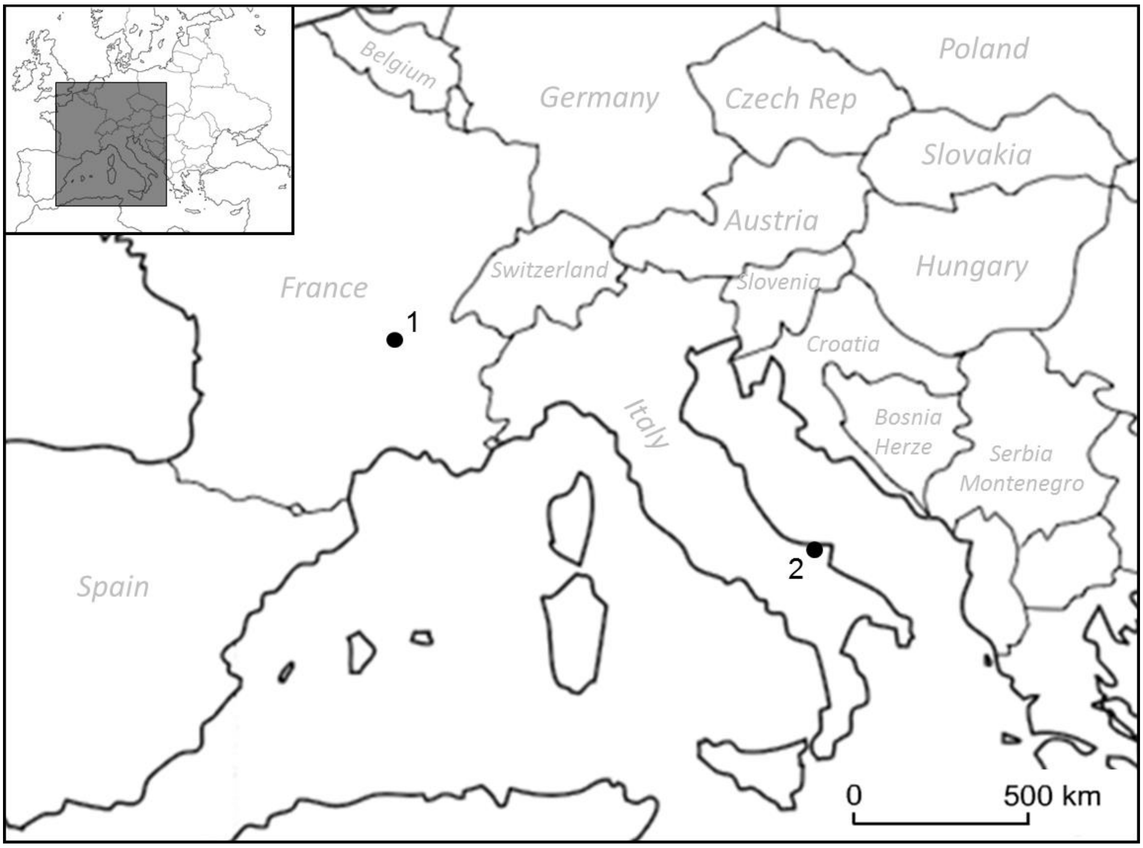

Figure 79. Location of La Vigne-Brun (1) and Grotta Paglicci (2)

Cores from La Vigne-brun were formed on large flakes and shaped via the production of crests which produced a slight curvature to the blade face (Digan, 2008). This curvature was important to the production of straight blades as it allowed the force applied to the blade when struck to travel in a straight line, resulting in a feather termination. The core platform was frequently renewed in this production process (Digan, 2008). The preferred method of detachment was from a single platform and the blade face, as well as having a longitudinal curvature cores have the necessary transverse curvature to facilitate the removal of straight bladelets (Digan, 2008). Digan (2008) also describes the use of a second opposed platform for the correction of errors on the blade face. Another important aspect described by Digan (2008) was the rotation of blades around the blade face onto one face of the core. When this face becomes unsuitable due to a loss of convexity, a new platform was often created to intersect this initial blade face (Digan, 2008). The production of bladelets follows the same reduction strategy as outlined above with the addition of the partial cresting below a hinge fracture at the base of the core

(Digan, 2008). This demonstrates continuity between the production sequence of both blades and bladelets in this sequence. There was also a slight difference in the timing of the creation of a second opposed platform; in bladelet production this second platform occurs later in the sequence, whereas in the production of large blades the platform was created early in the reduction sequence. Digan (2008) ascribes this to the need to maintain the longitudinal curvature of the blade face, which in larger cores became less convex after only a few removals, unlike the smaller bladelet cores where this curvature could be maintained for longer periods of the reduction process.

Excavations at the cave site of Grotta Paglicci (Figure 79) in Southern Italy recovered a full Gravettian sequence with the earliest manifestations dated to 28,100 ± 400 BP (Wierer, 2013). The production of cores from this site involved a similar manufacturing process as the sites discussed above from France and Germany. Production was unidirectional with the aim of producing long, straight blanks (Wierer, 2013) (Figure 80). Crests were established on both the front and back of the core to establish the required convexity and the maintenance of the narrow frontal flaking face (Wierer, 2013). Flakes were detached from the core platform down the lateral edges to develop transverse convexity (Wierer, 2013). As seen in La Vigne-Brun (Digan, 2008), partial cresting was also established beneath a hinge fracture in order to re-establish the longitudinal convexity and remove the error (Wierer, 2013). Core tablets were rare in this assemblage, but scars on the core platforms themselves attest to the continued preparation of the platform as blade detachment progressed (Wierer, 2013). The development of an opposed striking platform was conducted sporadically when maintenance of the core was required (Wierer, 2013). Again, there is a continuation in production techniques from blades to bladelets (Wierer, 2013).

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Figure 80. Cores from Grotta Paglicci. After Wierer (2013)

The notion of the Gravettian as a continuation of the Aurignacian requires modification after reviewing the archaeological record from sites in Italy, France, and Germany. While, in terms of a reduction strategy, precore formation remained minimal, the cores were more standardised in the approach to blade production. Like the Aurignacian, flakes were used as the blank for bladelet tools; however, unlike the Aurignacian, the Gravettian sees a development of a standardised approach in the production of both blades and bladelets. The core type established during this period was the Type II B-1 core, although many of the cores became Type IV B-2 during manufacture due to the requirement for longitudinal convexity.

The Badegoulian

The Badegoulian has been identified in France and Cantabrian Spain (Ducasse & Langlais, 2007). This period is stratigraphically located between the Final Solutrean and the Magdalenian (Fourloubey, 1998; Ducasse, 2010, 2012). The Badegoulian assemblages were characterised by the production of scrapers with little to no blade manufacturing conducted (Morales, pers. comms. 2012) with flake tools dominating the assemblages (Aubry et al., 2007). Ducasse and Langlais (2007) present an argument for the continuation of certain technical elements from this period to the Magdalenian, but it is interesting to note that this industry directly follows the Solutrean at many sites in France and is marked by a lack of blade production.

The Magdalenian

The Magdalenian is considered to be a continuation of the Aurignacian and Gravettian industries (Stanford & Bradley 2012, p.120). The Magdalenian in Europe dates to around 16,500 and 13,000 BP, after the Solutrean period in Spain and France (between 25,000-16,500 BP) (Stanford & Bradley 2012, p.119). Blade and bladelet production continued on cores with bifacial ridges retained while new blade tool forms were introduced, including insets and microliths (Stanford & Bradley 2012, p.119). The Magdalenian is characterised by marked regional variability and as Stanford and Bradley (2012, p.120) note, the genesis for each region during the Magdalenian may be questioned.

The blade production technique used during the Magdalenian involved the formation of a thick bifacial core. Usually, one bifacial edge was removed to set up a blade face leaving a bifacial ridge to the back of the core throughout production. As noted by Stanford and Bradley (2012, p.120) there was marked regional variation in the assemblages, although in an assessment of the Magdalenian, Keeley (1988) attributed this to typological concerns and functional variability, while technological practices were more uniform. The formation of these bifacial cores for the production of blades has been identified in the vast majority of Magdalenian sites, including the established peripheries of the Magdalenian culture (Wiśniewski et al., 2012).

The British Magdalenian was characterised by the production of unidirectional and bidirectional crested blade cores and a high degree of platform preparation; including the ubiquitous use of the *en éperon* technique

(Figure 81) (Barton, 1990; Pettitt et al., 2012). As Pettitt et al. (2012) note, this same industry characterised the Magdalenian assemblages across Europe as well. This is confirmed by the work of Fisher (2006), who discusses the Magdalenian blade production sequences in southern Germany. In this paper, Fisher (2006) describes the use of partial or complete bifacial precore shaping with long ridges to guide blade removals. Crested blades were a ubiquitous part of these assemblages alongside the careful preparation of the blade platform including trimming to control the dorsal edge (Fisher, 2006). This careful preparation of the blade platform occurs on as many as 97.2% of all blades in some assemblages (Fisher, 2006). There are three distinct core types from the German Magdalenian, single platform unidirectional cores (Type II B-1), double opposed platform bidirectional cores (Type IV B-2) and a final type consisting of multiple platforms set up with little relationship to each other (Type V) (Fisher, 2006). Of these, the first and second types were the most dominant.

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Figure 81. The *en éperon* platform type. After Barton (1990)

These same cores were also noted from Magdalenian assemblages in Poland. The hunting site of Klementowice (Figure 82) in eastern Poland yielded 27 cores from precore to discard (Wiśniewski et al., 2012). These cores (Figure 83) were produced in the same manner as described above. Wiśniewski et al. (2012) also note the convexity of the flaking surface was maintained using opposed platforms. Two opposed bidirectional platforms (Type IV B-2) were the most common core type from Klementowice. This same pattern is noted across Poland (Połtowicz, 2006).

Figure 82. Location of Klementowice (1)

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Figure 83. Blade core from Klementowice. After Wiśniewski et al. (2012)

The Magdalenian then, was defined by the creation of bifacial precores that were then reduced from either a single unidirectional approach or a double opposed bidirectional approach. Furthermore, a rescue operation conducted within the Grand-Pressigny region of France revealed a number of similar Magdalenian cores which clearly indicated the use of frontal flaking (Foucher & San Juan, 1991) (Figure 84), this is consistent with the sites above. Accordingly, the morphological use of these cores consisted of frontal (side) flaking which creates the crested back associated with the Magdalenian cores. Thus, the technology of the Magdalenian can be categorised as containing both Type II B-1 and Type IV B-2 cores. In this respect, the continuum between the Gravettian industries and the Magdalenian becomes apparent. This is represented by the creation of a bifacial ridge on a flake, to the establishment of fully bifacial cores. Both of these industries retain characteristics that separate them out from the Solutrean, with the use of natural blocky pieces and the utilisation of a blade face and flattened back. It is this contrast that Stanford and Bradley (2002; 2012; Bradley & Stanford 2004; 2006) state as an important technological consideration.

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Figure 84. Magdalenian blade cores. After Foucher and San Juan (1991)

As discussed in chapter 2, one of the major factors of production across all blade industries in the Upper Palaeolithic of Europe was the maintenance of both the longitudinal and transverse convexity of the core blade face. The convexity is created and maintained for a very specific manufacture purpose. The convexity of the blade face allows the force applied to the blade platform to travel through the core and exit in a straight line, creating a feather termination. If the blade face becomes too straight, the chances of a hinge or step fracture increase as the energy is transferred straight into the centre of the piece rather than across the surface. The purpose of this convexity lies in the desire for straight blades to serve as blanks for tool production.

Discussion

In summary, while there was a certain degree of technological continuation and evolution, in the form of innovation of core production during the Upper Palaeolithic. The Solutrean is an industry unlike those preceding it. For example, the Gravettian sites of Hohle Fels (Floss & Kieselbach, 2004) and Geiβenklösterle (Moreau, 2010) and the Solutrean site of Les Maitreaux (Aubry et al., 1998) are located near sources of high quality raw materials. During the Gravettian, flakes were detached from the large blocks of raw material and these served as the blade cores, with detachments following a frontal morphology. In contrast, Solutreans selected blocky pieces of raw material at Les Maitreaux. Following precore shaping of the initial piece, the core was worked along one face, or occasionally the full circumference. These represent important differences in technological choice and innovation.

Similarly, the industries that follow the Solutrean represent different approaches to blade production. In their analysis of the final Solutrean and the Magdalenian in France, Aubry et al. (2007) discuss the role that the Badegoulian played in the transition. They suggest that the Badegoulian represented sporadic activity in short episodes. The rigidity of both the Solutrean blade technology and Magdalenian blade technology is a stark contrast to the apparent flexibility and variability of the Badegoulian.

Thus, the Solutrean does not fit within a linear pattern of blade production, although it does retain some similar practices. These practices include the use of crested blades, the use of core tablets for rejuvenation and platform preparation. However, it is the precore preparation and the core maintenance from the flat backs that remove Solutrean cores from the continuum. With the evidence provided from those sites in close proximity to raw material outcrops, it is apparent that this technique is not directed by the availability or size of the material. Instead, it represents specific choices in the reduction process undertaken by the knappers in order to keep blade production viable. This choice indicates a different technological approach and stands as a distinguishing trait of the Solutrean in Europe.

Chapter 11
Asian Blade Technology

Like the industries of the Upper Palaeolithic of Europe, the industries of Asia encompass a wide variety of types and production schemes. This chapter highlights the Asian blade industries that concern the ancestral roots of the industries present in Beringia.

The previous chapter (10) briefly discussed the Aurignacian. Numerous authors identify the Middle East as the region from which blade technologies spread into both Europe and Asia (Bar-Yosef & Kuhn, 1999; Churchill & Smith, 2000; Mellars, 2006; Boëda et al., 2013). In an assessment of the Upper Palaeolithic beyond Western Europe, Otte (2004, p.144) discussed evidence for the arrival of the Aurignacian in Asia. This evidence comes from three sites that Otte (2004, p.150) identifies as indicative of a migration that carried the Aurignacian concurrently into Asia. This movement into Asia via the Middle East is supported by the work of Boëda et al. (2013) for the site of Shuidonggou. Figure 85 provides the locations of the major sites discussed in this chapter.

Figure 85. Location of major sites discussed in this chapter

The first two sites identified by Otte (2004, fig.146) are located along the Anuy River; Anuy and Ust Karakol (Figure 86). Both of these sites date to the beginning of the Upper Palaeolithic around 50,000 – 35,000 BP (Otte 2004, p.146). The Anuy assemblage consisted of retouched blades and thick flakes which served as cores for bladelet removals (Figure 87). While deposits at Ust Karakol demonstrate a development of blades in sequential layers from the site with the appearance of Aurignacian tools (Otte 2004, p.146). A third site is located at Zagros in Iran, the archaeological sequence dates to between 40,000 BP and 29,400 BP (Otte 2004, p.146). These assemblages are closely related to the Aurignacian identified in the Middle East and Europe (*see* Chazan 2001a; Chazan 2001b; Bordes 2006).

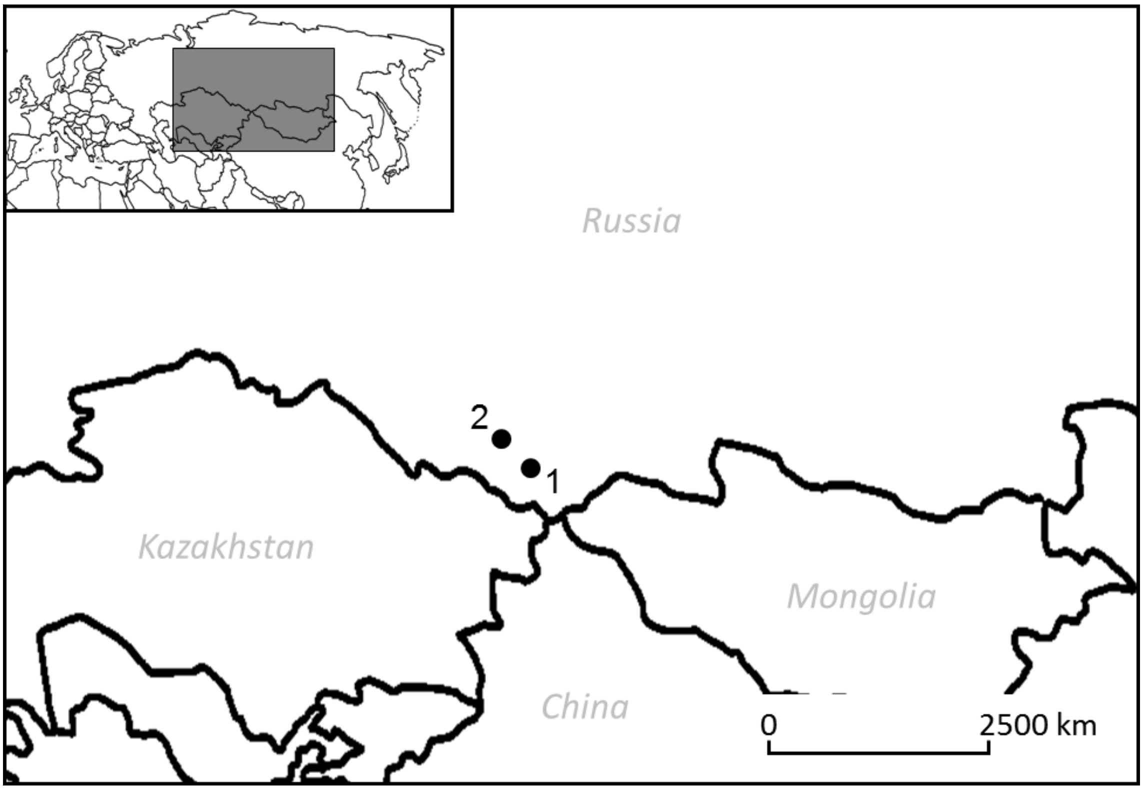

Figure 86. Location of Anuy (1) and Ust Karakol (2)

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Figure 87. Carinated cores from the Altaic Aurignacian. After Otte (2004)

Gravettian-like industries from Asia

Vishnyatsky and Nehoroshev (2004, p.80) discuss the emergence of the Upper Palaeolithic in Russia. One of the most important areas, is that of the district of Kostenki (Figure 88), located on the middle Don on the Russian Plain (Vishnyatsky & Nehoroshev 2004, p.84). The initial Upper Palaeolithic sites from Kostenki were divided into two separate archaeological cultures, the Streletskian and the Spitsynian (Bradley & Giria, 1998; Vishnyatsky & Nehoroshev, 2004, p.80).

The industries of the Streletskian contain bifacially worked triangular points with either concave or occasionally straight bases, bifacial points with rounded bases, endscrapers and Mousterian-like retouched points (Bradley et al., 1995; Vishnyatsky & Nehoroshev, 2004, p.80). The cores from this industry were described as flat, with prismatic forms rare (Vishnyatsky & Nehoroshev 2004, p.85). This would appear to be largely due to the fact that flakes predominate over blades. In contrast, the assemblage of the Spitsynian contained prismatic cores for the production of blades (Bradley et al., 1995; Vishnyatsky & Nehoroshev, 2004, p.80). These blades served as blanks for the production of retouched blades and endscrapers.

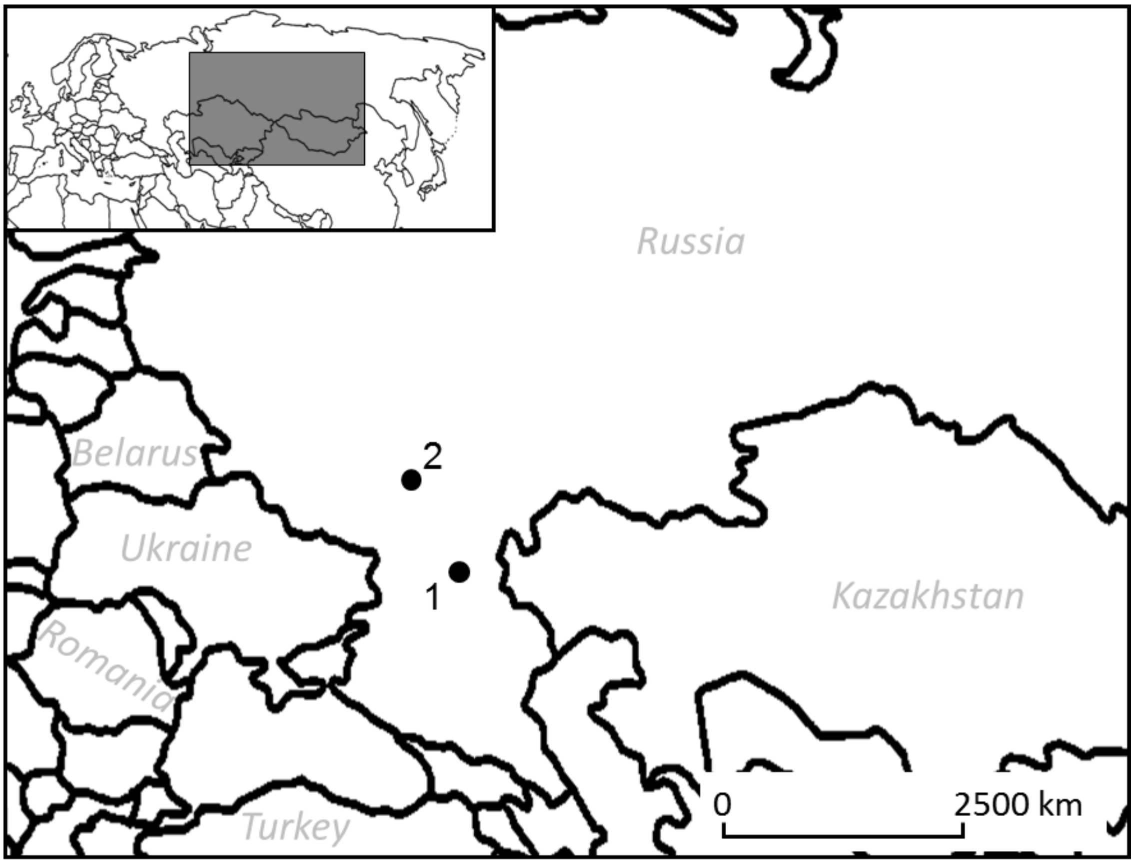

Figure 88. Location of Shlyakh (1) and Kostenki (2)

The assemblage was also characterised by a type of burin on oblique retouched truncations (Vishnyatsky & Nehoroshev 2004, p.87). The Streletskian industries were present through to the late Upper Palaeolithic which persists alongside the development of another lithic industry, the Gorodtsov (Vishnyatsky & Nehoroshev 2004, p.89). The technology of the Gorodtsov was dominated by blade production including the presence of the thick carinated pieces of the Aurignacian assemblages (Vishnyatsky & Nehoroshev 2004, p.90).

In an analysis of the Kostenki, Avdeevo, and Zaraysk industries, Bradley and Giria (1998) indicate that production required a projection on the core, either a dominant ridge or a crested ridge. Cores were first bifacially shaped and the platform was produced at the thick end of the precore aligned with a bifacial edge (Bradley & Giria, 1998). Platform preparation was then conducted via the removal of small flakes which isolated the platform (Bradley & Giria, 1998). Bradley and Giria (1998) indicate that platform preparation was conducted on an individual basis. Blade production was likely conducted using direct percussion along the frontal edge of the core and after the removal of the first blade, subsequent blades were detached on either side of this scar (Bradley & Giria, 1998). Occasionally, bladelets were detached which enhanced the flaking surface projection near the platform (Bradley & Giria, 1998). Refitting sequences from Kostenki indicated that production seldom passed three successful blades before an error required correction (Bradley & Giria, 1998). Error correction included the detachment of a corner blade to remove half the hinge (Bradley & Giria, 1998). Another option discussed by Bradley and Giria (1998) was to remove the projecting area below the hinge via unifacial or bifacial ridge flaking. The flattening of the core's blade face was corrected via the detachment of corner blades (Bradley & Giria, 1998). These cores represent Type II B-1 (single faceted platforms, with unidirectional frontal flaking) cores and are similar to the Gravettian cores with full bifacial precore formation.

Alongside these industries there are also more Gravettian like assemblages dominated by blades. The site of Shlyakh (Figure 88) is dated to around 45,000 BP and importantly contains evidence for blade manufacturing from a core (Vishnyatsky & Nehoroshev 2004, p.94). While no further detail is provided in the text concerning the reduction sequence, an illustration of this sequence suggests a technology based on the frontal production of blades on a flake (Figure 89), with the lateral face of the core also utilised (Vishnyatsky & Nehoroshev, 2004, fig.6.4). This is very similar to the idealised cores presented by Bradley and Giria (Bradley & Giria, 1998, fig.28) and represents Type II B-1 production.

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Figure 89. Core from Shlyakh. After Vishnyatsky and Nehoroshev (2004)

There is a suggestion of the formation of a crested ridge to initiate the first detachment with cresting on the back of the core, indicating a partial bifacial precore as in the Kostenki assemblages (Bradley & Giria, 1998). The assemblages of Kostenki were also studied by Grigor'ev who noted the presence of both Aurignacian and Gravettian like tools (Grigor'ev, 1993, p.51). Blade manufacturing is also present in lithic industries along the Dnestr river in Ukraine (Borziyak, 1993, p.82).

A continuation of Gravettian style blade production assemblages has also been recovered from initial Upper Palaeolithic sites in Mongolia. Two cave sites, Tsagaan Agui and Chikhen Agui, have been excavated from the Mongolian Gobi in Bayankhongor Aimag (Derevianko et al., 2004, p.207) (Figure 90). Both sites are located in the limestone outlier on the southern piedmont of the Gobi Altai massif (Derevianko et al., 2004, p.207). The reduction sequence from both localities has been described as blade production from flat-faced levallois-like cores (Derevianko et al., 2004, p.207). Dating from these two sites yielded an age range of 33,000 to 27,000 BP (Derevianko et al., 2004, p.207).

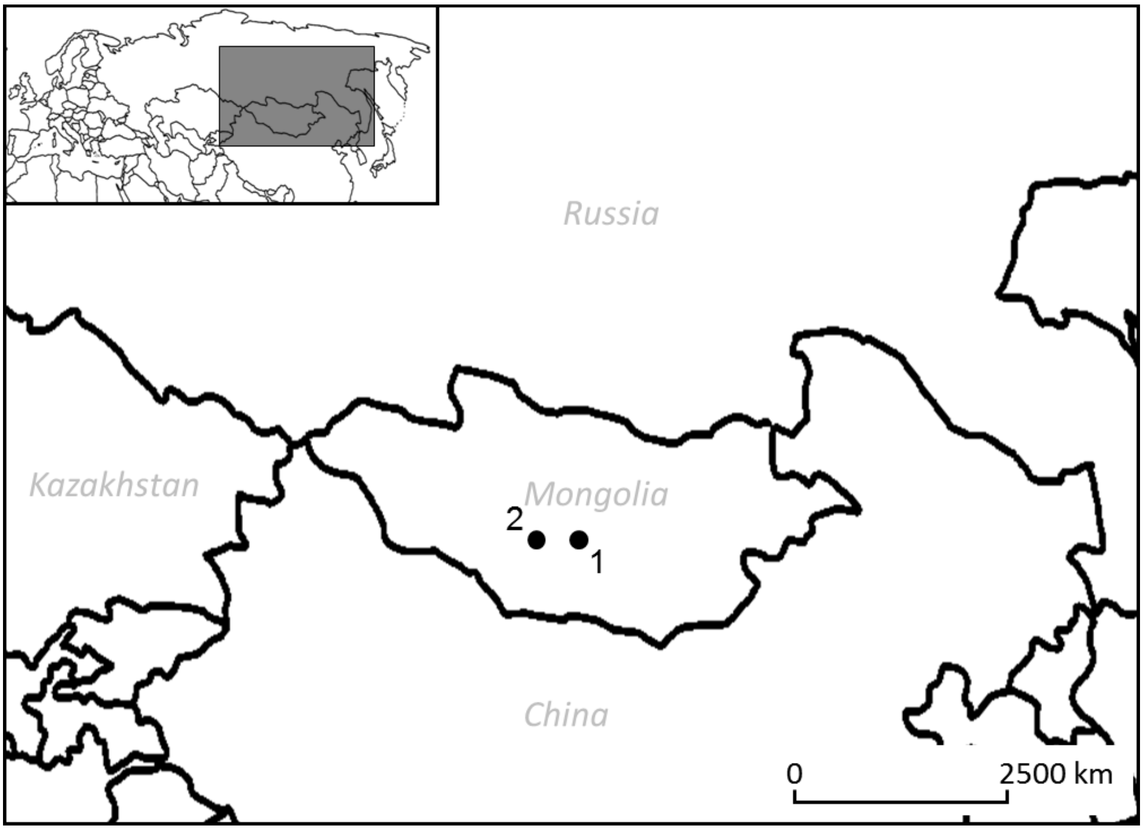

Figure 90. Location of Tsagaan Agui (1) and Chikhen Agui (2)

Derevianko et al. (2004, p.212) indicate that at the site of Tsagaan Agui, raw material constraints were a factor in the blade industries as it was low quality and contained numerous voids or large secondary crystal inclusions. A production sequence for specific blade manufacture was identified from the lower strata. This industry consisted of broad, flat-faced cores that were utilised unidirectionally. These cores were formed on large flake blanks (Derevianko et al. 2004, p.213), but in contrast to the flake blanks used during the European Gravettian which were worked frontally from one end, these cores were worked along the face. The illustration of one of these cores depicts the lateral, transverse flaking of the back of the core (Figure 91), giving the core a flat back (Derevianko et al., 2004, fig.14.3). While this style of flaking is rare, cores with flat backs were also reported by Bradley and Giria (1998) from Kostenki. There is a slight longitudinal convexity to the blade face and the platform of the core was faceted, indicating a Type II A-1 (single faceted platforms, with unidirectional facial flaking) core technology. Derevianko et al. (2004, p.213) also discuss the use of corner blades, formed by the creation of lateral crests, as a method of transferring blade removals from the primary blade face to the narrow lateral face. A similar practice is seen at the site of Shuidonggou in northwest China (discussed below).

Figure 91. Blade core from Tsagaan Agui. After Derevianko et al. (2004)

The assemblage recovered from the site of Chikhen Agui, 200km west of Tsagaan Agui, contains the same core industry with one exception: the cores from this locality are bidirectional with opposed platforms (Derevianko et al. 2004, p.218) (Figure 92). As such, these cores represent a Type IV B-2 (double faceted platforms, with bi-directionally opposed frontal flaking) scheme of production. The high degree of platform preparation and faceting, alongside the flattened backs of these cores remains consistent between Chikhen Agui and Tsagaan Agui. A high frequency of crested and plunging (described as "overpassed") blades were recovered from the assemblage at Chikhen Agui (Derevianko et al. 2004, p.219). The tools in these assemblages include retouched blades, scrapers, notches, and denticulates (Derevianko et al. 2004, p.222).

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Figure 92. Blade cores from Chikhen Agui. After Derevianko et al. (2004)

In a more recent assessment of the Upper Palaeolithic industries of Mongolia, Gladyshev et al. (2012) discuss the presence of the technology outlined above in relation to a chronological sequence and the rise of microblade manufacture. In this assessment, Gladyshev et al. (2012) analysed the site of Tolbor 15 (Figure 93), located on the second terrace of the west bank of the Ikh Tulberiin Gol. Approximately 33,000 artefacts were recovered from the excavation, which included macro blade cores from the lowest horizons, and then microblade cores from level AH5 and above (Gladyshev et al., 2012). The AH5 horizon had an associated radiocarbon date of 28,640 ± 310 BP with the deepest unit, containing the macro blade cores dated to 29,150 ± 20 BP (Gladyshev et al., 2012). Gladyshev et al. (2012) associated the presence of crested and semi-crested blades from levels 7 and 6 to the rejuvenation of these macro cores by moving the core blade face from the broad face of the core to the narrow back of the core. The cores are described as tabular, single platform cores and illustrations (Gladyshev et al., 2012, fig.2) show a number of similarities to the assemblages from Tsagaan Agui and Chikhen Agui. One similarity was the transverse flaking across the back of the core to create a flat back. This is of specific interest to this thesis as the flaking of a core to create a flat back is found in two other industries; Clovis and the Solutrean.

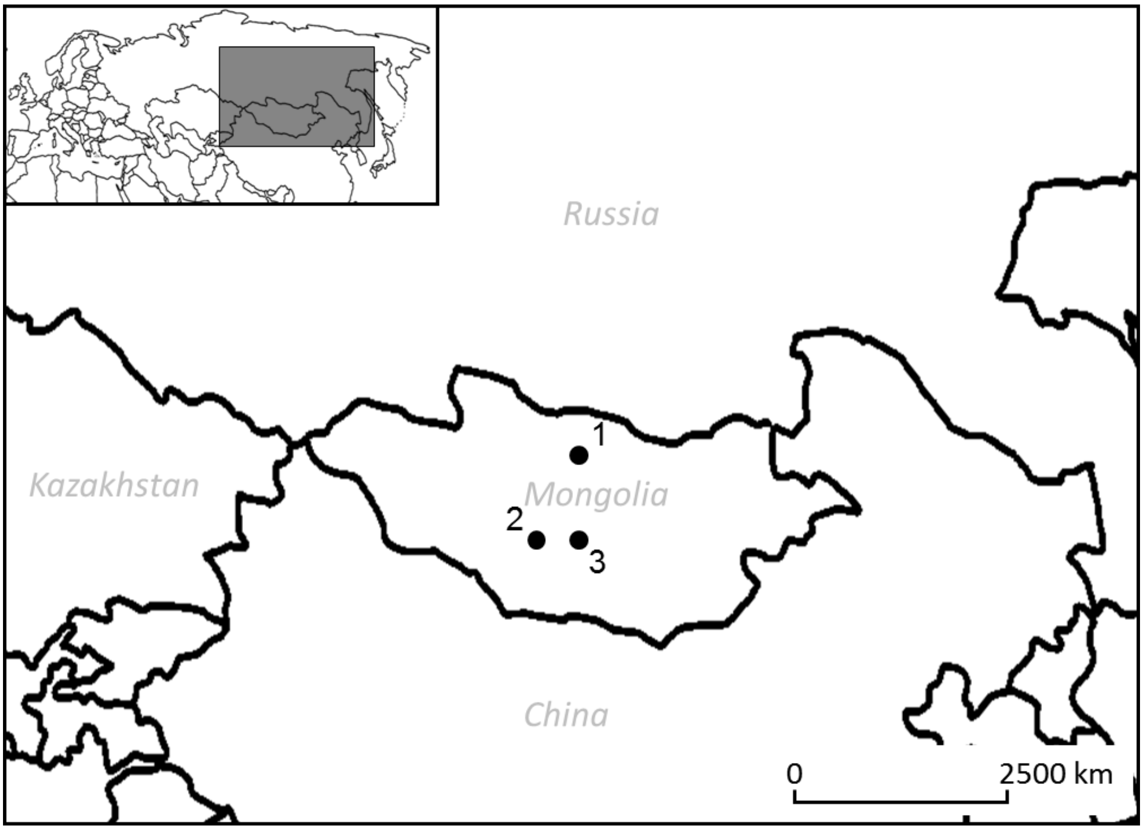

Figure 93. Location of Tolbor-15 (1), in relation to Chikhen Agui (2) and Tsagaan Agui (3)

Additionally, both single platform, unidirectional cores and bidirectionally opposed, two platform cores have been recovered. One of the cores exhibits the retention of cortex along one of the lateral sides of the core, while another retains a cortical back (Gladyshev et al., 2012, fig.2) (Figure 94). The illustrations also provide technical detail of the sides of these cores. Interestingly, the lateral edges of those cores with flat backs are bifacially worked (Gladyshev et al., 2012, fig.2) (Figure 94).

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Figure 94. Cores from Tolbor-15. After Gladyshev et al (2012)

This would indicate that this technology utilised thick bifacial preforms to produce these macro blade cores, like the Gravettian at Kostenki (Bradley & Giria, 1998), production began down one crested margin of the core.

This technology was replaced by a burgeoning microblade industry around 28,640 ± 310 BP. Wedge-shaped microblade cores (Type 1 B-1: single plain platform, with unidirectional frontal flaking), which exhibited a ridge or keel on the bottom opposite the core platform formed via bifacial cresting, dominate the blade industry at Tolbor-15 (Gladyshev et al., 2012).

Both the microblade and the specific wedge-shaped cores from Tolbor-15 were described as being produced on flakes with retouched preparation to the back and basal edge with blades detached from the frontal edge of the core (Gladyshev et al., 2012). In the later levels (AH2 & 1) this microblade industry developed into the creation of thick fully bifacial cores (Gladyshev et al., 2012). The most important aspect of this assemblage was the use of pressure flaking to detach blades from the microblade cores.

Before exploring the adoption of pressure blade manufacturing, it is worth noting the chronological sequence of the macro blade production discussed above. The Gravettian-like assemblages from Kostenki, Avdeevo, and Zaraysk discussed by Bradley and Giria (1996) date to between 24,000 BP and 15,600 BP, making these industries younger than the Shlyakh (Vishnyatsky & Nehoroshev, 2004) and Tolbor-15 (Gladyshev et al., 2012) assemblages. However, Vishnyatsky and Nehoroshev (2004, p.89) note that the assemblages at Kostenki that date to ~30,080 BP (and hence predate those discussed by Bradley and Giria (1996)) would look “more natural” in the Middle Palaeolithic. This would indicate that the Gravettian-like assemblages at Kostenki are contemporaneous with the Solutrean in France and Spain, and with the development of microblade pressure industries in Eastern Asia (below).

A recent analysis of blade core traditions in south-central Siberia (close to the sites of Anuy and Ust Karakol) during the Middle Upper Palaeolithic and Late Upper Palaeolithic, indicated the use of both bipolar core and blade cores (Graf, 2010, 2011). Again, technological detail is absent; however, the illustrations provided for the macro blade industries, attributed to the Middle Upper Palaeolithic (between 32,000 and 21,000 BP), identify the use of large, blocky nodules (Graf, 2010, fig.5).

One of these cores appears to have platform preparation scars that show preparation of each individual blade platform with detachment from around almost one half of the entire core’s circumference (Type II D-1: single faceted platform, with unidirectional semi-circumferential flaking). A second smaller core indicates the use of facial detachments on a blocky nodule that retains cortex on the back of the core (Graf, 2010) suggestive of a Type I B-1 (single plain platform, with unidirectional frontal flaking) core. A similar core, with a cortical back and prepared platform was also illustrated for the Late Upper Palaeolithic (Graf, 2010, fig.5). Interestingly, this core appears to lack any convexity to the blade face, which appears to have produced a series of step and hinge fractures that likely resulted in its discard. There is no evidence for any precore production on this particular core.

In summary, this data indicates that the development of blade technologies in Asia followed the Aurignacian tradition out of the Middle East. However, subsequent technological developments associated with more Gravettian-like production appear to have diversified at a regional or local level.

The development of microblades

The oldest dated sites with evidence for the use of pressure flaking were found in Japan and Korea. However, in a recent synopsis of pressure techniques, Inizan (2012, p.35) concludes that a loosely defined geographic region around modern Mongolia is the most likely region from which pressure blade manufacturing emerged.

This is confirmed by recent dating from the microblade levels at Tolbor-15 (Gladyshev et al., 2012). It also pushes back the earliest dated sites to Mongolia and establishes the presence of this technique prior to its emergence in Japan and Korea.

The cluster of sites called the Shuidonggou Complex (Figure 95) is one of the few archaeological sites in northern China that contains evidence of formal systematic blade production (Brantingham et al., 2004, p.223). In their assessment of the assemblage from locality 1, Brantingham et al. (2004, p.231) note the presence of levallois-like, unidirectional and bidirectional cores. These two core types appear to be produced intentionally. The evidence for this comes from the creation of a second platform in the early reduction sequence of these bidirectional cores. This is in contrast to technologies where a second platform is established in the later reduction stages of a single platform unidirectional core (Brantingham et al., 2004, p.231). Limited numbers of core tablets were recovered from the excavations and these were often irregular in morphology. Blade platforms were established by heavy faceting (Brantingham et al. 2004, p.234).

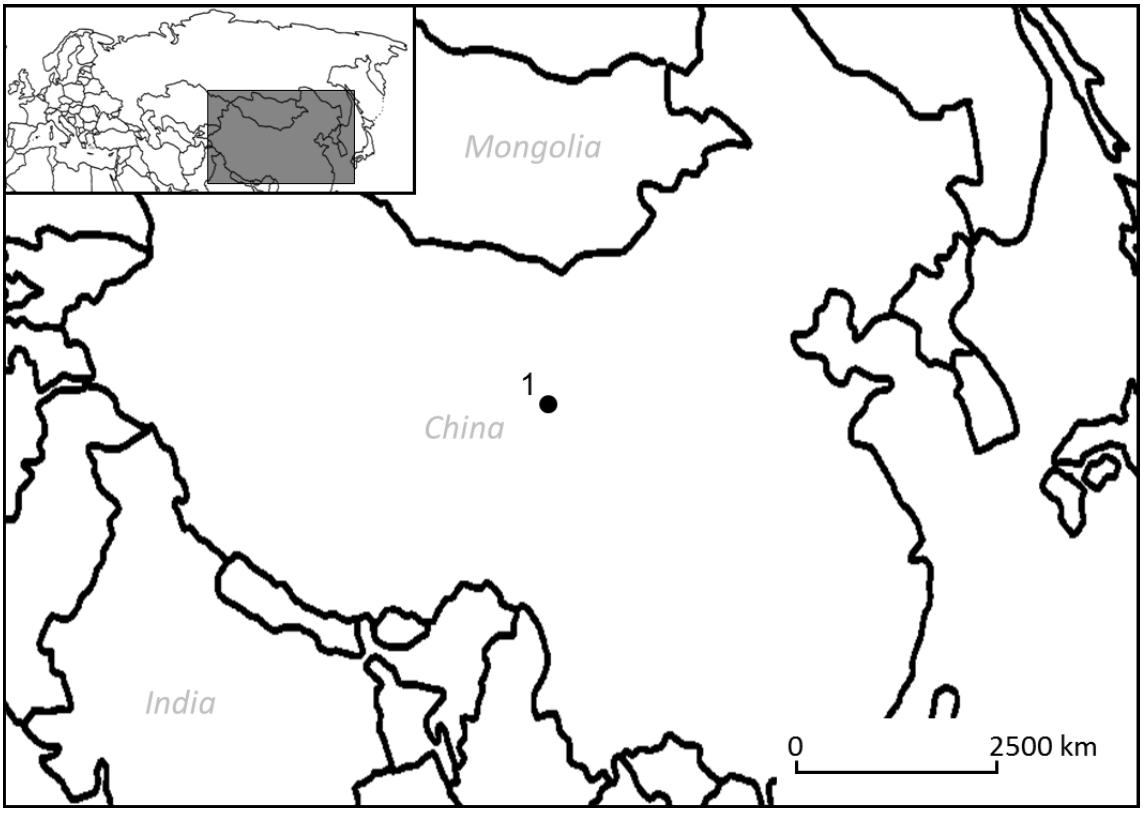

Figure 95. Location of Shuidonggou (1)

There are also a number of crested pieces that Brantingham et al. (2004, p.234) attribute to preparing the lateral edge of the core in order to move the blade detachment face from the front to the side of the core. This was similar to the process discussed by Derevianko (see above). Locality 2 at Shuidonggou contained microblades and microblade cores and also indicates the use of bipolar reduction techniques (Brantingham et al. 2004, p.236).

In their discussion on the assemblages from Shuidonggou, Brantingham et al. (2004, p.241) state that the technological features of this assemblage appear obtrusive into this area of China as flake and core industries dominate the archaeological record. The dating of locality 2 yielded a date range of 27,000 to 25,000 BP (Brantingham et al. 2004, p.241). This assemblage is therefore younger than the Mongolian assemblages that contain similar technological traits and it is likely that this technology migrated into this region of China from Mongolia (Brantingham et al. 2004, p.241).

In 2012, Pei et al. (2012) published an article on the recent findings from six new localities at Shuidonggou. This report detailed the excavations and dating from five of these localities from which over 50,000 artefacts were recovered (Pei et al., 2012). Dating for the entire complex provided an approximate range for occupation spanning 26,000 years, from 32,000 to 6,000 BP (Pei et al., 2012). Occupation was not continuous for this period and the authors suggest that the data indicates two peaks of occupation, one occurring around 32,000 to 24,000 BP and a later period from around 13,000 to 11,000 BP (Pei et al., 2012). This early peak of occupation is dominated by the levallois-like blade cores described above. However, a small number of microblade cores were recovered. During this early phase, these two separate industries overlapped before ultimately, the microblade cores became the only technology in use (Pei et al., 2012).

In a detailed assessment of this industry, Boëda et al. (2013) concluded that there were two major blade production strategies, levallois and non-levallois (Figure 96). The major focus of this analysis was on the volumetric considerations of core use. The difference between the levallois production and non-levallois production techniques can be found in the use of core volume (Boëda et al., 2013). Levallois production utilised the entire core as an active volume in the creation of blades, these cores were worked bidirectionally, or occasionally feature centripetal flaking (Boëda et al., 2013). In contrast, the non-levallois industries had an active and a passive volume. The active volume serves as the focus for all blade detachments and flaking, while the passive volume remains unworked (Boëda et al., 2013). These cores were shaped using crested blade removal (Boëda et al., 2013). In their conclusion, Boëda et al. (2013) state that the presence of these two technologies indicates a transitional phase during this period, one that is marked by the progression of technology towards the standardisation of blade products.

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Figure 96. Levallois (A-B) and non-Levallois (C) blade cores from Shuidonggou. After Boëda et al. (2013)

The site of Shuidonggou, as suggested by numerous authors (Derevianko et al., 2000, 2004; Inizan, 2012; Pei et al., 2012; Boëda et al., 2013) fits within the model of an expanding blade production technology. While the roots of this technology have yet to be fully explored, two distinct technological patterns emerged in China. The first falls between 35,000 and 23/22,000 BP and is characterised by flake and core technologies, as defined by the blade production from the Mongolian assemblages, with Shuiddongou at the fringes of this development (Qu et al., 2013). This blade production takes the form of macro blade cores. After 23/22,000 BP, microblade industries become the dominant manufacturing technique across northern China. The south remains largely core and flake dominated. This trend lasts until around 12/11,000 BP (Qu et al., 2013). Yi et al. (2013) attribute this wide uptake of microblade industries to a rise in the need for the serial and systematic production of regular blades in order to adapt to the onset of the cold climate of the Younger Dryas.

By around 18,000 BP – 16,000 BP microblade industries dominate the archaeological assemblages of these regions, including Mongolia, northern China, Korea, Japan, and importantly Far East Russia. In an analysis of the microblade industries from Primorye and the Amur River Basin (Figure 97), Doelman (2009) explores the variability of these industries, including the fact that contextual constraints may play a role in their development, for example, access to and quality of raw material. Doelman (2009) identifies eight core preparation strategies and outlines their production. All of these cores represent variations of Type I B-1 (single plain platform, with unidirectional frontal flaking) cores. While the region discussed by Doelman (2009) falls within the Beringian region as defined by Goebel and Buvit (2011) (chapter 11), her typological outline encompasses the wider regions of Eastern Asia and so is discussed here.

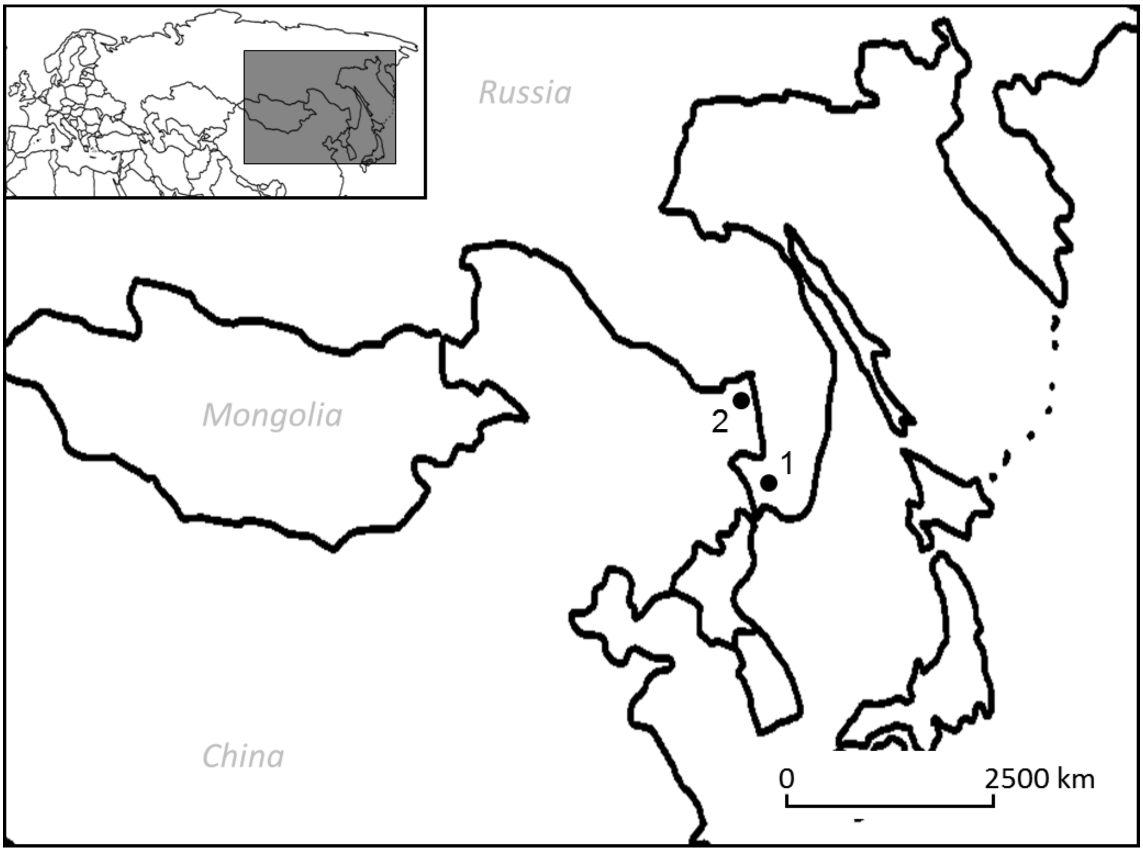

Figure 97. General location Primorye sites (1) and Amur River basin (2) Microblade sites used by Doelman

The first strategy (Figure 98) used a flake that has overshot or plunged across the face of a nodule. The ventral face of the flake was then used as the core platform while blades were detached from the distal tip of the flake on the dorsal surface. Platform preparation to remove overhanging platform margins was common (Doelman, 2009). In some cases the lateral margins of the cores were trimmed which narrowed the core and produced the distinctive keel. These cores were not bifacial but rather stem from a split pebble technique (Doelman, 2009). Occasionally, cores of this variety retained cortex along the ridge of the keel (Doelman, 2009).

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Figure 98. Microblade production strategies as identified by Doelman (2009). Insert shows Yubetsu (A), Horoko (B), and Togeshita (C) technique. Adapted from Doelman (2009).

The second production strategy (Figure 98) was essentially the same as the first, but production started at the proximal end of the core (Doelman, 2009).

The third strategy (Figure 98) began in the same manner as the previous two, with a split core/pebble, but in this technique, the core was rotated 90° so that the new flake scar becomes the side and a platform was established on the original ventral face of the flake (Doelman, 2009).

The fourth production (Figure 98) strategy identified by Doelman (2009) consisted of utilising a flake with the distal termination removed. The flake scar was then used as a platform to detach blade down the lateral margins of the flake towards the core.

The fifth strategy (Figure 98) is described as a bullet core, where the entire circumference of the core was reduced (Doelman, 2009).

Strategy six (Figure 98) was developed on naturally occurring slabs of obsidian where blade detachments occurred on the thickest end of the slab (Doelman, 2009).

The seventh strategy (Figure 98) was that of the Yubetsu technique (Doelman, 2009) which is discussed in greater detail below. Finally, Doelman (2009) includes an eighth strategy, which was a technique used to prolong the use life of the cores described above by rotating the core 180° and using the opposite end to detach a new series of blades (Doelman, 2009). This study of microblade industries highlights the diverse nature of microblade technologies.

Morlan (1967) outlined a technique of microblade technology in the pre-ceramic strata of Hokkaido, Japan, known as the Yubetsu technique (Figure 98A). It has since been widely documented and analysed (Morlan, 1967; Bleed, 1996; Kajiwara, 2008; Doelman, 2009; Takakura, 2012). Yubetsu cores started as thick bifacial preforms. Flakes were then struck longitudinally down the margins of the biface, similar to the tranchet flakes of Mesoamerica (Shafer, 1983), but with the intention of creating a flat striking surface. These flakes are referred to as ski spalls. Often, numerous ski spalls were removed from the core until a flat edge was established. The flat edge became the platform for blade detachments, which began at one edge of the core, in a frontal mode of flaking (Type I B-1).

A similar major reduction strategy is the Horoka technique (Figure 98B), which differs from the Yubetsu method in the formation of a precore. Rather than forming a biface, the Horoka technique used the split core technique as described by Doelman (2009) above where large flakes were used as blanks for microblade production. In an analysis of the Japanese material, the further use of ski spalls as a method of platform rejuvenation was also identified (Bleed, 1996). Bae (2010) noted the presence of this technique in the Upper Palaeolithic industries of Korea. In Ikawa-Smith's (2004) assessment of the Upper Palaeolithic along the Pacific Margin of northeast Asia, the Yubetsu and Horoka techniques were a ubiquitous feature of the post 20,000 BP industries. The use of pressure for the removal of blades was documented in Japan from around 20,000 BP and appeared fairly suddenly (Takakura, 2012). This technology persisted for around 9,000 years.

Summary

The archaeological record of Asia, as outlined above, represents a progression in technology from macro blade to microblade core industries, which spread across wide geographical ranges. By 20,000 BP the microblade industries dominated the archaeological record of Japan, northern China, Mongolia and the Russian Far East. In his analysis of the pressure techniques in the Russian Far East, Tabarev (2012) concluded that the rise and widespread use of microblade cores was strongly associated with the need for compact portable cores. The hunting practices (which included salmon fishing) necessary for survival in the cold environments required a portable technology (Tabarev, 2012a). This conclusion was based on Tabarev's (1997) early experimental work in which a small Yubetsu type core was placed in a wooden grip along with a small hand held pressure flaker. This kit would allow the core to be curated for long periods and sharp blades to be removed on an "as needed" basis.

In his analysis of microlithisation in Eurasia, Kajiwara (2008) connected the Aurignacian of Europe to the microblade industries of Far East Asia and Alaska. He discusses the common characteristics between Siberian industries and those of Japan, Korea and China, namely the presence of two distinct technologies. The first is based on the precore production of a biface and the second is produced on flakes with laterally retouched platforms (Kajiwara, 2008). At the site of Ustinovka 6 near Vladivostok, the microcores recovered exhibited consistent knapping techniques to those from Hokkaido (Kajiwara, 2008). This reinforces the conclusions of Tabarev (2012) indicating that the spread of this technology represented an increasing need for a portable technology that produced highly standardised blades. One unique characteristic of the Aurignacian and the industries of Siberia is the presence of peripheral grooves on antler shafts, indicating an emergence of inset technology (Kajiwara, 2008). Thus, the technologies present in Beringia can be considered as an eastward expansion of these technologies.

Chapter 12

Beringian Blade Technology

In a 1912 publication on the origins of the “American Aborigines”, opinion was divided on whether a physical “land-bridge” had existed allowing entry into the Americas (Fewkes et al., 1912). This changed when Johnston (1933) suggested that during the Wisconsin glacial period, sea levels would have been sufficiently low for a land bridge to have existed (Meltzer, 2009, p.241). In 1937, a Swedish botanist named Eric Hultén (1937) proposed the term “Beringia” for the arctic lowland that would have been exposed during the Wisconsin glaciation and offered a refugium for boreal plant species (Hopkins, 1967).

The term Beringia now encompasses two distinct regions: the extreme northeast of Asia and the northwest of North America (Goebel & Buvit, 2011). Figure 99 highlights the major sites discussed in this chapter and provides an approximation of the area considered as Beringia. The far northeast of Siberia is considered as Western Beringia, and includes the Kamchatka, Chukotka, and Magadon regions and northeast Sakha Republic (Goebel & Buvit, 2011). Eastern Beringia includes Alaska, the Canadian Yukon and the Northwest territories (Goebel & Buvit, 2011). Historically, studies of Beringian assemblages lack significant detail concerning blade reduction processes. This is likely due to the small size and scale of these assemblages.

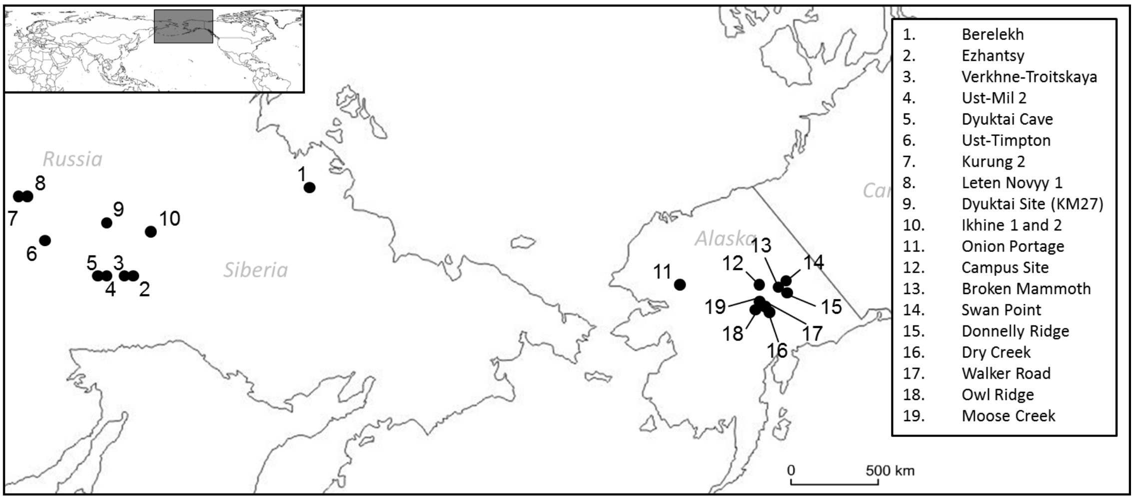

Figure 99. Location of major sites discussed in this chapter

The blade technologies present in Beringia represent only a small portion of the entire cultural components, with a heavier reliance on bifacial and flake technology (*see* Hoffecker 1996a; West 1996a; Goebel & Buvit 2011; Graf 2011; Smith et al. 2013; Goebel et al. 2013). This includes the Mesa (Kunz & Reanier, 1995, 1996; Kunz et al., 2003) and Sluiceway-Tuluaq complex which may be contemporaneous with Nenana but technologically distinct (Goebel et al., 2008). This chapter focuses on those sites with a blade component.

Numerous sites in far Western Beringia (Figure 100) have yielded microblade cores: Dyuktai Cave (Mochanov & Fedoseeva, 1996a; Flenniken, 1987), Ust-Mil 2 (Mochanov & Fedoseeva, 1996b; Goebel, 2002; Vasil'ev et al., 2002), Verkhne-Troitskaya (Mochanov & Fedoseeva, 1996c; Pitblado, 2011; Vasil'ev et al., 2002), Ezhantsy (Vasil'ev, 1993; Mochanov & Fedoseeva, 1996d; Goebel, 2002), Ikhine 1 and 2 (Mochanov & Fedoseeva, 1996e; Tabarev, 1997; Vasil'ev, 2001; Pitblado, 2011), Ust-Timpton (strata Vb-x) (Mochanov & Fedoseeva, 1996f; Pitulko, 2011), Kurung 2 (Mochanov & Fedoseeva, 1996g; Stanford & Bradley, 2012), Leten Novyy 1 (stratum IV) (Mochanov & Fedoseeva, 1996h), and the Dyuktai site at KM 27 of the Yakutsk-Pokrovsk highway (Mochanov & Fedoseeva, 1996i).

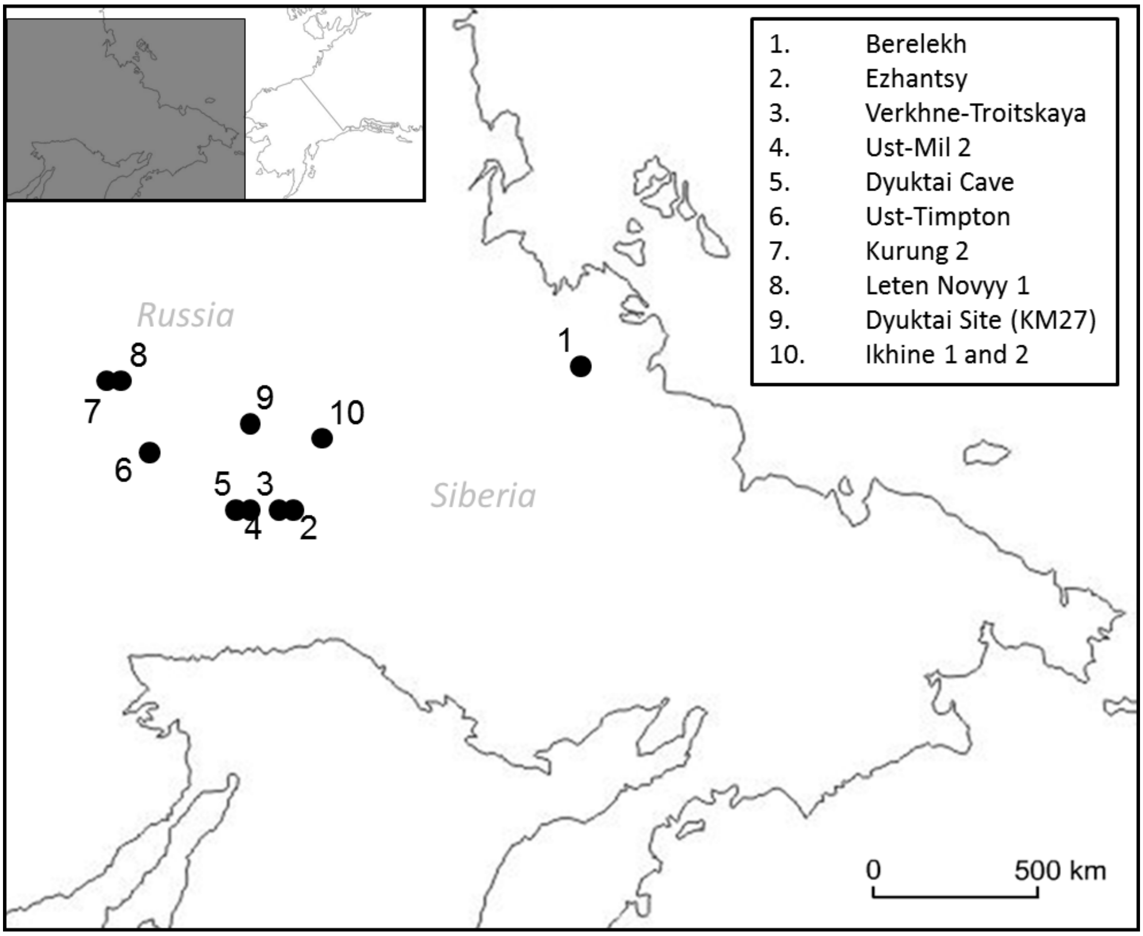

Figure 100. Location of Sites in Western Beringia

The cores fall into two main categories; flake blank and biface precore. Both core categories fit within the Type II B-1 (single faceted platform, with unidirectional frontal flaking) class (Figure 101). Further, both types appear to have been flaked using a pressure technique. The assemblages from Berelekh (Mochanov & Fedoseeva, 1996j; Pitulko, 2011) and Ustinovka 1 (Vasilievsky, 1996; Tabarev, 1997; Doelman, 2009) contained pressure-flaked microblade systems similar to those found across eastern Eurasia.

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Figure 101. Blade cores from Western Beringia; Dyuktai Cave (A-C) after Mochanov & Fedoseeva (1996b); Ust-Mil 2 (D-G) after Mochanov & Fedoseeva (1996h); Leten Novyy 1 (H-K) after Mochanov & Fedoseeva (1996f); Ezhantsy (L-N) after Mochanov & Fedoseeva (1996c); Verkhne-Troitskaya (O-S) after Mochanov & Fedoseeva (1996j); Ustinovka 1 (T) after Vasilievsky (1996).

The blade assemblages from Eastern Beringia (Figure 102) contained the same core types as Western Beringia. These include the assemblages recovered from the Campus Site (Morlan, 1970; Powers & Hoffecker, 1989; Mobley, 1996; Saleeby, 2010), Donnelly Ridge (West, 1996b; Saleeby, 2010; Vasil'ev, 2011; Shott, 2013), Broken Mammoth (Holmes, 1996; Dumond, 2011), and Swan Point (Holmes et al., 1996; Waguespack, 2007; Goebel et al., 2008) in Central Alaska; Dry Creek (Goebel et al., 1991; Hoffecker et al., 1996), Owl Ridge (Hoffecker, 1996b; Slobodin, 2011), Walker Road (Goebel et al., 1991, 1996), and Moose Creek (Hoffecker, 1996c; Slobodin, 2011) in North Central Alaska; and Onion Portage (West, 1996c; Buchanan & Collard, 2008; Saleeby, 2010; Slobodin, 2011) in Northern Alaska. These microblade cores (Figure 102) feature the same technological traits described above and in the previous chapter. Southwest British Columbia appears to be the farthest extent of the spread of small microblade cores produced using pressure (Smith, 1971; Carlson, 1979).

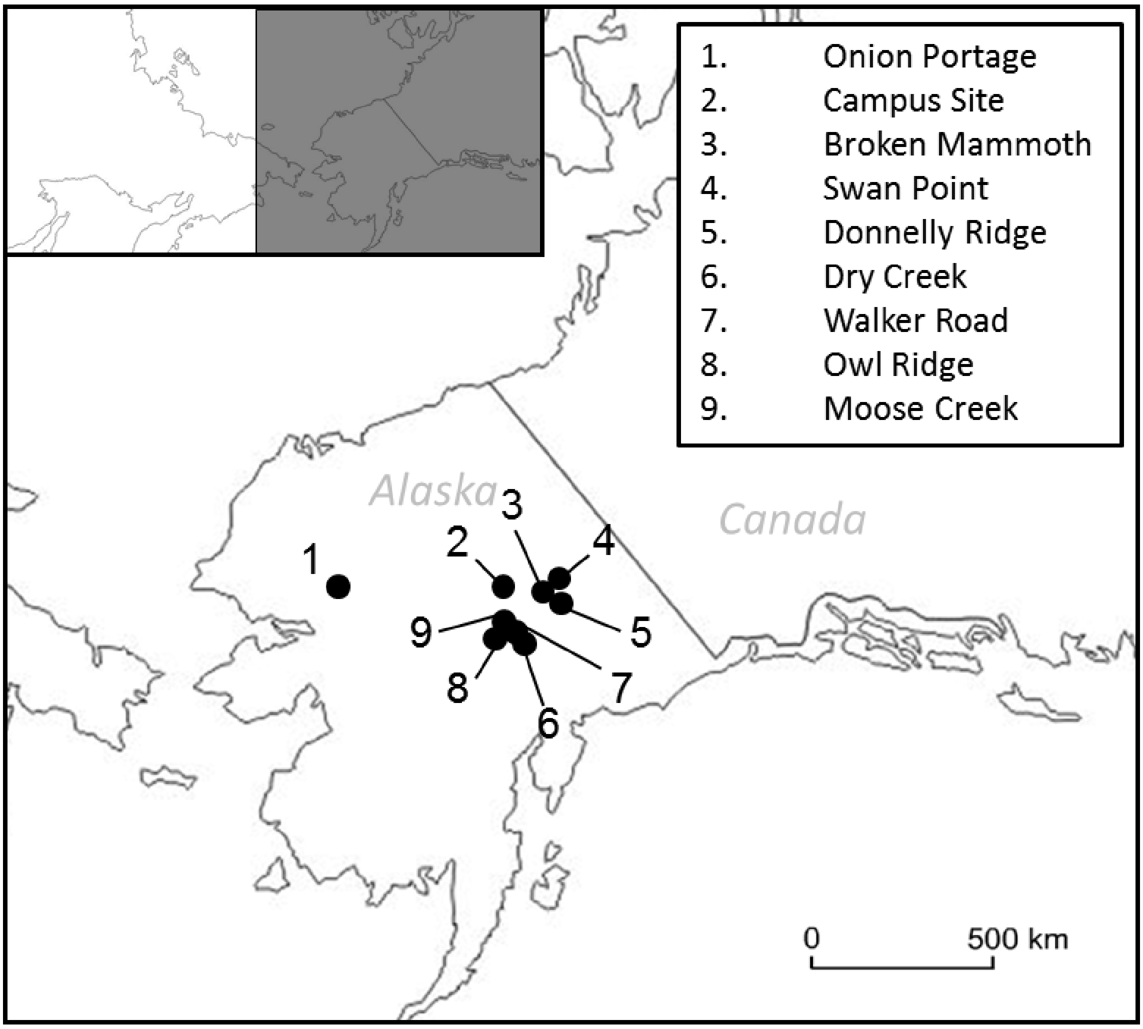

Figure 102. Location of Eastern Beringian sites

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Figure 103. Blade cores from Eastern Beringia; Campus Site (A-D) after Mobley (1996); Broken Mammoth (E-I) after Holmes (1996); Swan Point (J-K) after Holmes et al. (1996); Dry Creek (L-P) after Hoffecker et al. (1996); Onion Portage (Q-R) after West (1996b).

In his assessment of Beringian microblade cores, Morlan (1970) concluded that the cores from the New World were, on the whole, smaller than those cores in Japan and Siberia. The microblade industries of Beringia do not represent a single sequential evolutionary package; instead, Morlan (1970) suspected that the distribution and chronology of these industries implied a greater complexity.

As Waguespack (2007) outlines in her analysis of the earliest peopling of America, the dating of Eastern Eurasia closest to Beringia is significantly older than Western Beringia. Dating from Eastern Eurasia places a continuous occupational presence in the region from ~20,000 calBP (Waguespack, 2007). Recent dating on the oldest sites from Western Beringia indicated that the region was not inhabited until after 15,000 calBP at Berelekh (Pitulko, 2011) while the oldest layer (layer 7) at Ushki-1 dates to about 13,000 calBP (Goebel et al., 2010).

The early date of around 20,000 calBP conforms closely to the original assessment of the microblade industries of Siberia by Goebel (2002), who proposed that humans wielding microblade cores advanced north through Siberia as the glaciers retreated around 18,000 BP.

Goebel (2002) concluded that these microblade traditions originated in Mongolia and states that the lack of evidence for long-term hunting or occupational camps implies that groups were highly mobile. As such, the technology was organised to be highly mobile (Goebel, 2002).

These conclusions support the hypothesis that Beringia was populated by highly mobile hunter-gatherer groups who invested in microblade technology. The arrival of these groups in the New World (i.e. Alaska) should be considered as pericontemporaneous with the arrival of Clovis, and younger than the pre-Clovis sites along the Atlantic Seaboard and the Southern extent of the plains.

Genetic analysis also suggests that populations may have retreated south just prior to the LGM due to the colder dryer conditions, leaving Beringia unoccupied during the last glacial period (Derenko et al., 2001; Volodko et al., 2008). If this was the case, then Asian populations either had to be present in the Americas before the LGM, or they arrived after the LGM, which would leave a very short time frame for the development of Clovis technology.

The blade technology of Beringia

Before discussing those blade core assemblages that exhibit bifacial and/or flake blank microblade cores that are common to Beringia, it is worth considering those blade cores that do not fit this standard. These cores indicate subtle changes to the typical microblade morphology found in Beringia. However, they are unlikely to represent different technological processes, but simply outliers.

The Swan Point site assemblage contained microblade cores (Figure 102) and is regarded as one of the earliest documented assemblages in Alaska (Saleeby, 2010). The most recent dating of the site indicated an age of 14,150 – 13,870 calBP (Potter et al., 2013). Alongside the bifacially flaked microblade cores, one microblade core appears to be worked using a facial side of the core (Type 1 A) (rather than a frontal edge, Type I B) and a second microblade core indicates the use of semi-circumferential flaking (Type 1 C) (Figure 103 J-K). Both of these cores are flat backed (Holmes et al., 1996, fig.6,9) and one of these cores (Figure 103 J) indicates the use of transverse lateral flaking across the back. What remains unclear, due to the lack of technological descriptions, is whether this flaking was intentional, or if this was the remnant of the bifacial precore.

The Whitmore Ridge site contained numerous larger blades as well as two cores, which lacked the technological precision and time investment usually seen on smaller microblade cores. This site yielded an oldest age of 12,083 ± 228 calBP (10,270 ± 70 ^{14}C BP), making it later than Clovis (West et al., 1996; Waters & Stafford, 2007a). Mt. Hayes 122 contained conical cores, which West (1996d) connects to the Whitmore Ridge cores, but these date to about 10,200 calBP (Slobodin, 2011). Finally, the Long Lake site contained larger wedge shaped cores (>5cm); however, dating indicated the site is significantly younger than Clovis with an age of 7496 ± 87 calBP (6606 ± 115 ^{14}C BP) (Reger & Bacon, 1996).

Microblade production

Flenniken (1987) conducted a replicative experiment into the production of Dyuktai microblade cores as detailed from numerous Siberian sites. He broke the reduction sequence of these cores down into five stages (Flenniken, 1987). Figure 104 illustrates the terminology used by Flenniken when outlining this technology which represents a Type I B-1 core. In stage 1, Flenniken (1987) argued that raw material could be obtained in a wide variety of sizes and shapes, but that these selections did not alter the production of a bifacial blank. The second stage of production began with the use of freehand, direct, hard hammer percussion. It followed one of two options available to the knapper: 1) remove a large flake from the original piece, suitable for shaping into a biface, or 2) shape the entire piece of raw material into a bifacial core. If the raw material was thin and tabular, alternate flaking could be used to remove the square edges. This initial bifacial working, coupled with the fact that regardless of raw material morphology knappers always produced a biface, led Flenniken (1987) to argue that the size of the core and blades produced was a cultural preference rather than a material constraint. This technique produced a series of flakes, including primary and secondary decortication flakes and flakes that Flenniken (1987) described as bifacial “thinning” flakes. These flakes are unlikely to be thinning flakes as this would be counterproductive to producing a microblade core, and are likely shaping flakes associated with forming the precore. The third stage involved the use of heat treatment to improve the knapping qualities of the raw material. Flenniken (1987) bases this stage on two examples of heat treated artefacts from Kukhtui and Ust-Mil. Once completed, the fourth stage was to prepare both the platform and core face for blade removals. Mass was removed to straighten the edges, usually at both ends and then abraded in order to prepare for the removal of the first ski spall (Flenniken, 1987). To remove a ski spall (Figure 104), the core was placed against an anvil stone and struck using hard hammer direct percussion, the anvil allowed for the flat removal of a ski spall rather than a plunging fracture. For this removal, Flenniken (1987) also indicated that for detachment, it was also necessary to keep the angle between the platform and blade face at nearly 90°. It was often necessary for a series of ski spalls to be removed in order to produce an appropriate platform. This first ski spall would be a crested blade (Flenniken, 1987). The fifth and final stage of this process was to begin the removal of pressure blades. The first blade removal would be another crested blade followed by a series of removals intended to keep the blade face rounded (Flenniken, 1987). This technique involved the use of corner blades to open up the face of the core as described by Bradley and Giria (1996). As with many blade industries, the face needed to retain a slight convexity to avoid hinge or step fractures and allow for the continued production of blades. The only preparation conducted on the core or blade prior to detachment was the removal of the small spur, created by the negative bulb of the previous detachment. This was removed via reduction of the platform, where a small pressure flake was detached down the blade face removing this spur (Flenniken, 1987).

Figure 104. Flenniken's schematic of Dyuktai blade manufacture. After Flenniken (1987)

In Flenniken's (1987) conclusion, he reiterates that blade manufacturing during the Dyuktai was specific to the cultural system, rather than an adaptive response to raw material availability. This view was supported by Clark (2001) in his assessment of the Beringian archaeological data. Clark (2001) concluded that there was a single Beringian tradition that had its roots in the Old World microblade techniques of Asia, which migrated to Eastern Beringia.

As discussed, the archaeological record from Beringia exhibits a tradition of microblade technology that is pericontemporaneous to Clovis in North America (Hall, 2000; Stanford & Bradley, 2002; Bradley & Stanford, 2004, 2006; Stanford & Bradley, 2012).

In a recent assessment of the dating for sites in Alaska, Vasil'ev concluded that the earliest unambiguous traces of people in Eastern Beringia date to 13,840 – 12,900 calBP (Vasil'ev, 2011, p.119). This is likely a conservative estimate, Potter et al. (2013b) indicate that Swan Lake (14,150 – 13,870 calBP) and the Little John site (14,050 – 13,720 calBP) contain assemblages that are older than the proposed dates. Importantly, there is another cultural complex in Alaska that did not produce microblades. It is identified as a macroblade industry.

Macroblade production

Powers and Hoffecker (1989) defined the Nenana complex based on the tool assemblages recovered from Walker Road, Dry Creek, and Moose Creek. The Nenana complex consisted predominantly of a core and blade industry with unifacially worked end and side scrapers, perforators, wedges, bifaces, and bifacially flaked projectile points (Goebel et al., 1991, p.49). Nenana cultural deposits have been identified at Walker Road (component 1) and Dry Creek (component 1 & 2) (Goebel et al., 1991), and from Broken Mammoth (cultural zones 4 and 3) (Krasinski & Yesner, 2008). The blades were detached from single or double platform cores (Vasil'ev, 2011, p.119; Goebel, 2011, p.205). In an assessment of the possible origins of the Nenana complex, Vasil'ev (2011, p.119) suggests the possibility of a connection with Siberia and places the Nenana complex, at around 12,900 calBP. This includes the industries of Afontova and Kokorevo (Graf, 2011).

Other sophisticated macroblade industries have been identified from Golubaia 1 (dated to 15,340 – 13,840 calBP) and from a series of assemblages located near the confluence of the Derbina and Yenisei rivers (dated to 13,840 – 11,580 calBP) (Vasil'ev 2011, p.124). In Alaska, the blade industry of Akmak has also been identified (Anderson, 1970). The technology of Akmak was originally considered as a local innovation (Anderson, 1968; Holmes, 2001), but a recent re-analysis of the Akmak material indicated some similarities with the assemblages found at the Druchak-Vetreny and Kheta sites in Priokhotye (Slobodin, 2011).

Unfortunately, few detailed technological descriptions of any of the Beringian blade technologies exist. The macroblade cores are described as having single (Type I), double (Type III or IV), or sometimes multiple platforms (Type V) that were often informal and manufactured on cobbles or pebbles (Goebel et al., 1991; Goebel, 2011).

The most complete technological descriptions come from the assemblages recovered from Zhokov Island (Figure 105) (Giria & Pitulko, 1994). Bradley and Giria (1996) explored the technological processes involved in the production of these microblade cores and noted that the precore preparation of the core included producing a number of blades that were simply by-products of the process with no indication of further use. The desired blades, those suitable for inserts, were only produced once the specific attributes of the core were produced (Bradley & Giria, 1996). In this respect, this technology had a high degree of manufacturing blades compared to the production blades. Dates from the site vary from 8200 ± 40 BP to 7450 ± 220 BP (Giria & Pitulko, 1994) and so while the technology is well understood, the site is too young for any discussion on Clovis origins.

Figure 105. Location of Zhokov Island (1)

In an assessment of Clovis origins, Goebel et al. (1991) analysed the tool types present in the Nenana, Denali and Clovis complexes. Their conclusion was that Nenana and Clovis assemblages had more commonalities and suggested that the two were historically related to the same dispersal event (Goebel et al., 1991). As discussed above, the Nenana is unlike the majority of assemblages in Beringia. However, this type of typological analysis can lead to misconceptions and misinterpretations of the archaeological relatedness of an industry.

Goebel (2011, p.199) re-assessed the Nenana Complex from the Walker Road site, taking a “behavioural and technological approach” to the lithic analysis. This site is located along the Nenana River on the south-facing bluff of the Healy terrace overlooking the confluence of the Nenana River and a smaller, unnamed creek (Goebel, 2011, p.199). The weighted mean of the radiocarbon dates obtained from the Nenana levels indicated a date of 13,100 ± 130 calBP, and Goebel states that this is a good approximation for the entire Nenana assemblage (Goebel 2011, p.200).

The cultural layers at Walker Road yielded 4,980 lithic pieces which included 62 cores (Goebel 2011, p.200). Goebel (2011, p.200) states that blade production centred on minimally prepared cores, and that microblade technologies were absent. In his analysis of the 62 cores, Goebel (2011, p.202) found that the majority (53 cores) were bipolar, with four unidirectional cores, a multidirectional core and four core fragments. Bipolar production largely produced flakes rather than blades (Goebel 2011, p.202). Goebel (2011, p.202) states that the four unidirectional and one multidirectional core were used for blade manufacture and notes that the final removals from these cores often obliterated the true blade face, leading to the ultimate discard of the core, but only one core is depicted which indicates the use of a Type II B-1 core (Figure 106). In his analysis of platforms, 61% were smooth, while 19.2% were complex (Goebel 2011, p.202). Unfortunately, Goebel (2011, p.202) does not provide any further detail regarding what smooth and complex actually mean. He does indicate that the smooth platforms are simply core and flake reduction (Goebel 2011, p.202). The assemblage also contained 36 blades, with blade widths widely distributed from 6mm to 52.5mm (Goebel 2011, p.202). The lack of formal blade core preparation, coupled with this broad distribution of blade widths, led Goebel to conclude that blade production at Walker Road was not part of a formalised blade technology (Goebel 2011, p.202).

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Figure 106. Nenana macroblade core. After Goebel (2011)

In his conclusion, Goebel (2011, p.212) indicates that Clovis and Nenana assemblages are contemporaneous, suggesting that the expedient nature of the Walker Road Nenana assemblage indicates a lack of self-provisioning unlike the Paleoindians at the same time. This notion is then contradicted when he states that Nenana could represent an antecedent population to Clovis (Goebel 2011, p.212). Goebel (2011, p.212) continues by stating that the Nenana industry or the earlier microblade industry identified at Swan Lake could also be antecedents to Clovis. These scenarios have little evidence to support them.

The microblade assemblage from Swan Point indicates a human presence at around 14,150 – 13,870 calBP (Potter et al., 2013). This supports Goebel's (2011, p.212) statement concerning microblade cores. However, the dating of the Nenana complex (~13,100 calBP) is contemporaneous with the dates of Clovis, including Lange-Ferguson, SD; Anzick, MT; Sloth Hole, FL; Paleo Crossing, OH; and Murray Springs, AZ (Waters & Stafford, 2007a).

While the dating from Swan Lake is older than the traditional date of Clovis, there remains the issue of the land based route from Beringia to the United States. Dyke et al. (2002) indicated that the Laurentide and Cordilleran ice sheets separated at between 14,500 – 14,000 BP. However, Mandryk et al. (2001) suggest that this route was not feasible for human migration until after 12,000 BP. Dixon (2013) concluded that Eastern Beringia appears to be a terrestrial extension of Asia creating a "cul de sac" blocked by the vast glaciers of the Laurentide and Cordilleran. The presence of these glaciers meant that no land route to the New World existed until around 13,000 – 12,500 calBP (Dixon, 2013). As such, it would be impossible for a founding population from these sites to migrate into the United States.

Furthermore, the specific technologies present in Alaska represent a different technological approach to blade manufacture when compared to Clovis. As Goebel (2011, p.212) states, these technologies need "some major transformations" to be ancestral to Clovis.

Recent studies have found that once the terrestrial corridor was opened, there was a northward movement of Paleoindian technology into Alaska (Dixon, 2013; Goebel et al., 2013; Smith et al., 2013). The site of Serpentine Hot Springs, located on the Seward Peninsula, yielded evidence of fluted points dating to around 12,400 calBP (Goebel et al., 2013). Artefacts recovered from this site indicate the presence of fluted points along with microblade technology

(Goebel et al., 2013). This would indicate that only a select portion of the Paleoindian technological toolkit dispersed northward to Alaska. While the assemblage at Serpentine Hot Springs provides no evidence for Clovis ancestors, it is another important aspect of Beringian archaeology, indicating the continual presence of microblade industries in this region as well as the bifacial technologies present at Mesa (Kunz & Reanier, 1995, 1996; Kunz et al., 2003) and Sluiceway (Goebel et al., 2008).

A pacific coastal route

While this thesis focuses on the origins of Clovis, it is important to recognise that it is unlikely that North America was populated via a single migration route. As Stanford and Bradley (2012) recognise, later cultures in North America undoubtedly derive from Asia.

Dixon (2013) suggests the presence of a pacific coastal route, which was open from around 16,000 calBP. It is this second route that forms the Pacific coastal group identified by Collins et al. (2013, p.523), that stretches from the pacific margins of Beringia to Monte Verde in Chile, South America. The Pacific coastal pattern includes the projectile points of the Western Stemmed Tradition (Beck & Jones, 2010) (Figure 107) and Collins et al. (2013, fig.529) note the presence of relatively thick, narrow projectile points and bifaces without a blade component.

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Figure 107. Western Stemmed projectile points; Haskett site (A-B) after Collins et al. (2013); Paisley Caves (C-D) after Jenkins et al. (2012)

The site of Paisley Caves (Figure 108) represents one of the most securely dated assemblages along the Pacific Coastal margin route. The oldest human coprolites from the site dated to ~14,433 calBP (12,300 ^{14}C BP) (Gilbert et al., 2008) making the site older than the known Clovis occupation of the United States. The assemblage from Paisley Caves included fluted points of the Western Stemmed Tradition (Figure 107) and relatively thick, narrow bifacial points but lacked any evidence of a blade component (Jenkins et al., 2012; Hockett & Jenkins, 2013).

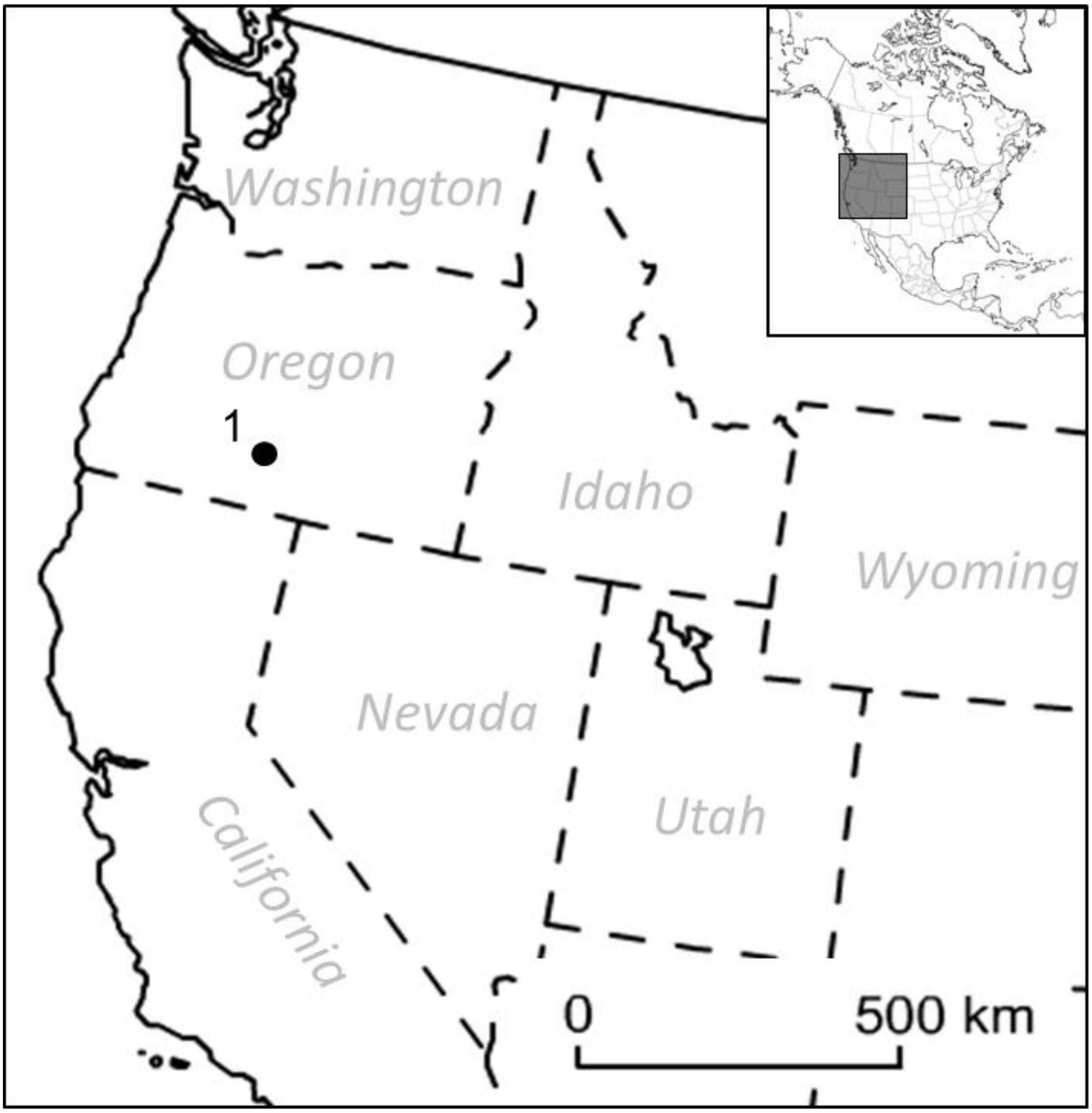

Figure 108. Location of Paisley Caves (1)

Erlandson et al. (2011) note the presence of crescents (Figure 109) along the pacific margin. These chipped stone crescents are found with Western Stemmed Points in California, Great Basin, and Columbia Plateau sites (Erlandson et al., 2011). These artefacts appear to be almost unique to the Pacific coastal Margins with a single crescent found in the Fenn Clovis cache (Frison & Bradley, 1999).

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Figure 109. Chipped stone crescents associated with Western Stemmed points. After Beck and Jones (2010)

This raises the probability that the First Americans that settled along the Pacific margins were maritime adapted people and, according to Erlandson (2013) may have settled around 16,000 BP. Analysis of human bones at On Your Knees Cave indicates a marine-based diet supporting the idea of a maritime adaptation (Dixon et al., 1997; Kemp et al., 2007). However, dating on the bones indicates an age of 10,373 calBP (Kemp et al., 2007).

While this growing body of data provides evidence for a major migration route into North America. It does not address the origins of Clovis. What is apparent is that some of the techniques of Clovis appear in the Western Stemmed Tradition but they arrived relatively late through either diffusion or migration (Beck & Jones, 2010). The lack of any blade components also indicates that the microblade traditions of Beringia do not appear to have moved south with the spread of populations into North America.

Summary

In summary, Beringian material is similar to Asian materials, in that it is dominated by pressure flaked microblade technologies (cores of Type II B-1). However, there are some indications of other blade manufacturing technologies in Siberia and Alaska. The locations in far north-eastern Siberia appear to follow on from the early industries identified from around the Anuy Basin in Siberia (Otte, 2004) and the early Mongolian Sites (Zwyns et al., 2014), as well as from the industries identified by Doelman (2009) in Primorye. Many of the early industries have been described as Gravettian-like (Otte, 2004). The Alaskan microblade material represents a north-eastern expansion of the microblade industries out of Siberia but only account for a small proportion of the entire assemblages present in the region, with flake and bifacial technology predominating. Dixon (2013) states, Eastern Beringia appears to be little more than an extension of Asia. The exception to this is the later expansion of the Paleoindian technologies of the United States into the region (*see* Kunz & Reanier 1995; Kunz & Reanier 1996; Kunz et al. 2003; Goebel et al. 2008; Goebel et al. 2013)

Rather than the need for “some major transformations” as indicated by Goebel (2011, p.212), Clovis technology represents a completely different approach to lithic reduction and blade production. That approach is radically different from any of the Beringian material and this is discussed by Stanford and Bradley (2012, fig.160) who make the same observations and come to the same conclusions.

Chapter 13
Methodology

Numerous methods of data recording and collection have been tried and tested when it comes to lithic analysis; each aims to answer specific questions relating to the research. Often these methods focus on a specific assemblage or location, making the practice of comparing and contrasting key cultures difficult. This study will incorporate data from the assemblage at the Gault Site, Central Texas, and Laugerie-Haute, south-central France, acknowledging the individual traits of each culture.

This chapter discusses how these two specific sites and assemblages were selected for study and discusses the methods of recording that were utilised to address the aims and objectives of this study.

Hypothesis

The data collected for analysis was used in conjunction with the data presented in the literature review (chapters 7 – 12). While any similarities may not directly indicate cultural relatedness, the quantitative data and existing literature on the first peopling of America, can be used to test the hypothesis introduced in chapter 1.

Null Hypothesis

There is strong evidence to prove a correlation between the blade industries of Asia and North America. This challenge's Stanford & Bradley's (2012) assertion of a connection between Clovis and Solutrean technologies, thus negating some of the work conducted. This study demonstrates that A) Clovis antecedents came from a tradition rooted in Asia and B) there is only a certain number of ways in which to produce the blades and any similarities identified in Clovis and Solutrean may simply reflect unique adaptations to environmental factors; suggesting multiple variations of a similar technology can evolve independently from one another.

Alternate Hypothesis

Major similarities in the blade technologies between the Solutrean and Clovis technologies suggest the possibility of a link between the two. This may either be an historical/cultural link, indicating that there was interaction across the ice-edge corridor of the Atlantic during the LGM; or a technological link between Clovis and the Solutrean in terms of convergence. Similarities between the *chaîne opératoire* and reduction sequences of both industries may indicate a shared knapping tradition, while the differences in formal tool types may represent the changing dynamic in the priorities of a group as it reached North America.

Sample Selection

The assemblages from the Gault Site (Clovis) and Laugerie-Haute (Solutrean) were chosen for this study based on the existing documentation, assemblage contents, and previous analysis that identified a significant blade component including cores. Technology is not static, elements change and certain tool types may be present during either the initial sequences or later sequences. Hence sites with depositional horizons were selected.

The overall aim of the data collection was to study the manufacturing and reduction sequences present at the Gault Site (Clovis) and Laugerie-Haute (Solutrean) in-depth. The data was then compared to assess the similarities and differences that exist in each reduction sequence. As such, this thesis does not provide a comprehensive overview of the broader patterning present in the cultural ranges for either Clovis or the Solutrean. However, as discussed below, previous researchers have noted the similarities of both of these sites to the wider archaeological record for each period.

Finally, data was also collected from the Keven Davis cache and from three casts of the Blackwater Draw to evaluate cached blades during Clovis and from Pavo Real for the evaluation of early sequence blade reduction. The Magdalenian levels at Laugerie-Haute were also analysed to provide a small comparative dataset to both Clovis and Solutrean technology.

Sample

Clovis

The Gault site, Central Texas, was the main focus of the Clovis research. Contextual information regarding this site is presented in chapter 8. This site was selected for analysis due to the high number of blade cores and blades recovered in-situ from this locality. Previous analysis of the Gault Site concluded that this site represents a Clovis workshop (Collins, 2002) and so provides data relevant to reduction strategies.

Analysis from the Carson-Conn-Short site (Stanford et al., 2006), Topper site (Steffy & Goodyear, 2006), and Paleo Crossing (Eren & Redmond, 2011) indicates that the manufacturing and reduction sequences present are similar, if not identical to the reduction strategies present at the Gault site. Thus, the Gault site provides an intact Clovis sequence with all stages of manufacture present that also represents a wider practice of blade core reduction during this period.

Two further sites were also analysed due to their individual assemblages. Pavo Real, located just outside of San Antonio, Texas, was selected due to the presence of early stage blade cores (Collins et al., 2003). Excavations at Pavo Real revealed an undisturbed Clovis workshop. This site has also yielded a number of refits the provide data regarding the reduction strategy of Clovis knappers (Collins et al., 2003).

The Keven Davis Clovis cache, Texas, and Blackwater Draw blades were also analysed as they provided data on the type of blades that were being cached during the Clovis period. Thus these blades may represent desirable end products of blade production.

Older than Clovis

The blade assemblage recovered from stratigraphic levels below Clovis at the Gault site were analysed to provide a comparative sample to Clovis and the Solutrean. As discussed in chapter 8, the blade assemblage was recovered from a possibly disturbed area of the site. While blades and a core were also recovered from outside this possible disturbance no detailed stratigraphic work has been completed to address the integrity of this component. As such, the findings presented in this thesis concerning the older then Clovis blade component at the Gault site are preliminary.

Solutrean

The site of Laugerie-Haute in the Dordogne, south-central France contains Solutrean blade production sequences on a scale comparable to the Gault site. Analysis focused on the Laugerie-Haute Est assemblage. Laugerie-Haute is a deeply stratified site that has yielded evidence from blade production during all periods of the Solutrean (Smith, 1966; Bordes, 1978; Demars, 1995b; Delpech, 2012). The published data concerning Laugerie-Haute (discussed in chapter 9) states the presence of blade cores recovered from these occupational levels. While recent work has suggested that Laugerie-Haute Ouest was affected by solifluction (Delpech, 2012), the stratigraphic integrity of Laugerie-Haute Est remains intact and numerous authors have discussed the similarities between the assemblages at the two localities (Smith, 1966; Demars, 1995b, 1995a; Bosselin & Djindjian, 1997).

Furthermore, Renard (2002; 2011), Aubry et al. (2003) and Almeida (2005) have all noted similarities in the production sequences present at Laugerie-Haute to the wider archaeological record of the Solutrean; including the sites of Abri Casserole, Marseillon, La Celle-Saint-Cyr, and Les Maitreaux.

As such, Laugerie-Haute provides high resolution data on reduction strategies used in blade manufacture during the Solutrean that is comparable to the Gault Site and Clovis.

Magdalenian

The Magdalenian assemblage from Laugerie-Haute was analysed to collect data on subsequent blade technology in Europe. The Magdalenian is also contemporaneous to Clovis and previous authors have cited similarities between Clovis and the Magdalenian in Europe (Greenman, 1963).

Broader technological analysis and sampling

Broader technological analysis, in the form of technological attributes, was conducted on data from the existing literature. This includes the data for the Proto-Aurignacian, Aurignacian, Gravettian, Russian Gravettian, Asian non-Levallois tradition, Asian microblade tradition, Dyuktai, Nenana, and the older than Clovis components present on the Eastern Seaboard of the United States.

Sample discussion

The aim of this thesis was to assess the manufacturing technologies of Clovis and the Solutrean specifically focusing on an in-depth analysis of two major sites, The Gault Site (Clovis) in the US and Laugerie-Haute (Solutrean) in France. It is important to note that these two sites, while considered representative to a certain degree of their respective technologies (see above), do not cover the full range of the manufacturing traditions present. This has been addressed and expanded upon where possible in the literature review (chapters 7-12). A combination of these data (literature and collected) was then used for the final analysis.

Data has been included from Pavo Real for the unique insights into primary blade core reduction for Clovis, while both the Keven Davis and Blackwater Draw blade caches have been included to highlight this aspect of Clovis behaviour. Access to French material was more problematic due to museum and research institution constraints, but given the numerous connections in the technological scheme of production highlighted by numerous authors (Renard, 2002; Aubry et al., 2003; Almeida, 2005; Renard, 2011) it was considered the most representative in terms of data on the production sequence. While this connection also extends into the Spanish Solutrean, it should be noted that the data collection does not cover this region. This is due in part to collections access, but mainly due to the lack of full scale manufacturing sites excavated in Spain (Straus, 2000b). This lack of data, including blade cores, makes analysis of the production techniques almost impossible.

The inclusion of the Clovis blade cache data highlights a major difference in the overall pattern of use between these two industries, with the Solutrean producing blades as blanks for other tools while Clovis, in some cases, cached their blades. With the inclusion of this data, metric measurements (specifically length) may be affected. This was not considered an important factor as the emphasis of this thesis was placed on the manufacturing technology and reduction strategy. While length is informative on overall core size, it reveals very little concerning the actual manufacturing process.

The OTC material from Gault was included on a preliminary basis for comparative purposes. The sample size remains very small and dating is currently ongoing and remains problematic. Thus, while included in the statistical analysis, any outcomes should be regarded as preliminary observations subject to change or amendment.

Quantitative Data

The method of data collection has been devised to specifically encompass the platform preparation and core maintenance of Clovis, Solutrean and Magdalenian technologies. Two distinct data types were recorded; metric and descriptive data. Metric attributes were measured with a metric caliper. All measurements were recorded in millimeters and rounded to the nearest hundredth. Descriptive data was collected either as an identification of the type, or as a presence/absence using the number 1 for a present trait, and a 0 if absent.

Blade metric data

Maximum length, width, and thickness were recorded. Maximum blade length is measured in a straight line, from proximal to distal end. Width of blade was measured from the widest point between the two lateral edges. Thickness was measured from the point of maximum thickness between the ventral and dorsal faces. These basic dimensions are recorded in order to calculate the mean and standard deviation for blades from each assemblage. Figure 110 illustrates these measurements on a blade. Ratio of blade length to width was also calculated by dividing length by width. Following the work of Collins (1999) the primary blade measurements (length, width, and thickness) were then used to express the shape of the blades using four calculations:

1. *Length + width + thickness:* Provides a generalised expression of the overall size of a blade.
2. *Length divided by length + width + thickness:* The ratio of length to the sum of the primary dimensions
3. *Width divided by length + width + thickness:* The ratio of width to the sum of the primary dimensions
4. *Thickness divided by length + width + thickness:* The ratio of thickness to the sum of the primary dimensions

These calculations were used to assess the general size of the blades in the assemblages. The ratio calculations (numbers 2-4) were used to indicate which primary measurement had the greatest influence on the overall shape of the blade. While a blade, by definition, is longer than it is wide, these calculations were used to compare the similarities and differences in the use of width and thickness between the blade assemblages from each cultural sample.

The width and depth of blade platforms were recorded where present on an artefact. The maximum width of a platform was measured in a straight line across the dorsal face of the blade while maximum depth was recorded as a straight-line between the dorsal and ventral surfaces.

Index of Curvature was calculated for all complete blades. The index of curvature is a ratio of two linear measurements taken on the interior surface of the blade; these measurements are (Figure 110a) the straight-line distance between the distal and proximal points of contact of the interior blade surface and a flat plane and (Figure 110b) the maximum perpendicular distance between that plane and the interior surface of the blade. The greater the value of the index the more curved the blade (Collins, 1999, p. 86).

Following the work of Boldurian and Hoffman (2009), point of maximum curvature was also recorded. This is the point at which the curve of the blade is at its most extreme and is recorded as a percentage in relation to length (Figure 110c).

Platform angle was not recorded for this thesis. Platform angle is an important aspect of identifying specific blade technologies but was not recorded due to issues with consistent recording. Platform preparation, blade and core morphology, curvature and varying sizes of the bulbs of percussion make systematic and reproducible measurements of platform angle very difficult. Angle measurements require a stable reference point that can be difficult to establish consistently for all blades and blade cores.

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Figure 110. Blade metrics. After Collins (1999)

Blade descriptive data

The first observations made on the blades concerned the type. Blade type consists of the overall morphology of the blade, but type also reveals important technological information. The blades illustrated in Figure 111 can be representative of a stage of removal, for example a fully cortical blade was the first removal, while a true blade would be produced after a series of blade removals that set up the correct spacing for a "true" double ridged blade to be removed. Centre, side, and corner blades may be produced at any point during the manufacturing depending on the technology. These blade types also define manufacturing blades and production blades; cortical, crested, and corner blades all have an effect on the core in terms of continuing blade production. Centre, side, and true blades are production blades as these blades do not necessarily help to continue the reduction process but often serve as blanks for tool production.

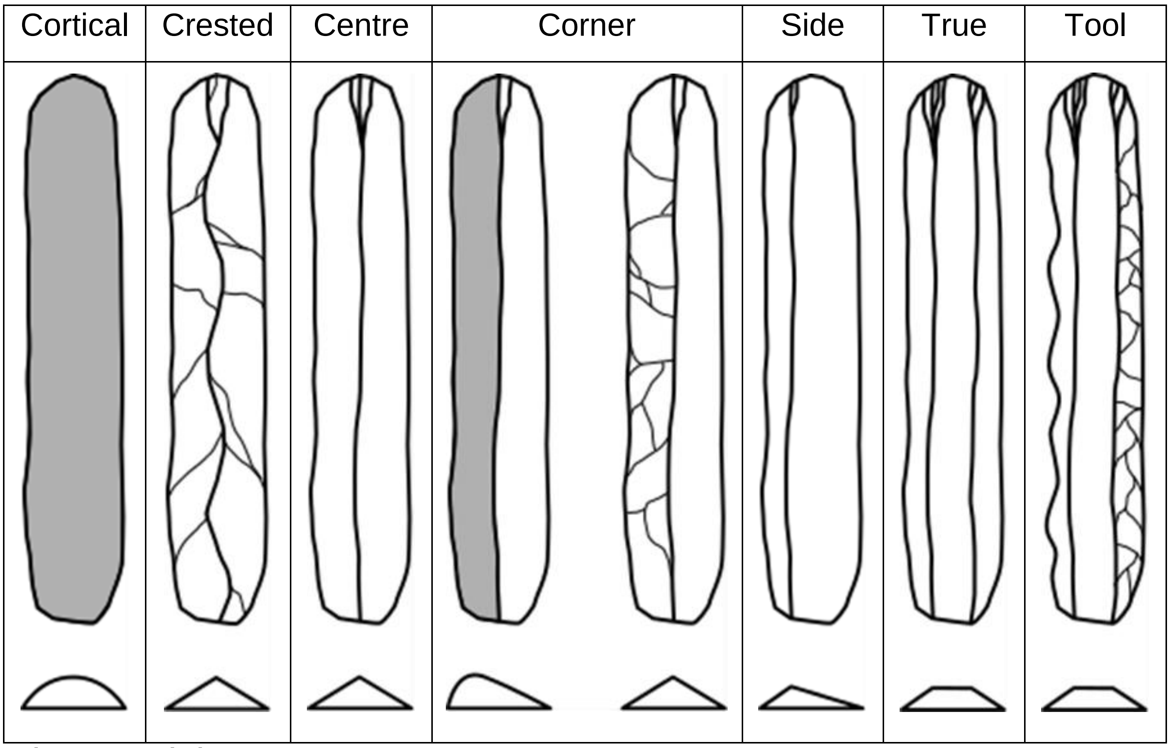

Figure 111. Blade types

Alongside the blade type, the number of dorsal ridges was counted and the lateral edges were defined as parallel, expanding (towards the distal tip) or contracting (towards the distal tip). Platforms were recorded with a description of the platform type following Tixier et al. (1983). These descriptions are illustrated in Figure 112. Cortical platforms retain 100% cortex. Plain platforms lack any form of preparation. The remaining platforms all show some form of preparation with the complex platform being the most heavily prepared.

Figure 112. Blade platform descriptions. After Inizan et al. (1999)

Figure 112 does not include the categories of missing and crushed. Crushed platforms are those that may retain some evidence of preparation, but when struck, small flakes were detached from the platform which subsequently collapsed, obscuring the initial platform.

Specific platform preparation attributes were recorded in accordance with Bradley et al. (2010). Figure 113 illustrates these attributes. Faceting is evident on a platform as small flakes that were removed from the blade face into the core platform. Reducing is the opposite of faceting where small flakes are removed from the platform on the core down along the blade face. Releasing occurs on the core platform and is evident by flakes converging behind the platform while isolating is created by lowering the margin between the core platform and blade face in order to raise the platform above this margin.

Figure 113. Platform preparation attributes. Adapted from Bradley et al. (2010)

The blade distal termination and blade scar pattern were also recorded. Blade termination (Figure 114) provided an indication of how successful blade detachment was, as well as providing evidence for errors produced during production. If one distal termination type is represented in higher proportions it may indicate a desired termination type. Blade dorsal scar pattern (Figure 115) was used as a more reliable indicator of core use as the cores themselves only provide evidence for the final removals and may conceal opposing platform use.

Figure 114. Blade distal terminations. After Butler (2005)

Unidirectional	Asymmetrically opposed	Opposed	Crossed	Multi-directional

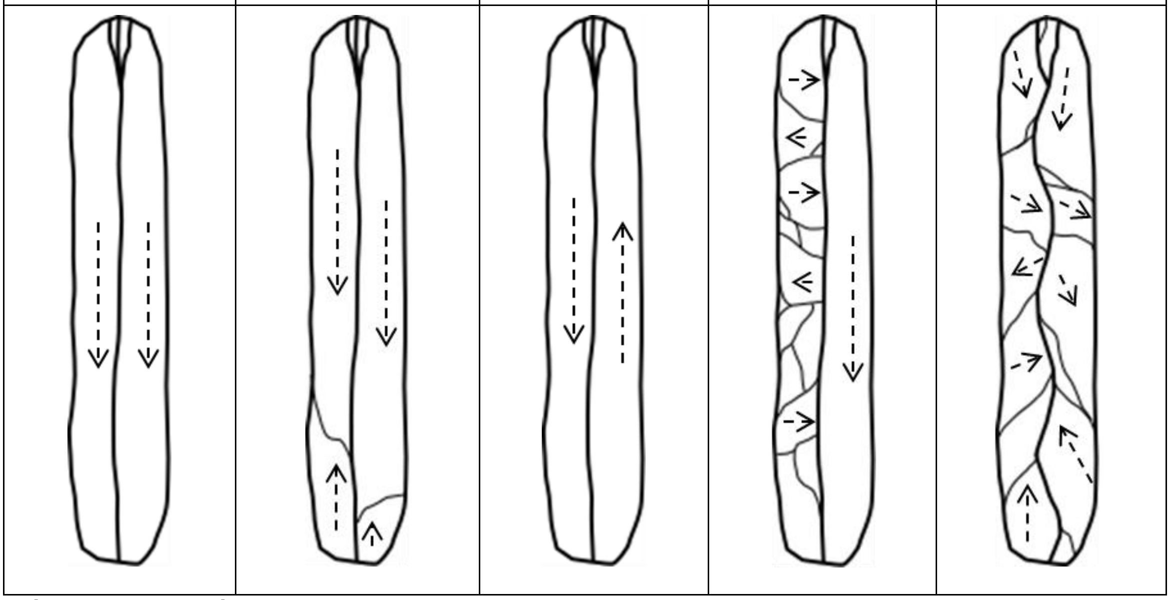

Figure 115. Dorsal scar patterns

Core descriptive data

The condition of the core was recorded as an assessment of possible discard and the reason as to why it was discarded. This fell into three categories; exhausted, battered, and platform loss. Exhausted cores were those cores that were discarded due to loss of a viable blade face for the continued detachment of blades. Battered cores were those cores that had stopped being used for blade production and were subsequently flaked using a different strategy from blade manufacture. The final category represents the cores that were discarded due to a catastrophic error that resulted in the core platform becoming unsuitable for continued blade production, usually via the loss of a correct striking angle. Finally, the flaking patterns on the back and lateral margins of the core were recorded.

Core type (Figure 116), in terms of the taxonomy was recorded for comparisons between Clovis, Solutrean and Magdalenian. This data also provided qualitative data (discussed below).

The final data collected for the blade cores was the lateral margin scar patterns. These scar patterns follow the same terminology and directions as used in Figure 115 for dorsal scar patterns. Right lateral margins are those to the right of the core's blade face when looking at the blade face with the platform up and vice versa for the left lateral margins (Figure 117). It should be noted that cortical margins are also included in the dorsal scar pattern analysis as they indicate the absence of lateral margin alteration; however, technically, cortex is not a scar.

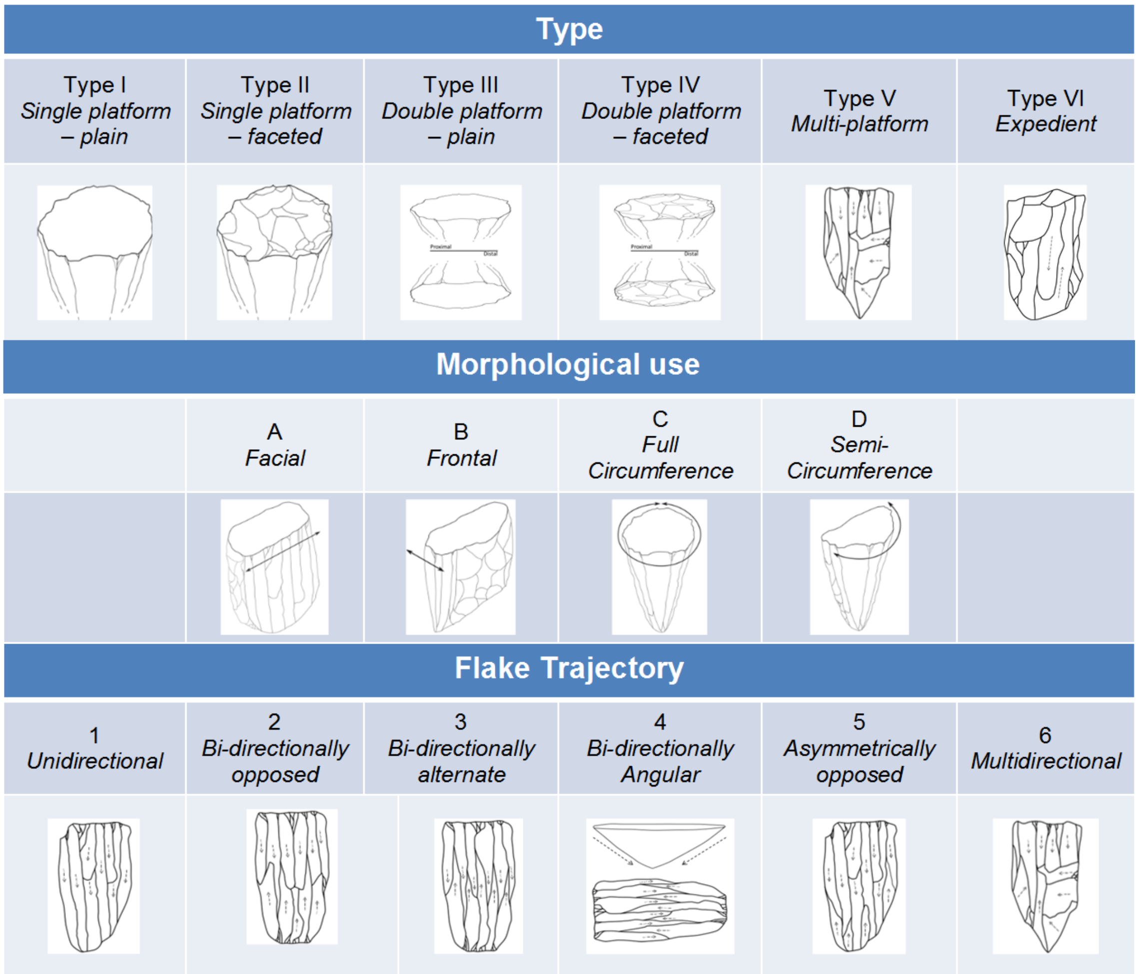

Figure 116. Core taxonomy

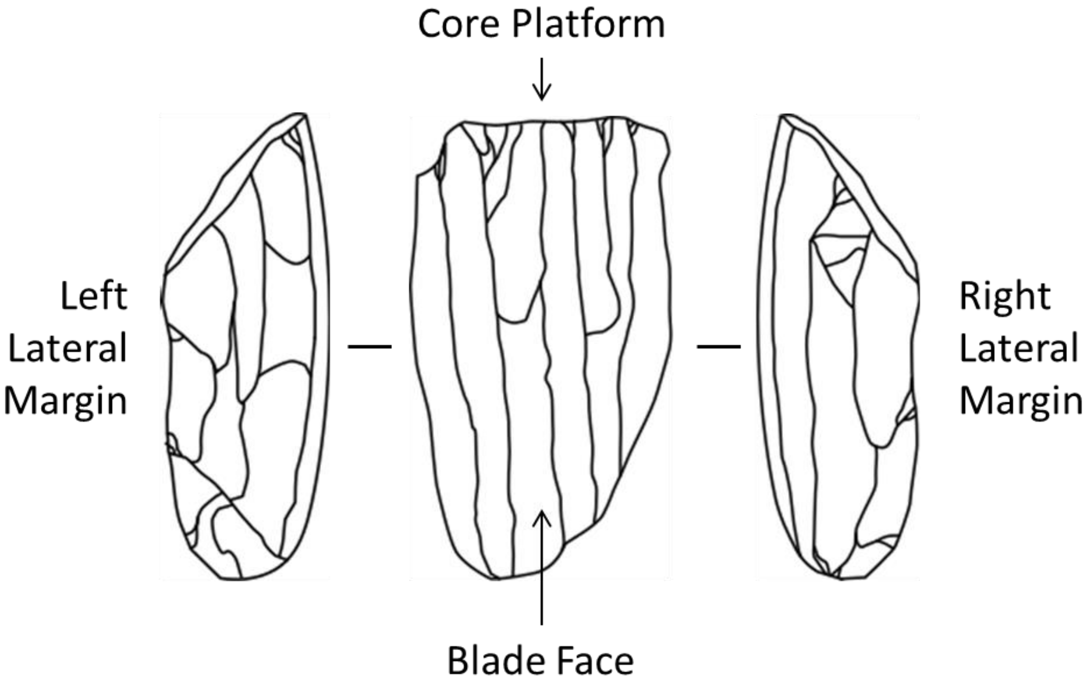

Figure 117. Illustration of the right and left lateral core margins

Statistical methods

A combination of bi-variate and multi-variate statistical analysis was used to compare the data from Clovis, Solutrean, and Magdalenian assemblages. It is important to note that statistical tests can only be used to infer patterning in the data. First the mean and standard deviations for each metric variable was calculated and compared. Metric analysis also included the calculation of range which is the difference between the highest and lowest measurement. The second stage of analysis consisted of assessing the distribution of the data and testing the normality of this distribution. Distribution normality was tested using two methods. The first method provides a basic description of the data fit by dividing the skewness (a measure of the asymmetry of the distribution) by the standard error (the measure of how much variance there is between samples) and by dividing the kurtosis (a measure of the extent to which observations cluster around a central point) by the standard error. Data that fits a normal distribution curve will generate results of less than +2 or -2 (i.e. between -1.99 and +1.99) (Hosfield, 2008). The second method for testing the normality of a distribution is the Shapiro-Wilk test (Shapiro & Wilk, 1965). Put simply, the test uses statistical significance by calculating a ρ-value. This test uses the following null (H_o) and alternate (H_a) hypothesis:

H_o: The population is normally distributed.

H_a: The population is not normally distributed.

The null hypothesis is rejected if the ρ-value is < 0.05. This was used to test the normality of the data before conducting further significance testing, as certain statistical tests require a normal distribution.

The first statistical significance test that was used was ANOVA (analysis of variables) (Shennan, 2004). This test requires normally distributed data and was used to determine if two populations (in this instance, technologies) were statistically significantly different. The hypotheses used for the ANOVA test is:

H_o: There is no statistically significant difference between the populations

H_a: There is a statistically significant difference between the populations

As this test calculates a ρ-value, the same rule applies as in the Shapiro-Wilk test; the null hypothesis is rejected if the ρ-value is < 0.05.

A second significance test was used when the data was not normally distributed following the results of the Shapiro-Wilk test. The Kruskal-Wallis is a nonparametric equivalent to the ANOVA test (Urdan, 2010). This test uses 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 difference. Conversely, the alternate hypothesis indicates statistically significant differences. The null hypothesis is rejected if the ρ-value is < 0.05.

The Tukey-Kramer HSD (Urdan, 2010) test was also used following ANOVA analysis. This test provides a method for identifying where statistical significance has come from following a test on 3 or more populations. Tukey-Kramer HSD compares each population with each other 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.

Chi-squared analysis following the Pearson method was also used on the data to test for a measure of association. This analysis indicates if an associated pattern is present in the data or if the data is derived from independent classifications (Shennan, 2004). Put simply, Chi-squared is a measure of association between two sets of data and analysis indicates whether there is a statistically significant pattern in the data. A significant result may indicate a relationship in the data. However this relationship is based solely on statistical analysis and like all tests outlined here, a statistical relationship does not imply a definite real-world relationship. The Chi-squared test calculates a ρ-value, and the null hypothesis is rejected at < 0.05. The hypotheses for chi-squared analysis are:

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 final statistical method used was multivariate cluster analysis. In this analysis, all the data from each group was compared in terms of distance from the mean, these distances are then paired to the group with the closest distance. Hierarchical cluster analyses create pairs between groups that share the most similarities. This paring is then continued until all technologies were grouped. The length of the lines also indicates the Euclidean distances between each group, essentially indicating the degree of similarity (Shennan, 2004).

Thus groups with similar variables cluster together while different groups form a separate cluster. Data was processed using Microsoft Excel® and SAS Institute Inc. JMP® Pro 10.0.0.

Qualitative Analysis

In terms of understanding a specific knapping technology, there is only so much information that can be understood from quantitative sampling. Many unique and individual characteristics, such as how errors were corrected and how a blade was struck from the core rely heavily on the observations of the researcher.

These observations (outlined below) were recorded for each assemblage, allowing for an overview of the culture to be established in terms of the technology and use of materials to create blades.

Core types

The taxonomy outlined it chapter 6 (*see* Figure 116) was used to compare core use in Clovis, Solutrean, and Magdalenian. Understanding the type of core used in terms of platform preparation, morphology and blade trajectory enabled the construction of a basic knapping sequence. This included how the core platform was used and how often preparation and maintenance of the core platform took place, as well as how the overall core was used for the production of blades and how many platforms were used.

Precore production and core preparation

The preparation of a core was identified in order to establish how a core was created and what initial steps of manufacture were undertaken. Initial shaping, the creating of a ridge, the working of the platform and core face and the maintenance and correction of errors were all important factors. This can be difficult to assess as the record often only reflects the discarded or abandoned cores, but the overall core morphology is retained which provides evidence for the use of the core. This morphology, along with the blades themselves can be used to understand precore production and shaping. For example, the presence of a cortical blade can be used to determine if the blade face was created first by the removal of a cortical ridge. Alternatively, a crested blade may indicate some form of precore ridge shaping. Methods of precore production and preparation were then compared between the assemblages.

Platform production and maintenance

The next step in the qualitative analysis was to assess how the platform was produced and maintained. While the core type addresses the differences between prepared and unprepared platforms, a complete analysis of flaking methods and trajectories was assessed and compared. Platform use is a good indicator of how the core was worked. The use of a single platform or opposed platforms indicates two different styles of core use, but if the scars are asymmetrically opposed (where scars from one platform travel up to and beyond the median point and opposite scars rarely if ever cross this line) then this may indicate the use of the second platform primarily as a method for maintenance and error corrections. Platform preparation may also indicate if the platform was specifically set up to facilitate multiple blade removals, or whether continual preparation was required for each new blade detachment.

Blade production

The most important aspect of blade technology is how the blades themselves were struck from a core. Specifically how similar blade production is in terms of sequencing and spacing. This section also assessed how individual blade platforms were treated. While much of the platform data was address in the quantitative assessment, platform preparation provided an indication as to the mode of production.

Core platform maintenance

As blade detachment removes mass from the core platform, it became necessary to maintain the core platform. This was dependent on the production of a platform and how blades were detached. Some core platforms may require constant preparation and maintenance in order to keep the surface viable for producing blades. Other techniques may require little platform maintenance. Methods of maintenance were assessed for similarities and differences in how the core platform was treated.

Core face maintenance

Errors during blade production needed to be corrected in order to keep the core viable for blade detachment. The methods used for correcting these errors along the core face were assessed and compared. Alongside this, the maintenance of the core face was also assessed for methods of keeping the core morphology viable for continued production. Core face maintenance is interlinked with core platform preparation and core type as different corrective strategies are advantageous depending on the core type. An assessment of core face maintenance was made using evidence from both the blades and cores. This was then compared between Clovis, older than Clovis, Solutrean, and Magdalenian assemblages.

Blades

The final step of the qualitative analysis was to assess the blades themselves in order to establish what blade forms were desired from the production sequence. Many quantitative components can be used to indicate the nature of the desired blades produced. However a study of the blades in terms of retouch and tool use (including some microwear analysis where possible) and evidence for backing, may indicate the type of tools desired by the flint knapper.

Wider contextual analysis

While the data was collected in order to specifically address the Clovis and Solutrean blade technologies and reduction process, the discussion section of this thesis deals with wider technologies associated with Clovis. Specifically, this focus is on the material from Beringia that has been proposed as the ancestor to Clovis. Comparisons between Clovis and the Beringian material were made based on the published technological data from the Beringian assemblages. This data consisted mainly of core types, in terms of the taxonomy of cores, as there is little detailed technological analysis.

Chapter 14

Results and Intra-assemblage analysis

This chapter presents the results of the data collection from each assemblage. This includes the division of the Solutrean into the Lower, Middle, and Upper assemblages based on the analysis of the site (Demars, 1995a; Bosselin & Djindjian, 1997; Delpech, 2012).

Clovis

A total of 242 provenienced specimens from undisturbed Clovis contexts were analysed. This consisted of 208 Clovis blades, recorded from 4 sites; 161 from the Gault site, 33 from Pavo Real, 11 from the Keven Davis cache, and a further 3 from Blackwater Draw. Alongside this, 34 blade cores were recorded, 31 from the Gault site and 3 from Pavo Real. A further 5 blade cores from Pavo Real were studied, but due to the lack of formal core preparation (early stage/roughout) they are not included in the statistical results and are discussed in chapter 19.

Clovis Blades

The average dimensions (length x width x thickness) of Clovis blades was 94.31 x 30.35 x 12.10 mm with a standard deviation (SD) of 25.63 x 11.04 x 5.90 mm. The average ratio for these blades was around 3:1 as expected from a blade technology. The longest blade recorded was 170.20 mm compared to 42.80 mm for the shortest blade with a range of 127.40 mm. The widest blade was 71 mm while the narrowest blade was 2 mm with a range of 69.40 mm. For thickness, the thickest blade was 49.50 mm compared to 2.30 mm for the thinnest blade with a range of 47.20 mm. Table 2 displays the descriptive statistics for the Clovis blades.

Of the 208 blades, 164 retained a recordable platform. The average dimensions (width x depth) of blade platforms was 9.93 x 4.29 mm (SD=4.64 x 3.21 mm). The widest platform was 26.10 mm and the narrowest was 2.70 mm with a range of 23.40 mm. The deepest platform was 23.90 mm and the shallowest was 1.29 mm with a range of 22.80 mm.

The calculation for the index of curvature can be found in the methodology chapter. Clovis blades had an average index of curvature of 9.30 (SD=3.34). The most heavily curved blade had an index of 17.33. For point of maximum curvature, the average was 60.00% (SD=9.81) with the highest score of 86.54 and a lowest score of 34.40 mm giving a range of 52.13.

Table 2. Clovis descriptive statistics

	Length	Width	Thickness	Platform Width	Platform Depth	Index of Curvature	Point of Maximum Curvature
Mean	94.31	30.35	12.10	9.93	4.29	9.30	60.00
Median	90.90	28.30	11.30	8.90	3.55	8.92	60.44
Standard Deviation	25.63	11.04	5.90	4.64	3.21	3.34	9.81
Standard Error	2.09	0.90	0.48	0.44	0.31	0.37	1.10
Skewness	0.45	1.22	2.47	1.06	3.32	0.34	-0.36
Kurtosis	-0.16	2.34	12.18	1.02	14.86	-0.57	0.48

The distribution data for Clovis blade length width and thickness is illustrated in Figure 118. These histograms, together with the Skewness and Kurtosis (Table 2) can be used to assess the normality of the data. Normality was assessed by dividing skewness (Skew) by standard error (SE), and by dividing kurtosis (K) by standard error (SE). The results of these calculations are listed in Table 3.

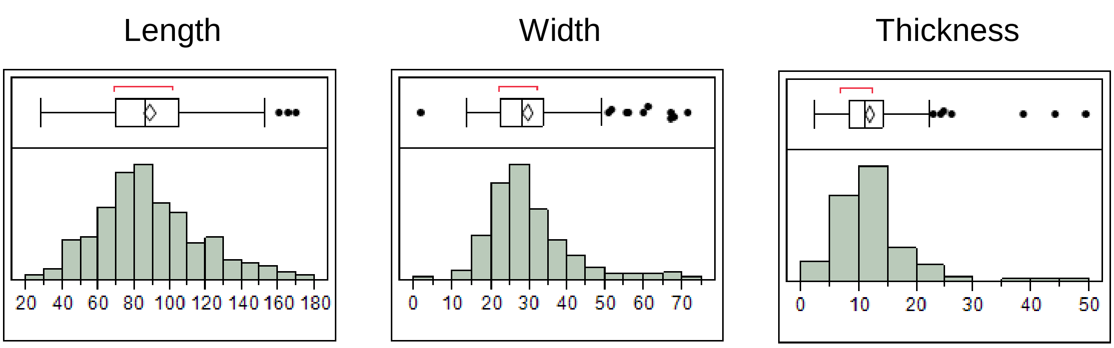

Figure 118. Histograms of Clovis blade length, width and thickness

Table 3. Normality tests for Clovis blade metrics

	Length	Width	Thickness	Platform Width	Platform Depth	Index of Curvature	Point of Maximum Curvature
Skew/SE	**0.22**	**1.36**	5.16	2.38	10.73	**0.90**	**-0.33**
K/SE	**-0.08**	2.60	25.37	2.29	48.08	**-1.53**	**0.44**
Red numbers indicate normal data distribution							

The results presented in Table 3 indicate that blade length, index of curvature, and point of maximum curvature are normally distributed. Blade width and thickness, and platform width and depth are not normally distributed. These data also indicate that those results that are not normally distributed are positively skewed and further, indicate that this is unlikely to be the result of "random chance" in the data.

In terms of the stage of production, 17 (8.2%) initial blades were recorded, compared to 141 (67.8%) manufacturing blades and 41 (19.7%) production specific blades. The remaining 24 (11.5%) were obscured by the build-up of calcium carbonate ($CaCO_3$) on the dorsal surface. Calcium carbonate is the mineralisation of calcium through the process of Ca ions reacting with C ions in water. These accumulate in small deposits on the flaked surface which obscures the artefact details. In terms of blade type, the most dominant was side blades with 76 (36.5%) examples while only 4 (1.9%) were cortical. The full breakdown of blade types is presented in Table 4. Only 5 (2.4%) were true blades. Associated with this, 75.5% (n=157) of blades had a single ridge on the dorsal surface, compared with 18.3% (n=38) with two ridges and a further 3 (1.4%) having 3 or more ridges, the remaining 10 (4.8%) were obscured by $CaCO_3$. The majority, 86.5%, of blades were parallel sided (n=180) while 6.3% (n=13) were expanding compared to 3.4% (n=7) converging.

Table 4. Clovis blade types

Blade Type	**N**	**%**
Centre	31	14.9
Corner	52	25.0
Cortical	4	1.9
Crested	13	6.2
Side	76	36.5
Tool	16	7.7
True	5	2.4
Unknown	11	5.3
Total	208	100

The blade platform descriptions are shown in Table 5. The most common type of platform was the complex category with 54 (26%). Furthermore, 30 (14.4%) platforms were plain, while 22 (10.65%) of platforms were crushed. Only 5 (2.4%) spurred platforms were identified in this sample.

Table 5. Clovis blade platform description

Description	**N**	**%**
Cortical	7	3.4
Crushed	22	10.6
Dihedral	18	8.7
Complex	54	26.0
Linear	11	5.3
Missing	46	22.1
Plain	30	14.4
Punctiform	11	5.3
Spur	5	2.4
Winged	4	1.9
Total	208	100

For specific platform preparation attributes, blades with missing platforms (n=46) were excluded from the percentage calculations as the lack of evidence does not reflect the absence of these techniques. The two most common techniques were platform isolation and platform grinding with 98 (60.5%) for both. This was closely followed by releasing with 97 (59.9%) examples in this sample. Faceting was identified on 86 (53.1%) specimens while reducing was less common with only 73 (45.1%) examples. The presence of grinding along the dorsal surface (*see* Bradley et al. 2010, p.66) was identified on 84 (51.9%) of specimens.

Platform preparation was compared across blade types and included plain blade platforms with no preparation. The most common combination of attributes found on centre (29.2%), crested (37.5%), and side (30%) blade types was the use of all five traits; faceted, reduced, released, isolated, and ground. Conversely, corner (27.9%) and cortical (66.6%) blades used no preparation at all. However, 21% of corner blades showed the use of all five traits. A count of the different types of combinations indicates that there was no standard way of preparing platforms. A total of 9 different combinations of these 5 traits were used on centre blades, compared to 14 different combinations used on corner blades. This supports the idea that blade platforms were prepared individually, as these traits were only used when appropriate for the preparation of that platform.

Distal termination was also recorded with feathered terminations being the most common at 46.3% (n=75). Hinge terminations occurred on 34 (21%) of the blades and 30 (18.5%) examples of a plunging terminations were recorded, a further 15 (9.3%) were snapped. The remaining 7 (4.9%) were too obscured by $CaCO_3$ to make any positive assessment.

Blade scars on the dorsal surface provide a proxy for understanding the platform preparation of the cores. The breakdown of the dorsal scar pattern is presented in Table 6. Unidirectional scars were the most common with 101 (62.3%) of specimens featuring this trait. A crossed pattern was identified on 23 (14.2%) of blades. Interestingly, 16 (9.9%) of blades had opposed scars while only 9 (5.6%) were asymmetrically opposed. Furthermore, 7 (3.4%) were classified as unidirectional hinge removal flakes (struck from the same platform as the original hinged blade) while only 2 (1%) examples of opposed hinge removals were identified.

Table 6. Clovis dorsal Scar pattern

Pattern	**N**	**%**
Unidirectional	101	62.3
Asymmetrically opposed	9	5.6
Opposed	16	9.9
Crossed	23	14.2
Multidirectional	6	3.7
Obscured	7	4.3
Total	162	100

Clovis Blade Cores

As outlined above, the majority of blade cores recorded were from excavated Clovis contexts at the Gault site (n=31) while a further 3 cores were recorded from Pavo Real. Out of the 34 Clovis blade cores, 30 (88.2%) were discarded due to the blade face becoming exhausted. A total of 17 (56.6%) of these cores were exhausted due to crushing and loss of a suitable core platform. There was also evidence of battering on 14 (41.2%) of the blade cores analysed.

In terms of core platform preparation, all cores analysed had prepared platforms. Type II cores were the dominant type with 31 (91.2%) with only 3 (8.8%) type IV cores. Type II A cores were further sub-divided by the flake scar patterns on the back of the core with the majority, 24 being flat backed (80%). Evidence for the creation of a crest was identified on 4 (13.3%) cores. These 4 cores retained a crest along both the back and one lateral margin creating an almost 90^0 angle. Only 2 (6.7%) cores retained a cortical back.

The lateral margin scar pattern on both sides of the Type II, facial cores was also recorded (Table 7). The most common scar pattern identified was unidirectional with 40 (58.8%) specimens. The unidirectional flaking was struck from the back of the core to the front in every example. The second most common dorsal type was the retention of cortex on one lateral margin, which occurred on 9 (13.2%) of the lateral margins. No examples of cores were recorded that retained cortex on both lateral margins.

Table 7. Clovis blade cores: lateral margin scar pattern

Lateral Scar pattern	**N**	**%**
Unidirectional	40	58.8
Bidirectional	3	4.4
Opposed	2	2.9
Asymmetrically Opposed	1	1.5
Crossed	2	2.9
Multidirectional	3	4.4
Cortex	9	13.2
CaCo3	8	11.8
Total	68*	100.0

*This total is double the number of cores analysed as each core has two lateral margins

Older than Clovis

Excavations at the Gault site have yielded evidence for a blade technology that is stratigraphically older than Clovis (OTC). The 8 blades and 3 cores excavated from these units were analysed. As discussed previously (*see* Chapter 8 and 13) there remains some uncertainty as to whether or not these blades are from an undisturbed older than Clovis stratigraphic layer at the Gault site. As such this data set remains preliminary.

OTC Blades

The average dimensions (length x width x thickness) of OTC blades was 101.30 x 36.17 x 17.13 mm with a standard deviation (SD) of 21.96 x 6.47 x 4.91 mm. The average ratio for these blades was around 2.8:1. The longest blade recorded was 129.40 mm compared to 69.30 mm for the shortest blade with a range of 60.09 mm. The widest blade was 46.10 mm while the narrowest blade was 26.20 mm with a range of 19.90 mm. The thickest blade was 21.30 mm compared to 7.80 mm for the thinnest blade with a range of 13.50 mm.

Of the 8 blades, only 1 blade was missing the striking platform. The average platform dimensions (width x depth) were 14.00 x 4.09 mm (SD=6.09 x 2.43 mm). The widest platform was 22.60 mm and the narrowest was 5.80 mm with a range of 16.80 mm. The deepest platform was 7.40 mm and the shallowest was 1.30 mm with a range of 6.10 mm.

Older than Clovis blades had an average index of curvature of 11.16 (SD = 4.00). The most heavily curved blade had an index of 14.34. For point of maximum curvature, the average was 65.04 mm (SD=4.10) with the highest score of 68.27 and a lowest score of 59.11 mm giving a range of 11.17. Table 8 lists the descriptive statistics for the OTC blades.

Table 8. Older than Clovis descriptive statistics

	Length	Width	Thickness	Platform Width	Platform Depth	Index of Curvature	Point of Maximum Curvature
Mean	101.30	36.17	17.13	14.00	4.09	11.16	65.04
Median	105.45	35.85	18.65	14.00	3.10	12.48	66.39
Standard Deviation	21.96	6.47	4.91	6.09	2.43	4.00	4.11
Standard Error	8.97	2.64	2.01	2.72	1.09	2.00	2.05
Skewness	-0.38	0.00	-1.76	0.15	0.47	-1.65	-1.59
Kurtosis	-0.75	1.62	3.36	1.09	-1.19	2.91	2.57

In terms of the stage of production, 1 (12.5%) initial blade was recorded, compared to 2 (25%) manufacturing blades and 8 (62.5%) production specific blades. In terms of blade type, the most dominant was corner blades with 4 (50%) pieces while the other 4 blades were equally divided between centre and true blades (table 8). A total of 37.5% (n=3) of blades had a single ridge on the dorsal surface, compared with 50% (n=4) with two ridges and a single blade (12.5%) having 3 ridges. Half, 50%, of blades were parallel sided (n=4) while the other half were expanding. Data normality tests were not conducted on the OTC assemblage due to the small sample size.

Table 9. Older than Clovis blade types

Blade Type	**N**	**%**
Centre	2	25
Corner	4	50
True	2	25
Total	208	100

The platform descriptions are shown in Table 10. The most common type of platform was the complex category with 3 (37.5%). Furthermore, 2 (25%) platforms were plain and 2 (25%) of platforms were crushed.

Table 10. Older than Clovis blade platform description

Description	**N**	**%**
Cortical	0	0
Crushed	2	25
Dihedral	0	0
Complex	3	37.5
Linear	0	0
Missing	1	12.5
Plain	2	25
Punctiform	0	0
Spur	0	0
Winged	0	0
Total	8	100

For specific platform preparation techniques, the one blade with a missing platform was excluded from the percentage calculations. The three most common techniques were platform faceting, isolation, and grinding with 4 (57.1%) for each. This was closely followed by reduction with 3 (42.9%) examples in this sample. Releasing occurred on 2 (28.6%) examples. The presence of grinding along the dorsal surface was identified on 2 (28.6%) specimens.

Due to the small sample size of the OTC blade assemblage, it is not possible to draw any clear patterns from the data concerning platform preparation by blade type. Only 1 corner blade and 1 true blade utilised all five traits. However, an equal number of corner and true blades exhibited no preparation.

Blade termination was also recorded with plunging terminations being the most common with 4 examples (50%). Snap terminations occurred on 2 (25%) blades and a further 2 (25%) examples of a plunging termination were recorded.

Blade scars on the dorsal surface provide a proxy for understanding the platform utilisation of the cores. Unidirectional scars were the most common with 6 (75%) of specimens featuring this trait. A crossed pattern was identified on 2 (25%) of blades. One blade in the OTC sample was a partially crested blade.

OTC Blade Cores

Three cores were excavated from contexts below Clovis at the Gault site. Out of the 3 Clovis blade cores analysed, only 1 core appeared to be exhausted from platform collapse and crushing. A further core was discarded due to the loss of striking angle.

In terms of core platform preparation, all cores analysed had prepared platforms. Two Type II cores were identified (66.6%) with only 1 (33.3%) type IV core. The Type II cores were flat-backed while the single Type IV core did feature both conical and wedge-shaped features, with about 75% of the core being utilised to remove blades while a remnant flake scar was retained across the back of the core.

The flake scar direction on both lateral margins of the wedge-shaped, facial cores was also recorded. The most common dorsal configuration identified was cortical with 3 (50%) specimens. The second most common scar pattern was the unidirectional flaking to the blade face from the core back, which occurred on 2 (33.3%) specimens. The third core retained flake scars from the initial platform, the back and blade face of the core, creating a multidirectional lateral scar pattern on the right lateral edge.

Solutrean

A total of 367 provenienced specimens from Solutrean contexts at Laugerie-Haute were analysed. The analysis of these blades was further broken down by chronological period, from the Lower (n=114), Middle (n=143) and Upper (n=110) Solutrean. Furthermore 1 Lower, 7 Middle and 4 Upper Solutrean blade cores were recorded. These formal subdivisions were retained for analysis due to the technological differences outlined in chapter 9.

Lower Solutrean Blades

The average dimensions (Table 11) of Lower Solutrean blades were 65.86 x 24.28 x 8.08 mm with a standard deviation (SD) of 14.45 x 7.07 x 3.00 mm. The average ratio for these blades was around 2.7:1. The longest blade recorded was 112.30 mm compared to 37.30 mm for the shortest blade with a range of 75.00 mm. The widest blade was 40.80 mm while the narrowest blade was 13.20 mm with a range of 27.60 mm. The thickest blade was 16.00 mm compared to 3.30 mm for the thinnest blade with a range of 12.70 mm.

Of the 114 blades, 94 retained a recordable platform. The average dimensions of blade platforms (Table 11) was 9.93 x 4.06 mm (SD=5.51 x 2.75 mm). The widest platform was 28.30 mm and the narrowest was 2.80 mm with a range of 25.50 mm. The deepest platform was 13.50 mm and the shallowest was 0.80 mm with a range of 12.70 mm.

Lower Solutrean blades had an average index of curvature (Table 11) of 8.03 (SD=2.17). The most heavily curved blade had an index of 11.64. For point of maximum curvature, the average was 62.48 mm (SD=8.75) with the highest score of 87.17 and a lowest score of 38.86 mm giving a range of 38.86.

Table 11. Lower Solutrean descriptive results

	Length	Width	Thickness	Platform Width	Platform Depth	Index of Curvature	Point of Maximum Curvature
Mean	65.86	24.28	8.08	9.93	4.06	8.03	62.48
Median	64.40	21.90	7.50	8.80	3.30	8.22	60.57
Standard Deviation	14.45	7.07	3.00	5.51	2.75	2.17	8.75
Standard Error	1.69	0.83	0.35	0.76	0.38	0.58	2.34
Skewness	0.59	0.30	0.45	1.75	1.92	-0.13	1.57
Kurtosis	0.68	-1.07	-0.54	3.39	3.38	-0.82	4.85

Figure 119 illustrates the data distributions for length, width, and thickness of the Lower Solutrean assemblage. Table 12 indicates that length, width, thickness, and index of curvature are normally distributed. Platform width and depth, as well as point of maximum curvature have non normal distributions. The results also indicate that platform width, depth, and point of maximum curvature are positively skewed.

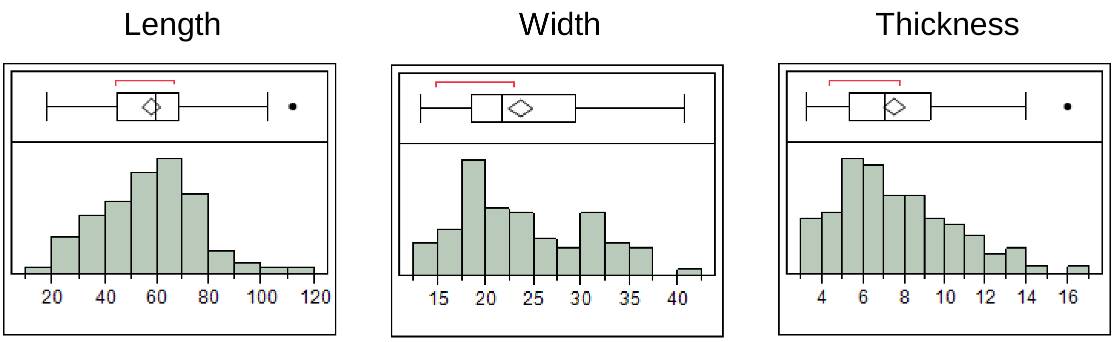

Figure 119. Histograms of Lower Solutrean blade length, width and thickness

Table 12. Normality tests for Lower Solutrean blade metrics

	Length	Width	Thickness	Platform Width	Platform Depth	Index of Curvature	Point of Maximum Curvature
Skew/SE	**0.35**	**0.36**	**1.28**	2.31	5.08	**-0.23**	**0.67**
K/SE	**0.40**	**-1.30**	**-1.52**	4.49	8.95	**-1.42**	2.07
							Red numbers indicate normal data distribution

In terms of the stage of production, 11 (9.6%) initial blades were recorded, compared to 40 (35.1%) manufacturing blades and 60 (55.3%) production specific blades. In terms of blade type, the most dominant was true blades with 43 (37.7%) pieces while only 1 (0.9%) were cortical (Table 13). Seven (6.1%) were corner blades. Associated with this, 51.7% (n=59) of blades had two ridges on the dorsal surface, compared with 44.7% (n=51) with only one ridge. A further 3 (2.6%) had 3 or more ridges. The majority, 84.2%, of blades were parallel sided (n=96) while 6.1% (n=7) were expanding compared to 9.6% (n=11) converging.

Table 13. Lower Solutrean blade types

Blade Type	**N**	**%**
Centre	16	14.0
Corner	7	6.1
Cortical	1	0.9
Crested	8	7.0
Side	39	34.2
Tool	0	0.0
True	43	37.7
Total	114	100.0

The platform descriptions are shown in Table 14. The most common type of platform was the plain category with 30 (26.3%). Furthermore, 23 (20.2%) platforms were complex while 18 (15.8%) platforms were crushed. Only 6 (5.3%) spurred platforms were identified in this sample.

Table 14. Lower Solutrean blade platform description

Description	**N**	**%**
Cortical	0	0.0
Crushed	18	15.8
Dihedral	6	5.3
Complex	23	20.2
Linear	6	5.3
Missing	20	17.5
Plain	30	26.3
Punctiform	5	4.4
Spur	6	5.3
Winged	0	0.0
Total	114	100.0

Blades with missing platforms were excluded from the percentage calculations for specific platform production techniques. The most common technique was platform grinding with 48 (51.1%) specimens. This was followed by reducing with 45 (47.9%) specimens. Faceting and isolation were identified on 35 (37.2%) specimens while reducing was less common with only 73

(45.1%) examples. The presence of grinding along the dorsal surface was identified on 6 (5.3%) of specimens.

The most common combination of platform preparation traits on centre blades (30.8%) during the Lower Solutrean was the use of all five traits; faceted, reduced, released, isolated, and ground. The use of all five traits was the second most common trait on corner (33.3%), side (27.2%), and true (28.2%) blades; however, the most common platform on these three types exhibited no preparation, with 50%, 48.5%, and 41% respectively. A count of the different combinations used on centre (n=7), side (n=7) and true (n=8) blades indicates that these traits were used when required and confirms the idea of individual blade platform preparation.

Blade termination was also recorded with feathered terminations being the most common at 40.4% (n=38). Snap terminations occurred on 37 (39.4%) of the blades analysed and 15 (16%) examples of a plunging terminations were recorded, a further 4 (4.3%) were hinged.

The breakdown of dorsal scar pattern is presented in Table 15. Unidirectional scars were the most common with 57 (60.6%) specimens featuring this trait. An opposed pattern was identified on 24 (25.5%) of the blades. Only 8 (8.5%) blades had a crossed pattern, while 3 (3.2%) blades had asymmetrically opposed scars. One unidirectional hinge removal flake and one opposed hinge removals were identified.

Table 15. Lower Solutrean blade Scar Pattern

Pattern	**N**	**%**
Unidirectional	57	60.6
Asymmetrically opposed	3	3.2
Opposed	24	25.5
Crossed	8	8.5
Multidirectional	0	0.0
Cortex	2	2.1
Total	94	100

Lower Solutrean Cores

As outlined above, one Lower Solutrean blade core was recorded from this assemblage. This core was a Type II core with a single, prepared platform. One face of the core was used for blade removals while the back was bi-laterally flat. Both lateral edges were flaked unidirectionally from the core back.

Middle Solutrean Blades

The descriptive statistics for the Middle Solutrean blades are listed in Table 16. The average dimensions (length x width x thickness) of Middle Solutrean blades was 62.23 x 23.74 x 8.56 mm (SD=15.29 x 7.56 x 3.74 mm). The average ratio for these blades was around 2.6:1. The longest blade recorded was 113.50 mm compared to 31.50 mm for the shortest blade with a range of 82.00 mm. The widest blade was 66.50 mm while the narrowest blade was 11.70 mm with a range of 54.80 mm. For thickness, the thickest blade was 18.60 mm compared to 2.20 mm for the thinnest blade with a range of 16.40 mm.

Of the 143 blades, 126 retained a recordable platform. The average dimensions of blade platforms was 10.52 x 4.32 mm (SD=4.38 x 2.17 mm). The widest platform was 23.40 mm and the narrowest was 3.20 mm with a range of 20.20 mm. The deepest platform was 11.40 mm and the shallowest was 1.60 mm with a range of 9.80 mm.

Middle Solutrean blades had an average index of curvature of 7.61 (SD=2.18). The most heavily curved blade had an index of 13.02. For point of maximum curvature, the average was 54.08 mm (SD=10.90) with the highest score of 73.69 and a lowest score of 36.91 mm giving a range of 36.78.

Table 16. Middle Solutrean descriptive statistics

	Length	Width	Thickness	Platform Width	Platform Depth	Index of Curvature	Point of Maximum Curvature
Mean	62.23	23.74	8.56	10.52	4.32	7.61	54.08
Median	60.50	22.20	7.80	10.05	3.55	7.37	51.85
Standard Deviation	15.29	7.56	3.74	4.38	2.17	2.18	10.90
Standard Error	1.72	0.85	0.42	0.60	0.30	0.42	2.10
Skewness	0.60	2.58	1.18	0.73	1.55	0.55	0.26
Kurtosis	0.56	12.43	0.73	0.52	2.63	0.99	-1.10

Distribution analysis (Figure 120) and normality testing of Middle Solutrean blade metric results indicate that length, platform width, and point of maximum curvature are normally distributed. The remaining variables; width, thickness, platform depth and index of curvature are not normally distributed.

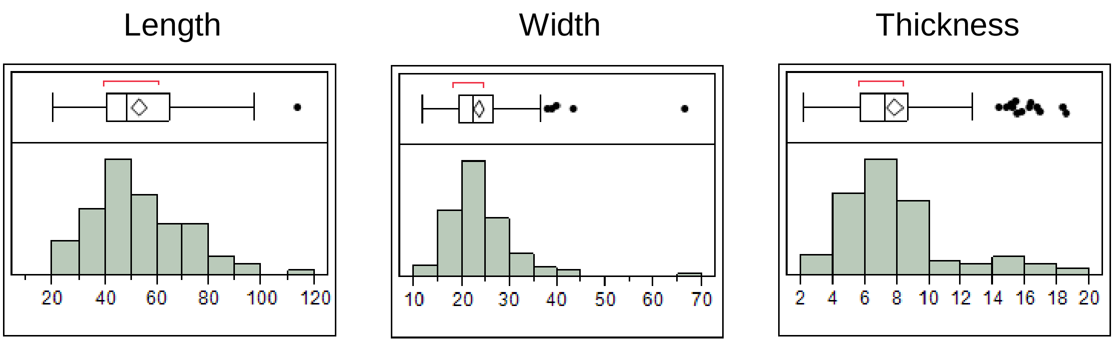

Figure 120. Histograms of Middle Solutrean blade length, width and thickness

Table 17. Normality tests for Middle Solutrean blade metrics

	Length	Width	Thickness	Platform Width	Platform Depth	Index of Curvature	Point of Maximum Curvature
Skew/SE	**0.35**	3.04	2.80	**1.22**	5.23	**1.30**	**0.12**
K/SE	**0.32**	14.61	**1.73**	**0.87**	8.89	2.36	**-0.52**
Red numbers indicate normal data distribution							

In terms of the stage of production, 8 (5.6%) initial blades were recorded, compared to 72 (50.3%) manufacturing blades and 63 (44.1%) production specific blades. In terms of blade type, the most dominant was true blades with

48 (33.6%) pieces while only 3 (2.1%) were cortical (Table 18). 45 (31.5%) were side blades compared to 24 (16.8%) corner blades. Associated with this, 55.2% (n=79) of blades had one ridge on the dorsal surface, compared with 41.3% (n=59) with two ridges. A further 3 (2.1%) had 3 or more ridges. The majority, 71.3%, of blades were parallel sided (n=102) while 16.1% (n=23) were expanding compared to 12.6% (n=18) converging.

Table 18. Middle Solutrean blade types

Blade Type	**N**	**%**
Centre	16	11.2
Corner	24	16.8
Cortical	3	2.1
Crested	7	4.9
Side	45	31.5
Tool	0	0.0
True	48	33.6
Total	143	100.0

The platform descriptions are shown in Table 19. The most common type of platform was the complex category with 43 (30.1%). Furthermore, 23 (16.1%) platforms were plain while 26 (18.2%) of platforms were crushed. Only 8 (5.6%) spurred platforms were identified in this sample.

Table 19. Middle Solutrean blade platform description

Description	**N**	**%**
Cortical	0	0.0
Crushed	26	18.2
Dihedral	8	5.6
Complex	43	30.1
Linear	10	7.0
Missing	17	11.9
Plain	23	16.1
Punctiform	2	1.4
Spur	8	5.6
Winged	6	4.2
Total	143	100

The most common technique was platform grinding with 89 (70.6%) specimens. This was followed by isolating with 78 (61.9%) examples. Releasing was identified on 77 (61.1%) of specimens. Faceting was less common with only 69 (54.8%) examples compared to reduction on 68 (54%). The presence of grinding along the dorsal surface was identified on 17 (11.8%) of specimens. Blades with missing platforms were excluded from the percentage calculations.

The use of all five platform traits (faceted, reduced, released, isolated, and ground) was the most common combination on centre (50%), side (42.5%), and true (46.5%) blades and the second most common trait on corner (30.4%) and crested (40%). The most common platform on corner (43.5%) and crested (60%) blades exhibited no preparation. Side blades exhibited the highest number of different platform combinations (n=9) along with true blades (n=9) with crested blades only exhibiting 2 different combinations. This indicates the platform preparation was a selective process and blade platforms were established on an individual basis.

Blade termination was also recorded with snap terminations being the most common at 45.2% (n=57). Feathered terminations occurred on 43 (34.1%) of the blades analysed and 20 (15.9%) examples of a plunging terminations were recorded, a further 6 (4.8%) were hinged.

The breakdown of dorsal scar pattern is presented in Table 20. Unidirectional scars were the most common with 101 (80.2%) specimens featuring this trait. A crossed pattern was identified on 9 (7.1%) blades. Only 7 (5.6%) blades had an opposed pattern, while 4 (3.2%) blades had asymmetrically opposed scars. Furthermore, 4 (2.8%) could be classified as unidirectional hinge removal while 3 (2%) examples of opposed hinge removals were identified.

Table 20. Middle Solutrean blade Scar pattern

Pattern	N	%
Unidirectional	101	80.2
Asymmetrically opposed	4	3.2
Opposed	7	5.6
Crossed	9	7.1
Multidirectional	3	2.4
Cortex	2	1.6
Total	126	100

Middle Solutrean Cores

All Middle Solutrean blade cores were discarded due to the blade face becoming exhausted. There was also evidence of battering on 2 (28.6%) of the blade cores analysed.

In terms of core platform preparation, all cores analysed had prepared platforms. Type II cores were the dominant type with 4 (57.1%) with 3 (42.9%) type IV cores. All cores were worked using one face of the core while 4 (57.1%) were flat backed compared to 2 (28.6%) crested and 1 (14.3%) cortical backed. The flat backed cores further sub-divided by the flake scar patterns on the back of the core with half bi-laterally flattened and the other half multi-directionally flat. Both crested cores were bifacially crested.

The most common scar pattern identified on the lateral edges was unidirectional with 11 (78.6%) specimens. The unidirectional flaking was struck from the back of the core to the front in every example. The second most common scar pattern was bidirectional flaking, which occurred on 2 (14.3%) of the lateral margins. One multidirectional lateral edge was identified.

Upper Solutrean Blades

The average dimensions of Upper Solutrean blades were 53.95 x 22.57 x 8.29 mm (SD=12.06 x 5.74 x 3.06 mm) (Table 21). The average ratio for these blades was around 2.4:1. The longest blade recorded was 78.50 mm compared to 24.00 mm for the shortest blade with a range of 54.50 mm. The widest blade was 38 mm while the narrowest blade was 12.10 mm with a range of 25.90 mm.

For thickness, the thickest blade was 17.60 mm compared to 1.90 mm for the thinnest blade with a range of 15.70 mm.

Of the 110 blades, 101 retained a recordable platform. The average dimensions (width x depth) of blade platforms was 10.92 x 4.60 mm (SD=4.59 x 2.43 mm) (Table 21). The widest platform was 21 mm and the narrowest was 4.50 mm with a range of 16.50 mm. The deepest platform was 11.50 mm and the shallowest was 1.00 mm with a range of 10.50 mm.

Upper Solutrean blades had an average index of curvature of 8.13 (SD=2.74) (Table 21). The most heavily curved blade had an index of 12.48. For point of maximum curvature, the average was 61.40 mm (SD=9.86) (table 20) with the highest score of 75.22 and a lowest score of 47.09 mm giving a range of 28.13

Table 21. Upper Solutrean descriptive statistics

	Length	Width	Thickness	Platform Width	Platform Depth	Index of Curvature	Point of Maximum Curvature
Mean	53.95	22.57	8.29	10.92	4.60	8.13	61.40
Median	53.65	21.95	7.80	10.45	4.10	7.71	62.69
Standard Deviation	12.06	5.74	3.06	4.59	2.43	2.74	9.86
Standard Error	1.78	0.85	0.45	0.74	0.39	1.12	4.03
Skewness	0.09	0.50	0.64	0.62	0.90	0.70	-0.17
Kurtosis	-0.20	-0.15	0.95	-0.22	0.58	-0.40	-0.15

Analysis of the distribution of the data (Figure 121) and normality tests (Table 22) demonstrate that length, width, platform width, index of curvature, and point of maximum curvature are normally distributed. Blade thickness and platform depth are not normally distributed and the results indicate that this is not the result of random choice.

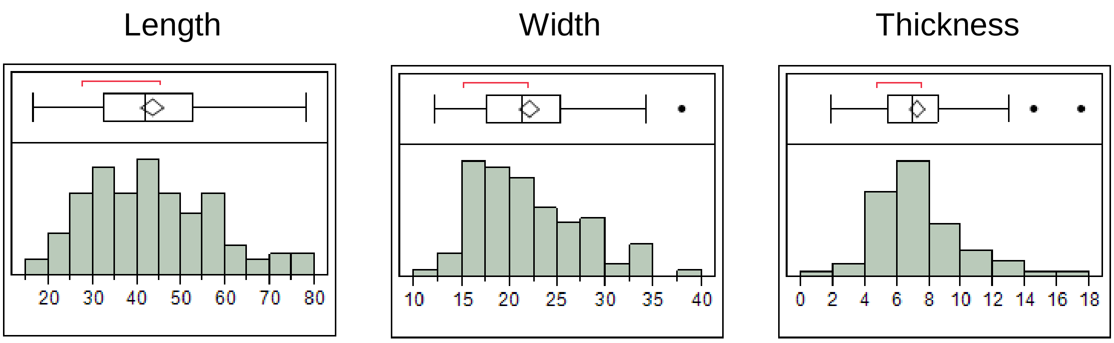

Figure 121. Histograms of Upper Solutrean blade length, width and thickness

Table 22. Normality tests for Upper Solutrean blade metrics

	Length	Width	Thickness	Platform Width	Platform Depth	Index of Curvature	Point of Maximum Curvature
Skew/SE	**0.05**	**0.59**	**1.43**	**0.83**	2.29	**0.63**	**-0.04**
K/SE	**-0.11**	**-0.18**	2.11	**-0.29**	**1.48**	**-0.35**	**-0.04**
Red numbers indicate normal data distribution							

In terms of the stage of production, 8 (7.3%) initial blades were recorded, compared to 67 (60.9%) manufacturing blades and 35 (31.8%) production specific blades. In terms of blade type, the most dominant was side blades with 48 (43.6%) pieces while only 3 (2.7%) were cortical (Table 23). Twenty-nine (26.4%) were true blades compared to 11 (10%) corner blades. Associated with this, 66.4% (n=73) of blades had one ridge on the dorsal surface, compared with 30.9% (n=34) with two ridges. A further 3 (2.7%) were cortical and so did not retain dorsal ridges. The majority, 72.7%, of blades were parallel sided (n=80) while 13.6% (n=15) with an equal number, 13.6% (n=15), converging.

Table 23. Upper Solutrean blade types

Blade Type	**N**	**%**
Centre	12	10.9
Corner	11	10.0
Cortical	3	2.7
Crested	6	5.5
Side	48	43.6
Tool	1	0.9
True	29	26.4
Total	110	100

The platform descriptions are shown in Table 24. The most common type of platform was the plain category with 21 (19.1%) closely followed by complex platforms with 19 (17.3%) examples. Furthermore, 20 (18.2%) platforms were linear while 17 (15.5%) of platforms were crushed. A total of 12 (10.9%) spurred platforms were identified in this sample.

Table 24. Upper Solutrean blade platform description

Description	**N**	**%**
Cortical	5	4.5
Crushed	17	15.5
Dihedral	4	3.6
Complex	19	17.3
Linear	20	18.2
Missing	9	8.2
Plain	21	19.1
Punctiform	2	1.8
Spur	12	10.9
Winged	1	0.9
Total	143	100

The most common technique was platform grinding with 72 (71.3%) specimens. This was followed by reducing with 70 (69.3%) specimens. Releasing was identified on 56 (55.4%) specimens. Both faceting and isolation were identified on 55 (54.5%) examples. The presence of grinding along the dorsal surface was identified on 12 (10.9%) specimens. Blades with missing platforms were excluded from the percentage calculations.

The most common combination of platform preparation traits on centre (77.7%), corner (72.7%), side (48%), and true (48.1%) blade types was the use of all five traits; faceted, reduced, released, isolated, and ground. Conversely, 75% of crested blades exhibited no platform preparation and the single cortical blade also exhibited no preparation. Side blades exhibited the highest number of trait combinations (n=6), followed by true blades with 5 different combinations with the rest having between 2 and 3 combinations. This may indicate that platforms were heavily prepared using all five traits in the Upper Solutrean.

Blade termination was also recorded with snap terminations being the most common at 52.7% (n=58). Feathered terminations occurred on 41 (37.3%) of the blades and 6 (5.5%) examples of a plunging terminations were recorded, a further 5 (4.5%) were hinged.

The breakdown of dorsal scar pattern is presented in Table 25. Unidirectional scars were the most common with 98 (89.1%) of specimens featuring this trait. A crossed pattern was identified on 6 (5.5%) of blades. Only 3 (2.7%) blades had an opposed pattern, while 2 (1.8%) blades had asymmetrically opposed scars. Furthermore, 2 (1.8%) could be classified as unidirectional hinge removal blades while 3 (2.7%) examples of opposed hinge removals were identified.

Table 25. Upper Solutrean blade Scar pattern

Pattern	**N**	**%**
Unidirectional	98	89.1
Asymmetrically opposed	2	1.8
Opposed	3	2.7
Crossed	6	5.5
Multidirectional	1	0.9
Cortex	0	0.0
Total	110	100

Upper Solutrean Cores

All 4 Upper Solutrean blade cores were discarded due to exhaustion. Two of the cores were discarded due to the loss of an appropriate angle between the platform and core face. There was also evidence of battering on 2 of the blade cores analysed.

In terms of core platform preparation, all cores analysed had prepared platforms. Type II cores were the dominant type with 3 (75%) and 1 (25%) type IV core. All cores were worked using one face of the core while 3 (75%) were flat backed compared to 1 (25%) crested. In contrast to other crested cores, the crest on this core was perpendicular to the blade face, in effect creating two flat surfaces that met at approximately 90^0. All flat backed cores were bi-laterally flattened. All cores were worked unifacially along the lateral edges from the flat back to the blade face.

Magdalenian

A total of 76 provenienced blades and 16 blade cores from Magdalenian contexts at Laugerie-Haute were analysed.

Magdalenian Blades

The average dimensions of the Magdalenian blades were 63.95 x 23.64 x 7.74 mm (SD=16.35 x 7.51 x 3.72 mm) (Table 26). The average ratio for these blades was around 2.7:1. The longest blade recorded was 118.10 mm compared to 33.20 mm for the shortest blade with a range of 84.90 mm. The widest blade was 38.20 mm while the narrowest blade was 8.90 mm with a range of 29.30 mm. For thickness, the thickest blade was 20 mm compared to 2.30 mm for the thinnest blade with a range of 17.70 mm.

Of the 76 blades, 66 retained a recordable platform. The average dimensions (width x depth) of blade platforms was 8.67 x 3.95 mm (SD=4.21 x 2.37 mm) (Table 26). The widest platform was 18.50 mm and the narrowest was 2.10 mm with a range of 16.40 mm. The deepest platform was 10 mm and the shallowest was 1.60 mm with a range of 8.40 mm.

Magdalenian blades had an average index of curvature of 6.99 (SD=2.57) (Table 26). The most heavily curved blade had an index of 11.23.

For point of maximum curvature, the average was 58.12 mm (SD=8.17) with the highest score of 70.97 and a lowest score of 45.68 mm giving a range of 25.28.

Table 26. Magdalenian descriptive statistics

	Length	Width	Thickness	Platform Width	Platform Depth	Index of Curvature	Point of Maximum Curvature
Mean	63.95	23.64	7.74	8.67	3.95	6.99	58.12
Median	63.90	24.30	7.50	7.50	3.05	5.85	59.83
Standard Deviation	16.35	7.51	3.72	4.21	2.37	2.57	8.17
Standard Error	2.49	1.14	0.57	0.76	0.43	0.77	2.46
Skewness	0.64	-0.09	1.19	1.00	1.37	0.82	0.04
Kurtosis	1.67	-0.35	1.84	0.40	1.14	-1.02	-0.88

Distribution analysis (Figure 122) and normality testing (Table 27) indicate that blade length, width, platform width, index of curvature and point of maximum curvature are normally distributed. Blade thickness and platform depth are not normally distributed and the data indicates that this is not random choice.

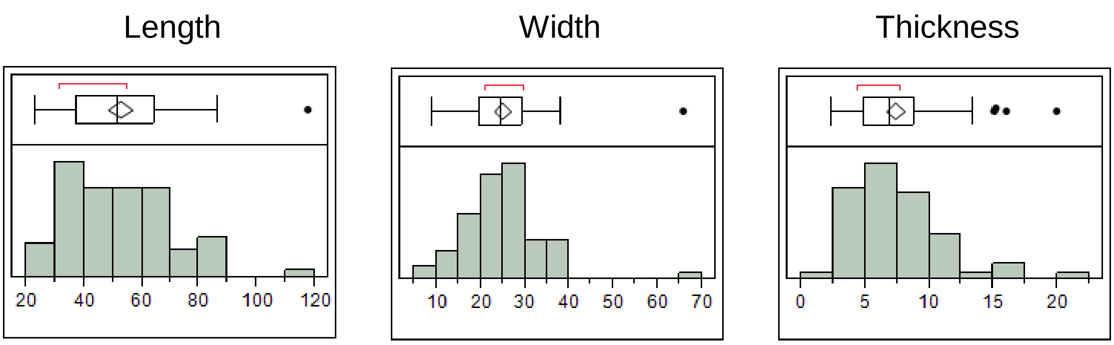

Figure 122. Histograms of Magdalenian blade length, width and thickness

Table 27. Normality tests for Magdalenian blade metrics

	Length	Width	Thickness	Platform Width	Platform Depth	Index of Curvature	Point of Maximum Curvature
Skew/SE	**0.26**	**-0.08**	2.10	**1.32**	3.16	**1.07**	**0.02**
K/SE	**0.67**	**-0.31**	3.25	**0.52**	2.64	**-1.32**	**-0.36**
Red numbers indicate normal data distribution							

In terms of the stage of production, 8 (10.6%) initial blades were recorded, compared to 42 (55.3%) manufacturing blades and 26 (34.2%) production specific blades. In terms of blade type, the most dominant was side blades with 29 (38.2%) pieces while only 3 (3.9%) were cortical (Table 28). Interestingly 10 (13.2%) were corner blades. Associated with this, 63.2% (n=48) of blades had one ridge on the dorsal surface, compared with 34.2% (n=26) with two ridges. A further 2 (2.6%) were cortical. The majority, 81.6%, of blades were parallel sided (n=62) while 15.8% (n=12) were expanding compared to 2.6% (n=2) converging.

Table 28. Magdalenian blade types

Blade Type	**N**	**%**
Centre	8	10.5
Corner	10	13.2
Cortical	3	3.9
Crested	3	3.9
Side	29	38.2
Tool	1	1.3
True	22	28.9
Total	76	100

The platform descriptions are shown in Table 29. The most common type of platform was the spur category with 17 (22.4%). Furthermore, 16 (21.1%) platforms were plain while 13 (17.1%) of platforms were crushed. Only 6 (7.9%) complex platforms were identified in this sample.

Table 29. Magdalenian blade platform description

Description	**N**	**%**
Cortical	1	1.3
Crushed	13	17.1
Dihedral	5	6.6
Complex	6	7.9
Linear	6	7.9
Missing	10	13.2
Plain	16	21.1
Punctiform	2	2.6
Spur	17	22.4
Winged	0	0.0
Total	76	100.0

Blades with missing platforms were excluded from the percentage calculations for specific platform production techniques. The most common technique was platform reduction with 32 (48.5%) specimens. This was followed by faceting with 28 (42.4%) examples in this sample. Isolation and releasing were identified on 27 (40.9%) specimens while grinding was less common with only 17 (25.8%) examples. The presence of grinding along the dorsal surface was identified on 3 (3.9%) specimens.

Analysis of the platform preparation types by blade types, including plain platforms indicates that it was more common to leave platforms plain across all blade types. Corner blades exhibit either no preparation (25%) or reduction (25%) as the two most common forms of preparation, while with true blades, 28.6% of platforms were plain compared to 23.8% of platforms that were reduced. A count of the different combinations of platform preparation on centre (n=4), corner (n=6), cortical (n=2), crested (n=2), side (n=8), and true (n=7) blades indicates that while no preparation was common, platforms were prepared on an individual basis when required.

Blade termination was also recorded with snap terminations being the most common at 50% (n=33). Feathered terminations occurred on 20 (30.3%) of the blades analysed and 13 (19.7%) examples of plunging terminations were recorded.

The breakdown of dorsal scar pattern is presented in Table 30. Unidirectional scars were the most common with 59 (89.4%) specimens featuring this trait. An opposed pattern was identified on just 1 (1.5%) blade. Only 6 (9.1%) blades had a crossed pattern. One unidirectional hinge removal flake and one opposed hinge removals were identified.

Table 30. Magdalenian blade Scar pattern

Pattern	**N**	**%**
Unidirectional	59	89.4
Opposed	1	1.5
Crossed	6	9.1
Total	94	100

Magdalenian Cores

All Magdalenian blade cores (n=13) were discarded due to the blade face becoming exhausted.

In terms of core platform use, the majority of cores analysed had plain platforms with 81.3% (n=13). Type I cores were the dominant type with 11 (68.75%) while 2 (12.5%) type II cores were recorded with a further 2 Type III cores. All cores were worked from one frontal edge of the core with 8 (50%) had crested backs compared to 7 (43.8%) cortical and 1 small bladelet core with blade flakes around the entire circumference creating a keeled core.

The most common scar pattern identified on the lateral edges was unidirectional with 28 (87.5%) specimens. The unidirectional flaking was struck from the plain platform of the core to the opposite edge forming a keel in every example. The second most common scar pattern was crossed flaking, which occurred on 3 (9.4%) of the lateral margins. One cortical lateral edge was identified.

Chapter 15

Inter-assemblage analysis: Quantitative Analysis

This chapter examines similarities and differences that exist between the individual cultural assemblages, including separating the Solutrean into its Lower, Middle and Upper constituents. The use of these categories allowed for the identification of both general and specific relationships.

Cross Cultural Comparisons

Blade Size and Shape

The OTC blades had the largest mean length, width and thickness measurements (Table 31); however, the single largest blade was found in the Clovis assemblage, measuring 170.20 mm. On average, Clovis and OTC blades were larger than blades from Solutrean and Magdalenian assemblages. Clovis blades had the greatest range in measurements of length, from 42.80 mm – 170.20 mm (Table 32). Additionally, Clovis blades had the greatest width to length ratio, at 3.1:1.

Shape, as it relates to the proportions of blades, can be calculated in two steps. The first calculation involves combining the measurements for average length, width and thickness for each culture, providing a very rough indication of mass. OTC blades had the highest average score at 154.60, followed by Clovis at 136.76 with the Upper Solutrean having the lowest score of 84.80 (Table 31). Scores from the four assemblages from France were all similar (Table 31); this is best exemplified in Figure 123 and by calculating the range between all assemblages which indicates a range of 16.33.

For the second calculation, the average length, width and thickness calculations were each divided into the sum from the first calculation, indicating which attribute had the greatest influence on the overall shape of the blade. Thus, shape can be inferred from the contribution each measurement had on the overall dimensions, regardless of individual size.

For example, length contributes 0.68 of its size to Clovis blades, while width contributes 0.23 and thickness 0.09. From all six cultures, the proportions of length, width, and thickness were very close, with a range across all assemblages of 0.09, 0.08, and 0.02 respectively (Table 31).

Table 31. Mean average blade metrics and ratios

	Length (l) (mm)	Width (w) (mm)	Thickness (t) (mm)	w-l ratio	l+w+t	l/(l+w+t)	w/(l+w+t)	t/(l+w+t)
Clovis	94.31	30.35	12.10	3.11	136.76	0.69	0.22	0.09
OTC	101.30	36.17	17.13	2.80	154.60	0.66	0.23	0.11
Lower Solutrean	65.86	24.28	8.08	2.71	98.22	0.67	0.25	0.08
Middle Solutrean	62.23	23.74	8.56	2.62	94.52	0.66	0.25	0.09
Upper Solutrean	53.95	22.57	8.29	2.39	84.80	0.64	0.27	0.10
Magdalenian	63.95	23.64	7.74	2.71	95.33	0.67	0.25	0.08

Table 32. Comparisons of mean average length

Length	Clovis (mm)	OTC (mm)	Lower Solutrean (mm)	Middle Solutrean (mm)	Upper Solutrean (mm)	Magdalenian (mm)
Max	170.20	129.40	112.30	113.50	78.50	118.10
Min	42.80	69.30	37.30	31.50	24.00	33.20
Range	127.40	60.10	75.00	82.00	54.50	84.90

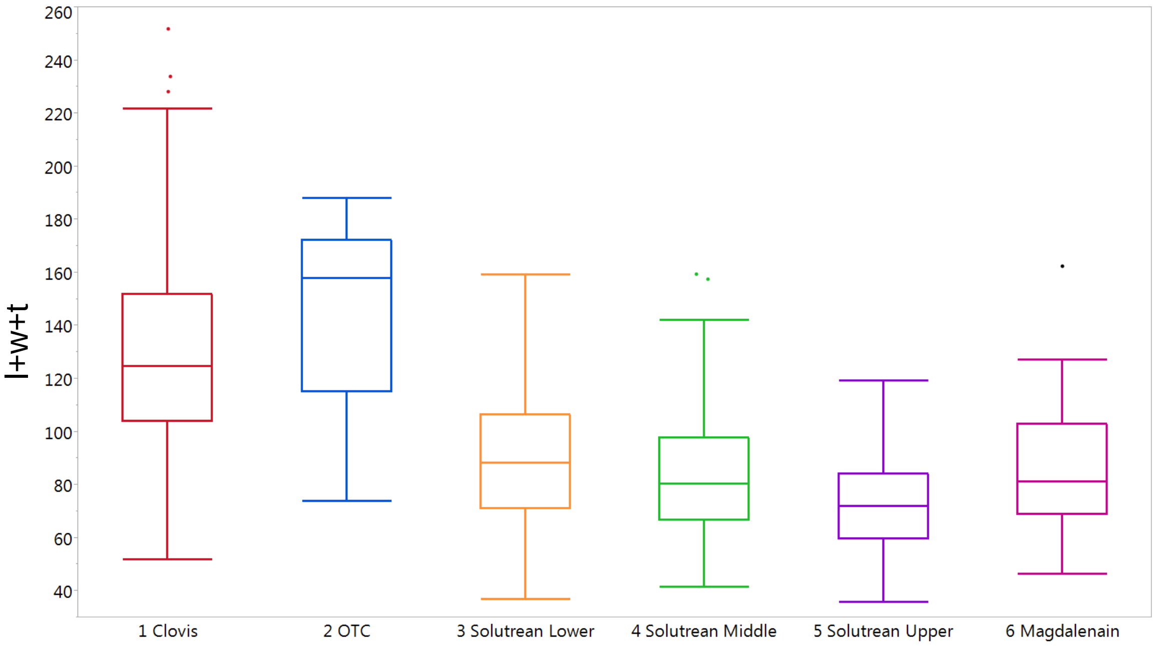

Figure 123. Box plots of l+w+t measurements for all assemblages

Significance testing was conducted on this data. The previous chapter outlined the normality tests on the data which demonstrated that not all variables were normally distributed. A further analysis of all of the metric data used in Table 31 was conducted using the Shapiro-Wilk test as presented in the methodology.

The results of the Shapiro-Wilk (w) test are reported in Table 33. All variables had a ρ-value of < 0.05, therefore the null hypothesis is rejected and the alternate hypothesis, the population is not normally distributed is accepted. Due to this result, nonparametric testing was used to test for statistical significance between assemblages.

Table 33. Shapiro-Wilk test for normal distribution

	Statistic (w)	**Significance (ρ-value)**
Length	0.94	< 0.0001
Width	0.89	< 0.0001
Thickness	0.82	< 0.0001
W:l ratio	0.41	< 0.0001
l+w+t	0.93	< 0.0001
l/(l+w+t)	0.98	< 0.0001
w/(l+w+t)	0.96	< 0.0001
t/(l+w+t)	0.97	< 0.0001

Kruskal-Wallis was used to identify if the metric attributes listed in Table 31 were statistically significantly different between assemblages. The results of the Kruskal-Wallis test are listed in Table 34. In this instance all 8 attributes have a ρ-value of < 0.05 therefore the null hypothesis is rejected, there is a statistically significant difference.

Table 34. Kruskal-Wallis Test for significance between assemblages

	Statistic	**DF**	**Sig (ρ-value)**
Length	270.54	5	< 0.0001
Width	89.10	5	< 0.0001
Thickness	138.34	5	< 0.0001
W:l ratio	132.34	5	< 0.0001
l+w+t	251.79	5	< 0.0001
l/(l+w+t)	117.21	5	< 0.0001
w/(l+w+t)	132.44	5	< 0.0001
t/(l+w+t)	26.83	5	< 0.0001

The results of the Kruskal-Wallis test can be used to infer that the blade metrics are not derived from the same population. The differences in these metrics however, do not necessarily indicate a difference in the technology. Availability, size and quality of raw material may all effect blade metrics. Subsequent use of blades as tools may also obscure their original lengths. A clue to the use of blade blanks as tools can be found in the Solutrean data. The histogram illustrated in Figure 124 indicates that there are 3 outliers above 100mm. It is possible that longer blades were selected for use as a tool which has skewed this data. This interpretation would require testing which is beyond the scope of this thesis.

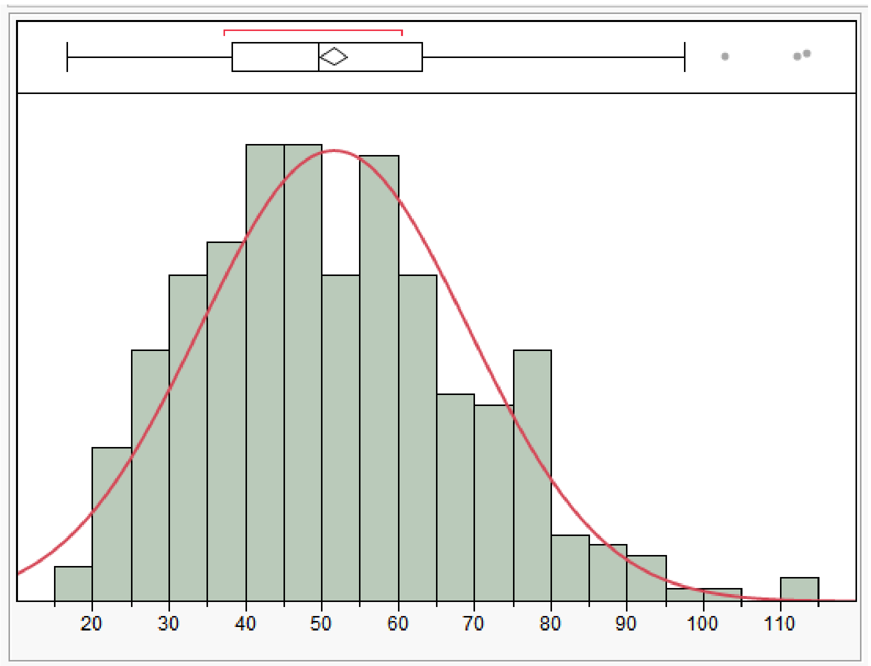

Figure 124. Histogram of Solutrean blade length (X axis is count)

Platform Width and Depth

The OTC sample contained the widest platforms on average, followed by the Middle and Upper Solutrean (Table 35). The range of depths between each culture was only 0.65 mm, indicating that all blades were struck in the same manner. The widest individual platform (Table 36) was identified in the Lower Solutrean (28.30 mm), which also had the greatest range (25.50 mm). Conversely, Clovis contained the deepest platform (23.90 mm) and had the greatest range (22.80 mm).

Table 35. Platform dimensions

	Width (mm)	Depth (mm)
Clovis	9.93	4.29
OTC	14.00	4.09
Lower Solutrean	9.93	4.06
Middle Solutrean	10.52	4.32
Upper Solutrean	10.92	4.60
Magdalenian	8.67	3.95

Table 36. Comparison of platform dimensions

	Width			Depth		
	Maximum	**Minimum**	**Range**	**Maximum**	**Minimum**	**Range**
Clovis	26.10	2.70	23.40	23.90	1.10	22.80
OTC	26.60	5.80	20.80	7.40	1.30	6.10
Lower Solutrean	28.30	2.80	25.50	13.50	0.80	12.70
Middle Solutrean	24.90	3.20	21.70	13.90	1.50	12.40
Upper Solutrean	21.00	2.60	18.40	11.50	1.00	10.50
Magdalenian	18.50	2.10	16.40	10.00	1.20	8.80

The Shapiro-Wilk test was used on the platform metrics (Table 35). The results indicated that neither platform width (w = 0.94, ρ = <0.05) nor the platform depth (w = 0.80, ρ = <0.05) were normally distributed following the Shapiro-Wilk hypothesis above. Thus, nonparametric significance testing was used. Table 37 presents the Kruskal-Wallis significance test for platform length and width between assemblages. In both cases the ρ-value is > 0.05 therefore the null hypothesis is accepted, there is no statistically significant difference.

Table 37. Kruskal-Wallis Test for significance between assemblages

	Statistic	DF	Sig (ρ-value)
Platform width	10.02	5	0.07
Platform depth	6.58	5	0.25

These results indicate statistical similarities between the platform sizes across all assemblages. From this it is possible to infer similarities in platform production that produced similar sizes. This is confirmed in the analysis of platform preparation combinations which shows that across all three Solutrean assemblages and Clovis, the most common platform trait combination was to use all five traits; faceted, reduced, released, isolated, and ground.

Index of Curvature

The index of curvature provides an expression of an arc and indicates how heavily curved a blade is. On average, the most heavily curved population of blades were found in the OTC sample, with both the highest index of curvature value (11.16) and the highest point of maximum curvature value (65.04) (Table 38 & Table 39). The highest index of curvature from an individual artefact (Table 38) came from the Clovis sample (17.46) while the Lower Solutrean had the highest point of maximum curvature (87.27). Clovis had the greatest range of both the index of curvature (14.15) and the point of maximum curvature (52.13) (Table 38 & Table 39).

Point of maximum curvature (Table 39) is useful in understanding where the curve occurs along the length of the blade, specifically if it is close to the proximal, distal or medial location

Table 38. Mean, SD, maximum, minimum and range for index of curvature data from all assemblages

	Mean index of Curvature	Standard deviations	Maximum	Minimum	Range
Clovis	9.30	3.32	17.46	3.30	14.15
OTC	11.16	4.97	14.34	3.17	11.17
Lower Solutrean	8.03	2.17	11.64	4.50	7.14
Middle Solutrean	7.61	2.17	13.02	3.47	9.55
Upper Solutrean	8.13	2.74	12.48	5.20	7.28
Magdalenian	6.99	2.57	11.23	4.22	7.02

Table 39. Mean, SD, maximum, minimum and range for point of maximum curvature comparison

	Point of maximum curvature (%)	Standard deviations	Maximum	Minimum	Range
Clovis	60.00	10.05	86.54	34.40	52.13
OTC	65.04	3.63	68.27	59.11	9.16
Lower Solutrean	62.48	8.75	87.17	48.31	38.86
Middle Solutrean	54.08	11.08	73.69	33.65	40.04
Upper Solutrean	61.40	9.86	75.22	47.09	28.13
Magdalenian	58.12	8.17	70.97	45.68	25.28

The Shapiro-Wilk test of normality indicated that the index of curvature was not normally distributed ($w = 0.97$, $\rho = <0.05$) while the point of maximum curvature was normally distributed ($w = 0.98$, $\rho = <0.13$). This significance testing was conducted on the index of curvature using the Kruskal-Wallis test and ANOVA was used to test point of maximum curvature.

The Kruskal-Wallis (X^2) test for index of curvature indicates no statistical significance ($X^2 = 9.67$, $\rho = 0.08$). This result indicates that while Clovis has traditionally been viewed as producing heavily curved blades (Collins, 1999; Bradley et al., 2010) the data does not indicate that this is a unique trait to Clovis. Further examination of this data indicates the possibility that this is the result of statistical inference and not necessarily reflective of a real world significance. Figure 125 highlights the greater range present in the Clovis assemblage as well as the higher mean. This would indicate that Clovis knappers favoured more curved blades. Thus while curved blades are not unique to Clovis, the degree of curvature produced likely had some significance.

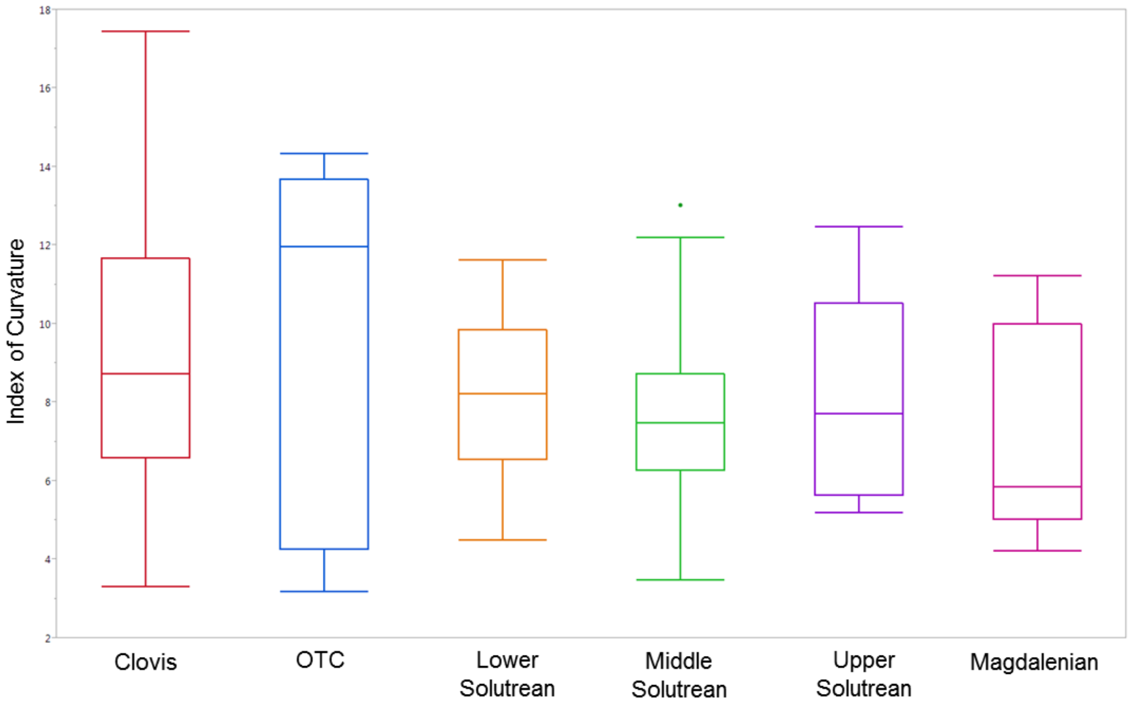

Figure 125. Box plots of the index of curvature for all assemblages

ANOVA analysis of point of maximum curvature indicated statistically significant differences *(F (5,156) = 2.74, p = 0.021)* between these assemblages. Further testing using Tukey-Kramer HSD indicates that this statistical significance comes from the Middle Solutrean period (ρ = 0.04). The mean point of maximum curvature for the Middle Solutrean is 54.08mm (Table 38). The point of maximum curvature for the remaining 5 assemblages excluding the Middle Solutrean does not show any statistically significant difference *(F (4,126) = 0.88, p = 0.48)*. Figure 126 highlights the difference between the Middle Solutrean and highlights the relatively small distribution of the point of maximum curvature on Clovis blades.

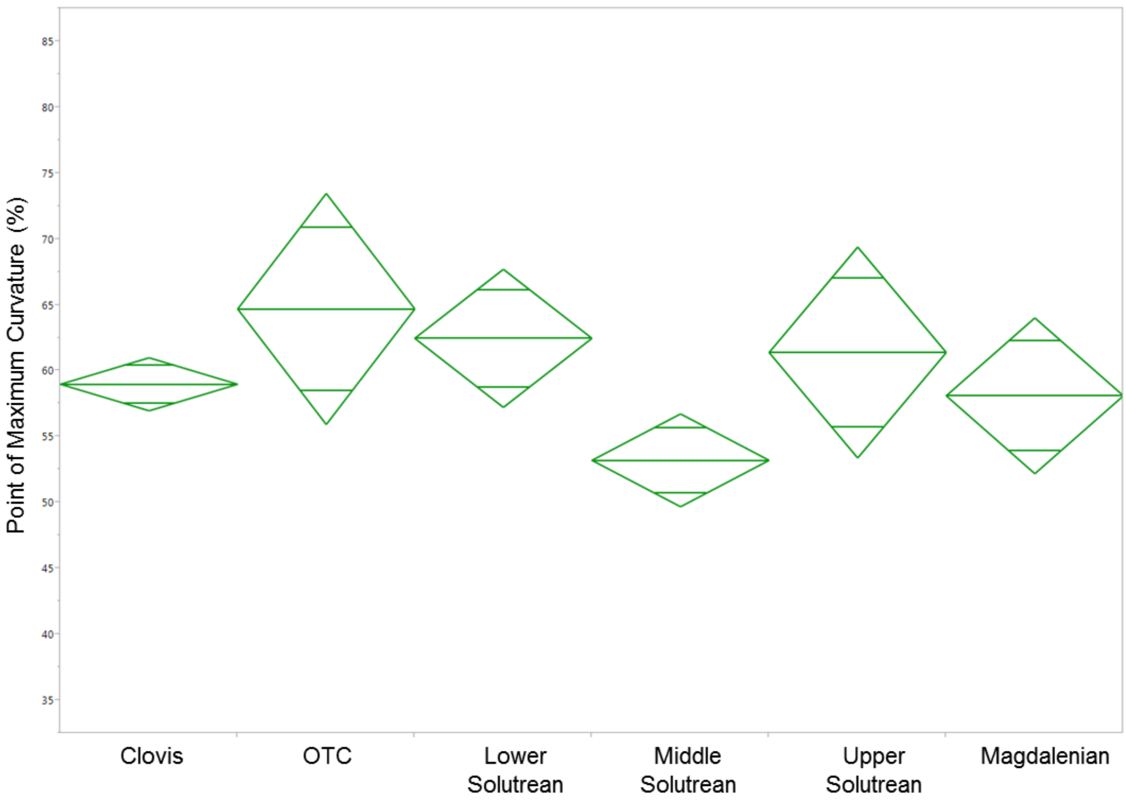

Figure 126. Anova plot showing means and 95% confidence intervals for the point of maximum curvature (%) for all assemblages

These measurements can be reconstructed and overlain for comparative purposes (Figure 127). This visualisation demonstrates the similarities between the index of curvature and the point of maximum curvature. Figure 128 demonstrates the greater lengths and heavier curves present in both Clovis and OTC technologies when the average lengths are applied to the curvatures of each industry.

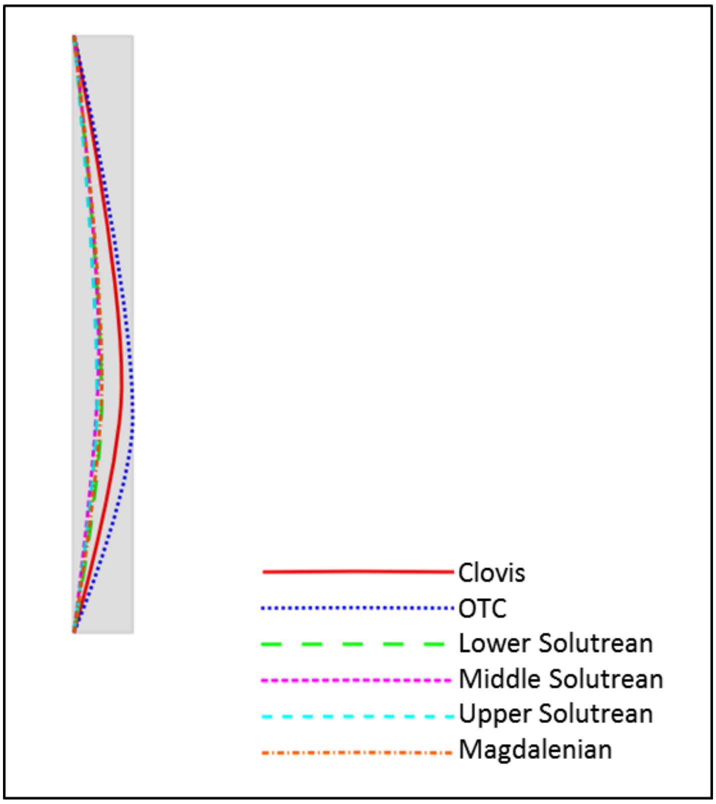

Figure 127. Average blade curvature

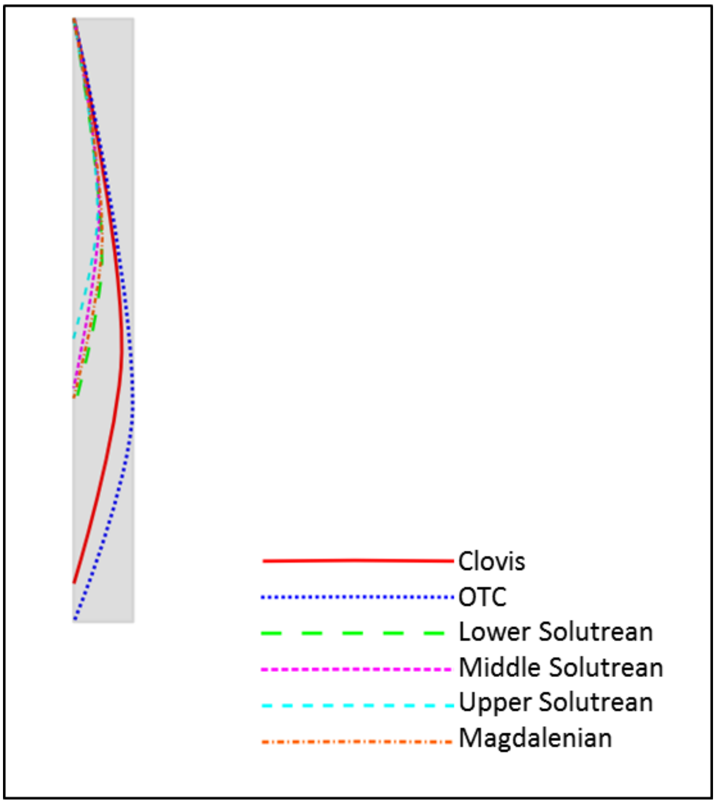

Figure 128. Curvature with average length

Figure 127 and Figure 128 demonstrate the broad similarities in the blade produced in all 6 assemblages as confirmed by the statistical significance testing above.

From this analysis, the size and shape of blades produced does appear to vary between the blades in North America and in France as demonstrated statistically. It is important to place this data in the context of the technologies. As briefly mentioned above, during the Solutrean, emphasis was placed on producing blade blanks for reshaping into projectile points. Heavy curvature would have had a negative effect on producing these points. In this respect, the lengths recorded in this study may have been affected by the selection of longer blanks for point production. The evidence for this comes from the maximum lengths of blades recorded from all three periods of the Solutrean, which are all greater than 100mm, yet the average lengths are around 50mm. Blades above 50mm may have been selected as blanks for the production of *pointes a face plan* as highlighted in Figure 124.

Blade Type

Blade type can provide an indication as to how the blade detachment affected the morphology of the core as well as what, if any, technological purpose it served. A technology with a high degree of true blades is likely to be more systematic; while, a technology that uses more corner, side and crested blades is likely less so (Table 40). When each blade type is counted and then converted into a percent of the total assemblage, marked similarities in types of blades between assemblages become apparent (Figure 129).

Chi-squared (X^2) was used to investigate the probability of a relationship between the European assemblages. The results indicate no statistically significant relationship between these assemblages; $X^2(18, N = 442) = 18.70$, $\rho = 0.41$. Chi-squared analysis was then used to compare all 6 assemblages. The results indicate a statistically significant relationship between all assemblages $X^2(30, N = 631) = 99.79$, $\rho = < 0.05$. Further investigation of this significance indicates that this statistically significant relationship is between Clovis and the three Solutrean assemblage $X^2(6, N = 547) = 73.00$, $\rho = < 0.05$, while there is no statistically significant relationship between the Magdalenian and Clovis or the three Solutrean periods.

The Clovis blade assemblages contained a higher percentage (25%) of corner blades. Due to the small sample size for the OTC blade assemblage it is likely that the entire blade reduction sequence is not represented. Clovis had the lowest percentage of true blades (2.4%)

Table 40. Blade type

	Clovis N (%)	OTC N (%)	Lower Solutrean N (%)	Middle Solutrean N (%)	Upper Solutrean N (%)	Magdalenian N (%)
Centre	31 (14.9)	2 (25)	16 (14)	16 (11.2)	12 (10.9)	8 (10.5)
Corner	52 (25)	4 (50)	7 (6.1)	24 (16.8)	11 (10)	10 (13.2)
Cortical	4 (1.9)	0 (0)	1 (0.9)	3 (2.1)	3 (2.7)	3 (3.9)
Crested	13 (6.3)	0 (0)	8 (7)	7 (4.9)	6 (5.5)	3 (3.9)
Side	76 (36.5)	0 (0)	39 (34.2)	45 (31.5)	48 (43.6)	29 (38.2)
Tool	16 (7.7)	0 (0)	0 (0)	0 ()	1 (0.9)	1 (1.3)
True	5 (2.4)	2 (25)	43 (37.7)	48 (33.6)	29 (26.4)	22 (28.9)

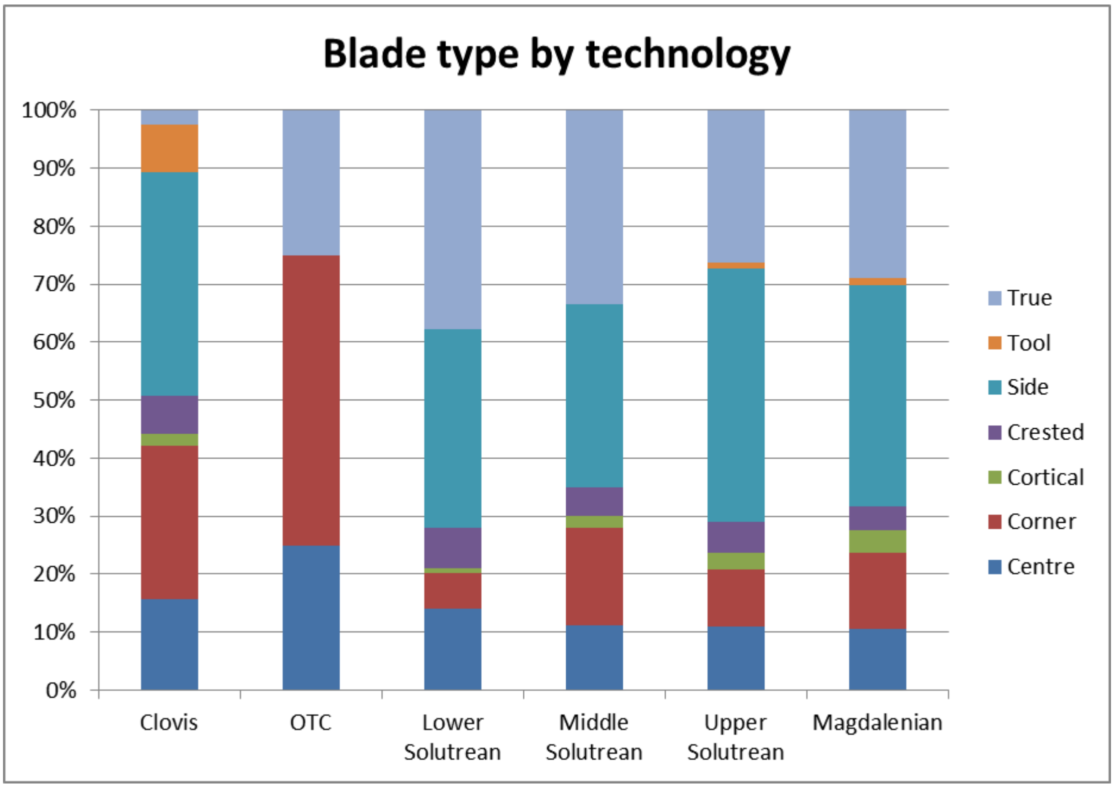

Figure 129. Blade type

This major difference in the number of corner blades (25%) in the Clovis sample may indicate a reduction strategy that routinely opened up the sides of the blade core to facilitate further removals. This is in contrast to the assemblages from France where the low percent (between 10 – 14%) of corner blades may indicate that once the blade face was established, it is rare for the core edges to be opened up for any further blade removals. The low number of true blades for Clovis may indicate that these were not specific end products of the reduction sequence, which may contrast to the Solutrean and Magdalenian.

All six industries are similar in the numbers of parallel, expanding and converging edges (Table 41) and the number of dorsal ridges (Table 42). The calculated values for chi-squared test indicate that both edge morphology [$X^2(20, N = 629) = 75.51$, $\rho = < 0.05$] and number of dorsal ridges [$X^2(10, N = 635) = 45.23$, $\rho = < 0.05$] confirms this and suggests a statistically significant relationship between all 6 assemblages. This is consistent with the nature of systematic blade production from a purposefully created core.

Table 41. Edge Morphology

	Clovis N (%)	**OTC N (%)**	**Lower Solutrean N (%)**	**Middle Solutrean N (%)**	**Upper Solutrean N (%)**	**Magdalenian N (%)**
Parallel	180 (86.5)	4 (50)	96 (84.2)	102 (71.3)	80 (72.7)	62 (81.6)
Expanding	13 (6.3)	4 (50)	7 (6.1)	23 (16.1)	15 (13.6)	12 (15.8)
Converging	7 (3.4)	0 ()	11 (9.6)	18 (12.6)	15 (13.6)	2 (2.6)

Table 42. Number of ridges

	Clovis N (%)	**OTC N (%)**	**Lower Solutrean N (%)**	**Middle Solutrean N (%)**	**Upper Solutrean N (%)**	**Magdalenian N (%)**
1	157 (75.5)	3 (37.5)	51 (44.7)	79 (55.2)	73 (66.4)	48 (63.2)
2	38 (18.3)	4 (50)	59 (51.8)	59 (41.3)	34 (30.9)	26 (34.2)
3	3 (1.4)	1 (15.2)	3 (2.6)	3 (2.1)	0 (0)	0 (0)
4 +	10 (4.8)	0 (0)	0 (0)	0 (0)	3 (2.7)	2 (2.6)

Platform descriptions

The breakdown of platform descriptions by technology is presented in Table 43. This is depicted graphically in Figure 130. Chi-squared analysis indicated a statistically significant pattern between all 6 assemblages, $X^2(45, N = 655) = 119.90$, $\rho = <0.05$. This indicates that all assemblages were similar in terms of the platforms used based on descriptions.

Table 43. Platform description comparisons

	Clovis N (%)	OTC N (%)	Lower Solutrean N (%)	Middle Solutrean N (%)	Upper Solutrean N (%)	Magdalenian N (%)
Cortical	7(4.4)	0(0)	0(0)	0(0)	5(4.95)	1(1.32)
Crushed	22(13.84)	2(28.57)	18(19.15)	26(20.63)	17(16.83)	13(17.11)
Dihedral	18(11.32)	0(0)	6(6.38)	8(6.35)	4(3.96)	5(6.58)
Complex	53(33.33)	3(42.86)	23(24.47)	43(34.13)	19(18.81)	6(7.89)
Linear	11(6.92)	0(0)	6(6.38)	10(7.94)	20(19.8)	6(7.89)
Missing	0(0)	0(0)	0(0)	0(0)	0(0)	10(13.16)
Plain	28(17.61)	2(28.57)	30(31.92)	23(18.25)	21(20.79)	16(21.05)
Punctiform	11(6.92)	0(0)	5(5.32)	2(1.59)	2(1.98)	2(2.63)
Spur	5(3.14)	0(0)	6(6.38)	8(6.35)	12(11.88)	17(22.37)
Winged	4(2.52)	0(0)	0(0)	6(4.76)	1(1)	0(0)

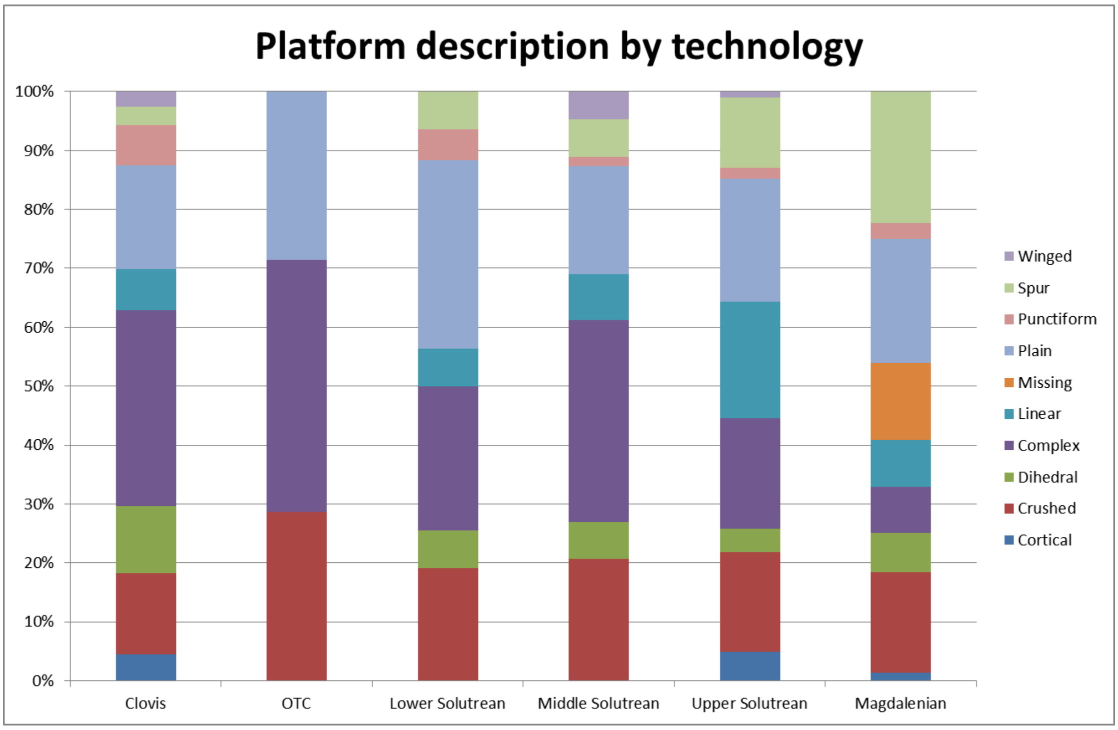

Figure 130. Platform description by technology

More detailed analysis reveals two major trends. The first major trend in blade platforms was the number of faceted platforms and plain platforms in the Lower Solutrean and Magdalenian (Figure 130). In both of these technologies, plain platforms were found in greater numbers. The Upper Solutrean had an almost equal number of plain to complex platforms, 19 and 21 respectively (Table 43). The second major trend was the increase in the percentages of spurred platforms from the Middle Solutrean through to, and including the

Magdalenian (Figure 131). Conversely, few spur platforms (Figure 132) were identified in Clovis and none in the OTC assemblage. Of these spur platforms; *en éperon* preparation was only identified in the Upper Solutrean and Magdalenian assemblages.

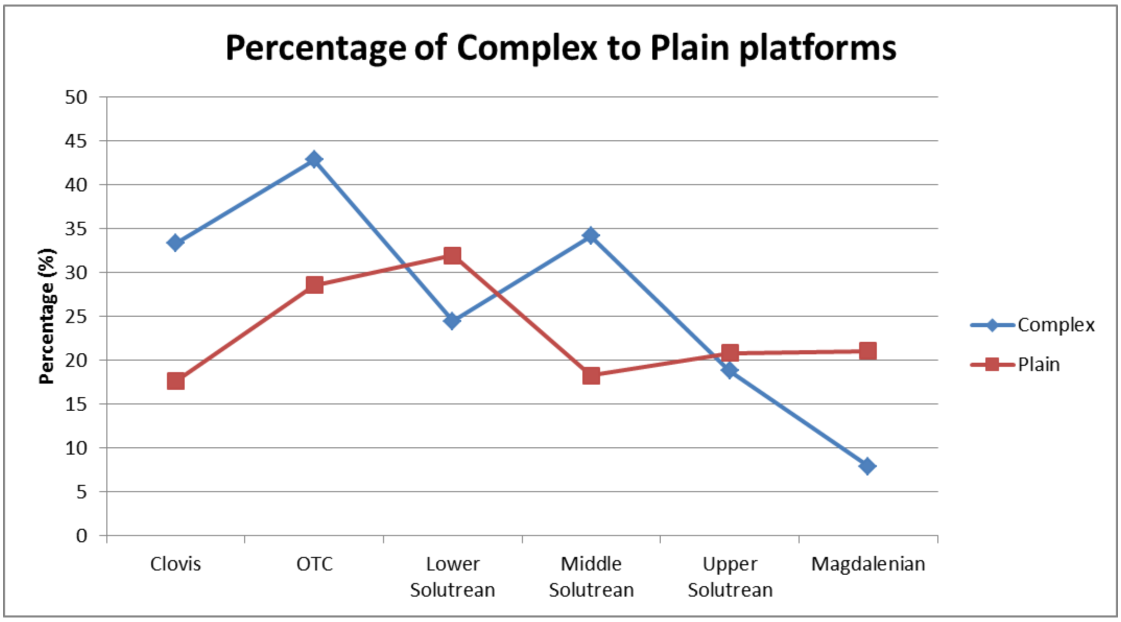

Figure 131. Comparison of complex and plain platforms

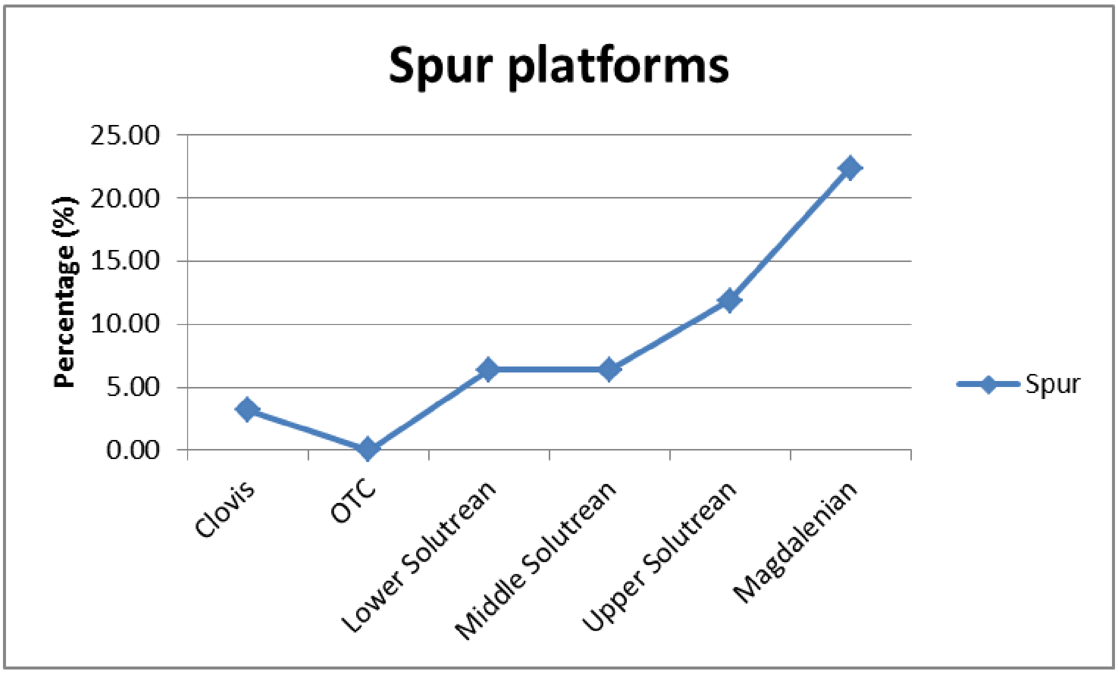

Figure 132. Spur platform comparison

Platform attributes

Analysis of the platform preparation techniques revealed a more complex pattern than analysis of platform description alone. A Chi-squared test indicated that there was no statistically significant pattern in the use of faceting between technologies (Table 44). In contrast to this, reducing, isolating, grinding and releasing all indicate a statistically significant pattern.

Table 44. Chi-Squared test for platform attributes by technology

	Statistic	*df*	Sig (ρ-value)
Faceted	7.31	5	0.1985
Reduced	13.58	5	**0.0185**
Isolated	11.11	5	**0.0492**
Ground	25.25	5	**0.0001**
Released	12.45	5	**0.0291**
Red numbers indicate statistical significance			

Chi-squared analysis was then conducted looking at the combined use of all 5 of these attributes on a platform and how this compared between assemblages. This test revealed no statistically significant pattern between the use of all 5 traits and technology, $X^2(5, N = 1488) = 19.17$, $\rho = 0.51$. This indicated that each technology utilised each attribute slightly differently for platform preparation. This pattern can be seen in Figure 133, which illustrates the differing proportions (in terms of a percentage) of each attribute within a technology.

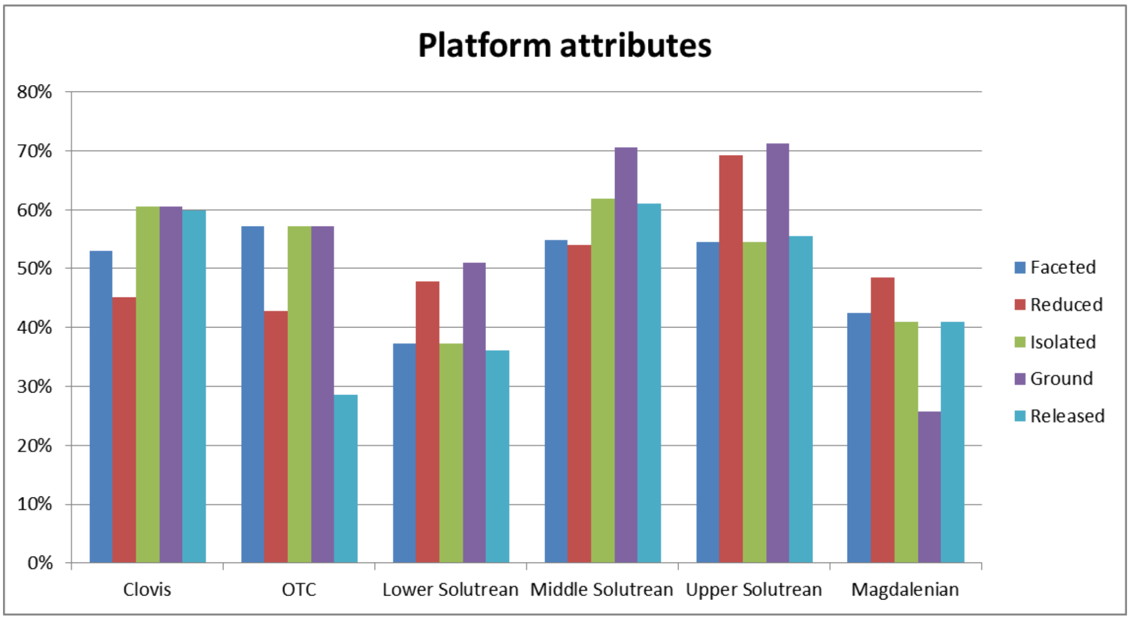

Figure 133. Platform attributes by technology

Patterning in the data reveals some similarities between each technology. The graph in Figure 134 illustrates the similarities between Clovis, Middle, and Upper Solutrean and OTC, while also showing some similarities between Lower Solutrean and Magdalenian. These similarities can be defined using correlation analysis. This analysis revealed a negative correlation between the Magdalenian and the 5 other assemblages (Table 45). This analysis also revealed a strong positive relationship between Clovis and the Middle Solutrean. A strong positive relationship between the Lower Solutrean and Upper Solutrean was also present. The Magdalenian had a strong negative correlation to both Clovis and the Middle Solutrean.

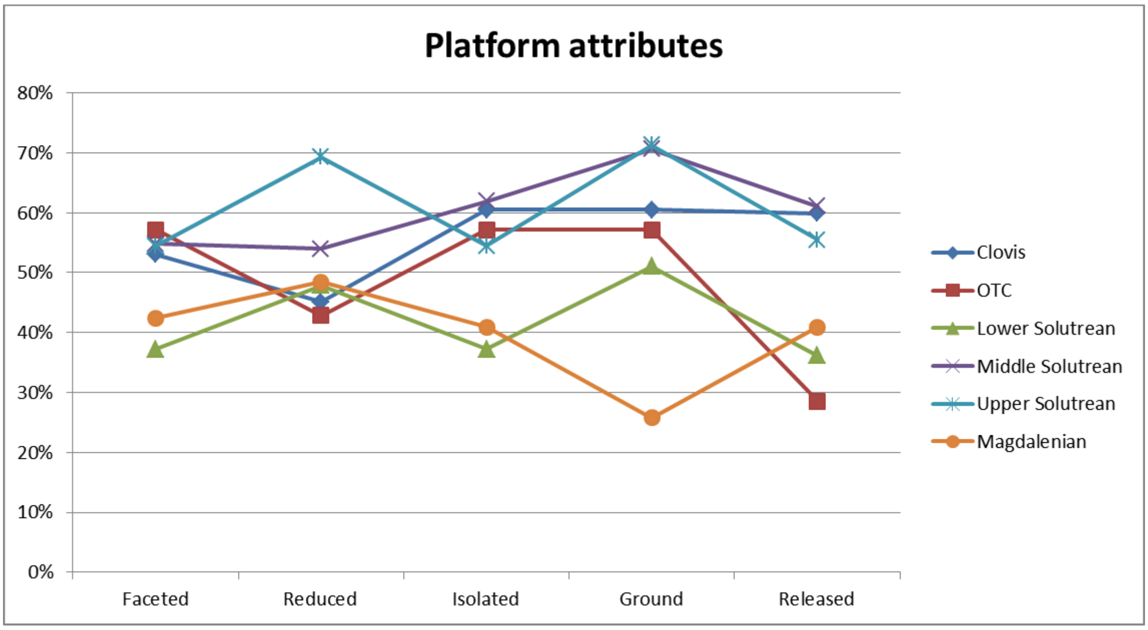

Figure 134. Technology by platform attributes

Table 45. Correlation analysis of platform attributes by technology

	Clovis	**OTC**	**Lower Solutrean**	**Middle Solutrean**	**Upper Solutrean**	**Magdalenian**
Clovis	n/a	0.11	-0.28	0.78	-0.33	-0.69
OTC	0.11	n/a	0.22	0.22	0.09	-0.37
Lower Solutrean	-0.28	0.22	n/a	0.38	0.99	-0.43
Middle Solutrean	0.78	0.22	0.38	n/a	0.33	-0.94
Upper Solutrean	-0.33	0.09	0.99	0.33	n/a	-0.36
Magdalenian	-0.69	-0.37	-0.43	-0.94	-0.36	n/a

The number of platform attributes present on a single platform was also assessed. For the Solutrean period, there was a trend toward increasing complexity in platform preparation, seen in the numbers of blades exhibiting all five traits (Figure 135). Clovis, OTC and the Lower Solutrean period all had around the same percentage of blades with all five traits; conversely, the Magdalenian has a smaller proportion (16.6%).

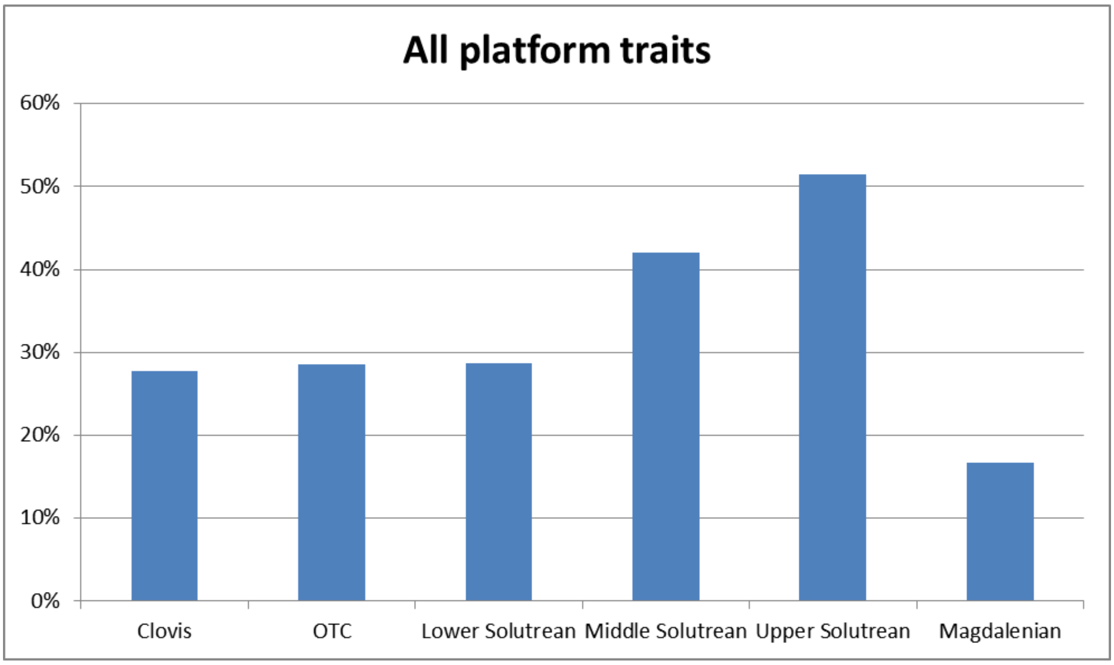

Figure 135. Comparison of percentage of blade's exhibiting all five platform preparation techniques

The data from the blade platforms indicated a number of significant findings to this study. For the Solutrean as a whole, the data suggested an increase in the complexity of platforms. Alongside this, there was a development of the specific spur platform; the *en éperon* technique. Coupled with this, there was an increase in the length of reduction scars (the removal of small flakes from the front of the platform, see Figure 113) along the dorsal surface (a trait that was only identified qualitatively) and the use of heavy preparation. This increase in complexity appears to end with the Upper Solutrean. However, the *en éperon* technique continued into the Magdalenian, where platforms either utilised this heavy form of preparation, or were unprepared and plain. This shift may indicate a different approach to detachment, and may be the result of a switch from direct percussion to pressure. From this perspective, several factors indicated similarities between the Clovis data and the data from the Lower and Middle Solutrean. This is seen in the use of platform preparation techniques and general similarities in the platform types.

Blade platform attributes by blade type

Analysis of the blade platform attributes utilised on each type of blade was also conducted. The previous chapter highlighted the fact that it was common amongst all assemblages to use either all five of these attributes or none at all. Due to the large number of possible combinations for five traits across 7 different blade types, analysis divided these traits into 3 groups; group 1 represented blades with all five traits, group 2 contained those blades that exhibited no traits, and a third group consisted of the presence of between 1 and 4 traits. These traits served as a proxy for preparation, e.g. no traits equals no preparation. Tools on blades were excluded from this analysis due to the small sample size.

Analysis indicates that for centre blades (Figure 136A) every assemblage had a higher percentage of blades with preparation with the use of all five attributes highest in the Upper Solutrean. This pattern was repeated in the analysis of corner blades (Figure 136B), side blades (Figure 136D), and true blades (Figure 136E). The lack of preparation was also highest for corner, side, and true blades during the Lower Solutrean. The analysis of the platform attributes on crested blades indicate that in Clovis and the Lower Solutrean, preparation was used heavily, while during the Middle, Upper, and Magdalenian corner blades exhibited predominantly unprepared platforms (Figure 136C). Cortical blades exhibited little to no preparation in Clovis, Upper Solutrean, and the Magdalenian assemblages, while it was more common to prepare the platforms in the Lower and Middle Solutrean (Figure 136F). Chi-square analysis indicated a significant pattern was present in the distribution of platform attributes by blade types separated by culture $X^2(5, N = 529) = 773.61$, $\rho = < 0.05$.

These results demonstrate that blade platform preparation was conducted individually for each blade removal, and that this was common across all assemblages. While the statistical analysis indicated a statistical significance, this is largely derived from differences in the use of preparation across blade types with very few differences between each culture.

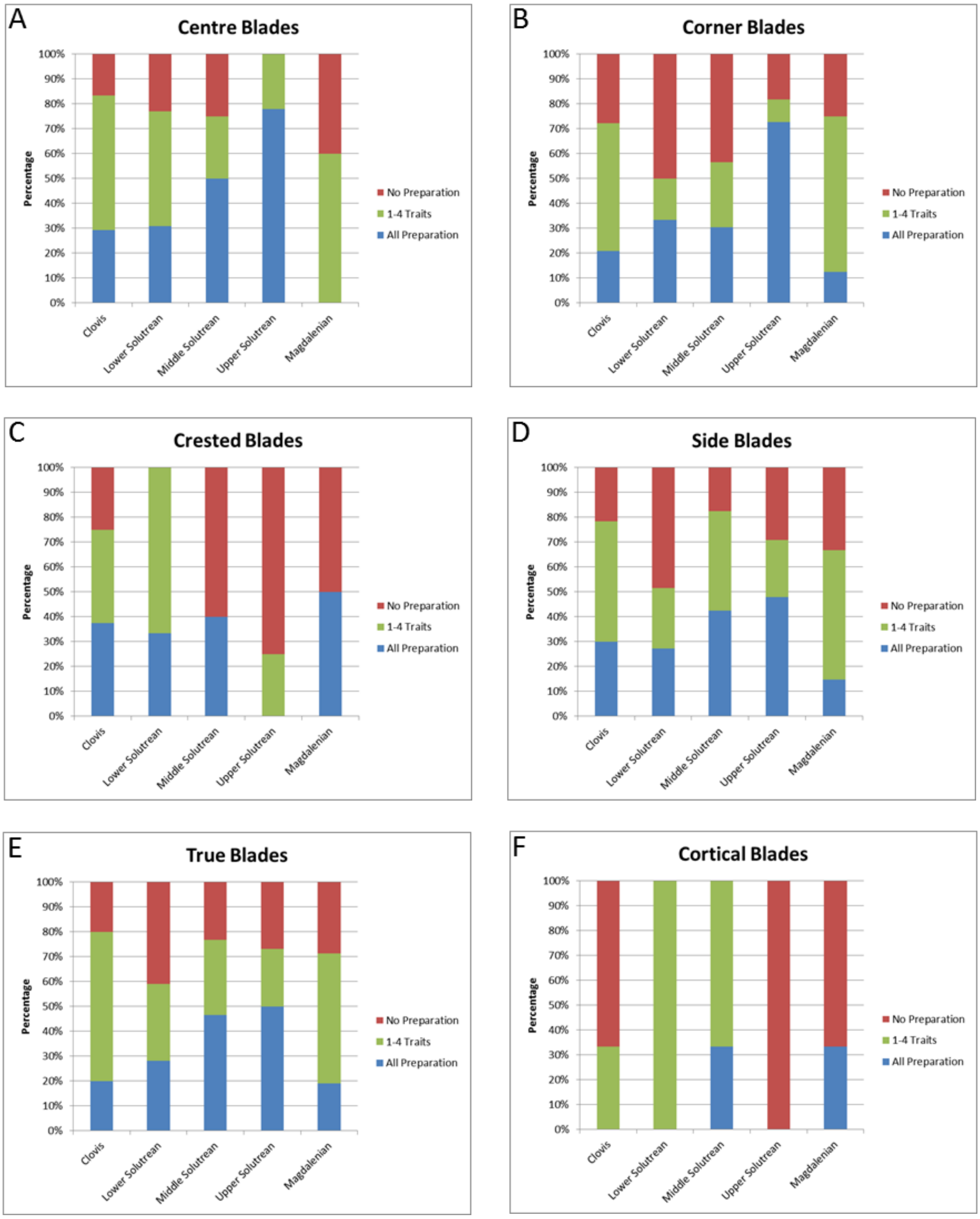

Figure 136. Cultural comparisons of total percent of all preparation and no preparation by blade type

Blade termination

The results of the Chi-squared tests (Table 46) indicated that a significant pattern in the distribution of hinged and snapped blades was present in the data, while no significant pattern was present in the blunt/feathered category. Analysis by technology indicated a significant pattern in termination types, $X^2(5, N = 659) = 113.03$, $\rho = < 0.05$. Comparisons of blade termination data indicated a higher number of snap terminations in the Solutrean and Magdalenian periods (Figure 137). This may be a result of the blades from the Solutrean and Magdalenian representing the discarded material that was not suitable as a blank for further tool production. When the snap terminations were removed (Figure 138), additional patterns emerge. For example, Clovis had more hinged flakes; and, there were more blades in Clovis that removed cortex from the distal ends of the core, indicating cortex to the base of the core. Feathered terminations were the most common terminations for all industries, closely followed by plunging blades. Feathered terminations represented the ideal removal of a blade in all 6 of these assemblages, as they did not create other problems for the knapper to solve. The number of plunging blades indicated that it was not uncommon for a blade to travel the entire length of the core and remove a portion of the base of the core. This may be the result of applying too much energy into the core.

Table 46. Chi-squared Test for blade terminations

	Statistic	***df***	**Sig (ρ-value)**
Blunt/feathered	6.05	3	0.3011
Hinged	41.04	3	**< 0.0001**
Plunging	9.46	3	0.0922
Snap	66.24	3	**< 0.0001**
Red numbers indicate statistical significance			

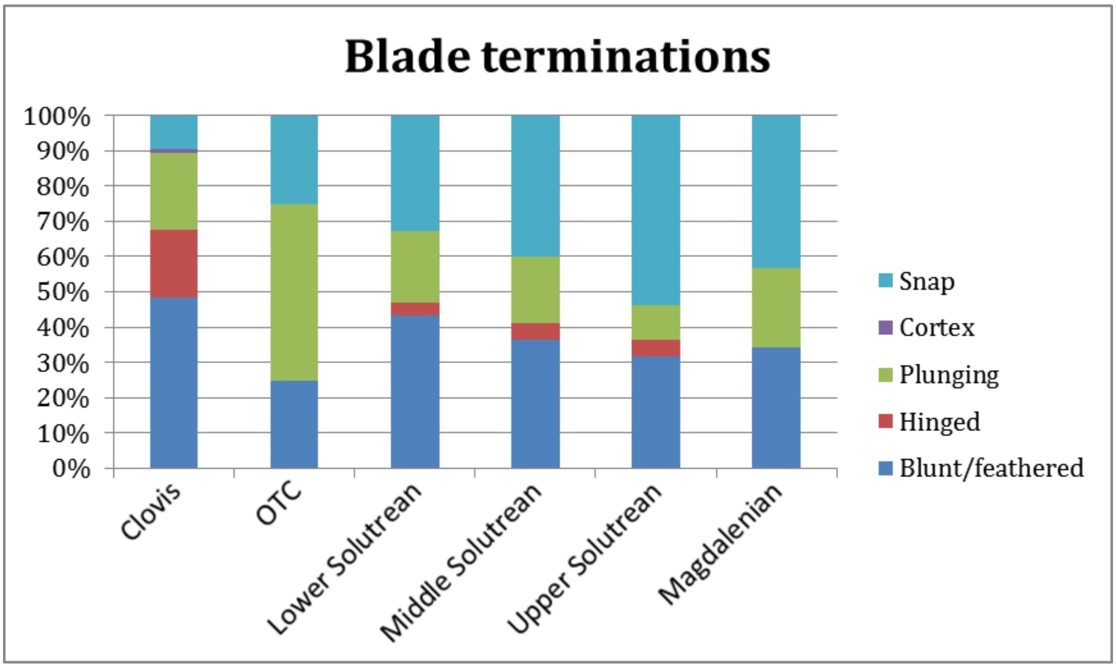

Figure 137. Blade termination data

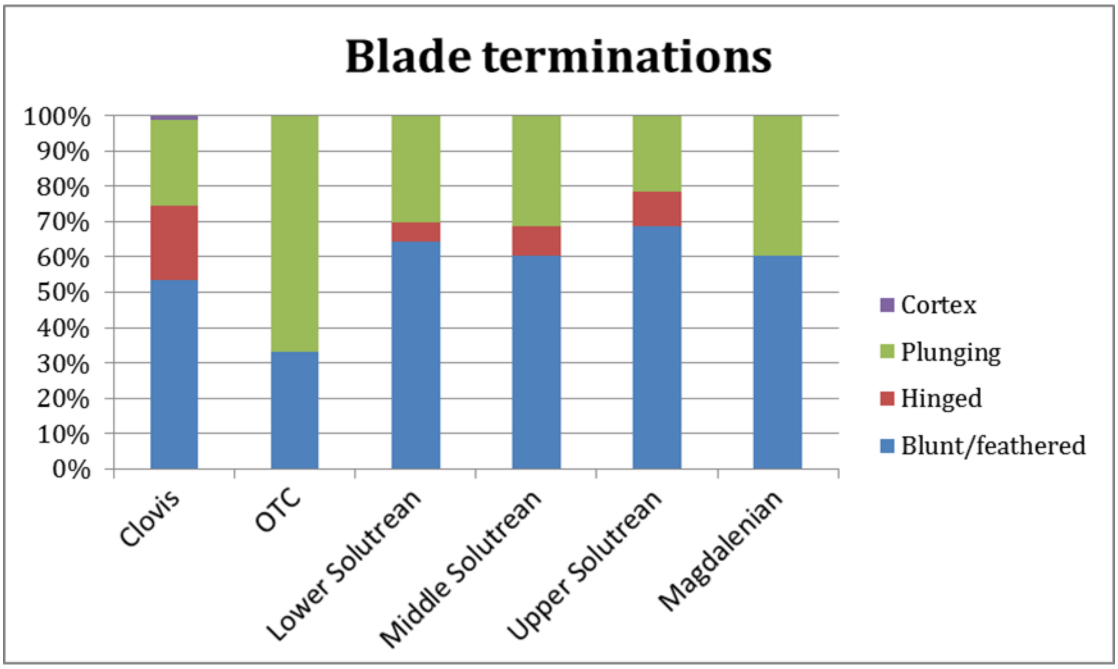

Figure 138. Blade terminations excluding snapped blades

Directionality

Table 47 presents the results of the Chi-Squared test. This indicated that there was a significant pattern in the distribution of unidirectional, opposed and multidirectional blade scars. Analysis by culture indicated a significant pattern between all technologies $X^2(5, N = 659) = 86.63$, $\rho = < 0.05$. The blade scars on the dorsal surface of a blade provided a strong indicator for the directionality of the cores. The data presented in Figure 139 indicated that all blade technologies except OTC contained opposed scar patterns. This opposed scar pattern indicated the use of a second, opposed platform. Unidirectional removals were the most common trait; however Clovis, Solutrean and Magdalenian assemblages had evidence for the use of either opposed or asymmetrically opposed removals. The Magdalenian had the highest proportions of unidirectional removals, while the Lower Solutrean had the highest number of opposed blade scars.

Table 47. Chi-squared analysis of dorsal scar direction

	Statistic	*df*	Sig (ρ-value)
Unidirectional	14.06	4	**0.0152**
Asymmetrically opposed	9.87	4	0.0789
Opposed	42.87	4	**< 0.0001**
Crossed	5.82	4	0.3239
Multidirectional	12.96	4	**0.0238**
Red numbers indicate statistical significance			

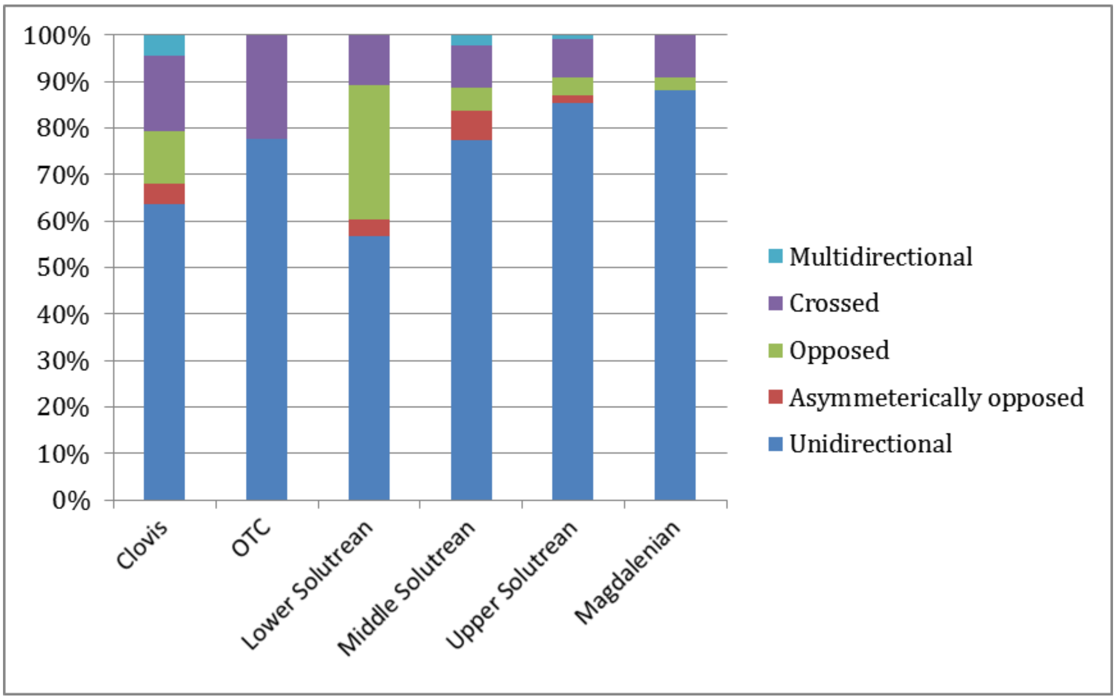

Figure 139. Dorsal scar Directionality

Blade Core Analysis

Three main attributes of blade cores were analysed for statistical comparison: the morphology of the back of the core, the number of platforms and whether or not these platforms were prepared.

Analyses of the backs of cores provided details about precore formation. They indicated a heavy reliance on flattening the back of the core in Clovis, OTC and the three Solutrean assemblages (Figure 140). By contrast, the Magdalenian had no flat back cores which indicated a different reduction strategy.

Both the Middle and Upper Solutrean had the highest proportions of opposed platform cores (Figure 141). Interestingly this data differs from the data recorded in the dorsal scar patterns (Figure 139). This is most likely due to the fact that many of these cores were discarded. The final blade removals on these cores may have eradicated evidence for the use of an opposed platform; or, subsequent battering may have removed the second platform. This may indicate that opposed platforms were utilised as a corrective step in both the Middle and Upper Solutrean.

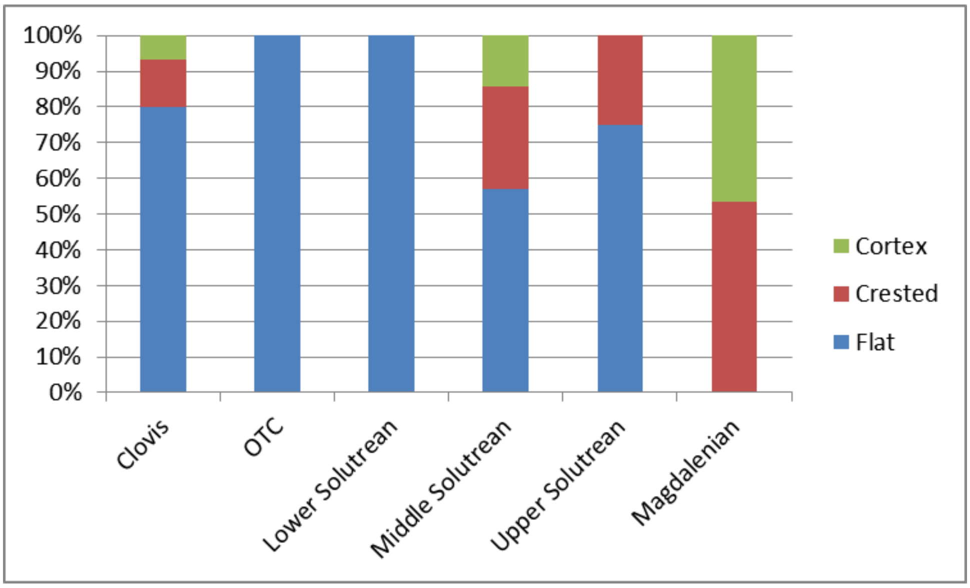

Figure 140. Core back morphology

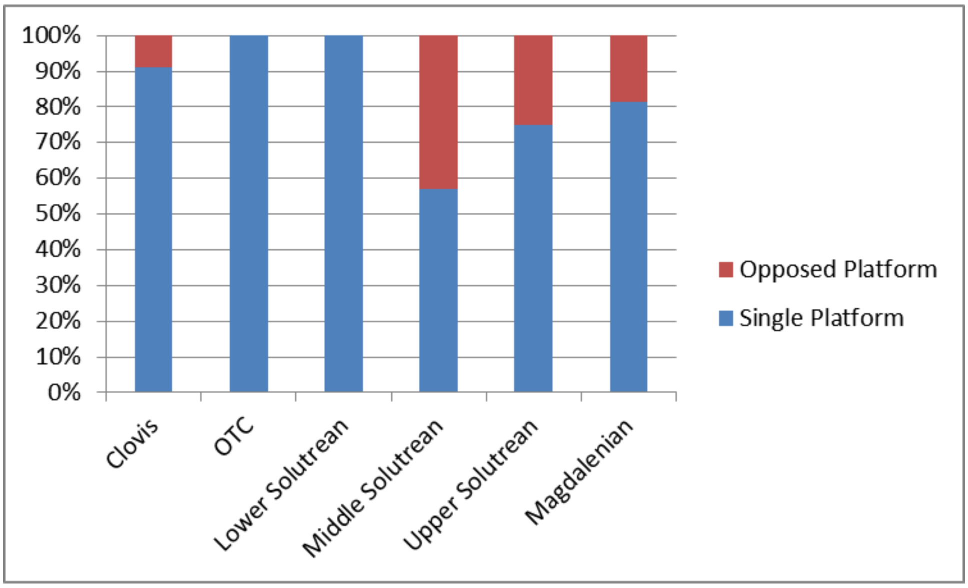

Figure 141. Single platform vs. opposed platform cores

The data for core preparation provided a stark contrast between the technologies of Clovis, OTC and the Solutrean compared to the Magdalenian (Figure 142). The Magdalenian data indicated that the majority of core platforms were plain, in contrast to the other assemblages, none of which have any plain platforms.

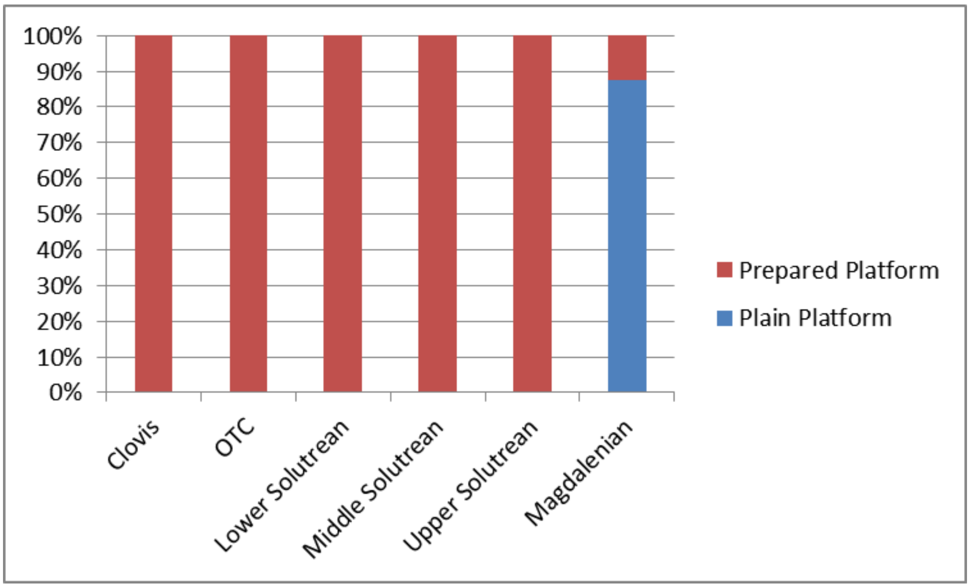

Figure 142. Percentage of prepared vs. plain core platforms

Multivariate Cluster Analysis

The above analysis indicated that there were some major similarities in the data, including similarities in the blade cores and blade platform production. There were also some differences, including curvature, lengths and blade types. One method to assess the data in its entirety is to use a multivariate statistical method known as cluster analysis. Cluster analysis was conducted using Ward's method with standardised data.

In order to conduct a hierarchical cluster analysis on this data, technological traits were selected that were most indicative of the actual technological strategies. For this reason, elements such as the metrics were excluded from the analysis. Instead, traits such as platform preparation were included as these represent specific knapping choices. Traits were recorded as presence or absence, and then converted into a numerical score. Traits that were present were labelled with a 1, while traits that were absent were labelled with a 0. The average score was then calculated for each trait, so if precisely half (50%) of the specimens exhibited that trait, the score would be 0.5. Thus, a score of 0 indicated the total absence of a trait, while a score of 1 indicated that the trait was present across the whole assemblage.

The first test was based on the blade data. This included the platform preparation techniques, directionality and error correction (Table 48). The cluster analysis based on this data indicated two primary clusters: Middle and Upper Solutrean and Lower and Upper Solutrean. Clovis clustered nearest to the Middle and Upper Solutrean, while OTC clustered with the Lower Solutrean and Magdalenian (Figure 143),

Table 48. Raw data for blade cluster analysis

	Clovis	OTC	Lower Solutrean	Middle Solutrean	Upper Solutrean	Magdalenian
Faceted	0.41	0.50	0.31	0.48	0.50	0.37
Reduced	0.35	0.38	0.39	0.48	0.64	0.42
Isolated	0.48	0.50	0.31	0.55	0.50	0.36
Ground	0.47	0.50	0.42	0.62	0.65	0.22
Released	0.47	0.25	0.30	0.54	0.51	0.36
Unidirectional	0.61	0.88	0.55	0.76	0.85	0.88
Asymmetrically opposed	0.04	0.00	0.04	0.06	0.02	0.00
Opposed	0.11	0.00	0.28	0.05	0.04	0.03
Crossed	0.15	0.25	0.11	0.09	0.08	0.09
Multidirectional	0.04	0.00	0.00	0.02	0.01	0.00
Front Ground	0.40	0.25	0.05	0.12	0.11	0.04
Unidirectional Hinge removal	0.03	0.00	0.01	0.03	0.02	0.00
Opposite hinge removal	0.01	0.00	0.01	0.02	0.03	0.00

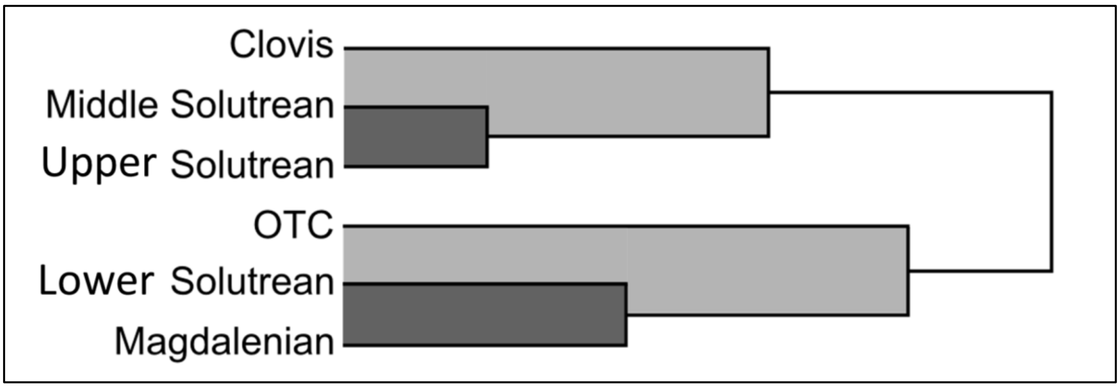

Figure 143. Cluster analysis of blade traits

A second cluster analysis was then conducted focusing on the blade cores themselves. The traits used in this analysis included the shaping of the back of the core and the use of platforms (Table 49). This analysis (Figure 144) separated out the Magdalenian from the other five industries. In this analysis, Clovis had more similarities with OTC and the Lower Solutrean.

Table 49. Raw data for Core cluster analysis

	Clovis	OTC	Lower Solutrean	Middle Solutrean	Upper Solutrean	Magdalenian
Flat	0.71	1.00	1.00	0.57	0.75	0.00
Crested	0.12	0.00	0.00	0.29	0.25	0.50
Cortex	0.06	0.00	0.00	0.14	0.00	0.44
Single Platform	0.91	1.00	1.00	0.57	0.75	0.81
Opposed Platform	0.09	0.00	0.00	0.43	0.25	0.19
Plain Platform	0.00	0.00	0.00	0.00	0.00	0.88
Prepared Platform	1.00	1.00	1.00	1.00	1.00	0.13

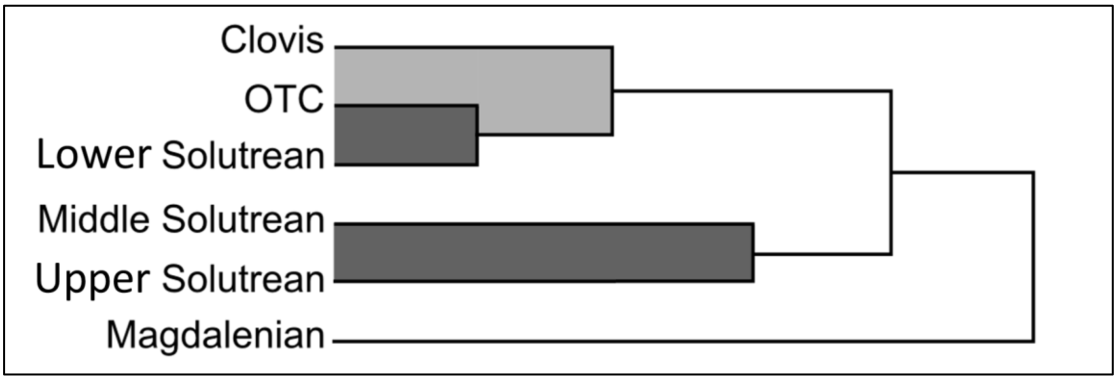

Figure 144. Cluster analysis of blade core data

In the next stage of the analysis, all of the data were grouped together to assess the technology as a whole. For this analysis both sets of data were combined (Table 48 & Table 49). The single and opposed platform data were then removed as the blade scar data provided information on the reduction sequence as a whole, rather than on the discarded core remnants which may not be a true reflection of the core's use. This analysis (Figure 145) grouped the Middle and Upper Solutrean together, which created a second cluster with Clovis. The Lower Solutrean and OTC assemblages created a third group, although not as closely related as the first two. Magdalenian was separated out from the other groups.

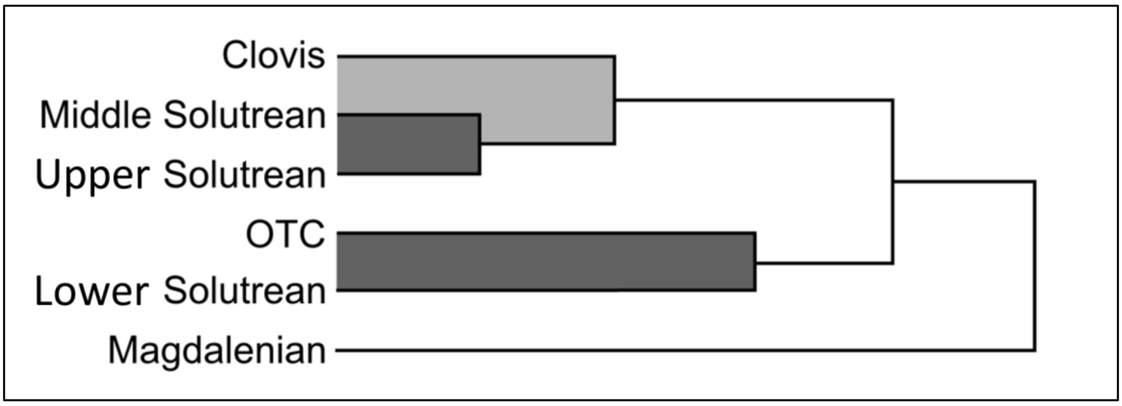

Figure 145. Final Cluster Analysis

Demars (1995) concluded that the Solutrean should only be separated into two subperiods; an early phase and a later evolved phase, combining the Middle and Upper Solutrean periods (see chapter 9). If the Middle and Upper Solutrean periods are combined for this analysis, the results remain identical with the replacement of the first cluster with a group of evolved Solutrean and Clovis. This data supports the conclusion presented by Stanford and Bradley (2012) that Clovis and the Solutrean are alike. The surprising result is the group formed from the OTC and Lower Solutrean industries. Exploring this connection further, it is likely that this is a result of a bias in the data due to the small sample size of available cores.

This analysis also excludes certain features of the technology that represent possible manufacturing choices made during production. The most apparent is the high degree of curvature exhibited by both Clovis and OTC blades. There also appears to be a marked difference in the use of blades, as indicated by the length of blades. In Clovis, there is little evidence that the blades served as blanks for the specific creation of projectile points. In contrast, the Solutrean produced blades as blanks for *pointes à face plan* and *pointes à cran*. The evidence from the blade dimensions may indicate that these blades were the waste material not suitable for further reduction.

The final stage of the cluster analysis used presence and absence traits for multiple technologies. The technologies used for this analysis are listed in Table 50 which lists core morphological traits. Table 51 presents the data on directionality and blade types.

Table 50. Presence/absence attributes of core technology by culture

	Percussion	Pressure	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Frontal	Facial	Semi Circumference	Full Circumference	Flat
Proto-Aurignacian	1	0	1	0	0	0	0	0	1	0	0	0	1
Aurignacian	1	0	1	0	0	0	0	0	1	0	0	0	1
Gravettian	1	0	0	1	0	0	0	0	1	0	0	0	0
Solutrean	1	0	0	1	0	1	0	0	0	1	0	1	1
Magdalenian	1	0	0	1	0	1	0	0	1	0	1	0	0
Russian Gravettian	1	0	0	1	0	1	0	0	1	1	0	0	1
Asia Non-levallois	1	0	0	1	0	1	0	1	1	1	0	0	1
Asia Microblade	0	1	0	0	1	0	0	0	1	0	1	0	0
Dyuktai	0	1	1	0	1	0	0	0	1	0	1	0	0
Nenana	1	0	0	0	0	0	0	1	0	1	0	0	1
OTC Gault	1	0	0	1	0	1	0	0	0	1	0	0	1
OTC Atlantic	1	0	0	0	0	0	0	1	0	1	0	1	0
Clovis	1	0	0	1	0	1	0	0	0	1	0	1	1

Table 51. Presence/absence attributes of core technology by culture

	Unidirectional	Bidirectional	Asymmetrical	Multidirectional	Biface	Blade	Bladelet	Microblade
Proto-Aurignacian	1	0	0	0	0	0	1	0
Aurignacian	1	0	0	0	0	1	0	0
Gravettian	0	1	0	0	1	1	0	0
Solutrean	1	0	1	0	0	1	0	0
Magdalenian	1	1	1	0	1	1	1	0
Russian Gravettian	1	1	1	1	0	1	1	0
Asia Non-levallois	1	1	1	0	0	1	0	0
Asia Microblade	1	1	0	0	1	0	0	1
Dyuktai	1	0	0	0	1	0	0	1
Nenana	1	0	0	0	0	1	1	0
OTC Gault	1	0	1	0	0	1	0	0
OTC Atlantic	1	0	0	0	1	0	1	0
Clovis	1	0	1	0	0	1	0	0

For the purposes of this analysis, the Solutrean was combined as a single culture. Figure 146 shows a cluster formed by Clovis and Solutrean with the OTC assemblage from Gault forming a second level cluster to this group. This analysis also revealed a number of other pairs that are important to this research. This analysis indicated that the Asian Microblade traditions and Dyuktai form a separate cluster from the other technologies. The closest technology to Clovis and Solutrean was the Russian Gravettian and Asia Non-levallois technologies. The technologies of Nenana and the OTC on the Atlantic Seaboard formed a separate cluster that is then related to the Aurignacian. This may be due to the more expedient nature of these blade technologies.

These results indicate a clear technological similarity between Clovis and Solutrean. It also highlights that neither Dyuktai nor Nenana cluster with Clovis in terms of blade technology.

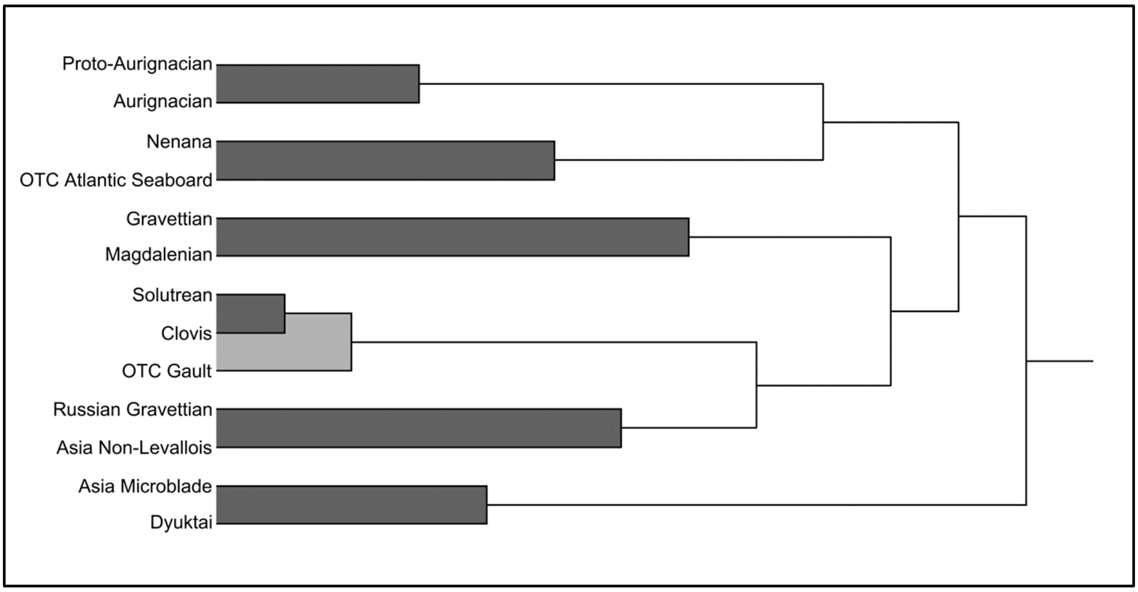

Figure 146. Cluster analysis of all industries

Summary

In conclusion, the overall technologies of Clovis, OTC, Solutrean, and Magdalenian share a number of similarities consistent with blade production while differences can be found in the specific nature of reduction strategy. Statistical analysis revealed significant differences between the blade metrics and the point of maximum curvature (specifically in the Middle Solutrean), while no significant differences were identified between the platform metrics and index of curvature. Significant patterns in the data were found between platform types and attributes as well as blade termination and dorsal scar direction while analysis by specific technology revealed the each assemblage utilised these attributes differently as no significant pattern was identified.

Further analysis revealed that these technologies can be grouped according to specific manufacturing techniques, placing Clovis in a group with the Middle and Upper Solutrean. However, while the technology of production appears to be highly comparable, there appears to be a number of differences in the use of the blades as blanks. Quantitative analysis has revealed a number of similarities in the data sets while highlighting some divergence. As statistical significance does not always indicate real-world significance; qualitative similarities and differences are explored in the following chapter.

Chapter 16

Qualitative Analysis

This chapter assesses the qualitative results, specifically it examines the reduction strategies and manufacturing techniques utilised in the production of blades. In order to assess the respective manufacturing approaches, the blade reduction stages identified by Collins (1999) and Bradley et al. (2010) are used.

Core Types and Raw Material

The industries of Clovis, OTC and the Solutrean all used a similar core type for blade production. Type II A-1 (single faceted platform, with unidirectional facial flaking) cores, along with the variation of Type IV A-2/5 (double faceted platforms, with bi-directionally/asymmetrically opposed facial flaking), were the most dominant form identified in the analysis. Magdalenian core choice differed in the use of the frontal portion of the core coupled with plain platforms, resulting in Type I B-1 (single plain platform, with unidirectional frontal flaking) cores. The use of a second opposed platform was observed in all but the OTC industries. This use of a second platform appears inconsistently and exhibit only slight preparation with few signs of continual maintenance. This indicates a variant on the core types (Type II A-2 and Type I B-2).

Clovis blade manufacturing also utilised conical cores, specifically Type II C-1 (with a variant Type II C-2) for blade production. In examination of the cores from Pavo Real, core 30E-1 had the potential to be either a Type II A-1 or Type II C-2 core (wedge-shaped or conical). This early stage core has a series of core tablet flakes removed from the platform and formed part of refit group 5 (Collins et al., 2003). While this knapping strategy is consistent with conical core preparation, only 2 or 3 blades were detached. The angle between these detachments and the core platform was acute and it is possible that this core may have become a wedge-shaped core, but it was discarded before any further shaping and blade production took place.

The conical cores examined from the Gault site were all recovered from the highest Clovis elevations. This may indicate that these cores were a later development of Clovis. Debitage analysis revealed the use of core tablets and core trimming flakes, consistent with conical core preparation, throughout the

Clovis horizons despite a lack of conical cores. This evidence indicates that conical cores may have been taken away from the main production area. At this stage the purposes behind this remain unclear.

No conical cores were present in the Solutrean assemblages analysed for this thesis. However, it should be noted that one Solutrean conical core was recovered from the site of Les Maitreaux (Stanford & Bradley, 2012). In contrast, two conically shaped cores were examined from the Magdalenian assemblage at Laugerie-Haute. These cores were smaller than the cores found in Clovis, and retained a distinctive keel on the base of the core indicative of bifacial preforming. For this reason, the following assessment is based on the knapping strategies of the Type II A-1 (wedge-shaped) cores from Solutrean and Clovis.

Regardless of specific core forms, Clovis, OTC and the Solutrean industries appear to have imposed the same knapping strategy onto the raw material. Specifically, the reduction methods followed the natural ridges of the cores in the early stages. The Magdalenian, as discussed below, differs in the use of bifacial shaping.

Precore Production and Core preparation

It is clear from the evidence that all five technologies utilised some form of precore formation. Clovis and Solutrean industries would utilise natural or existing ridges to remove the initial blade and set up the blade face if the appropriate morphology was present. Alternatively, a partial or crested ridge would be created if no suitable natural ridge was present. At around the same time as this, the back of the core was prepared in order to create the necessary angle for the platform. Flakes were struck, often unidirectionally, from the edge of the core opposite to the face selected for blade production. These flakes ran perpendicular to the blade detachment direction of the core face. The result of this technique was that the core platform and core back often became one continuous face from which all aspects of blade core maintenance could be facilitated. The core platform was worked via the detachment of flakes from the existing blade scars back into the mass of the core. These removals frequently terminated in hinges. With the platform, core back and blade face established, blade detachment began. The initial blade could be cortical, partially crested or fully crested depending on the guiding ridge.

In contrast, the Magdalenian industry used bifacial shaping of the core to establish a precore. One bifacial edge of the core was subsequently removed and blade production began. The plain platforms were the result of direct hard hammer flakes that left deep negative scars on the top of the core.

Platform Production and Maintenance

The production of blades required individual core and blade platform preparation. Complex blade and core platform preparation was more prevalent in Clovis and Solutrean than in the Magdalenian where plain core platforms were more common with the use of reducing on blade platforms. In Clovis and Solutrean, flakes were removed from the blade face across the core platform. The negative bulbs left by these flakes served to isolate and release the blade platform. This form of preparation frequently resulted in the production of hinges towards the back of the core platform. These hinges required frequent maintenance in order to remove them from the platform surface.

In this respect, core platforms were not just created on a core before blade production began, but rather were the result of continual blade removals. Thus, blade production in Clovis and Solutrean technologies was a more fluid and dynamic process rather than a deliberate set of stages. A core may have a number of blades removed before any shaping or precore formation was conducted if the angles on the nodule were conducive to detachment.

The evidence from the Magdalenian represented a more systematic approach than seen in Clovis and Solutrean where a bifacially flaked precore and plain platform were established prior to any detachments.

Blade Production

Blade production continued following a dynamic system whereby each blade would be prepared for removal by flaking the core platform and preparing the striking platform of the blade. At this stage in the manufacturing process, Clovis and Solutrean knappers approached production with differing behaviors. This becomes more apparent when the Solutrean is subdivided into its respective periods.

Figure 147 presents a summary of the platform preparation data from the previous quantitative chapter. This highlights the major differences observed in the data and provides a summary for the qualitative observations in the use of platform preparation discussed below.

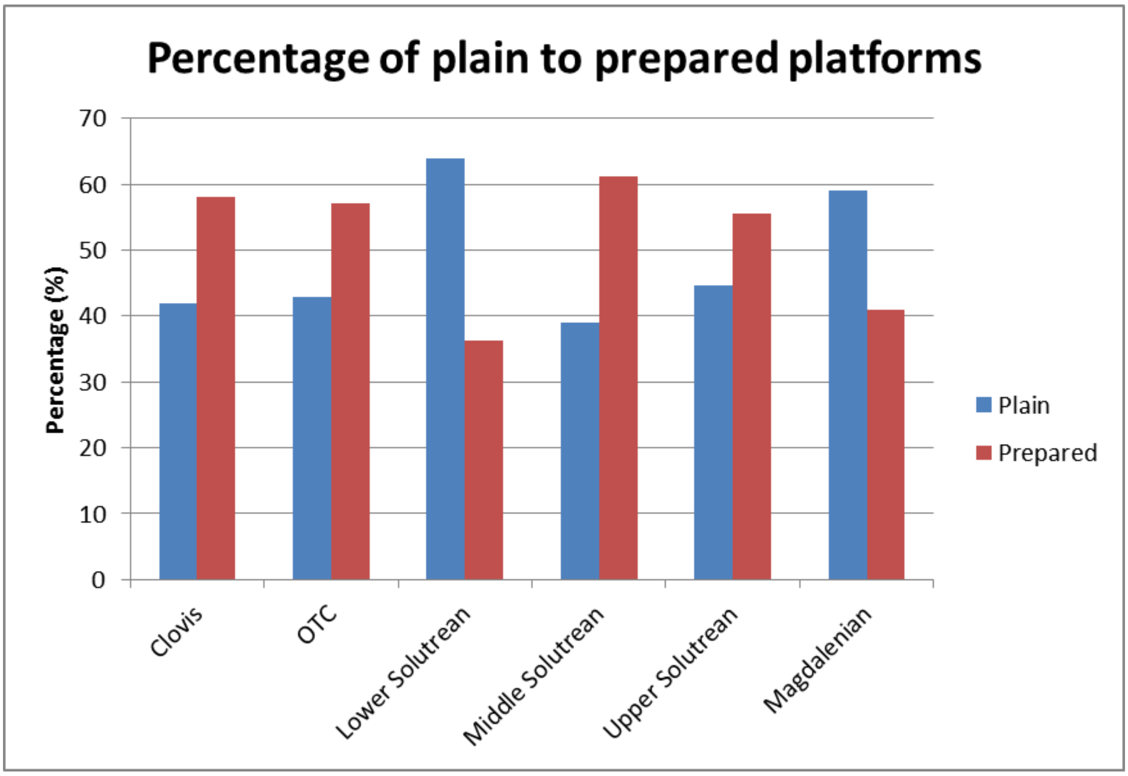

Figure 147. Comparison of plain to prepared platforms

The Lower Solutrean is characterised by flat, plain platforms with little to no prior preparation (Figure 147). These platforms tended to be wide, and the majority was struck with a hard hammer. There is evidence for the use of soft hammers and platform preparation was present on some blades. By contrast, the Middle Solutrean was characterised by a reliance of platform preparation (Figure 147). These platforms were wide and faceted. Reduction scars were minimally invasive and frequently created micro-hinges on the face of the core. Front face grinding was conducted prior to the detachment along with the grinding of the platform itself. While plain platforms were still used during the Upper Solutrean (Figure 147), the production technology was marked by the development of highly prepared platforms (those that exhibited more than two preparation techniques), including spurred platforms, similar in style to the *en éperon* technique of the Magdalenian. One of the major differences between the Middle and Upper Solutrean was the use of more invasive, reduction flakes (small flakes from the front of the platform, see Figure 113) on the dorsal surface.

While platform maintenance appears to have developed during the Solutrean in terms of complexity, all three Solutrean periods shared similar technological approaches in terms of blade production. They focused on maintaining a slight curvature to the blade face to produce straight blades. There were also a higher proportion of side blades to corner blades. This indicates that the blade face of a core was established across the full width of the face fairly early in the production sequence. Once the blade face was established, corner and side blades were removed when required to maintain a slight horizontal convexity to the blade face.

The platform preparation on Clovis (Figure 147) was very similar to the Middle Solutrean. Complex platforms with short, sometimes hinged reduction flakes along with platform and front dorsal grinding was common in Clovis blade production. However, Clovis blades were more heavily curved than those in the Solutrean; yet, they tended to flatten out as the production sequence continued. It is likely that the heavily curved blades from the Clovis caches and kill sites were from an early phase of core reduction due to their length. However, the act of creating heavily curved blades was an intentional act and maintained during manufacture (see below).

Clovis also had a higher proportion of corner blades to side blades. This may indicate a different approach was used for core face reduction, one in which the reduction strategy used the full width of the core without any prior creation of a specific core face.

Magdalenian blade platforms were generally plain (Figure 147) with invasive reduction scars. When preparation was used, complex *en éperon* platforms predominate, and were often more complex than those in the Upper Solutrean. This highlights a dichotomy in the Magdalenian between the use of no preparation, or heavily prepared platforms. In terms of blade production, the Upper Solutrean strategy followed a similar detachment pattern used in the Magdalenian, except that the core was created on a frontal edge in the latter.

The platform reduction flakes in the Upper Solutrean and Magdalenian are more invasive across the dorsal surface than they are in the Middle Solutrean which has short, less invasive reduction scars. This form of reduction is also present in both the Clovis and OTC assemblages.

Core Platform Maintenance

Maintenance of the core platform was an important process during blade manufacturing; and, it was a process that all industries routinely conducted. Clovis and Solutrean blade production used similar approaches. Both reduction strategies left a series of hinges across the core platform. Furthermore, as blades were detached, the mass of the platform was reduced. This reduced the angle between the platform and blade face. Errors in blade detachments became more frequent as this angle was lost. Both industries corrected this via the removal of flakes either from the sides of the platform or laterally across the flat back of the core.

Core tablets were used during the Magdalenian to renew the angle between the core and blade face as large flakes with deep bulbs of percussion served to correct this angle and maintain the platform in one detachment.

Core Blade Face Maintenance

During production, errors on the blade face may end the reduction sequence. Generally these errors consisted of hinge or step fractures terminating along the blade core face. These errors were removed by the detachment of a blade from the same platform (using two blade to remove half of the hinge at a time) or from an opposing platform. This practice was identified in both Clovis and Solutrean. No hinged blades or hinges were retained on the dorsal surface on any of the blades in the Magdalenian assemblage. While it is unlikely that no errors occurred during Magdalenian blade production, it is possible that this reduction in errors is linked to a different method of detachment (e.g. pressure flaking versus direct percussion).

Blades

The technological steps of manufacture undertaken during Solutrean and Clovis production share numerous similarities in organisation and manufacturing processes; however, there was a divergence in end product use. As discussed in Chapter 9, blades were used as blanks for the production of specific projectile point types throughout the Solutrean. There is little evidence to support this same technological investment in Clovis. However, Clovis blades are used as blanks for a variety of tool types, including endscrapers and becs/gravers (Shoberg, 2010; Smallwood, 2013; Eren et al., 2013a). Both

Solutrean and Clovis blades were used as tools without modification. Further, both Industries had some evidence for the use of backing (abrupt retouch to blunt one edge), while this practice was most prevalent in the Magdalenian.

While there are differences in the use of the end products (discussed below), the technological aspects of blade production contain numerous parallels. These go beyond just appearance and it is clear from the evidence that the organisation of flat back cores in both Clovis and Solutrean contain many shared characteristics. This included the use of a second platform for error correction, the formation of precores and the maintenance of the core platform. The specific traits of platform production also corresponded, particularly between Clovis and the Middle Solutrean.

The sequence of blade removals also appears to have followed a strategy the worked from one side of the blade face and then back. However, the smaller numbers of corner blades in the Solutrean assemblages may indicate that once the blade face established, removals did not proceed to the very edge of the core.

Clovis and OTC

With only three OTC cores recovered from the Gault site, it is difficult to fully assess the technological aspects in full. What is clear is that these cores share the same traits as Clovis Type II A-1 cores. This includes all diagnostic Clovis features, including flat backs, prepared platforms, flaked sides and heavy curvature. Unlike the other blade technologies recovered from contexts older than Clovis, these three cores certainly share the same production strategy used during Clovis.

The differences between Clovis and Solutrean production

Three major differences between Clovis and Solutrean production were observed and analysed. The curvature of blades, certain aspects of the conical cores, and to a certain extent, the use of these blades all separate out the *chaîne opératoire* of Clovis from the European assemblages.

Clovis blades were frequently curved. Data from the previous chapter indicated that both Clovis and OTC had an average curvature greater than the European industries. Furthermore, the cached Clovis blades retained the greatest curvature. Blades from the workshop sites of Gault and Pavo Real provide a more complete sample of blade curvature. Evidence from these sites indicates that curvature was developed and controlled through the frequent removal of plunging blades. Initial blades tended to be straighter, while the cores themselves frequently featured a single blade scar that both expands and plunges. Bradley et al. (2010, p.44) suggests the removal of flakes along the base of the core may have served to reduce curvature. Evidence from the blades and cores indicate that this is not the case. The distal portions of the plunging blades tend to be either flat (having removed a portion of the flattened base) or partially crested. Both of these actions create mass at the distal end of the blade face of the core. This increase in mass forces a turn in the fracture, creating a reverse hinge or plunging fracture. The mechanics of this are discussed in flake propagation by Baker (2003). Put simply, Baker (2003) indicated that these plunging blades occurred due to a single crack that suddenly turned towards the back of the core. Baker (2000) explored this phenomenon of reverse hinge fractures in his paper on Folsom fluting and the reason behind reverse hinge fractures he termed overshot errors. In his experiments on flake propagation, Baker (2000) states that a reverse hinge or overshot would only occur when a support or "anvil" is placed away from the edge of the flaking surface. This same explanation is true for the plunging blades on a core. Flaking present on the base of Clovis cores indicates that flakes were removed from the flat back, along the distal face towards the blade face, but were not used for the creation of a second platform. These flakes would allow the core to be held at a different angle and be supported accordingly, thus shifting the "anvil" away from the blade face back towards the centre mass and so form a plunging, heavily curved blade. Therefore, Clovis knappers were specifically preparing the distal end of the core opposite the platform for the creation of heavily curved blades. These basal flaking scars are also present on the base of some of the heavily curved blades. This technique is not present in Solutrean industries. This concept is illustrated in Figure 148. The arrow (Figure 148A, C) indicates the "anvil" point or point of stabilisation. Finally, it is important to note that while Clovis blades were on average more heavily curved, the statistical analysis indicated no significant differences between the assemblages. This is likely an example of a statistical inference not recognising subtle, yet important differences in these technologies. Figure 149 illustrates the flattening of the distal margin of a blade core recovered from the

Gault site. Figure 150 illustrates a plunging termination which was the result of the flattening of the distal margin.

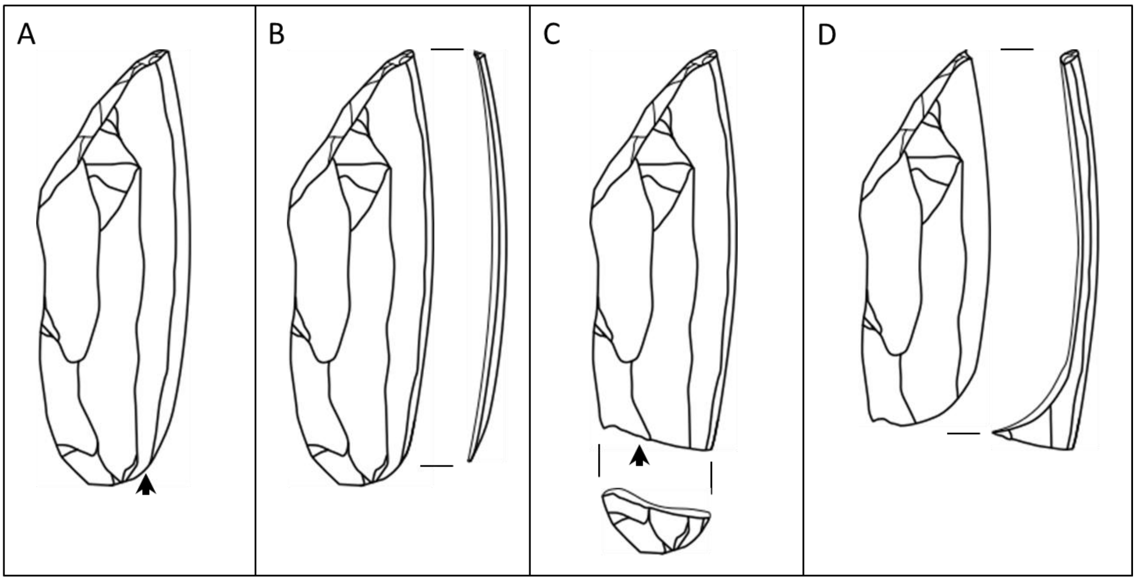

Figure 148. Schematic of intentional curvature

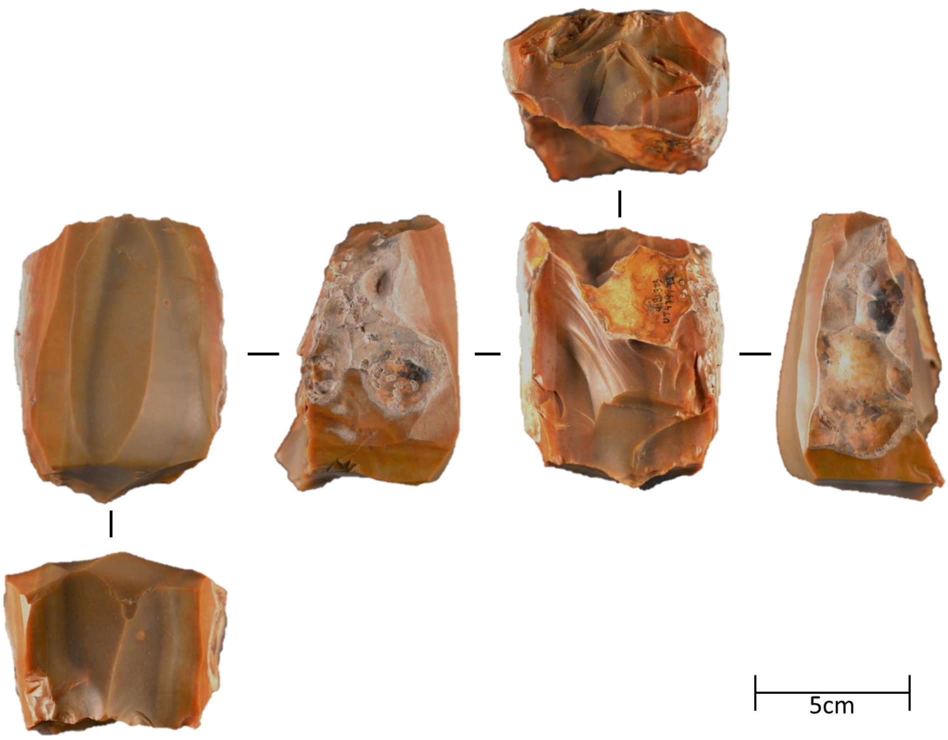

Figure 149. Blade core 4799-45 from the Gault site. Core base exhibits intentional flaking to produce curved blades

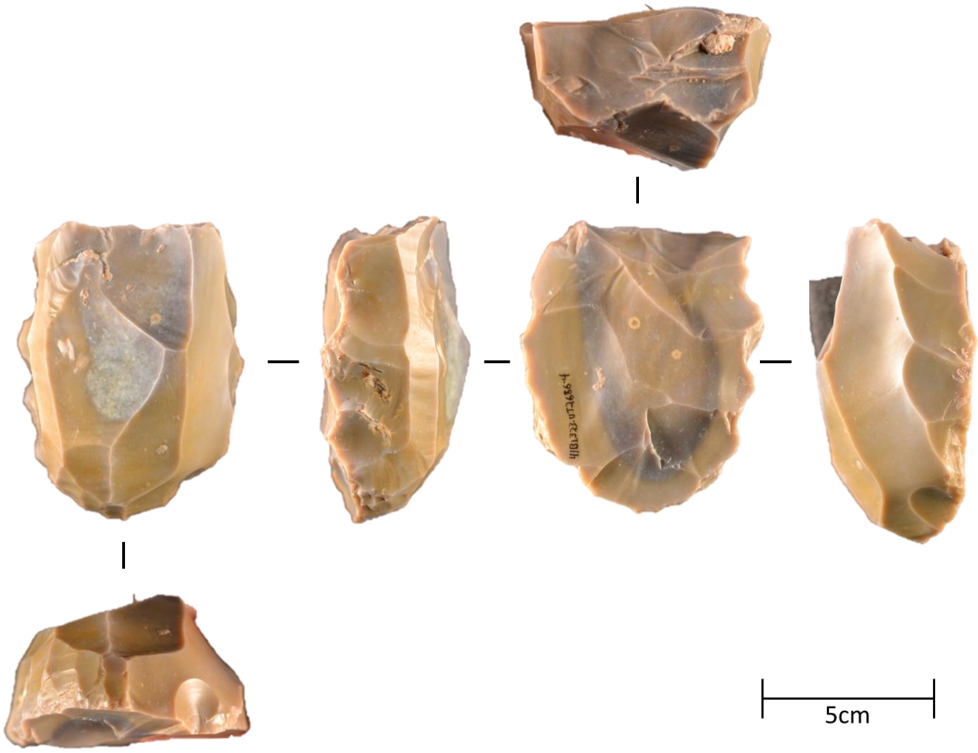

Figure 150. Blade core 2686-4 from the Gault site. Core base exhibits plunging blade termination after flaking produced a flat distal margin.

As discussed, one conical core was recorded from the Solutrean, recovered from excavations at Les Maitreaux (Stanford & Bradley, 2012). Clovis blade technology was distinctive for its use of two core types, both Type II A-1 and Type II C-1 (Collins, 1999; Bradley et al., 2010). The major difference in these cores is the platform angle and the use of the entire circumference of the core in conical pieces. At Pavo Real, where a number of early stage blade cores exist, the blade cores could have been shaped further into either Type II A-1 or Type II C-1. While recognised as Type II C-1 cores (Collins et al., 2003), at least two of the Pavo Real cores retain slightly squared margins. These would have allowed the knapper to flake across the core creating a flat back and an acute platform angle. The most intriguing feature of these cores was the lack of negative bulbs in the blade scars. The lack of negative bulb scars indicates the removal of core tablets just prior to core discard. The removal of a preparation flake as the last action before discard presents an anomaly; if the core was being prepared for subsequent removals, why was it discarded? This remains unclear and beyond the scope of this research. Ultimately, the manufacture of Type II C-1 cores during Clovis distinguishes it from Solutrean technologies.

One final distinguishing characteristic is the use of the final product, the blades themselves. The Solutrean blades served as blanks for the production of projectile points. In Clovis, scrapers on blades, serrated (denticulated) blades and gravers are present (Shoberg, 2010; Smallwood, 2013; Eren et al., 2013a). However, only two (one from Gault, one from Pavo Real) narrow unifacial pieces that may have served as projectile points have been recovered. With only two of these items, the production of projectile points followed an alternate reduction strategy based on bifacial reduction of cores or flakes. This final point represents only a small feature in the use of blades for producing projectile points. And both Solutrean and Clovis used these blades as the basis for other tools, including scrapers and gravers (*see* Smith 1962; Demars 1995; Bradley et al. 2010; Shoberg 2010; Smallwood 2013; Eren et al. 2013).

Summary

It is clear from the data that the blade technologies of Clovis and Solutrean share a number of common traits. This includes the use of flat backed, acute angled cores as well as a common approach to preparation and maintenance. However, differences in the use of curvature, Type II C-1 cores and the use of the end products distinguish Clovis blade technology from Solutrean blade technology.

Chapter 17

Discussion and Conclusions

Clovis and Solutrean Blade Technologies

Stanford and Bradley (2002; 2004; Bradley & Stanford 2006; 2012) have presented numerous quantitative and qualitative comparisons between Solutrean and Clovis technologies. Their detailed analyses of Solutrean and Clovis bifacial technology found that both technologies share similar flaking techniques, similar uses of intentional overshot technology and similar uses of invasive pressure retouch. According to Stanford and Bradley (2012), the major difference between these two bifacial technologies was the final product. Solutreans produced bi-pointed, leaf-shaped bifaces, while Clovis produced narrow, concave, basally thinned (fluted) points. As discussed in the previous chapter, a similar difference was observed in their blade manufacturing technologies between the manufacturing and end products. This chapter focuses specifically on the assertion by Stanford and Bradley (2002; 2004; Bradley & Stanford 2006; 2012) that the ancestors of Clovis may have been derived from a Solutrean population. Specifically, this chapter focuses on direct comparisons between the two technologies. As discussed early, the hypothesis itself requires the presence of Older than Clovis assemblages that retain the technology left behind by the founding group of Solutreans. This connection, in terms of the blade technologies, is subsequently discussed in the wider context of this research.

Production Technologies

From initial core production to blade production and core maintenance, Solutrean and Clovis industries used a shared set of techniques. Both Solutrean and Clovis industries intentionally flattened the backs of cores (Figure 151), both created and maintained an acute platform angle for blade removals, and both occasionally used an opposed striking platform for the removal of errors. In a wider context, the Solutrean manufacturing industry features a number of key characteristics (e.g. blade production using flat backed cores, biface reduction using full-face and overshot percussion flaking, invasive pressure retouch, point styles using concave bases, and invasive basal thinning (“fluting”) as a means of removing the bulb) that are the foundation of Clovis technology. During the Solutrean they do not appear within the same reduction sequences as they do in Clovis.

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Figure 151. Comparison of Clovis (A-C) and Solutrean (D-E) blade cores. Clovis Type II A-1 cores; A-B from the Gault site, C from Carson-Conn-Short after Stanford et al. (2006). Solutrean Type IV A-2 (D) and Type II A-1 cores after Renard (2002).

As noted above, Solutrean biface manufacturing techniques were used for the creation of bi-pointed laurel leaf points (a separate industry from the blade production), while the blade technology was used to produce blanks. These blanks were then re-worked and reduced to create *pointes à face plan* in the Lower Solutrean and *pointes à cran* in the Middle and Upper Solutrean. The reworking of these blanks also included the formation of concave base points, mainly in Spain (Schmidt, 2013) and the use of basal thinning (Renard, 2011).

The use of concave based points was identified in both the Spanish and French Solutrean (Schmidt, 2013). Technologically, these points were produced on blade blanks, as is evidenced by the curvature of some of these tools. Scars on their bases also showed evidence for basal thinning. Basal thinning was a technique that appears in the proto-Solutrean assemblages associated with Vale Comprido points (Zilhão & Aubry, 1995; Renard, 2011). This technique was also present in the Early Solutrean (Renard, 2011), and was used to remove the negative bulb from blades. Both the concave base style and the use of basal thinning are associated with hafting.

Importantly, these techniques are not the only defining traits of the Solutrean and are not found across the entire range of the Solutrean culture. Thus, the technological ingredients for Clovis blades were present in the Solutrean, but not the recipe. More specifically, if Clovis technology is rooted in the Solutrean, it represents an amalgamation of techniques that were spread across the entire Solutrean range, both temporally and spatially.

There are also a few differences in the types of blades produced and in how these blades were subsequently used. Clovis blades tended to be heavily curved, and Type II A-1 blade cores were intentionally prepared to produce these heavily curved blades. To effectively produce these blades; Clovis knappers followed a reduction sequence that involved the use of full or partial cresting, the production of heavily worked strong platforms and the flaking of the base of the core in order to produce plunging blades. In contrast to this, Solutrean cores were designed to retain a small degree of convexity, which was maintained throughout the reduction sequence, to produce straighter blades. This is because a convex face is more likely than a straight face to produce feathered, straight terminations as opposed to hinged terminations. Solutrean blade blanks also appear to have been used for the creation of specific point types, while Clovis points were manufactured using a separate technology.

This evidence highlights that Clovis and Solutrean reduction sequences followed the same set of manufacturing techniques. However, it also highlights that they diverged on the intentionality of production in terms of curved blades. Thus, this research supports Stanford and Bradley's (2002; 2004; Bradley & Stanford 2006; 2012) assertions that the two technologies followed the same reduction sequence but it provides the amendment that the two technologies were not used in the same way in terms of specific/desired blade production.

With such a wide variation in the manufacturing techniques of the Solutrean, it is possible that Clovis merely fits within this range. If so, then Clovis blade technology did not represent a continuum, but simply a convergence. However, the Solutrean culture itself provides a final piece of evidence that indicates its possible ancestry to the Clovis culture. Numerous authors have detailed the regional differences within the Solutrean (Smith, 1966; Straus, 1977; Plisson & Geneste, 1989; Zilhão & Aubry, 1995; Banks et al., 2009; Renard, 2011; Cascalheira et al., 2013). In her synopsis of the Solutrean, Renard (2011) concluded that the Upper Solutrean shows:

> "A phenomenon of regionalization that is most strongly expressed in the presence of distinct lithic point types in different regional contexts. This gives an image of more regionally divided societies, which would have developed specific point types while at the same time maintaining social relations with other groups, as is attested by the diffusion of some technical ideas over long distances" (Renard, 2011)

This conclusion provides further evidence for the amalgamation of Solutrean manufacturing techniques present in Clovis. Renard's (2011) conclusion, which is attested to by the variety of point styles present in the Solutrean, indicates that while this period is defined by an adherence to a unified technological system of manufacture, culture is not. Instead, cultural manifestations of the Solutrean operated in a more fluid and dynamic system, whereby the same technological package existed, but regional groups determined what aspects of this package were used. In essence, group identities were established only during the final stages of production. These identities were then tied to a wider cultural unit based on the shared use of this distinctive technological package. Operating under this cultural paradigm, Clovis could be considered a later, regional manifestation of the Solutrean.

Overall, these results highlight the importance of technological analyses. Typological trends in finished products of a reduction strategy are frequently used as evidence for cultural associations or as distinguishing traits to separate out two groups; however, finished products only represent one stage of the entire *chaîne opératoire*. The method of manufacture and the techniques and reduction practices used help provide a larger and more detailed perspective on the material culture. Therefore, points that look typologically alike may be separated on technological grounds or vice versa.

Theoretical Models of Culture

Clarke's (1968) theoretical work on the establishment of culture and the hierarchical construction of cultural relationships provides another method for assessing the similarities present. The foundation of this cultural hierarchical model lies in the typological attributes of artefacts within an assemblage. These attributes are culturally distinctive and can be further broken down by specific type states and type families. Comparisons based on the occurrence of shared specific type states or type families can then inform cultural connections between assemblages, groups and even cultures themselves.

However, both type states and type families exhibit purely typological constraints, thus limiting the scope of this theory. Technology and the specific nature of the reduction processes represent a systematic practice that influences both type states and type families. If the attributes of technology were incorporated into Clarke's model, certain aspects (i.e. pressure retouch) would fit into the type state while others (i.e. reduction processes, such as blade production or biface manufacture) would fit into the type family category. This theoretical system places culture at the peak of the hierarchy.

Beyond these, Clarke (1968) identified two further entities: the culture group and the technocomplex. Put simply, groups of cultures can be linked based on a range of shared general characteristics; but these shared characteristics are not essential for group membership, and are shared due to a linked response to common environmental stimuli. These culture groups also share a past trajectory. However, a technocomplex requires no prior relationship between two cultures, and represents a convergence of ideas. Clarke (1968) states that this convergence can be based on acculturation, inter-group communication, or shared responses to the environment.

The shared technological attributes of Clovis and Solutrean cultures would, based on Clarke's model, fit the technocomplex model based on the first criterion. There is a shared range of cultural characteristics. However, as Bradley and Collins (2013) state, Clovis is found across a range of differing climatic regions. Furthermore, Clovis has little to no past trajectory in terms of a blade technology. To date only the Gault Site has provided any clear evidence of a direct past trajectory leading to Clovis in terms of an OTC assemblage. However, due to possible geologic disturbances, this remains a preliminary assumption.

The shared traits identified from the Solutrean and Clovis technologies also appear to transcend the general characteristics identified by Clarke, as specific traits are present in both technologies. From this perspective, while Clovis and Solutrean fit the technocomplex model, there are more complex connections between the two that are not explained by this entity. Instead, they are explained via Clarke's culture group. This entity essentially combines two cultures based on a high level of shared affinities in the sets of type families. This entity represents the connections between Clovis and Solutrean technology more accurately than the technocomplex. There is a moderate to high level of specific type states (e.g. the end products) (Stanford & Bradley, 2012, p.160) (chapter 4), combined with a high level of affinity in terms of the production and manufacturing techniques present in both reduction sequences.

According to Clarke (1968), culture groups act as a network that offers channels of information, linking a largely congruent sociocultural system. This network is generally spread over wide geographic ranges, but contact can occur. This concept does not fit with the proposed model of the Solutrean crossing the Atlantic as there is a chronological gap. This highlights a further question raised by Stanford and Bradley: would researchers have any doubts about the origins of Clovis in the Solutrean, if the Solutrean technologies were found in Beringia. As such, the technologies certainly cannot be ascribed under the entity of culture. Despite the fact that numerous traits concur with the established criteria for culture, including shared specific artefact types (e.g. projectile points, endscrapers, gravers, bone rods, etc.) and a comprehensive selection of types from the material sphere (e.g. chert, bone, antler); Clovis and the Solutrean lack the clearly defined, limited and continuous geographical area stipulated by Clarke. However, recent modelling of the ice sheets during the LGM, indicates the presence of drift ice all the way down to the Iberian Peninsula (Roberts et al., 2014; Löfverström et al., 2014). While this may not indicate a clearly defined or continuous landmass, it does provide the route for a small group of Solutreans to reach North America.

Thus, cultural similarities between Clovis and Solutrean fit into Clarke's model somewhere between the culture group and the technocomplex. Both technologies share more than just the general characteristics associated with a technocomplex, but due to the temporal gap between the two they cannot be considered as a cultural network. This highlights two possible scenarios under which these similarities may have arisen. In the first scenario, these industries reflect similar responses to environmental conditions. In the second scenario, Clovis represents the furthest extent of an extended Solutrean culture group. As such, a small group of Solutreans would have carried their technology to North

America; however, it was short lived, leaving behind Solutrean technology on the shores of North America, but perhaps not their associated socio-economic systems. In order to fully explore and assess the concepts of convergence and recursion as relating to this research, it is appropriate to place Clovis and Solutrean technology in its wider context. This is presented in the next chapter.

Wider Context

The previous section presented two possible scenarios to explain the similarities between Clovis and Solutrean technologies. The first scenario ascribed these similarities and the almost identical nature of the blade manufacturing to the theoretical constructs of convergence and recursion. The second scenario placed Clovis within the technological continuum of the Solutrean. These are not presented as a model, but rather the two most likely scenarios that may explain the similarities in technology between Clovis and the Solutrean. This chapter assesses these scenarios and places them within the wider context of Clovis and Solutrean blade manufacture, and discusses the implications of a connection between the two.

Technological trait comparisons

A summary of the technological traits identified in both the literature review and in the data analysis is presented in Table 52. This table highlights the fact that the same production traits are present in both Clovis and the Solutrean. The Asian microblade traditions and the Dyuktai industries also share a number of common traits, diverging in platform use and directionality. These two traits represent a subtle change in the way the core is used to produce blades, but on the whole, both technologies begin production with bifacial precores and this bifacial morphology is maintained through to discard. This is crucial to identifying Clovis origins since the traits present in the far northeast of Russia in those regions considered as part of Beringia were different from those recognised in Clovis production. As such, the technologies of Beringia would have to undergo substantial technological changes in the production sequence to resemble Clovis. To date, no evidence for this technological transformation has been recovered from any archaeological sites in North America. The blade production of the Nenana industry has been identified as a possible Clovis progenitor (Goebel et al., 1991) despite the pericontemporaneous nature of these sites (Stanford & Bradley, 2012). Table 52 indicates the use of direct percussion on flat backed cores and unidirectional removals. While these traits fit within the range of Clovis, the flat backs are cortical and appear to represent an expedient method of production rather than the organised sequence of blade removals present in Clovis.

Table 52. Technological trait comparisons between blade industries discussed in this thesis

	Flaking Technique	Platforms (Core type)	Morphological Use	Flaking Trajectory	Core back morphology	Size Category
Proto-Aurignacian	Direct percussion	Single plain platforms	Frontal	Unidirectional	Flat	Bladelet
Aurignacian	Direct percussion	Single plain platforms	Frontal	Unidirectional	Flat	Blade
Gravettian	Direct percussion	Single faceted platforms	Frontal	Bidirectional	Biface	Blade
Solutrean	Direct percussion	Single or double faceted platforms	Facial or Full Circumferential	Unidirectional or Asymmetrical	Flat	Blade
Magdalenian	Direct percussion	Single or double faceted platforms	Frontal or Semi-Circumferential	Unidirectional, Bidirectional, or, Asymmetrical	Biface	Blade and Bladelet
Russian Gravettian	Direct percussion	Single or double faceted platforms	Frontal or Facial	Unidirectional, Bidirectional, Asymmetrical, or Multidirectional	Flat	Blade and Bladelet
Asia Non-levallois	Direct percussion	Single or double faceted platforms or expedient	Frontal or Facial	Unidirectional, Bidirectional, or, Asymmetrical	Flat	Blade
Asia Microblade	Pressure	Double plain platform	Frontal or Semi-Circumferential	Unidirectional, or Bidirectional,	Biface	Microblade
Dyuktai	Pressure	Single or double plain platforms	Frontal or Semi-Circumferential	Unidirectional	Biface	Microblade
Nenana	Direct percussion	Expedient	Facial	Unidirectional	Flat	Blade and Bladelet
OTC Gault	Direct percussion	Single or double faceted platforms	Facial	Unidirectional or Asymmetrical	Flat	Blade
OTC Atlantic Seaboard	Direct percussion	Expedient	Facial or Full Circumferential	Unidirectional	Biface	Bladelet
Clovis	Direct percussion	Single or double faceted platforms	Facial or Full Circumferential	Unidirectional or Asymmetrical	Flat	Blade

As with the microblade industries, Nenana would need to undergo significant changes in its production scheme and this would be archaeologically visible. With a lack of clear evidence supporting technological change to Clovis, and no similarities in the technological traits, the scenarios presented above and in the previous chapter provide the most probably explanations for the origins of Clovis technology.

Scenario 1: Convergence

Convergence and recursion are theoretical concepts relating to the influence that the environment has on human creativity and the influence that human creativity has on the environment. When applied to the archaeological record, they are useful concepts for understanding past human behavior.

Clarke's (1968) "technocomplex" was an entity that could link two separate cultures based on shared type-families. Clarke's type-families shared a similar pathway, responding to similar environmental stimuli. Along this pathway, their technology was developed through need and experimentation. This pathway toward development represented a group's past cultural trajectory.

The concept of a past cultural trajectory is difficult to establish for Clovis. The major issue surrounding this is the lack of early dates for an ancestral assemblage to Clovis. Further, modern research continues to place Clovis origins in Beringia and Asia (Rasmussen et al., 2014), ignoring the archaeological evidence of Clovis technology. The industries in Beringia are rooted in the pressure flaked microblade cores of Asia or represent an expedient production. These methods of production bear no similarities to the direct percussion macroblade techniques of Clovis.

Recursion is based on the conceptual abilities of humans. It implies that there are only a certain number of ways in which the human mind can conceive its creative potential. Following this logic, themes and designs will regularly recur in the archaeological record, thus creating examples of convergence. In this respect, convergence can occur without a clear past trajectory; but it is highly unlikely that a complex technology (i.e. Clovis) would appear in the archaeological record without a developmental history.

The concept of convergence can be linked to the idea that raw material quality influences the final product. Specifically, the constraints of the raw material (e.g. quality, weathering, size and flakeability) will affect the manufacturing process. This theoretical concept does not hold up to close scrutiny. While there are examples of differences in end products, the manufacturing process and the techniques within the technology are generally not altered; rather, restrictions in raw material would hinder the full use of the technological repertoire. Eren et al. (2014) demonstrated this in their analysis of handaxe production using different raw materials, and suggested that raw material quality should not be assumed as a constraint on a reduction sequence.

If convergence was the cause of the similarities between Clovis and Solutrean, then there should be other archaeological examples of their specific form of blade technology. This is not the case. Examples of flat backed cores have been found in Middle Palaeolithic blade assemblages in Africa (Soriano et al., 2007) and Russian Upper Palaeolithic assemblages (Bradley & Giria, 1998; Vishnyatsky & Nehoroshev, 2004; Gladyshev et al., 2012; Zwyns et al., 2014); however, the methods of pre-core formation, platform preparation and use, blade face utilisation and error correction are different.

Convergence also places an emphasis on shared environmental constraints. Specifically, two technologies can appear similar due to a shared environmental response. This is not the case for Clovis and Solutrean. The Solutrean technology was present during a period of global cooling, and while data from Laugerie Haute indicates changes in the faunal record (Delpech, 2012), the Solutrean was a cold climate adapted technology (Renard, 2002). Conversely, Clovis technology has been found in a number of different environments (Bradley & Collins, 2013). Thus, Clovis and Solutrean do not represent a shared response to a similar climate.

Based on the current data, there is no evidence to uphold the theory that the volume of similarities shared between Clovis and the Solutrean were a result of convergence or recursion. Clovis and Solutrean similarities transcend general typologies. They reflect an almost identical manufacturing process, based on shared technique traits, and represent a shared technological repertoire. Furthermore, they do not appear to represent a shared response to environmental factors, as the Solutrean occurred during much of the LGM, while Clovis occurred mainly during the Younger Dryas.

Scenario 2: Technological Continuum

Evidence concerning the past trajectory of Clovis, specifically the chronological gap between Clovis and the Solutrean, is emerging as research in

North America identifies sites that pre-date the earliest known manifestations of Clovis. These early sites demonstrate that the nature and timing of the first peoples into North America was not the result of one single migration. Instead, as Collins et al. (2013) identify, there are seven occupational and migrational patterns, two of which are directly relevant to the theory of the Solutrean-Clovis technological continuum.

The first migratory pattern comes from the northeastern United States along the Atlantic Seaboard, and includes large, thin, bi-pointed bifaces and evidence for some blade production. The second migratory pattern comes from sites with narrow, thick bifaces, without a blade technology, found along the Pacific coast. The assemblages from the Atlantic Seaboard contain bifacial material with traits associated with both Clovis and the Solutrean; and, these assemblages fill the chronological gap (Stanford & Bradley, 2012).

While Clovis bifacial points retain technological traits associated with the Solutrean, there is as yet, no strong evidence that blade manufacturing technology was continued from the Solutrean to Clovis. The blade technologies present on the Atlantic Seaboard feature small, possibly expedient cores. However, the blade from Parson's Island does indicate the use of precore preparation, possibly from one lateral margin to the front of the core. Thus no solid conclusions can be reached regarding the nature of blade production in the United States before Clovis.

The exception to this comes from the Gault site, where the blade technology found below the Clovis layers feature Type II A-1 (single faceted platform, with unidirectional facial flaking) cores that have the same technological traits as the Clovis blade technology. This finding does demonstrate a clear technological continuation from the older than Clovis (OTC) stratigraphic layers to Clovis. Current dating from these OTC layers has yielded dates between 14,000 and 13,000 BP (Collins, pers. comm. 2014). However, with unresolved issues surrounding a possible geologic disturbance, this remains a preliminary assumption.

As highlighted above, archaeological investigations in Mongolia and parts of China have identified the presence of a macroblade industry, dating between 40,000 and 25,000 calBP (Derevianko et al., 2000, 2004; Gladyshev et al., 2012; Pei et al., 2012; Li et al., 2013; Boëda et al., 2013). Though it is possible that the origin of Clovis was rooted in these technologies, the chronological gap is far greater than the one between Clovis and the Solutrean. Furthermore, there is an established trajectory toward microblade cores with a pressure technique for blade detachment in the far northeast of Asia, at the gates of Beringia.

On close examination, there is no evidence in Beringia or Asia for a possible ancestor to Clovis. Furthermore, the complexity of Clovis technology would require a significant amount of time to develop. This may have occurred in one of two ways. Patten (2005) identified the concept of incremental innovation. Once a group evolved, its technology remained stable. Change did not occur by discarding old principles. Based on the development of the Solutrean blade industries, the development of Clovis could require as many as 1,000 or 2,000 years.

In contrast to this incremental development, Bradley and Collins (2013) suggest the possibility that Clovis represented a revitalisation movement that responded to the stress of acute sea-level rise and the loss of highly productive littoral habitats by around 13,500 BP. Furthermore, they place the origin of Clovis along the southern areas of the Eastern seaboard (Bradley & Collins, 2013, p.252). While the idea of a revitalisation movement may explain the rapid spread of Clovis, it does not indicate how the technology developed. However, If Clovis is rooted in the technology of the Solutrean, then it would have already developed prior to its arrival on the Eastern seaboard and hence exhibit the complex manufacturing processes evident.

Crucially, the pericontemporaneous dates from Beringia do not support the spread of Clovis across North America via this route. Many of the dates from those sites with assemblages older than Clovis, including Monte Verde, Meadowcroft, Cactus Hill, Paisley Caves, and the Gault site, indicate the presence of humans in North America prior to 13,000 BP. This time span would place the origins of Clovis during the coldest phases of the LGM, with no ice-free corridor. Further, there is no evidence from the Pacific coast for an early blade technology.

During Clovis, the thin, wide platforms of the blades were almost identical to the platforms present on the bifacial production flakes. Faceting, isolating, reducing, releasing and grinding were all used in the same manner to produce a strong platform. This link between Clovis blade manufacturing technology and Clovis bifacial production technology suggests that blade production may have been derived from some of the same manufacturing techniques of bifacial production. However, for this technology to arise, it would require the presence of both bifacial thinning and macroblade technologies that utilised the same forms of percussion and the same need for platform preparation. Both of these technologies and shared production methods were present in the Solutrean; however, to date no detailed platform analysis exists on the bifaces. Middle Solutrean blade platform preparation was almost identical to Clovis, while Upper Solutrean blade platforms were heavily isolated to produce a more noticeable peak, if not fully spurred. If the biface flakes exhibited similar preparation and share similar platform types then this would provide a further example of how similar the technologies of Clovis and Solutrean are.

The OTC record shows that blade production was a component of the technological toolkit in the eastern United States. Assemblages from OTC sites demonstrate the use of expedient production methods. Again, the blade from Parson's Island hints at the use of precore formation and it is possible that raw material availability may, in some cases, have affected their ability to use the full repertoire of manufacturing techniques. Possibly, the knowledge of blade production was carried across to the New World, but was not utilised to its full extent until the population found a source of suitable raw material. However, due to the small sample sizes and the nature of these upland sites, it is possible that the evidence for blade manufacture has not yet been recovered.

Ultimately, given the lack of clear evidence for an OTC blade production strategy that incorporated the techniques of the Solutrean, it is impossible to take this concept any further. However, it is clear from the data that the technologies of Clovis and Solutrean blade production were virtually identical. This confirms the assertions of Stanford and Bradley with the amendment that the Clovis specifically aimed to produce curved blades but did not use blades to produce projectile points.

Discussion

As discussed, to date there is no known past trajectory of Clovis blade production. What remains unknown is whether or not a past trajectory is present, or if blade production simply appeared in its established form.

This past trajectory is crucial to the hypothesis developed by Stanford and Bradley (2002; 2004; Bradley & Stanford 2006; 2012) as the temporal gap between Solutrean and Clovis requires the presence of a similar technology in the older than Clovis assemblages.

Due to the chronological and geographical gaps that still exist between the Solutrean and Clovis, convergence and recursion cannot be ruled out completely as explanations for their shared technological traits. As discussed, it is possible that Clovis blade technology developed out of a basic method of working the available raw material. As such, the flat-backed nature of these cores would have been dependent on the material alone. However, if this was the case it would be expected in other areas, and to date, only the Solutrean exhibits the same use of a flat backed core.

There are no documented cases of convergence between two complex technologies appearing in the archaeological record without a past trajectory. Thus, for convergence to become a valid explanation there should be an older form of the technology present in the record, containing aspects of Clovis blade production. This technology should share a geographical range with Clovis and be chronologically older. This past trajectory is important for drawing any positive connections between Clovis and the Solutrean. There is no evidence in the current data from Beringia that indicates any aspects of Clovis manufacturing technology were present. Thus, for the Asian pressure blade technologies to have altered to converge with Solutrean, a wholesale change in the methods of manufacture and morphological use of the core would be required.

A proxy for this wholesale change is present in the Mesolithic of Ireland. Costa et al. (2005) discuss the complete technological shift from soft-hammer microlith production during the Early Mesolithic, to hard-hammer macrolith production during the Late Mesolithic. However, this shift occurs in the same geographic location. Furthermore, Costa et al. (2005) concluded that the change in technology was due to a response by the existing population to changes in the climate and environment. As Clovis is present in numerous different climates and environments then the use of the technology cannot represent an environmental adaptation.

In the United States, there is no evidence for microblade pressure precores present before the advent of Clovis. This concept of a wholesale change in technology may be strengthened through the analysis of spatial gradients (e.g. patterning in the dates that indicate a directional migration route). If Clovis manifested through a complete change in the material from Beringia, it would have spread from the northwest. As discussed in chapter 3, there are differing arguments concerning the spatial gradients of Clovis. Hamilton and Buchanan (2007) identified a northwest to southeast pattern while Stanford and Bradley (2012) suggested a westward expansion. Due to the nature of statistical analysis, it is possible that the westward pattern identified by Hamilton and Buchanan (2007) is the result of the statistical processing rather than a real world pattern. Therefore, it remains unclear if a genuine pattern exists in the dispersal of Clovis.

In summary, the almost identical nature of Clovis and Solutrean blade production sequences indicates that the origins of Clovis could be rooted in the technology of the Solutrean. Furthermore, no other viable candidate for the origin of Clovis blade technology exists. There is a lack of undisputable hard evidence, such as a laurel leaf or blade core manufactured on French flint found in undisturbed older than Clovis deposits in the United States.

This highlights the limitations of the current study: no single line of evidence, in this case technology, can be used to accept or reject the Clovis-Solutrean hypothesis in its entirety.

Theoretical considerations

As discussed in chapter 6, Petrie (2011, p.155) identifies the construction of culture as it relates to innovation and interaction, and states that innovation is a complex phenomenon which requires attention to detail in both the small and large scale processes. If material culture is accepted as a marker of culture, Petrie (2011, p.175) argues that it becomes straightforward to understand the relationships between material culture and social boundaries. In essence, this is what is defined by the Solutrean-Clovis hypothesis, the possibility of a social boundary. It is also possible to trace the spread of a culture based on the material culture through time and space (Bellwood et al., 2011, p.321). In a study of the migration of Austronesian languages and material culture in Taiwan and the Philippines from 2500 BC onwards, Bellwood et al. (2011, p.347) concluded that material culture can be transmitted through time and space with relatively high degrees of correlation. As such, the archaeological record can be a powerful witness to pinpointing the setting and timing of migration events (Bellwood et al., 2011, p.347). These ideas can be applied to the Clovis-

Solutrean hypothesis. The material culture and the large numbers of similarities that transcend simple appearances highlight the possibility of a connection between Clovis and the Solutrean. While archaeologists should always strive to utilise the hard sciences, such as dating and genetic analysis, it should not be to the detriment of the archaeological material, and the anthropological and sociological evidence that serve as indicators of past cultural migrations.

Further Considerations

In a recent article, researchers studied the genetic material of the Anzick burial (Rasmussen et al., 2014). The possible burial was of a possibly Clovis age, which may have been associated with Clovis material, yielded genetic evidence that matched the ancient populations of Asia and North America to some, especially South American, modern Native American populations (Rasmussen et al., 2014). This evidence was claimed to refute the hypothesis of Stanford and Bradley. While this new evidence has been used to support the concept of Clovis technology arriving in the New World from Beringia, it is problematic at best.

In their re-evaluation of the date range for Clovis, Waters and Stafford (2007a) assessed 12 dates relating to the Anzick bone fragments. The supporting material for their article indicates that out of the 12 dates obtained, 6 were rejected and the remaining 6 were labelled as “Clovis?” [sic *punctuation theirs]* (Waters & Stafford, 2007b). The date that they deem most reliable is 12,698 ± 42 calBP (10,705 ± 35 ^{14}C BP) (2007b) which falls at the very end of the range for Clovis, which they state is between ~13,000 and 12,700 calBP (11,050 and 10,800 ^{14}C BP) (2007a).

While this article is cited in the 2014 paper, the youngest date for Clovis is now placed at ~12,600 calBP (10,700 ^{14}C BP) with no explanation for this divergence from the original article. Therefore, while the genetic study provides a link to Asia, the evidence places the Anzick burial towards the latter/terminal Clovis period. As such, it provides no evidence for the origins of Clovis. It does however, indicate that one of the migration routes into the New World did indeed come from northeastern Asia, and once the ice sheets retreated after the LGM, it is highly likely that this remained the only viable route until the advent of boats capable of open sea travel.

Finally, following the arrival of Clovis in North America, much of the country appears to have undergone a cultural transformation, uniting many existing populations under the banner of Clovis. As discussed, this was recently explored in terms of a revitalisation movement (Bradley & Collins, 2013). While this self-titled "think piece" was not intended to provide an explicit interpretation, it is worth consideration. Bradley and Collins hypothesised that Clovis represented a social movement, incorporating the existing and related groups (Bradley & Collins, 2013). This explanation can only be explored by continued research, and as Bradley and Collins (2013) state, by incorporating a humanistic approach, where people become the active agents. Past hunter-gatherer societies can be far more complex than they are given credit for.

Summary

The wider aspect of this research deals with how blade technologies are studied and the influences technological analysis can have on research. By applying a technological framework to understanding culture, it is possible to draw links between cultures. While further testing of the entire hypothesis is required, it appears that the study of blade technologies and their manufacturing processes can have a positive impact on understanding the nature of the dispersal of modern humans. By following technologically specific traits, it is possible to trace the dispersal of ideas around the globe.

Technological analyses provides evidence for the earliest emergence of blade production in South Africa (Soriano et al., 2007; Wilkins & Chazan, 2012) and the Middle East around 400,000 to 200,000 BP (Shimelmitz et al., 2011). The Aurignacian industry appears to have split, with one development moving into Europe and another into modern day China and India (Kuhn, 2002; Otte, 2004; Shipton et al., 2012). By using technology, it is possible to track the emergence of the Gravettian in Europe (Floss & Kieselbach, 2004) and its roots from Europe back into Russia (Vishnyatsky & Nehoroshev, 2004). The Solutrean likely emerged out of Africa via Spain and Portugal (Renard, 2011), but may have also stemmed from the Szeletian and Streletskyan bifacial technologies (Bradley et al., 1995) and from the Blattspitzen bifaces (Roche, 1964). It is of particular interest that all forms of bifacial manufacture disappear from Northern Europe with the end Solutrean culture (Darmark, 2012). The Magdalenian appears to be rooted in the Eastern European technologies that developed out of the Gravettian (Otte, 2012) and the proto-Magdalenian identified at Laugerie Haute (Bordes, 1978) .

Bifacial technology does not reappear in the blade dominant cultures of Europe until the Neolithic, and has a plausible route along with the migration of the Beaker people into Europe via Russia (Sørensen et al., 2013). Thus, by tracing technology, it is possible to understand the nature of blade technology during the LGM: flat-backed macroblade cores and bifacial thinning technology on the shores of Western Europe and small microblade cores with intentionally thickened bifacial technology on the Eastern shores of China and Siberia.

There is a lack of evidence from Beringia to support the notion of a Clovis ancestor. Further, the technology of Asia represents a fundamentally different approach to blade production. There is no evidence for the development of a cultural trajectory that could lead to Clovis.

The overlap between the techniques of the Solutrean and Clovis production schemes make the Solutrean the most viable candidate for a Clovis ancestor. While the chronological gap between Solutrean and Clovis bifacial production has been effectively closed, the chronological gap between Solutrean and Clovis blade manufacturing remains enigmatic. Only the continued identification and study of potential OTC assemblages may reveal an answer to this enigma.

Finally it is worth noting that if, as archaeological research continues, the Clovis-Solutrean hypothesis becomes invalid; the convergence between these two technologies would represent the only example of the independent development of two deep, technologically complex industries. As such, the number of shared techniques of manufacturing and production should be explored in relation to human behaviour and technological evolution, adaptation and innovation.

The evidence presented in this thesis supports Stanford and Bradley's claim that Clovis and Solutrean blade manufacturing sequences are "virtually identical". However, the two technologies diverge during the production sequence where Solutrean favoured the production of straight blades, while Clovis intentionally altered the distal core margin to produce curved blades.

The analysis also demonstrates that a cultural connection between the two is possible. Further archaeological enquiry is a necessity before the hypothesis, in its entirety, can be fully assessed.

Conclusion

It is clear from the evidence that the null hypothesis must be rejected as there is no evidence to support a correlation between the blade industries of Asia, Beringia and North America. Thus, the alternate hypothesis is accepted. This hypothesis states that major similarities in the blade technologies between the Solutrean and Clovis indicate a positive link between the two. While convergence cannot be completely ruled out, there is a lack of evidence that would explain the number of similarities. Thus it remains highly likely that interaction across the ice-edge corridor of the Atlantic may have occurred during the LGM.

The similarities between the *chaîne opératoire* and reduction sequences of both industries indicate a shared knapping tradition, while some differences in formal tool types may represent a shift in the priorities of a group as it reached North America. Furthermore, the differences in the environment during Clovis (Younger Dryas) and Solutrean (Glacial Maximum) indicates that the similarities cannot be the results of a shared response to climatic conditions.

This supports the assertion of Stanford and Bradley that the blade technology was virtually identical. However their original statement must be amended. The technology of Clovis and Solutrean is almost identical; however, the end products, and thus those blades considered desirable during manufacture, are different. The intentionality for these differing end products is maintained to a certain degree through the reduction processes.

The data demonstrates that there was no ancestral technology in the archaeological record of Asia or Beringia from which Clovis is likely to have developed. In contrast, the Solutrean culture contains both the specific blade production techniques found in Clovis and a dynamic socio-cultural system where group identity was expressed through the production of individual point/blade styles but followed a universal reduction process.

With the increasing number of thinned bifacial laurel-leaf points and smaller bifacial projectile points being recovered along the Atlantic Seaboard, the chronological gap between the Solutrean and Clovis industries has disappeared. Today, there remains only a geographical discontinuity. The blade technologies do not fit this pattern. There are hints of precore formation from the side or back of a core present on the blade from Parson's Island, but this remains inconclusive.

The blade industries associated with these early North American assemblages have no defining technological traits. They have more in common with expedient blade technologies rather than complex manufacturing processes found in both Clovis and the Solutrean. This presents an enigmatic problem in the analysis of Clovis origins. However, blade cores recovered from below Clovis at the Gault site may provide the answer to this conundrum. Unfortunately, until the stratigraphy and dating is confirmed, it is impossible to know how old these cores really are.

In terms of a theoretical construct of culture, Clovis and Solutrean appear to fit within Clarke's concept of a culture group (Clarke, 1968, p.333). In this respect, Clovis can be viewed as a later manifestation of the Solutrean, where the technology and the specific type-family traits are shared, but the full socio-economic structures of the parent culture are not. Unlike the traditional model of a culture group, it would appear that intercommunication was limited due to vast ice sheets that would have made travel challenging. Thus a small, pioneering group of Solutreans may have brought their technology to North America, but either the group did not have the entire Solutrean cultural package or perhaps their entire culture did not survive in the new world, simply the technology. This technology then spread across North America.

Convergence has been used as an argument against the Atlantic ice hypothesis. However, even if it is assumed that the similarities in blade technologies from Europe and America are the result of a convergence of ideas; then, it must follow that a human population inhabited North America before the LGM.

Technology does not change suddenly, even in the known examples of technological shifts (*see* Costa et al. 2005). Neither climate nor high quality raw material would have any sudden or dramatic changes on the methods of manufacture. The phenomenon of change is not seen in the archaeological record without an accompanying deep-time span. If the microblade assemblages of Asia were already firmly established during the time of Clovis, then any pioneering groups into North America would carry with them indications of that technological manufacturing. Importantly, this technology would have to be present in assemblages older than Clovis and show signs of a technological transformation into Clovis.

As no examples of such a deep and complex convergence of technologies have been identified in any archaeological record, and without the presence of a past trajectory, convergence would require its own testing and evidence. The similarities between Clovis and Solutrean would have to stem from a culture pre-dating Clovis and rooted in Asia. Presently, this connection can only be made hypothetically, using some of the blade manufacturing evidence from Mongolia dating to between 30,000 to 25,000 BP (e.g. large blades, steep platform angles and prepared core platforms). Again, if this scenario were true, then any argument for convergence would also have to concede that a human population was present in North America before the LGM and that this population was developed through time with the technology and knowledge that was inherent to this group. These contingencies would have slowly created the technological similarities that are present in Clovis assemblages. To date no evidence for this has been recovered from either the Pacific coast or the northwestern regions of North America. Thus, claims of convergence are tenuous at best, as there is no evidence for a past technological trajectory for Clovis that is rooted in Asia and developed through time along the Pacific coastal Margin.

Before any progress can be made in understanding the complexities of the OTC archaeological record, hypotheses must be tested through the application of the scientific method. This could include the use of new technologies to inform research, the rigorous analysis of existing archaeological and genetic data, and the collection of new data to further test existing hypotheses.

Suggestions for Further Research

Further research should focus on the search for evidence concerning the nature and timing of the earliest groups to enter the New World. Specifically, this research should focus on OTC blade technologies and their relation to the Solutrean. This evidence is critical because, while the chronological gap no longer exists for bifacial manufacturing, a gap remains in the understanding of the development of Clovis blade technology.

It is important to continue the assessment of cultural patterns linked to the Pacific coast and northwestern interiors. Archaeology is continuously updated and rewritten; and, a site on either side of the North American continent has the potential to radically alter existing ideas about Clovis origins.

Future technological analyses of blade industries should focus on the specific aspects of pre-core production, platform preparation, blade removal and core and blade face maintenance. Evidence for all of these characteristics can be found in the cores, the blades and their associated debitage. By recognising these technological traits, and applying the taxonomy to the systematic study of blade technologies, then each archaeological culture will become more accessible, in terms of placing it within the wider context of technological development. With an expansion of this taxonomic approach to technology, the data can be used to explore in more detail the technological similarities and differences between cultures. This will contribute to a greater understanding of the origins and development of blade technologies across the globe.

The taxonomy used throughout this thesis provides a uniform system for the evaluation of blade industries. The taxonomy itself does not reveal any great depth in terms of technological traits, but focuses on the major core techniques utilised for production. In this respect, it is possible to assess the transformation of technologies from expedient Type VI cores through to the more complex Type I – V cores. Alongside this, numerous early industries use A or B flaking styles while later industries use C or D style flaking. Only by the application of this taxonomy to wider blade analysis will the information it contains become usable. As such it is laid down in this research as a new method for the analysis of blades rather than as a fully developed system. The blades produced can also provide valuable insights into human behavior. By discriminating between those blades that are important to the manufacturing process and the production specific blade types, it is possible to assess the relative complexity and technological investment in the technology. One example of this is the blade technology from Zhokhov where for every useable blade, 21 blades were discarded (Bradley & Giria, 1996).

The taxonomic data may be useful in the construction of archaeological phylogenies (O'Brien et al., 2001; Buchanan & Collard, 2008). By focusing specifically on technology, cladistics could be used to create a "nested series of taxa based on homologous characters shared by two or more taxa and their immediate common ancestor" (O'Brien et al., 2001). The application of the taxonomy provides a uniform approach to technological considerations. Cladistics can then be applied to this data as a means of exploring and interpreting the technological development of stone-tool traditions at local, regional and hyper-regional scales. This is the approach highlighted by O'Brien et al. (2014) in their critique of Stanford and Bradley's (2012) hypothesis. However, due to major criticisms of the relevance of this method (*see* Grant & Kluge 2003; Farris 2014) it was not conducted. As such, future research should focus on the application of these statistical models in understanding technology and possible cultural relationships.

Technology, in terms of the specific manufacturing process and production techniques used can provide a wealth of information to the study of past human behaviors and the intra- and inter-cultural connections that may have existed. While the archaeological record can often be sparing in the evidence left behind, it is possible to understand a technology through the careful assessment of the material that is recovered. It may never yield a complete picture, but specific traits are present and can contribute numerous pieces of evidence for the study of past human behavior and societies.

Conclusion

By applying a taxonomic approach to the analysis of blade technology, it is possible to associate similar industries with one another, even when the end products differ. While Francois Bordes (Bordes et al., 1964) may be correct that there are only a certain number of ways to break rocks, the methods, techniques, and traits that form the technological repertoire of a culture can vary greatly. It is through the analysis of these nuances that a technology can be defined and interpreted. Blade technologies are one of the most important aspects of Upper Palaeolithic archaeology; this thesis demonstrated the importance of detailed technological analyses for understanding the complexities of past human behavior.

This thesis presented data regarding the nature of Solutrean and Clovis blade manufacturing as well as an examination of blade technologies across parts of Eurasia, including Northern Europe, Russia, Mongolia, and Northern China. It discussed how technological analysis can be used to understand past human behaviors as well as interpret past human migrations. Specifically, it has established a positive link between the blade technologies of Clovis and the Solutrean while demonstrating the lack of any evidence for a technological ancestor of Clovis in Asia or Beringia. Additionally, as yet the OTC record does not fully support a continuation of Solutrean blade technologies into Clovis. However, with an identical manufacturing process and shared technological traits, the Solutrean remains the most viable root for the origins of Clovis technology. This hypothesis could be tested with a more detailed technological analysis of the Solutrean bifacial production methods and the Beringian blade production methods.

Appendix 1

Raw Data – Metrics and descriptions

Key:

Sol	= Solutrean
Magdal	= Magdalenian
Pf	= Platform
IofC A	= Index of Curvature, measurement A
IofC B	= Index of Curvature, measurement B
I of Curv.	= Index of Curvature
Max Curve. C	= Maximum curvature measurement C
PofM Curv.	= Point of Maximum Curvature

ID	Period	Length	Width	Thickness	Blade Stage	Blade Type	No of Ridges	Lateral Edges	Pf Width	Pf Depth	IofC A	IoC B	I of Curv.	Max Curve. C	PofM Curv.
1	Clovis	85.3	31.3	16.1	Primary	Side	1	Parallel	3.5	9.5	66.3	4.8	7.239819	36.8	55.50528
2	Clovis	73.8	29.2	12.3	Primary	Side	1	Parallel	8.7	23.9	66.5	5.3	7.969925	39.7	59.69925
3	Clovis	141	35.3	14.3	Initial	Cortical	1	Parallel	6.8	16.7					
4	Clovis	129	36.3	25	Primary	Corner	1	Expanding	17	16.4					
5	Clovis	166	47.6	20.2	Initial	Cortical	1	Parallel	13.4	3.7					
6	Clovis	101.9	28.3	15.8	Secondary	Side	2	Parallel	6.5	3.2	89.6	10.9	12.16518	50.6	56.47321

7	Clovis	130.9	33.3	20.8	Primary	Side	1	Parallel	13.2	3.6	120.9	13.7	11.33168	42.6	35.23573
8	Clovis	83.4	67.2	44.3	Primary	Centre	1	Expanding							
9	Clovis	75	24.9	8.4	Initial	Cortical		Parallel	5.7	3.8	63	4.4	6.984127	26.1	41.42857
10	Clovis	75.3	20.2	7.1	Primary	Side	1	Parallel	6.3	2.8	109.6	12.1	11.04015	61.4	56.0219
11	Clovis	118.7	50.7	15.8	Primary	Centre	1	Parallel	11.8	5	100.5	9.5	9.452736	55	54.72637
12	Clovis	114.5	39.8	26.2	Primary	Side	1	Converging	13	6.4	73.7	8.8	11.9403	46.4	62.95794
13	Clovis	90.9	47.6	23	Initial	Crested	1	Parallel							
14	Clovis	161.1	37.6	13.8	Primary	Centre	1	Parallel	8.4	6.6					
15	Clovis	121	68	14.9	Primary	Corner	1	Expanding	7.6	4.4	113.2	6.8	6.007067	66	58.30389
16	Clovis	150	43.8	18.3	Initial	Crested	1	Parallel	14.8	3.3	121.8	6.8	5.582923	43.3	35.55008
17	Clovis	80.5	16.1	8.3	Primary	Centre	1	Parallel							
18	Clovis	86.6	37.5	11.7	Primary	Side	1	Expanding	13.1	6.9	74.2	5.6	7.54717	47.5	64.01617
19	Clovis	70.4	26.8	9	Primary	Centre	1	Parallel							
20	Clovis	77.8	15.8	4.7	Primary	Side	1	Parallel							
21	Clovis	70.3	20	7.2	Secondary	Centre	2	Parallel	4.8	1.7	59	4.8	8.135593	42.7	72.37288
22	Clovis	76.4	20.3	15.3	Primary	Corner	1	Parallel	6.7	2.4					
23	Clovis	78.4	25.1	12	Primary	Corner	1	Parallel	14.2	3.4	54.7	4.9	8.957952	28.6	52.28519
24	Clovis	42.8	19.7	5.6	Primary	Centre	1	Converging	11.5	3	36	4	11.11111	16.9	46.94444
25	Clovis	80.9	27.1	9.9	Primary	Centre	1	Parallel	4.3	4.5					
26	Clovis	70.1	22.8	13.5	Primary	Side	1	Parallel	10.2	3	65.4	7.4	11.31498	41.4	63.30275
27	Clovis	35.5	24.6	5.3	Secondary	TRUE	2	Parallel	9.2						
28	Clovis	42.8	20.8	6.9	Secondary	Centre	2	Parallel	12.1	3.2					
29	Clovis	106	30	18.3	Primary	Corner	1	Parallel	3.6	2.7	93.7	10.2	10.88581	44.9	47.91889
30	Clovis	93.3	17.9	10.8	Initial	Crested	1	Parallel	3.4	2.4	87.8	2.9	3.302961	31.6	35.99089
31	Clovis	76.6	27.7	10.1	Secondary	Centre	2	Parallel	11.1	3.6	67.6	4.4	6.508876	48	71.00592
32	Clovis	125.9	42.2	11.3	Primary	Corner	1	Parallel	7.3	2.8	113.8	10.1	8.87522	55.3	48.59402
33	Clovis	77.8	18.2	10.4	Initial										

34	Clovis	88.3	19.2	6.9	Primary	Side	1	Parallel			84.1	9.1	10.82045	42.7	50.77289
35	Clovis	38.1	19	6.6	Primary	Corner	1	Parallel	3.3	1.1					
36	Clovis	57.5	19.5	6.9	Primary	Corner	1	Parallel			55.4	4.1	7.400722	42	75.81227
37	Clovis	64.6	22.2	10.6	Primary	Side	1	Parallel	15.1	5.1					
38	Clovis	130.1	34.9	12.3	Secondary	Side	2	Parallel	11.8	4.6	112.3	8.6	7.658059	58.4	52.00356
39	Clovis	91.9	26.3	11.4	Primary	Corner	1	Parallel	4.8	1.7	86.5	12.1	13.98844	55	63.58382
40	Clovis	92.8	29.7	16.4	Secondary	Side	2	Parallel	15.2	4.6					
41	Clovis	86.6	21.5	5.1	Primary	Side	1	Parallel	7.4	3.5	81.4	6	7.371007	46.5	57.12531
42	Clovis	140	42	12.1	Primary	Corner	1	Expanding	10.7	4.7	129.2	8.3	6.424149	94.9	73.45201
43	Clovis	72.5	19.1	8.1	Primary	Side	1	Parallel	11.3	4.2	66.7	5.4	8.095952	35.9	53.82309
44	Clovis	84.4	32.7	12.7	Primary	Side	1	Parallel	8.9	4.2	85.1	11.4	13.396	43.2	50.76381
45	Clovis	47	16.8	9	Initial	Crested	1	Parallel			41	5.2	12.68293	23.3	56.82927
46	Clovis	101.6	31.6	12.4	Secondary	Centre	2	Parallel	9.2	4.1	93.3	5.6	6.002144	62	66.4523
47	Clovis	79.9	24	7	Primary	Side	1	Parallel	10.3	3.8					
48	Clovis	144.3	44.5	17.8					17.4	7.5	132.2	8.9	6.732224	88.6	67.01967
49	Clovis	100.9	28.7	16.8					4.7	2	89	5.6	6.292135	68.1	76.51685
50	Clovis	97.3	29.1	12.3	Primary	Centre	1	Parallel	21.1	9.7					
51	Clovis	69.5	17	10	Secondary	Side	2	Parallel	8	4.7	65	5.3	8.153846	33	50.76923
52	Clovis	108.2	34	11.2	Primary	Side	1	Parallel	9.2	3					
53	Clovis	80.5	23.4	15.5	Secondary	Side	2	Parallel							
54	Clovis	98.1	31.1	14.6	Primary	Side	1	Converging							
55	Clovis	107.4	23.1	8.4	Primary	Centre	1	Parallel							
56	Clovis	87.9	28.2	11.5	Primary	Corner	1	Parallel	12.2	4.6	80.9	6.7	8.281829	43.9	54.26452
57	Clovis	79.8	34	14.5	Primary	Corner	1	Parallel	7.6	3.6	73.1	4.7	6.429549	43.2	59.09713
58	Clovis	119.1	29.4	13	Primary	Side	1	Parallel	10.5	3.7					
59	Clovis	83	20.7	6.4	Primary	Side	1	Parallel	5.7	1.2	80.6	9.4	11.66253	52.1	64.6402
60	Clovis	77.7	25.4	11.2	Primary	Corner	1	Parallel							

61	Clovis	54.2	30.4	8	Primary	Side	1	Parallel	9.2	2.9	46.4	8.1	17.4569	27	58.18966
62	Clovis	53.9	37.6	7.7	Primary	Side	1	Parallel							
63	Clovis	77.1	28.3	10.5	Primary	Corner	1	Expanding	9.8	1.8					
64	Clovis	69.6	31.5	13	Secondary	Side	2	Parallel	10.8	2.4	64.6	8.8	13.62229	41	63.46749
65	Clovis	72.1	24.6	6.8	Secondary	Centre	2	Expanding							
66	Clovis	94.7	32.7	11.3	Primary	Corner	1	Parallel	17.2	7.4	90.9	7.2	7.920792	38.9	42.79428
67	Clovis	78.9	23.3	8.3	Primary	Corner	1	Parallel	8.3	2.8	72.8	8.6	11.81319	43.2	59.34066
68	Clovis	78.1	24.1	10.2	Primary	Centre	1	Parallel	15.2	7.9					
69	Clovis	66.1	28.1	10	Primary	Corner	1	Parallel	11.1	4.3	58.5	4.7	8.034188	41.6	71.11111
70	Clovis	80.5	22.5	5	Primary	Side	1	Parallel							
71	Clovis	106.6	44.7	10.2	Primary	Side	1	Parallel	8.6	4.7	99.8	5.1	5.11022	49.9	50
72	Clovis	120.1	36.6	11.3	Primary	Side	1	Parallel	7.5	4	115.3	7.4	6.41804	69	59.84389
73	Clovis	102.4	51.5	17.6	Primary	Side	1	Parallel			101.1	16.5	16.32047	70.3	69.53511
74	Clovis	88.8	25.4	9.7	Primary	Corner	1	Parallel	5.9	3.2					
75	Clovis	100.6	29	12.4	Primary	Side	1	Parallel							
76	Clovis	90	24.7	7.2	Primary	Side	1	Parallel	11.2	2.1	82.3	4.4	5.346294	44.6	54.19198
77	Clovis	49.6	22.6	10.4	Primary	Side	1	Parallel							
78	Clovis	63.5	28.8	11.2	Primary	Centre	1	Parallel	7.9	2.1	55.9	4	7.155635	38.8	69.40966
79	Clovis	50	28	9.7	Primary	Side	1	Parallel	13.6	4.3					
80	Clovis	94.5	28.1	8	Primary	Corner	1	Parallel	15.4	4.3					
81	Clovis	60.5	20.8	8.3	Primary	Corner	1	Parallel							
82	Clovis	93	29.5	21.5	Primary	Corner	1	Parallel	8.8	3.1					
83	Clovis	72.5	25.5	9	Primary	Side	1	Parallel	4.1	2.2	68.6	10	14.57726	44.2	64.43149
84	Clovis	80.2	22.3	8	Primary	Side	1	Parallel	6	1.7	76.9	8	10.40312	53.1	69.05072
85	Clovis	82.6	37.4	19.9	Primary	Corner	1	Parallel							
86	Clovis	50	17.5	3.9	Primary	Centre	1	Parallel	11	3.8					
87	Clovis	65.6	22.8	3.8	Secondary	Centre	2	Parallel	4.8	1.5					

88	Clovis	120	35	10.1	Primary	Corner	1	Parallel	7.4	5.3	114.4	13.3	11.62587	75	65.55944
89	Clovis	87.1	34.2	12	Primary	Side	1	Parallel	12.6	3.6	77.9	3.1	3.979461	54.6	70.08986
90	Clovis	82.1	24.7	10.8	Secondary	Side	2	Parallel	8.7	3.2	75.4	6.9	9.151194	51.1	67.77188
91	Clovis	114.9	30.3	6.9	Primary	Side	1	Parallel	2.8	1.8	107.5	18	16.74419	66.4	61.76744
92	Clovis	49	29.5	3.1	Primary	Side	1	Parallel	6.4	1.9					
93	Clovis	65	29.9	9.7	Primary	Corner	1	Parallel	10.8	7	58.9	4.8	8.149406	36.6	62.13922
94	Clovis	70.1	20.8	4.6	Primary	Side	1	Parallel	5.1	1.9	64.6	6.9	10.68111	43.3	67.02786
95	Clovis	85.6	36.6	13.8	Primary	Centre	1	Parallel							
96	Clovis	65.6	21.1	9.5	Primary	Corner	1	Parallel							
97	Clovis	44	16.9	4.5	Primary	Side	1	Parallel							
98	Clovis	69.1	27.9	6.8	Secondary	Side	2	Parallel							
99	Clovis	87.1	25	14.5	Secondary	Side	2	Parallel							
100	Clovis	142.2	60.1	49.5					17.9	5.7					
101	Clovis	95.3	32.9	12.5	Primary	Corner	1	Parallel							
102	Clovis	76.8	26	20	Primary	Side	1	Parallel	10.1	1.3	71.3	4.1	5.750351	61.7	86.53576
103	Clovis	69.2	28.2	13.2	Primary	Corner	1	Parallel	12.4	7.9					
104	Clovis	119.1	56.2	13.1	Primary	Corner	1	Parallel							
105	Clovis	86.9	26.9	10.6	Primary	Corner	1	Parallel	10.8	6.2	77.3	5.1	6.597671	46.7	60.41397
106	Clovis	46	20.1	4.8	Primary	Centre	1	Parallel	10.3	4.9					
107	Clovis	60.5	22.2	6.9	Primary	Side	1	Parallel							
108	Clovis	91.6	23.6	8.3	Secondary	Centre	2	Parallel	14.8	5	86.5	11.1	12.83237	44.7	51.6763
109	Clovis	93	26.4	12.4	Primary	Corner	1	Parallel	8.5	2.6	90	15.6	17.33333	54.5	60.55556
110	Clovis	121.9	36.4	20.6	Primary	Centre	1	Parallel	15.4	5.3	109.5	15.3	13.9726	67.2	61.36986
111	Clovis	117.2	43.8	2.3	Primary	Centre	1	Parallel	11.4	4.8	111.2	6.2	5.57554	81.5	73.29137
112	Clovis	108.5	28.6	14	Initial	Crested	1	Parallel	6	3.3					
113	Clovis	94.1	34.4	8.8	Primary	Corner	1	Parallel	4.8	3					
114	Clovis	98.3	27.4	20.2	Primary	Corner	1	Parallel	11.2	5.3	89	7.5	8.426966	51.4	57.75281

115	Clovis	54.3	23.3	4.7					9.9	1.7	51.9	5.7	10.98266	22.8	43.93064
116	Clovis	88.4	25.5	6.2	Primary	Side	1	Parallel	8	2.4	77.2	3	3.88601	35.4	45.85492
117	Clovis	73.6	31	8.6	Primary	Corner	1	Parallel	14.1	7.3	60.6	5.5	9.075908	37.5	61.88119
118	Clovis	56.8	21.7	4.2	Primary	Side	1	Parallel	4.5	1.5	54.8	3	5.474453	31.1	56.75182
119	Clovis	109.1	31.3	9.3	Primary	Corner	1	Converging	7	2.3					
120	Clovis	85.8	36.4	8	Primary	Side	1	Parallel							
121	Clovis	108.7	20.9	8.9	Primary	Side	1	Parallel							
122	Clovis	56.6	13.9	8.8	Primary	Centre	1	Parallel	10.1	3.8					
123	Clovis	98.6	21.2	7.6	Primary	Side	1	Parallel							
124	Clovis	97.5	24.8	9.3	Primary	Side	1	Parallel							
125	Clovis	85.6	21.3	7.9	Primary	Centre	1	Parallel							
126	Clovis	63	26.3	8.4	Primary	Corner	1	Parallel	9.9	3.5					
127	Clovis	126.2	31.6	13.1	Primary	Corner	1	Parallel							
128	Clovis	44.8	16.8	6.9	Primary	Corner	1	Parallel							
129	Clovis	82.6	34.8	16.5	Primary	Corner	1	Parallel	20.6	7.7	72.7	4.4	6.05227	39.2	53.92022
130	Clovis	81.7	22.1	11.7	Primary	Crested	1	Parallel							
131	Clovis	76.8	21.4	8.2	Primary	Side	1	Parallel	5.1	1.9	74.8	6.5	8.68984	31.8	42.51337
132	Clovis	107.9	39.7	13.9	Primary	Side	1	Parallel	12.9	5.6	103.1	6.4	6.207565	49.4	47.91465
133	Clovis	122	43.8	22.3	Primary	Corner	1	Parallel	20.5	11.1	115.1	3.9	3.388358	39.6	34.40487
134	Clovis	116	27.1	13	Primary	Corner	1	Parallel	6.9	4.3					
135	Clovis	89.4	28.5	18.1											
136	Clovis	94.6	35.8	11.3	Primary	Side	1	Parallel	6.8	3.1					
137	Clovis	68.7	14.6	7.4		Crested									
138	Clovis	74.6	27.1	14.9	Initial	Crested	1	Parallel	10.2	6.7					
139	Clovis	65	16.4	5.1	Secondary	TRUE	2	Parallel	4.3	1.3					
140	Clovis	67.8	14.8	3.6	Primary	Side	1	Parallel	2.7	1.7					
141	Clovis	79.3	2	5.7	Initial	Crested	1	Parallel							

142	Clovis	100.3	34.5	13.3	Primary	Corner	1	Parallel	20.5	14.1	95	9.1	9.578947	44.1	46.42105
143	Clovis	88.9	28.3	13.9	Primary	Corner	1	Parallel	5.8	1.4	85	8.5	10	50.7	59.64706
144	Clovis	50.4	21.8	3.9	Primary	Side	1	Parallel			46	2.5	5.434783	18.9	41.08696
145	Clovis	58.5	24.8	8.8	Primary	Corner	1	Parallel	17.4	4.2	56.1	7.3	13.01248	41.3	73.61854
146	Clovis	102	29.5	14.1	Initial	Crested	1	Parallel							
147	Clovis	91.7	26.3	9.1	Secondary	Tool	2	Parallel							
148	Clovis	95.2	23	10.8	Secondary	Tool	2	Parallel	8.7	2.6	89.1	5.9	6.621773	54.2	60.83053
149	Clovis	60.1	13.7	4.8	Secondary	Tool	2	Parallel							
150	Clovis	79.9	67	17	Secondary	Tool	2	Parallel							
151	Clovis	109.1	19.3	14.4	Secondary	Tool	1	Expanding	7.7	1.4	106.4	15.8	14.84962	67.7	63.62782
152	Clovis	79.5	27.2	8.1	Secondary	Tool	2	Parallel	4.5	2.3	78.6	7.5	9.541985	46.6	59.28753
153	Clovis	127	55.6	12	Secondary	Tool	2	Parallel							
154	Clovis	57.7	21.3	9.6	Secondary	Tool	2	Parallel	9.1	3.3					
155	Clovis	83.7	29.8	15.2	Secondary	Tool	1	Parallel							
156	Clovis	98.1	33.3	13.3	Secondary	Tool	1	Expanding	14.4	5.2	86.7	6.4	7.381776	57.1	65.85928
157	Clovis	52	29.5	8.5	Secondary	Tool	2	Parallel	5.5	2.8					
158	Clovis	65.4	22.7	6.9	Secondary	Tool	2	Converging	6.3	2.1	62.6	6.1	9.744409	44	70.28754
159	Clovis	94.4	20	10.5	Secondary	Tool	2	Parallel	8.9	4.1	90.3	10.9	12.07087	57.7	63.89812
160	Clovis	72	23.8	10.8	Secondary	Tool	2	Parallel							
161	Clovis	61.1	27.8	13.1	Secondary	Tool	2	Parallel	5.7	3.8	57.3	3.9	6.806283	42.5	74.17103
162	Clovis	145	37.2	21	Primary	Centre	1	Parallel	7.2	3.2					
163	Clovis	105.5	31.4	18.7	Primary	Corner	1	Parallel	12.8	5.6					
164	Clovis	128.9	71.4	21.4	Primary		1	Expanding	17	3.2					
165	Clovis	76.6	45.9	17.7			4	Expanding	20.2	6.7					
166	Clovis	93.5	31.7	15.6	Secondary	Corner	2	Parallel							
167	Clovis	48.1	19.2	5.1	Secondary	Tool	2	Converging	8.9	4.2					
168	Clovis	96	43.4	15.5			3	Parallel	21	7.8					

169	Clovis	124.1	45.5	13.7	Primary	Side	1	Converging	20.8	6	98.3	4.2	4.272635	49	49.84741
170	Clovis	45	30.8	10.5	Secondary	TRUE	2	Parallel	7.3	2.9					
171	Clovis	132.5	49.1	16.9	Primary	Side	1	Parallel	9	2.8					
172	Clovis	84.2	27.1	13.1	Primary	Side	1	Parallel	10.9	2.3	78.1	4	5.121639	57	72.98335
173	Clovis	62.7	30.5	12.4	Secondary	Centre	2	Parallel	18.2	7					
174	Clovis	60.4	18.5	4.3	Secondary	TRUE	2	Parallel	8.5	2.9					
175	Clovis	71	27.6	11.8	Secondary	TRUE	2	Parallel	10.5	5.6					
176	Clovis	86.5	29.5	10.2	Primary	Side	1	Parallel	9.8	3.1	83.2	10	12.01923	50.3	60.45673
177	Clovis	126.9	29.5	11.1	Primary	Centre	1	Parallel	13	4					
178	Clovis	170.2	43.7	14.4	Primary	Centre	1	Parallel	17.7	7.5					
179	Clovis	56.3	23.9	14	Primary	Centre	1	Parallel	12.8	7.5					
180	Clovis	102.9	38	10.5	Primary	Side	1	Parallel	15.1	3.6					
181	Clovis	117.2	61.1	38.6	Primary	Side	1	Parallel	5	4					
182	Clovis	71.3	25.3	9.8	Primary	Side	1	Parallel	11.4	8.4	75.6	6.6	8.730159	48.4	64.02116
183	Clovis	77.8	27.4	11.7	Primary	Side	1	Parallel	9.5	3					
184	Clovis	65.1	38.1	19.4	Primary	Centre	2	Parallel	21.2	11.7					
185	Clovis	76.5	31	13.9	Primary	Side		Expanding	26.1	13.4	73.6	6.6	8.967391	49.7	67.52717
186	Clovis	33.4	25.2	10.5	Primary	Corner	1	Parallel	10.7	5.5					
187	Clovis	80.5	40.3	10.1	Initial	Cortical	1	Expanding	16.4	6.1					
188	Clovis	153.2	36.1	20.1	Primary	Corner	1	Parallel	11.7						
189	Clovis	150.9	39	24.3	Primary	Corner	1	Parallel	10.1	4.3	143.1	10.4	7.267645	78.4	54.78686
190	Clovis	102.9	29.1	18.2	Primary	Corner	1	Parallel	19.3	10.5	96.2	7.5	7.796258	52.6	54.67775
191	Clovis	135.1	40.4	15.2	Primary	Corner	1	Parallel	20.8	3.7					
192	Clovis	120.5	31.7	14.3	Primary	Corner	1	Parallel	5.2	3.7	105.3	5.1	4.843305	62	58.87939
193	Clovis	48.5	30.3	11.5	Primary	Corner	1	Parallel	12	4.1					
194	Clovis	86	22.5	15.3	Initial	Crested	1	Parallel	13.9	7.4					
195	Clovis	134.2	27.8	14.1	Secondary	Side	2	Parallel	8.9	3.2	134.2	20.2	15.05216	83.3	62.07154

196	Clovis	114.1	28.2	12.3	Secondary	Side	3	Parallel	9.8	1.6					
197	Clovis	119.1	32	10.6	Primary	Side	1	Parallel	8.4	1.9	116.6	13.2	11.32075	69.5	59.60549
198	Clovis	104.3	24.6	12.3	Primary	Side	1	Parallel	5	2.4	100.1	14	13.98601	60	59.94006
199	Clovis	110.1	32.8	14.2	Primary	Side	1	Parallel							
200	Clovis	88.1	19.6	10	Initial	Crested	1	Parallel	7	4.6	84.6	10.7	12.64775	47	55.55556
201	Clovis	89.2	31	8.7	Primary	Side	1	Parallel							
202	Clovis	80.3	23.9	8.8	Primary	Side	1	Parallel							
203	Clovis	80	25	10.9	Initial		1	Parallel	8.5	4.5	71	6.8	9.577465	49.3	69.43662
204	Clovis	45.7	18.6	7.5	Initial	Crested	1	Parallel	3.8	1.8					
205	Clovis	27.9	18.7	5.1					10.6	3.3					
206	Clovis	152.1	31.4	9.8	Primary	Side	1	Parallel	6.5	2.8	150.6	19.1	12.6826	84.8	56.3081
207	Clovis	136.5	33.2	11.6	Primary	Side	1	Parallel	5	3.4	132.4	14.1	10.64955	84.7	63.97281
208	Clovis	101.8	28.5	11.7	Primary	Side	1	Parallel	9.1	4	97.6	12.2	12.5	58.6	60.04098
209	OTC	115.3	34.5	19.7	Secondary	Centre	2	Parallel	14	2.94	103.2	14.8	14.34109	61	59.10853
210	OTC	109.3	46.1	17.6	Initial	Corner	1	Expanding	22.6	7.4	94.5	11.3	11.95767	63.5	67.19577
211	OTC	101.6	37	21.3	Secondary	Corner	2	Expanding	11.9	5.7	86.9	11.3	13.00345	57	65.59264
212	OTC	82.9	26.2	16.3	Primary	Corner	1	Parallel	5.8	3.1					
213	OTC	129.4	38.5	20.1	Primary	Corner	1	Parallel							
214	OTC	38.9	27.5	7.3	Secondary	TRUE	2	Parallel	26.6	6					
215	OTC	69.3	34.7	7.8	Secondary	Centre	3	Expanding	15.7	1.3	56.1	3	5.347594	38.3	68.27094
216	OTC	98.8	41.4	15.4	Secondary	TRUE	2	Expanding	15.1	3.5	88.2	2.8	3.174603	55.9	63.37868
217	Sol Lower	60.5	32.4	7.8	Secondary	TRUE	2	Parallel	8.6	3.2					
218	Sol Lower	48.9	18.1	3.5	Secondary	TRUE	2	Parallel	6.3	2					
219	Sol Lower	33.3	19.2	5.3	Primary	Side	1	Parallel	11.4	4.5					
220	Sol Lower	40.2	24.2	4.9	Secondary	TRUE	2	Parallel	8.6	2.3					
221	Sol Lower	42.9	25.4	8.8	Secondary	TRUE	2	Parallel	18.9	7.9					
222	Sol Lower	29.2	23.8	7.3	Primary	Side	1	Parallel	8.9	3.3					

223	Sol Lower	44	15	5.6	Secondary	TRUE	2	Parallel	6.4	3.6					
224	Sol Lower	61.6	17.1	6.4	Primary	Side	1	Parallel	11.7	6.8					
225	Sol Lower	49.1	32.6	5.8	Primary	Centre	1	Parallel	7.2	2.1					
226	Sol Lower	52.8	16.6	4.6	Secondary	TRUE	2	Converging	8.4	2.6					
227	Sol Lower	60.9	13.2	4.4	Secondary	Centre	3	Parallel							
228	Sol Lower	33.5	16.2	5.3	Secondary	TRUE	2	Parallel	10.1	3.3					
229	Sol Lower	52	18.3	4.1	Primary	Side	1	Parallel	9.6	4					
230	Sol Lower	27.7	20.3	6.4	Secondary	TRUE	2	Parallel	5.4	3.3					
231	Sol Lower	28.8	18.5	6.3	Primary	Side	1	Parallel	7.7	3.6					
232	Sol Lower	29.7	24.4	5.6	Primary	Side	1	Parallel	8	3.6					
233	Sol Lower	31.7	18.8	6.5	Secondary	TRUE	2	Parallel	8.8	6.3					
234	Sol Lower	38	16.5	3.5	Secondary	TRUE	2	Parallel	8.5	3.2					
235	Sol Lower	35.5	18.9	5.7	Secondary	TRUE	2	Parallel	15.4	4.2					
236	Sol Lower	36.6	17.5	4.2	Primary	Side	1	Parallel	11.1	4.2					
237	Sol Lower	34.8	17.5	5.1	Secondary	TRUE	2	Parallel	8.4	3.7					
238	Sol Lower	29.8	21.2	4.7	Secondary	TRUE	2	Parallel	7.9	2.3					
239	Sol Lower	54.5	13.9	3.5	Secondary	TRUE	2	Parallel							
240	Sol Lower	32.1	15.9	4.9	Primary	Centre	1	Parallel	10.3	2.8					
241	Sol Lower	45.1	17.5	5	Secondary	TRUE	2	Parallel	2.8	2.2					
242	Sol Lower	20.2	18	5.5	Secondary	TRUE	2	Parallel	5.6	2.4					
243	Sol Lower	42.2	19.7	5.8	Secondary	TRUE	2	Parallel	4.4	2.3					
244	Sol Lower	18.1	15	3.7	Secondary	TRUE	2	Parallel	5.3	3.1					
245	Sol Lower	27.5	25.8	7.3	Secondary	TRUE	2	Parallel	8.5	2.8					
246	Sol Lower	53.9	30.1	3.3	Secondary	Centre	3	Parallel	3.5	2.4					
247	Sol Lower	64.4	26.4	5.2	Primary	Side	1	Parallel	3.7	1.7					
248	Sol Lower	62.7	20.1	6.8	Primary	Corner	1	Parallel	7	0.8					
249	Sol Lower	74.8	30.8	8.7	Primary	Side	1	Converging	12.6	5.3					

250	Sol Lower	67.9	32.9	10.1	Secondary	Centre	2	Parallel							
251	Sol Lower	65.1	37.4	9.1	Secondary	TRUE	2	Parallel	17.5	7.8					
252	Sol Lower	59.9	20.2	9.2	Secondary	TRUE	2	Parallel							
253	Sol Lower	53.3	30.4	6.1	Primary	Side	1	Converging							
254	Sol Lower	79.1	23.1	9.6	Initial	Crested	1	Parallel							
255	Sol Lower	61.7	28.4	9.5	Secondary	Centre	2	Parallel							
256	Sol Lower	77.5	29.1	11.1	Secondary	Side	2	Parallel	13.1	2.5					
257	Sol Lower	78	36	11.6	Secondary	Side	2	Parallel	25.8	11.7					
258	Sol Lower	44.8	36.6	9.4	Secondary	Centre	2	Parallel	14.5	6.5					
259	Sol Lower	85.7	21.6	8.6	Secondary	TRUE	2	Parallel	8.9	3.1	76.5	5.2	6.797386	45.7	59.73856
260	Sol Lower	56.6	28.7	6.7	Primary	Side	1	Expanding							
261	Sol Lower	54.9	21.4	4.8	Secondary	Side	2	Parallel	3.3	1.3					
262	Sol Lower	50	30.4	6	Secondary	Side	2	Parallel	10.7	3.4					
263	Sol Lower	39.6	25.5	9.3	Secondary	Side	2	Parallel	8.9	2.2					
264	Sol Lower	47.9	16.3	6.9	Secondary	Side	2	Parallel							
265	Sol Lower	75.5	26.7	7.5	Secondary	Side	2	Converging	10.3	2.3	70.2	6.7	9.54416	43.1	61.39601
266	Sol Lower	48	24.9	5.5	Primary	Centre	1	Expanding	8.1	3.4					
267	Sol Lower	59	23.7	7.5	Primary	Side	1	Parallel	20.8	11					
268	Sol Lower	60	20.9	7.7	Primary	Side	1	Parallel	6.7	2.3					
269	Sol Lower	29.7	19	3.6	Secondary	Side	2	Parallel	7.7	2.4					
270	Sol Lower	69.8	40.8	8.3	Secondary	Centre	2	Expanding	17.3	6.2					
271	Sol Lower	112.3	33.1	13.7	Initial	Cortical									
272	Sol Lower	85.3	33.4	10.2	Primary	Side	1	Parallel							
273	Sol Lower	92.1	25.6	8.2	Primary	Side	1	Parallel							
274	Sol Lower	77.2	36.4	11.2	Secondary	Centre	2	Parallel	16.5	10.2					
275	Sol Lower	77.5	30.3	12.4	Primary	Side	1	Parallel	6.9	3.3					
276	Sol Lower	79.3	20.6	6	Primary	Side	1	Parallel	11.4	3.2					

277	Sol Lower	65.9	17.8	8.3	Secondary	TRUE	2	Parallel	7.4	3.6	58.7	4.9	8.34753	32.5	55.36627
278	Sol Lower	71.6	24.8	16	Initial	Crested	1	Parallel							
279	Sol Lower	61.9	32.6	12.4	Initial	Crested	1	Parallel							
280	Sol Lower	74	21.9	9.8	Initial	Crested	1	Converging							
281	Sol Lower	64.8	29.3	12	Initial	Crested	1	Parallel	11.5	3.3					
282	Sol Lower	61.8	15.1	7.2	Initial	Crested	1	Parallel	6.3	3.5					
283	Sol Lower	59	14.1	7.5	Initial	Crested	1	Parallel							
284	Sol Lower	44.6	20.6	8.8	Initial	Crested	1	Parallel	5.8	3.5					
285	Sol Lower	102.8	31.4	5.4	Secondary	TRUE	2	Parallel							
286	Sol Lower	81.1	20.8	6.7	Secondary	TRUE	2	Parallel	9.6	4.2					
287	Sol Lower	78.9	30.1	6.8	Secondary	TRUE	2	Parallel	9.1	2.5					
288	Sol Lower	74.9	19.6	5.3	Secondary	TRUE	2	Parallel	4.7	1.8					
289	Sol Lower	63.9	22.6	6.9	Secondary	TRUE	2	Parallel							
290	Sol Lower	55.7	30.1	13.3	Secondary	Side	2	Parallel	18.7	6.8					
291	Sol Lower	66	13.3	3.3	Secondary	TRUE	2	Parallel	4.5	3.3					
292	Sol Lower	67	20.2	5	Primary	Side	1	Parallel	9.8	3.7					
293	Sol Lower	57.4	19.7	4.6	Secondary	TRUE	2	Parallel	11.6	1.6					
294	Sol Lower	49.3	19.8	5	Secondary	TRUE	2	Parallel	15.3	4.3					
295	Sol Lower	76.1	32.1	6.4	Secondary	Centre	3	Parallel	7.2	2.6					
296	Sol Lower	66.7	17.9	6	Secondary	TRUE	2	Parallel	5.7	2.7					
297	Sol Lower	77.5	31.4	11.9	Primary	Side	1	Converging	10.2	4.7					
298	Sol Lower	64.4	21.6	11.4	Primary	Side	1	Parallel							
299	Sol Lower	93.9	33.8	8	Primary	Centre	1	Converging	11.5	3.3	86.6	3.9	4.503464	49.3	56.92841
300	Sol Lower	63.2	19	9.2	Primary	Centre	1	Parallel	7.5	4.2					
301	Sol Lower	75	19.9	7.4	Secondary	TRUE	2	Parallel	5.8	3.8					
302	Sol Lower	75.1	24.4	10.2	Primary	Side	1	Parallel	4.8	2.4					
303	Sol Lower	37.6	24.6	6.3	Secondary	TRUE	2	Parallel	23.9	7.2					

304	Sol Lower	64.8	26.8	9.4	Primary	Corner	1	Parallel	5.1	2.4					
305	Sol Lower	49.9	21.3	7.1	Secondary	Side	2	Parallel	8.8	3.5					
306	Sol Lower	67.3	30.7	10.3	Primary	Corner	1	Converging	8.8	3.7	65.3	7.6	11.63859	38.8	59.41807
307	Sol Lower	41.7	17.5	7.1	Secondary	TRUE	2	Parallel	10.2	4					
308	Sol Lower	50.8	17.8	6	Primary	Centre	1	Parallel	9.5	5.5					
309	Sol Lower	46.3	14.9	3.5	Secondary	Centre	2	Parallel	4.3	1.8	43.2	4.6	10.64815	25.2	58.33333
310	Sol Lower	64.3	25.5	13.1	Primary	Side	1	Parallel	5.1	2.1	62.8	6.2	9.872611	37.3	59.3949
311	Sol Lower	38.9	18.7	8.1	Primary	Side	1	Parallel	8.8	2.3	33.5	2.4	7.164179	22.7	67.76119
312	Sol Lower	57.1	22.9	8.8	Secondary	Side	2	Parallel	16.7	5					
313	Sol Lower	66	14.9	5.8	Primary	Side	1	Parallel	5.6	2.6	59.3	4.8	8.094435	38.2	64.41821
314	Sol Lower	61.3	28.8	8.9	Primary	Side	1	Parallel	6.1	2.4					
315	Sol Lower	75.8	28.3	13.5	Primary	Corner	1	Converging	28.3	13.5	62.8	5.4	8.598726	40.7	64.80892
316	Sol Lower	80.7	31.9	14	Primary	Side	1	Expanding	13.2	10.5	65.2	4.5	6.90184	31.5	48.31288
317	Sol Lower	58.3	20.2	8.6	Secondary	TRUE	2	Parallel	3.2	2.2					
318	Sol Lower	59.6	30.7	10.3	Initial	Corner	1	Expanding							
319	Sol Lower	74.4	36.3	10.6	Initial	Corner	1	Expanding	9.8	3.9					
320	Sol Lower	37.3	14.9	3.5	Secondary	TRUE	2	Converging	7.3	2.8	53.7	3.1	5.772812	35.4	65.92179
321	Sol Lower	59.4	33	10.7	Secondary	TRUE	1	Parallel	26.7	11					
322	Sol Lower	59.6	16.7	5	Primary	Side	1	Parallel	7.6	3.2					
323	Sol Lower	52.8	18.1	5.6	Secondary	TRUE	2	Parallel	8.5	4.4					
324	Sol Lower	57.2	18.7	7	Secondary	TRUE	2	Parallel	9.7	3.8					
325	Sol Lower	55.7	22.8	7.8	Primary	Corner	1	Parallel	8.4	4.8					
326	Sol Lower	36.1	22.9	6.2	Primary	Side	1	Converging	4.4	4.1					
327	Sol Lower	48.5	19.1	4.5	Secondary	TRUE	2	Parallel	6	1.7					
328	Sol Lower	55.6	18.7	11.2	Primary	Centre	1	Parallel	16.5	7.5					
329	Sol Lower	68.2	22.7	10.4	Secondary	TRUE	2	Parallel	15.1	6.3	55.8	5.5	9.856631	36.7	65.77061
330	Sol Lower	88.2	37	8.2	Secondary	TRUE	2	Expanding	5.7	2.3	80.3	3.8	4.732254	70	87.1731

331	Sol Middle	42.5	21	8.6	Secondary	TRUE	2	Converging	17.4	8.5	38.2	4.2	10.99476	14.1	36.91099
332	Sol Middle	55.6	25.1	8.6	Primary	Side	1	Parallel							
333	Sol Middle	53.3	29.3	9.2	Primary	Side	1	Parallel	8.1	2.4	52	3.1	5.961538	17.5	33.65385
334	Sol Middle	50.2	20.7	5.7	Primary	Centre	1	Converging	19.8	4.6					
335	Sol Middle	46.7	19.3	5.8	Primary	Side	1	Parallel	4.2	2.1	39.1	3	7.672634	16.1	41.17647
336	Sol Middle	46.9	22	6.2	Primary	Side	1	Parallel	10.1	6.7					
337	Sol Middle	48.5	22.6	6.7	Secondary	TRUE	2	Parallel	11.5	3.7					
338	Sol Middle	45.6	26.7	8.2	Primary	Side	1	Parallel	13.4	4					
339	Sol Middle	39.8	14.2	7.4	Primary	Side	1	Parallel	7.5	4.8					
340	Sol Middle	46.1	27.4	5.5	Secondary	TRUE	2	Converging	14.4	6.1	45.9	3.7	8.061002	24	52.28758
341	Sol Middle	48.3	23.8	15.3	Initial	Crested	1	Parallel							
342	Sol Middle	58.6	21.1	7.6	Primary	Side	1	Parallel	7.1	4.2					
343	Sol Middle	47.2	20.3	9.7	Secondary	Centre	2	Expanding							
344	Sol Middle	62.4	21.3	4.4	Secondary	TRUE	2	Parallel	12.7	6.8					
345	Sol Middle	62.8	28.4	6.8	Primary	Side	1	Expanding	13.8	5.7	56.8	4	7.042254	36.8	64.78873
346	Sol Middle	78.1	26.6	8.3	Secondary	Centre	2	Converging							
347	Sol Middle	60	27.3	9.2	Secondary	Centre	2	Parallel							
348	Sol Middle	47.4	27.4	8.1	Primary	Corner	1	Converging							
349	Sol Middle	68.8	26.7	6.8	Secondary	TRUE	2	Parallel							
350	Sol Middle	55.9	18.5	7.5	Secondary	TRUE	2	Converging	5.9	2.9	54.5	4	7.33945	39.4	72.29358
351	Sol Middle	64.6	25.2	7.9	Secondary	TRUE	2	Expanding	12.7	3.6					
352	Sol Middle	54.8	24.4	6.4	Primary	Centre	1	Expanding							
353	Sol Middle	70.4	22.2	6.5	Secondary	Centre	2	Converging	7.8	3.4					
354	Sol Middle	39.5	20.7	5.9	Secondary	TRUE	2	Parallel	8.8	2.8					
355	Sol Middle	20.1	16	5.3	Secondary	TRUE	2	Parallel	10.3	4.4					
356	Sol Middle	30.3	28.6	5.4	Secondary	TRUE	2	Parallel	19.2	6.1					
357	Sol Middle	97.5	43.3	18.6	Primary	Corner	1	Expanding	8.5	6.4	84.1	6.2	7.372176	40.3	47.91914

358	Sol Middle	56.6	23.6	12.1	Secondary	Side	1	Parallel	15.7	13.9	55.5	6.4	11.53153	33.2	59.81982
359	Sol Middle	60.7	22	6.4	Primary	Corner	1	Converging	9.4	4.5					
360	Sol Middle	82.4	32.5	6.4	Primary	Corner	1	Converging	7.9	3.6	74.9	2.6	3.471295	31.6	42.18959
361	Sol Middle	73.4	29.1	18.4	Primary	Corner	1	Parallel	4.8	2.9	67.5	4.7	6.962963	35	51.85185
362	Sol Middle	53.9	20.5	14.9	Primary	Corner	1	Parallel	9.7	3.4					
363	Sol Middle	65.7	28.4	8.4	Secondary	Corner	2	Parallel	9.7	3.9	63.2	3	4.746835	25.2	39.87342
364	Sol Middle	55.7	18.4	9	Primary	Corner	1	Converging	9.7	5.3	48.4	6.3	13.01653	31.2	64.46281
365	Sol Middle	46	21.2	9.8	Primary	Corner	1	Parallel	14.2	5.8	40.8	3.6	8.823529	23.8	58.33333
366	Sol Middle	65.9	16.7	7.8	Initial	Crested	1	Parallel	5.6	2.4	65.1	5	7.680492	36.3	55.76037
367	Sol Middle	50.7	20.3	7.7	Primary	Corner	1	Converging	8.8	3.2					
368	Sol Middle	48.5	15.5	6.4	Initial	Cortical	0	Parallel	11	2.9					
369	Sol Middle	47.9	16.5	8.3	Primary	Corner	1	Converging	10.4	1.9					
370	Sol Middle	54.7	19.3	6.5	Primary	Corner	1	Converging	10.5	3.7	54.6	3.8	6.959707	21.6	39.56044
371	Sol Middle	28.3	20.9	6.1	Primary	Corner	1	Parallel	14.1	3.6					
372	Sol Middle	52.2	24.2	7.8	Primary	Corner	1	Parallel	10.5	2.9					
373	Sol Middle	113.5	31.9	12.1	Primary	Corner	1	Expanding	10.1	3.1	103.1	7.1	6.886518	71.1	68.96217
374	Sol Middle	94.6	30.4	11.6	Secondary	TRUE	2	Converging							
375	Sol Middle	57.2	32.5	12.8	Primary	Side	1	Parallel	22.5	12.9					
376	Sol Middle	87.5	22.5	7	Secondary	TRUE	2	Parallel							
377	Sol Middle	48.5	22.9	5.7	Primary	Side	1	Parallel			45.1	5.5	12.19512	22.3	49.44568
378	Sol Middle	59.3	21.2	6.1	Secondary	TRUE	2	Parallel	5.9	1.7					
379	Sol Middle	71.7	16.6	6.5	Secondary	TRUE	2	Parallel	6.8	3.5	60.2	3.7	6.146179	26.1	43.35548
380	Sol Middle	75.4	23.5	6.6	Primary	Side	1	Parallel	6.3	3.1					
381	Sol Middle	48.6	18.1	8.4	Secondary	TRUE	2	Parallel							
382	Sol Middle	48.1	21.5	6.3	Primary	Corner	1	Parallel	7.9	3.4					
383	Sol Middle	44.8	22.7	5.8	Secondary	TRUE	2	Parallel	11.2	3.3					
384	Sol Middle	41.1	21.4	5.8	Secondary	TRUE	2	Expanding	5.4	2.1					

385	Sol Middle	59.5	23.6	4.3	Secondary	Centre	3	Parallel	3.3	2	55.3	2.1	3.797468	34.1	61.66365
386	Sol Middle	64.8	25.8	17	Initial	Crested	1	Parallel							
387	Sol Middle	65.6	19.2	7.5	Secondary	TRUE	2	Parallel							
388	Sol Middle	50.1	24.3	11.6	Primary	Side	1	Parallel	20.2	11.3					
389	Sol Middle	78.5	22.2	16.3	Secondary	Crested	2	Parallel	5.4	3.5	70.2	4.4	6.267806	33.1	47.151
390	Sol Middle	23.1	16.7	5.2	Secondary	Centre	3	Parallel	6.1	3.3					
391	Sol Middle	43	17.2	6.2	Secondary	TRUE	2	Parallel							
392	Sol Middle	46.8	26.5	8.1	Primary	Side	1	Expanding	7.4	5.2					
393	Sol Middle	43.7	18.8	6.4	Secondary	TRUE	2	Parallel	5.1	8.7					
394	Sol Middle	43.5	24.7	5.4	Secondary	TRUE	2	Parallel	7.1	3.4					
395	Sol Middle	47.7	16.9	4.6	Primary	Side	1	Parallel	9.7	2.4					
396	Sol Middle	35.6	18.5	3.8	Secondary	Centre	3	Parallel							
397	Sol Middle	35.9	15.2	6	Primary	Side	1	Parallel	10	5.7					
398	Sol Middle	34.9	20	5.4	Primary	Side	1	Expanding	8.4	4					
399	Sol Middle	34.2	24.2	7.4	Primary	Side	1	Parallel	10.4	2.2					
400	Sol Middle	62.4	25.1	5.6	Secondary	TRUE	2	Parallel	15.6	4.7					
401	Sol Middle	37.8	23.7	5.1	Primary	Centre	1	Expanding	11	2.9					
402	Sol Middle	39.6	16.6	4.6	Primary	Side	1	Parallel	15.5	5.2					
403	Sol Middle	48.5	26.2	9.7	Primary	Corner	1	Expanding	7.8	5.8					
404	Sol Middle	35.8	21.6	6.1	Secondary	TRUE	2	Converging	7.3	3.6					
405	Sol Middle	21.3	17.6	4.3	Secondary	TRUE	2	Parallel	6.8	4					
406	Sol Middle	69.6	11.7	15.4	Initial	Crested	1	Parallel							
407	Sol Middle	47.5	13.2	4.5	Primary	Side	1	Parallel							
408	Sol Middle	60.5	19.5	8.2	Secondary	TRUE	2	Parallel	11.1	2.9	55.5	4.6	8.288288	29.7	53.51351
409	Sol Middle	43.5	18.5	4.4	Primary	Side	1	Parallel	5	2.8					
410	Sol Middle	32.5	23.1	6.8	Secondary	TRUE	2	Parallel	13.1	2.9					
411	Sol Middle	55.8	27.3	6.7	Secondary	Centre	2	Expanding	8.7	3.7					

412	Sol Middle	29.9	22.3	4.3	Primary	Side	1	Parallel	5.9	2.6					
413	Sol Middle	57.3	26.3	8.1	Secondary	Side	2	Parallel							
414	Sol Middle	38.2	21.7	7.7	Secondary	Side	2	Parallel							
415	Sol Middle	31.5	15.7	3.2	Primary	Side	1	Parallel	6.9	2.1					
416	Sol Middle	50.5	22.1	7.6	Primary	Corner	1	Parallel	12.5	3.3	49.3	4.3	8.72211	23.9	48.4787
417	Sol Middle	40.9	20	5.6	Primary	Side	1	Parallel	11	4.3					
418	Sol Middle	45.8	23.2	7.9	Secondary	TRUE	2	Parallel	6.6	3.6					
419	Sol Middle	37.3	19	7.9	Primary	Side	1	Parallel	9.4	2.8					
420	Sol Middle	77.3	32.7	15.5	Initial	Cortical		Parallel	13.6	7.3					
421	Sol Middle	79.1	21.2	8.2	Secondary	TRUE	2	Parallel	9.4	2.4	76.2	4.4	5.774278	39.5	51.83727
422	Sol Middle	87.1	15.3	8.2	Secondary	TRUE	2	Converging							
423	Sol Middle	65.1	36.4	15.2	Secondary	TRUE	2	Expanding	11.2	7.8					
424	Sol Middle	59.1	15.7	7.9	Secondary	Crested	2	Parallel							
425	Sol Middle	37.5	24.2	5.7	Secondary	TRUE	2	Parallel	12.7	5.1					
426	Sol Middle	70.4	28.5	9.2	Primary	Corner	1	Converging	11.4	4.8					
427	Sol Middle	34.3	39	11.8	Secondary	Centre	2	Parallel	24.9	9.7					
428	Sol Middle	36.3	20.7	7.1	Secondary	TRUE	2	Parallel	6.1	2.8					
429	Sol Middle	42.7	27.9	9.3	Primary	Centre	1	Expanding	7.2	2.6					
430	Sol Middle	30.4	28.1	10.6	Secondary	TRUE	2	Parallel	8.2	4.4					
431	Sol Middle	51.5	13.6	4.9	Secondary	TRUE	2	Parallel	4.7	1.5					
432	Sol Middle	44.9	13.2	4.8	Primary	Side	1	Parallel							
433	Sol Middle	52.7	30	12.8	Primary	Side	1	Parallel	13	4.5					
434	Sol Middle	41.8	31.3	7.2	Primary	Side	1	Expanding	4.8	3.1					
435	Sol Middle	33.1	26.1	7.5	Primary	Side	1	Expanding	8.1	3					
436	Sol Middle	46.1	26.1	6.4	Primary	Side	1	Parallel	7.8	3.7					
437	Sol Middle	40.5	24.9	7.6	Primary	Side	1	Expanding	7.1	3.3					
438	Sol Middle	43.6	23.3	5.5	Primary	Side	1	Expanding	6	3.8					

439	Sol Middle	41.3	19	6.4	Initial	Cortical	1	Parallel	9.3	2.8					
440	Sol Middle	37.2	25.2	3.8	Primary	Corner	1	Expanding	6.1	2					
441	Sol Middle	26.1	18.2	2.9	Secondary	TRUE	2	Expanding	6.7	2.2					
442	Sol Middle	27	17.4	6.5	Primary	Corner	1	Parallel	8.5	3.2					
443	Sol Middle	24.4	20.7	6.1	Primary	Side	1	Parallel	7.2	2.4					
444	Sol Middle	22	22.1	3.6	Secondary	TRUE	2	Parallel	17.1	5.4					
445	Sol Middle	21.9	24.3	4.6	Secondary	TRUE	2	Parallel	16.7	3.7					
446	Sol Middle	40.2	21.8	4.6	Primary	Centre	1	Parallel	7.4	3.5					
447	Sol Middle	42.9	22.9	3.6	Secondary	TRUE	2	Parallel	16.9	3.7					
448	Sol Middle	33.7	25.9	5.8	Primary	Side	1	Parallel	7.1	2.5					
449	Sol Middle	23.7	26.7	8.3	Primary	Centre	1	Parallel	12.2	5.6					
450	Sol Middle	40.5	21.3	9.2	Primary	Side	1	Parallel	18.5	7					
451	Sol Middle	39.6	19.5	5	Secondary	TRUE	2	Parallel	7.2	2.7					
452	Sol Middle	76.9	32.9	9.4	Primary	Corner	1	Expanding	10.5	3.7					
453	Sol Middle	73.1	35.6	16.8	Primary	Side	1	Parallel	18.6	11.4	63.8	5.5	8.62069	26.1	40.90909
454	Sol Middle	83.1	15.7	4.6	Primary	Side	1	Parallel							
455	Sol Middle	74.4	19.6	5.4	Secondary	TRUE	2	Parallel	7.7	3.1					
456	Sol Middle	80.1	32.3	15.8	Primary	Side	1	Parallel							
457	Sol Middle	80.7	37.8	16.4	Primary	Corner	1	Parallel	15.1	4.5					
458	Sol Middle	57.7	22.4	8.9	Primary	Side	1	Parallel	13.1	3.4					
459	Sol Middle	50.5	20.9	3.4	Secondary	TRUE	2	Parallel	12.8	3.3					
460	Sol Middle	57.2	66.5	9	Primary	Corner	1	Parallel	23.4	8.9					
461	Sol Middle	45.2	15.7	2.2	Secondary	TRUE	2	Parallel							
462	Sol Middle	74.8	27.4	6.3	Primary	Side	1	Parallel							
463	Sol Middle	64	23	7.4	Secondary	TRUE	2	Parallel	4.5	2.2					
464	Sol Middle	78.6	30.7	9.1	Primary	Side	1	Expanding	9.1	3.4	72	6.7	9.305556	47.4	65.83333
465	Sol Middle	56.2	19	5.2	Secondary	TRUE	2	Parallel	3.2	1.6	50.8	3.8	7.480315	25.7	50.59055

466	Sol Middle	74.3	21.5	6.3	Secondary	TRUE	2	Parallel	6.4	3					
467	Sol Middle	73.2	20	8.7	Secondary	TRUE	2	Parallel	6.8	2	68.2	4.4	6.451613	30.8	45.16129
468	Sol Middle	68.3	30.8	14.4	Initial	Crested	1	Expanding	8.9	6.3	49.8	4	8.032129	36.7	73.69478
469	Sol Middle	43.6	22.2	7.5	Primary	Centre	1	Converging	14.8	3.8					
470	Sol Middle	64.3	29.9	8.7	Secondary	TRUE	2	Parallel	5.7	3.9	56.7	5.1	8.994709	39.2	69.1358
471	Sol Middle	90.4	40	11.6	Primary	Side	1	Parallel	11	4.6	72.9	5.9	8.093278	40.2	55.14403
472	Sol Middle	71.7	21.1	8.3	Primary	Side	1	Parallel							
473	Sol Middle	59.7	24.2	8.3	Secondary	TRUE	2	Parallel	13.7	5.2	54.2	3.3	6.088561	34.8	64.20664
474	Sol Upper	63.4	21.6	12.3	Primary	Side	1	Parallel	11.9	5.1	57.7	3	5.199307	43.4	75.21664
475	Sol Upper	78.5	29.2	11.4	Secondary	TRUE	2	Parallel							
476	Sol Upper	68	26.3	7.4	Primary	Corner	1	Parallel	16.3	6.3	60.1	7.5	12.4792	28.3	47.08819
477	Sol Upper	29.5	23.5	6.7	Primary	Centre	1	Parallel	8.6	2.9					
478	Sol Upper	39	15.7	7	Secondary	Centre	2	Parallel	4	1.9					
479	Sol Upper	45.2	17.9	4.6	Primary	Side	1	Parallel	14.4	2.4					
480	Sol Upper	58.2	29	11.3	Secondary	TRUE	2	Expanding	5.1	2.5					
481	Sol Upper	24.4	22.4	5.7	Secondary	TRUE	2	Expanding	3.7	1.9					
482	Sol Upper	24.7	27.4	6.7	Secondary	TRUE	2	Parallel	11.1	4					
483	Sol Upper	46.2	22.7	6.9	Secondary	TRUE	2	Parallel	9.7	2.1					
484	Sol Upper	36.2	15.2	8.8	Primary	Corner	1	Parallel	4.2	2.5					
485	Sol Upper	24	12.1	3	Secondary	TRUE	2	Parallel	5.5	2.5					
486	Sol Upper	60.2	21.9	9.3	Secondary	Centre	2	Converging							
487	Sol Upper	47.3	33.8	5.9	Primary	Side	1	Expanding	13.2	3.8					
488	Sol Upper	55.3	19.3	4.7	Secondary	TRUE	2	Parallel	4.3	2.8					
489	Sol Upper	43.4	23	6.2	Primary	Side	1	Parallel	14	6.5					
490	Sol Upper	73.8	22.4	6.2	Secondary	TRUE	2	Converging	6.5	4.3					
491	Sol Upper	50.8	20.9	8.5	Primary	Side	1	Converging	12.8	4.2					
492	Sol Upper	75.5	30.4	7.8	Secondary	TRUE	2	Expanding	7.8	1.6					

493	Sol Upper	40.4	27.2	12.1	Secondary	Side	2	Converging	20.3	8.9					
494	Sol Upper	27.9	15.6	4.1	Primary	Side	1	Parallel	9.9	2					
495	Sol Upper	41.9	25.9	8.2	Primary	Corner	1	Parallel	16	7					
496	Sol Upper	46.3	26.8	4.7	Primary	Centre	1	Expanding	7.4	2.6					
497	Sol Upper	34.4	21.4	7.5	Primary	Side	1	Parallel	6.9	5.7					
498	Sol Upper	49.1	19.3	7	Primary	Side	1	Parallel	8.7	2.8					
499	Sol Upper	50	17.9	4	Primary	Side	1	Converging	6.9	2					
500	Sol Upper	29	18.6	4.2	Secondary	TRUE	2	Parallel	7.5	3.1					
501	Sol Upper	23.7	25.3	6.3	Secondary	TRUE	2	Parallel	12	2.3					
502	Sol Upper	37.5	23.8	10	Primary	Centre	1	Expanding	10.5	5					
503	Sol Upper	33.8	15.9	4.7	Primary	Side	1	Parallel	7.4	2.3					
504	Sol Upper	50.2	21.5	4.4	Primary	Side	1	Converging	15.2	3.6					
505	Sol Upper	39	15.3	8	Initial	Crested	1	Parallel	4.9	1					
506	Sol Upper	32.1	15.5	4.4	Primary	Side	1	Parallel	5.9	1.3					
507	Sol Upper	34.2	21.2	4.8	Primary	Side	1	Expanding	2.6	1.9					
508	Sol Upper	32.9	19.5	7	Primary	Centre	1	Parallel	7.6	2.8					
509	Sol Upper	58.6	20.4	12.7	Initial	Crested	1	Converging	19.3	7.1					
510	Sol Upper	58.6	24.8	12.4	Initial	Crested	1	Converging							
511	Sol Upper	24.9	13.6	3.7	Secondary	TRUE	2	Parallel	4.3	2.4					
512	Sol Upper	49.7	17.3	7.7	Primary	Corner	1	Parallel	5	2.9					
513	Sol Upper	42.5	25.4	9.2	Primary	Corner	1	Converging	16.9	8.9					
514	Sol Upper	39.6	16.7	4.9	Primary	Corner	1	Converging	7.7	3.7					
515	Sol Upper	53.7	24.8	9.3	Primary	Side	1	Parallel	12.2	6.7					
516	Sol Upper	37.9	16	6.3	Primary	Side	1	Converging	9.6	5.2					
517	Sol Upper	30.6	17.2	6.4	Primary	Side	1	Parallel	14.1	6.4					
518	Sol Upper	30	19.4	6.6	Initial	Cortical	0	Parallel	13.1	1.2					
519	Sol Upper	38	19.3	4.8	Secondary	TRUE	2	Parallel	9.6	1.4					

520	Sol Upper	30	19.8	8.3	Secondary	TRUE	2	Parallel	5	2.6					
521	Sol Upper	49.5	33.2	10.4	Primary	Corner	1	Expanding	2.9	3.3					
522	Sol Upper	40.8	28.3	7.7	Secondary	TRUE	2	Parallel	8.2	3.1					
523	Sol Upper	38	21.7	4.9	Primary	Side	1	Expanding	8.2	3.4					
524	Sol Upper	47.2	19.6	7.4	Primary	Side	1	Parallel	4.7	1.6					
525	Sol Upper	27.3	18.9	5.7	Secondary	TRUE	2	Parallel	16	4.8					
526	Sol Upper	40.1	20.4	9.1	Primary	Corner	1	Parallel	7.6	6.3					
527	Sol Upper	27.8	20.7	5.1	Primary	Side	1	Parallel	6.9	2.5					
528	Sol Upper	44	24.1	6.9	Primary	Centre	1	Parallel	20.4	6.3					
529	Sol Upper	41.1	19.9	6.1	Secondary	TRUE	2	Parallel	7.7	2.4					
530	Sol Upper	44.9	21.4	10.1	Primary	Corner	1	Parallel	9.5	3.1					
531	Sol Upper	31	24.6	6	Primary	Side	1	Expanding	7.9	2.3					
532	Sol Upper	50.5	22.2	9.7	Primary	Side	1	Parallel	20.4	5.6					
533	Sol Upper	34.8	19.4	6.3	Primary	Side	1	Parallel	5.1	1.7					
534	Sol Upper	45.3	19.5	1.9	Primary	Side	1	Converging	10.7	5.1					
535	Sol Upper	28.5	18.9	4.7	Primary	Side	1	Parallel	4.4	1.5					
536	Sol Upper	29.4	16.5	6.9	Secondary	TRUE	2	Parallel	3.9	1.4					
537	Sol Upper	22.2	16.4	5.7	Primary	Side	1	Parallel	3.8	1.8					
538	Sol Upper	72.2	29.4	11.7	Primary	Corner	1	Parallel	9.9	9.6					
539	Sol Upper	35.2	16.3	5.8	Primary	Side	1	Parallel	5.5	2					
540	Sol Upper	37.5	17.1	8.2	Primary	Side	1	Converging	14	8.1					
541	Sol Upper	43.9	19.6	7.7	Primary	Side	1	Parallel	11	3.4					
542	Sol Upper	41.7	15.5	6.6	Primary	Corner	1	Parallel	6.4	2.2					
543	Sol Upper	49.6	38	9.8	Secondary	Centre	2	Expanding	12	5.2					
544	Sol Upper	48.3	31.8	10.8	Primary	Side	1	Expanding	10.6	3					
545	Sol Upper	60.4	14.1	8	Initial	Crested	1	Parallel							
546	Sol Upper	43.7	28.6	10.6	Primary	Side	1	Parallel	9.8	4					

547	Sol Upper	52.8	28.9	9.5	Primary	Centre	1	Parallel	15.5	6.6					
548	Sol Upper	53.6	28.8	17.6	Primary	Side	1	Parallel	21	11.5	34.1	2.9	8.504399	22.8	66.86217
549	Sol Upper	57.2	29	9.4	Primary	Side	1	Parallel	17	4.3					
550	Sol Upper	57.4	18.9	7.1	Secondary	TRUE	2	Parallel	4.5	3.4					
551	Sol Upper	45.4	22.3	7.5	Primary	Side	1	Parallel	14.6	5.6					
552	Sol Upper	33.1	21.7	4.9	Secondary	TRUE	2	Parallel	6.2	1.7					
553	Sol Upper	16.7	25.2	5	Secondary	TRUE	2	Parallel	10.4	3.2					
554	Sol Upper	25.4	25.4	4.4	Secondary	TRUE	2	Parallel	9.5	3.6					
555	Sol Upper	76.4	17.4	6.6	Secondary	Tool	2	Parallel							
556	Sol Upper	63.4	25.6	7.8	Primary	Side	1	Converging	10.2	5.9					
557	Sol Upper	57.2	16.8	5.3	Primary	Side	1	Converging	11.1	2.7	50	2.9	5.8	31.7	63.4
558	Sol Upper	57.4	28.4	6.6	Secondary	TRUE	2	Parallel	10	3.2					
559	Sol Upper	39.7	16.3	6.4	Secondary	TRUE	2	Parallel	5.5	2.4					
560	Sol Upper	56.8	22.7	6.6	Primary	Side	1	Parallel	11.3	3.1	47.6	4.7	9.87395	29.5	61.97479
561	Sol Upper	34.7	34.3	7.1	Primary	Side	1	Expanding	10.7	4.3					
562	Sol Upper	59.9	24.4	7.3	Primary	Centre	1	Parallel							
563	Sol Upper	44.6	17.7	5.6	Secondary	TRUE	2	Parallel	6.9	1.7					
564	Sol Upper	32.6	33	7.6	Primary	Side	1	Expanding	10.1	2.9					
565	Sol Upper	28.5	21.2	5.7	Primary	Side	1	Parallel	9.2	5					
566	Sol Upper	59	29.6	13.1	Secondary	Crested	1	Parallel	15.4	9.3	57.9	4	6.908463	31.2	53.88601
567	Sol Upper	67.7	19.6	9.6	Initial	Crested	1	Parallel	13.4	6.5					
568	Sol Upper	28.9	27.7	7.1	Secondary	TRUE	2	Parallel	6.9	3.1					
569	Sol Upper	38.2	24	9.8	Primary	Side	1	Parallel	13.1	2.9					
570	Sol Upper	33.1	23.4	6.4	Secondary	TRUE	2	Parallel	10.9	3.8					
571	Sol Upper	54	22	7.1	Primary	Side	1	Parallel	7	5.5					
572	Sol Upper	58.5	33.2	7.8	Initial	Cortical	0	Expanding							
573	Sol Upper	44.3	22.8	8.2	Primary	Side	1	Parallel	13.5	4.8					

574	Sol Upper	18.2	14.7	2.7	Primary	Centre	1	Parallel	3.6	2.1					
575	Sol Upper	70.9	32.7	14.6	Initial	Cortical	0	Parallel							
576	Sol Upper	30.2	18.4	4.9	Secondary	TRUE	2	Parallel	7.2	3.3					
577	Sol Upper	32.4	15	5.2	Primary	Side	1	Parallel	4.6	3.3					
578	Sol Upper	50.4	15.4	6.1	Primary	Side	1	Parallel	5	2.5					
579	Sol Upper	29.5	16.9	3.5	Primary	Side	1	Parallel	6.9	1.4					
580	Sol Upper	40	18	6.3	Primary	Side	1	Parallel	5.1	2.3					
581	Sol Upper	42.7	14.6	5.4	Primary	Centre	1	Parallel	7.1	3.1					
582	Sol Upper	41.9	20.3	10.1	Primary	Side	1	Parallel	15.9	8.6					
583	Sol Upper	25.2	15.9	4.1	Secondary	TRUE	2	Parallel	5.9	1.6					
584	Magdal	76.8	25.8	9.3	Primary	Centre	1	Parallel							
585	Magdal	66.9	26.7	8.3	Initial	Cortical	1	Expanding	8.2	5.3	59.8	3.5	5.852843	33.2	55.51839
586	Magdal	59.3	20.6	10.2	Initial	Corner	1	Parallel	7.1	2.2					
587	Magdal	64.4	28.2	10.6	Primary	Tool	1	Expanding							
588	Magdal	53.6	36.7	10.9	Secondary	TRUE	2	Parallel	10	5.9					
589	Magdal	36.6	14.4	4.8	Primary	Side	1	Parallel	10.3	2.8					
590	Magdal	32.1	17.5	4.6	Secondary	TRUE	2	Parallel	14.3	4.6					
591	Magdal	32	21	6.8	Initial	Cortical	0	Parallel	5.2	2.4					
592	Magdal	37.2	23.7	4	Primary	Side	1	Expanding	8.2	5.6					
593	Magdal	39	29.7	8.1	Secondary	TRUE	2	Parallel	5.5	3.2					
594	Magdal	32.3	21.1	10	Primary	Corner	1	Parallel	14.1	4.3					
595	Magdal	48.5	21.9	7.1	Secondary	TRUE	2	Parallel	11.8	5.4					
596	Magdal	37.3	27.8	3.8	Secondary	TRUE	2	Parallel	8.7	3.4					
597	Magdal	51.7	22.5	7.9	Primary	Centre	1	Parallel	6.5	1.7					
598	Magdal	52.1	32.7	15.3	Initial	Corner	1	Expanding	12.4	4.7					
599	Magdal	42.9	20.7	7.9	Primary	Side	1	Converging	15.3	5.5					
600	Magdal	37.7	27	6.9	Primary	Side	1	Expanding	12.5	7.1					

601	Magdal	34.9	18.2	5.1	Primary	Side	1	Parallel	10.7	5.3					
602	Magdal	62	30.1	7.8	Secondary	Side	2	Expanding	10.8	5.7					
603	Magdal	57.1	28.7	6.1	Secondary	Centre	2	Parallel							
604	Magdal	42.1	22.3	6.6	Secondary	TRUE	2	Parallel	8.3	3.6					
605	Magdal	42	24.4	7.6	Primary	Centre	1	Parallel	11.2	4.7					
606	Magdal	61.7	26.1	9.5	Primary	Corner	1	Parallel	4.5	2.5					
607	Magdal	43.3	16.6	8.9	Primary	Side	1	Parallel	7.9	4.1					
608	Magdal	25.8	15.5	6	Primary	Side	1	Parallel	5.7	2					
609	Magdal	78	23.2	8	Primary	Side	1	Parallel	6.1	2.2	71.3	3.7	5.189341	50.6	70.96774
610	Magdal	57.5	27.9	5.2	Primary	Side	1	Expanding	15.5	8.5					
611	Magdal	26.5	19.6	6.3	Primary	Side	1	Parallel	12.6	7					
612	Magdal	57.7	33.4	20	Primary	Centre	1	Expanding	8.3						
613	Magdal	31.6	29.5	3	Primary	Side	1	Expanding	10.3	3.2					
614	Magdal	68.4	29.2	16.1	Initial	Crested	1	Converging	8.9	3.3					
615	Magdal	27.7	27.6	6.5	Primary	Side	1	Parallel	17.4	5.2					
616	Magdal	40.2	24.6	4.4	Secondary	TRUE	2	Parallel	13.7	3.7					
617	Magdal	32.6	37.3	6.8	Initial	Cortical	0	Parallel	11.1	5.3					
618	Magdal	53.2	22.9	5.2	Primary	Side	1	Parallel	6.4	2.9					
619	Magdal	43.7	24.3	9.9	Secondary	Centre	2	Parallel	16.7	9.9					
620	Magdal	54.8	29.6	4.8	Secondary	TRUE	2	Parallel	11.5	4.1					
621	Magdal	43	35.7	10.4	Secondary	TRUE	2	Parallel	16.3	4.4					
622	Magdal	38.6	66	5.8	Secondary	TRUE	2	Parallel	7.5	3.3					
623	Magdal	23	25	7.4	Primary	Corner	1	Parallel	11.9	4.5					
624	Magdal	31.3	33.2	7.2	Secondary	Side	2	Parallel	9	3.6					
625	Magdal	32	30.4	3.6	Secondary	TRUE	2	Parallel	11	2.9					
626	Magdal	63.9	18.4	3.1	Primary	Side	1	Parallel	6.7	2.3					
627	Magdal	32.5	31.4	6.8	Primary	Side	1	Parallel	7.9	1.2					

628	Magdal	31.4	29.2	8.7	Primary	Side	1	Parallel	7.6	3.5					
629	Magdal	49.8	24.1	8.3	Primary	Centre	1	Parallel	17.1	6.2					
630	Magdal	47.7	19.3	8.4	Primary	Side	1	Parallel							
631	Magdal	118.1	36.7	7.7	Secondary	TRUE	2	Parallel	9.3	5.6	106.7	4.5	4.217432	52.2	48.92221
632	Magdal	29.7	18.2	5.1	Primary	Side	1	Expanding	5.2	2.9					
633	Magdal	49.6	23.7	7.4	Secondary	TRUE	2	Parallel	11.2	8.9					
634	Magdal	36.5	28.4	6.1	Primary	Side	1	Parallel	10.9	4.3					
635	Magdal	44.2	24.6	4.5	Primary	Side	1	Parallel	9.5	4.7					
636	Magdal	69	20.8	13.5	Initial	Crested	1	Parallel							
637	Magdal	82.9	25.6	5.6	Secondary	TRUE	2	Parallel	5.7	3.3	75.8	5.9	7.783641	41.3	54.48549
638	Magdal	86.7	23.9	6.1	Primary	Side	1	Parallel	7.2	2.3	81.9	9.2	11.23321	50.9	62.14896
639	Magdal	62.7	18.5	5	Primary	Side	1	Parallel	3	1.8	59.1	3.3	5.583756	37	62.60575
640	Magdal	74.8	25.2	15.1	Initial	Crested	1	Parallel			63.5	6.9	10.86614	43.9	69.13386
641	Magdal	69.1	28.2	8.4	Primary	Corner	1	Parallel							
642	Magdal	64.1	29.6	10.2	Primary	Corner	1	Parallel	10.1	3.2					
643	Magdal	58.4	16.9	7.5	Primary	Side	1	Parallel	5.2	1.6	59	5.9	10	35.3	59.83051
644	Magdal	53.1	17.8	4.7	Primary	Side	1	Parallel	5.9	2.5					
645	Magdal	64.3	14.8	4.6	Secondary	TRUE	2	Parallel	6.3	2.2					
646	Magdal	58.4	12.9	3.6	Secondary	TRUE	2	Parallel	7.5	2.3					
647	Magdal	49.6	10.1	4.4	Secondary	TRUE	2	Parallel							
648	Magdal	51.9	9.6	4.5	Secondary	TRUE	2	Parallel	4.8	1.6					
649	Magdal	45.2	8.9	2.9	Primary	Centre	1	Parallel							
650	Magdal	33.2	10.8	2.3	Primary	Side	1	Parallel							
651	Magdal	81.6	37.1	7	Secondary	TRUE	2	Parallel	9.4	3.7					
652	Magdal	85.6	23.6	9.4	Primary	Side	1	Parallel	6.9	2.6	78.5	4.9	6.242038	47.6	60.63694
653	Magdal	68.3	25	4.4	Secondary	TRUE	2	Parallel	7.5	3.9					
654	Magdal	85.9	25.5	11.6	Primary	Corner	1	Parallel	17.8	7.3	81.4	4.1	5.036855	40.2	49.38575

655	Magdal	76.6	38.2	6.6	Primary	Side	1	Expanding	5.4	2.9					
656	Magdal	56.1	15.8	4.7	Secondary	TRUE	2	Parallel	2.1	1.8	55.6	2.7	4.856115	25.4	45.68345
657	Magdal	65.8	21.1	4.6	Secondary	TRUE	2	Parallel							
658	Magdal	86.3	30.8	10	Primary	Corner	1	Parallel	18.5	10					
659	Magdal	69.7	36.9	11.5	Primary	Corner	1	Expanding							

Appendix 2

Raw Data – Blade Platforms

ID	Period	Pf Intact/present	Pf Desc	CaCo3	Lipped	Faceted	Reduced	Isolated	Ground	Released
1	Clovis	TRUE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
2	Clovis	TRUE	Dihedral	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
3	Clovis	FALSE	Missing	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
4	Clovis	TRUE	Cortical	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE
5	Clovis	TRUE	Cortical	FALSE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE
6	Clovis	TRUE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
7	Clovis	TRUE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE
8	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	Clovis	TRUE	Cortical	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	Clovis	TRUE	Dihedral	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE
11	Clovis	TRUE	Dihedral	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE
12	Clovis	TRUE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
13	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
14	Clovis	TRUE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
15	Clovis	TRUE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
16	Clovis	TRUE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	FALSE
17	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
18	Clovis	TRUE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
19	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
20	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

21	Clovis	TRUE	Punctiform	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
22	Clovis	TRUE	Faceted	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	TRUE
23	Clovis	TRUE	Dihedral	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
24	Clovis	TRUE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
25	Clovis	TRUE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE
26	Clovis	TRUE	Linear	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	TRUE
27	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
28	Clovis	TRUE	Dihedral	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	FALSE
29	Clovis	TRUE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
30	Clovis	TRUE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
31	Clovis	FALSE	Linear	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
32	Clovis	TRUE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
33	Clovis	FALSE	Punctiform	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
34	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
35	Clovis	TRUE	Punctiform	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
36	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
37	Clovis	TRUE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
38	Clovis	FALSE	Plain	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE	FALSE
39	Clovis	FALSE	Plain	FALSE	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
40	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
41	Clovis	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
42	Clovis	FALSE	Dihedral	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE
43	Clovis	FALSE	Dihedral	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE
44	Clovis	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
45	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
46	Clovis	FALSE	Dihedral	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE
47	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE

48	Clovis	FALSE	Faceted	FALSE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
49	Clovis	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
50	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
51	Clovis	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE
52	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE
53	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
54	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
55	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
56	Clovis	FALSE	Dihedral	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
57	Clovis	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
58	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
59	Clovis	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
60	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
61	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
62	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
63	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
64	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
65	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
66	Clovis	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
67	Clovis	FALSE	Faceted	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
68	Clovis	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
69	Clovis	FALSE	Cortical	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	TRUE
70	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
71	Clovis	FALSE	Faceted	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
72	Clovis	FALSE	Dihedral	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
73	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
74	Clovis	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE

75	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
76	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
77	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
78	Clovis	FALSE	Punctiform	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
79	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
80	Clovis	FALSE	Winged	FALSE	FALSE	TRUE	FALSE	FALSE	TRUE	FALSE
81	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
82	Clovis	FALSE	plain	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
83	Clovis	FALSE	Punctiform	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
84	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
85	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
86	Clovis	FALSE	Winged	FALSE	FALSE	TRUE	FALSE	FALSE	TRUE	FALSE
87	Clovis	FALSE	Punctiform	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
88	Clovis	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
89	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
90	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
91	Clovis	FALSE	Punctiform	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
92	Clovis	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
93	Clovis	FALSE	Cortical	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
94	Clovis	FALSE	Punctiform	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
95	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
96	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
97	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
98	Clovis	FALSE	Missing	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
99	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
100	Clovis	FALSE	Missing	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
101	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

102	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
103	Clovis	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
104	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
105	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
106	Clovis	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
107	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
108	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
109	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
110	Clovis	FALSE	Winged	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
111	Clovis	FALSE	Faceted	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
112	Clovis	FALSE	Faceted	FALSE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
113	Clovis	FALSE	Missing	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE
114	Clovis	FALSE	Plain	FALSE	TRUE	FALSE	FALSE	TRUE	TRUE	TRUE
115	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
116	Clovis	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
117	Clovis	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
118	Clovis	FALSE	Punctiform	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
119	Clovis	FALSE	Dihedral	FALSE	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
120	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
121	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
122	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
123	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
124	Clovis	FALSE	plain	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
125	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
126	Clovis	FALSE	Winged	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
127	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
128	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

129	Clovis	FALSE	Dihedral	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
130	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
131	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
132	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE
133	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
134	Clovis	FALSE	Cortical	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
135	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
136	Clovis	FALSE	Dihedral	FALSE	TRUE	FALSE	FALSE	TRUE	FALSE	TRUE
137	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
138	Clovis	FALSE	Dihedral	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
139	Clovis	FALSE	Linear	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
140	Clovis	FALSE	Punctiform	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
141	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
142	Clovis	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
143	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE
144	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
145	Clovis	FALSE	Dihedral	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
146	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
147	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
148	Clovis	FALSE	Dihedral	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
149	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
150	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
151	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
152	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
153	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
154	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
155	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

156	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
157	Clovis	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
158	Clovis	FALSE	Punctiform	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
159	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
160	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
161	Clovis	FALSE	Plain	FALSE	TRUE	FALSE	FALSE	TRUE	TRUE	TRUE
162	Clovis	FALSE	Cortical	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
163	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	FALSE	TRUE	FALSE
164	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
165	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
166	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
167	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
168	Clovis	FALSE	Plain	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
169	Clovis	FALSE	Plain	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
170	Clovis	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
171	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
172	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	FALSE	TRUE	FALSE
173	Clovis	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
174	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE
175	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE
176	Clovis	FALSE	Faceted	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
177	Clovis	FALSE	Faceted	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
178	Clovis	FALSE	Faceted	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
179	Clovis	FALSE	Faceted	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
180	Clovis	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
181	Clovis	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
182	Clovis	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

183	Clovis	FALSE	Faceted	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
184	Clovis	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
185	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE
186	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
187	Clovis	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
188	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
189	Clovis	FALSE	Faceted	FALSE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE
190	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
191	Clovis	FALSE	Crushed	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
192	Clovis	FALSE	Faceted	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
193	Clovis	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
194	Clovis	FALSE	Dihedral	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE
195	Clovis	FALSE	Spur	FALSE	TRUE	TRUE	FALSE	TRUE	FALSE	TRUE
196	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
197	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
198	Clovis	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
199	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
200	Clovis	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
201	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
202	Clovis	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
203	Clovis	FALSE	Spur	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
204	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
205	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
206	Clovis	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE
207	Clovis	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE
208	Clovis	FALSE	Dihedral	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE
209	OTC	TRUE	Faceted	FALSE	TRUE	TRUE	FALSE	TRUE	TRUE	FALSE

210	OTC	TRUE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
211	OTC	TRUE	Faceted	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE
212	OTC	TRUE	Plain	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
213	OTC	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
214	OTC	TRUE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
215	OTC	TRUE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
216	OTC	TRUE	Faceted	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
217	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
218	Sol Lower	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
219	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	FALSE
220	Sol Lower	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
221	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
222	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
223	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
224	Sol Lower	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
225	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
226	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
227	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
228	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
229	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
230	Sol Lower	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
231	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
232	Sol Lower	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
233	Sol Lower	FALSE	Dihedral	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
234	Sol Lower	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
235	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
236	Sol Lower	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE

237	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
238	Sol Lower	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
239	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
240	Sol Lower	FALSE	Dihedral	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
241	Sol Lower	FALSE	Punctiform	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
242	Sol Lower	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
243	Sol Lower	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
244	Sol Lower	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
245	Sol Lower	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
246	Sol Lower	FALSE	Punctiform	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
247	Sol Lower	FALSE	Punctiform	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
248	Sol Lower	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
249	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
250	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
251	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
252	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
253	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
254	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
255	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
256	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
257	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
258	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
259	Sol Lower	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
260	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
261	Sol Lower	FALSE	Punctiform	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
262	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE
263	Sol Lower	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

264	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
265	Sol Lower	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
266	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
267	Sol Lower	FALSE	Dihedral	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
268	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
269	Sol Lower	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
270	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
271	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
272	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
273	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
274	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
275	Sol Lower	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
276	Sol Lower	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
277	Sol Lower	FALSE	Dihedral	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE
278	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
279	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
280	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
281	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
282	Sol Lower	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
283	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
284	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
285	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
286	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
287	Sol Lower	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
288	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
289	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
290	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

291	Sol Lower	FALSE	Dihedral	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
292	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
293	Sol Lower	FALSE	Punctiform	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
294	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
295	Sol Lower	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
296	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
297	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
298	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
299	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
300	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
301	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
302	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
303	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
304	Sol Lower	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
305	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
306	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE
307	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
308	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
309	Sol Lower	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
310	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
311	Sol Lower	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
312	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
313	Sol Lower	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
314	Sol Lower	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
315	Sol Lower	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
316	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
317	Sol Lower	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE

318	Sol Lower	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
319	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
320	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
321	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
322	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
323	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
324	Sol Lower	FALSE	Dihedral	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
325	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
326	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
327	Sol Lower	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
328	Sol Lower	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
329	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
330	Sol Lower	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
331	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
332	Sol Middle	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
333	Sol Middle	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
334	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
335	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
336	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	FALSE
337	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
338	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
339	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
340	Sol Middle	FALSE	Winged	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
341	Sol Middle	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
342	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
343	Sol Middle	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
344	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE

345	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
346	Sol Middle	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
347	Sol Middle	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
348	Sol Middle	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
349	Sol Middle	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
350	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
351	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
352	Sol Middle	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
353	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
354	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
355	Sol Middle	FALSE	Dihedral	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
356	Sol Middle	FALSE	Dihedral	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
357	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
358	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
359	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
360	Sol Middle	FALSE	Linear	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
361	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
362	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
363	Sol Middle	FALSE	Winged	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
364	Sol Middle	FALSE	Dihedral	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
365	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
366	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
367	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
368	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
369	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
370	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
371	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

372	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
373	Sol Middle	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
374	Sol Middle	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
375	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
376	Sol Middle	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
377	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
378	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
379	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
380	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
381	Sol Middle	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
382	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
383	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
384	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
385	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
386	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
387	Sol Middle	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
388	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
389	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
390	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
391	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
392	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	FALSE	TRUE	FALSE
393	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
394	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
395	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
396	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
397	Sol Middle	FALSE	Dihedral	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
398	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE

399	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
400	Sol Middle	FALSE	Winged	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	FALSE
401	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
402	Sol Middle	FALSE	Dihedral	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
403	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
404	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
405	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
406	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
407	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
408	Sol Middle	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
409	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
410	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
411	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
412	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
413	Sol Middle	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
414	Sol Middle	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
415	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
416	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
417	Sol Middle	FALSE	Dihedral	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE
418	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
419	Sol Middle	FALSE	Dihedral	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
420	Sol Middle	FALSE	plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
421	Sol Middle	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
422	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
423	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
424	Sol Middle	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
425	Sol Middle	FALSE	Winged	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	TRUE

426	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
427	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
428	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
429	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
430	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
431	Sol Middle	FALSE	Punctiform	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
432	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
433	Sol Middle	FALSE	Faceted	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
434	Sol Middle	FALSE	Dihedral	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
435	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
436	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
437	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
438	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
439	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
440	Sol Middle	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
441	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
442	Sol Middle	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
443	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
444	Sol Middle	FALSE	Winged	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
445	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
446	Sol Middle	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
447	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
448	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
449	Sol Middle	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
450	Sol Middle	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
451	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
452	Sol Middle	FALSE	Spur	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE

453	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
454	Sol Middle	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
455	Sol Middle	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
456	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
457	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
458	Sol Middle	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
459	Sol Middle	FALSE	Winged	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
460	Sol Middle	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
461	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
462	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
463	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
464	Sol Middle	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
465	Sol Middle	FALSE	Punctiform	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
466	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
467	Sol Middle	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
468	Sol Middle	FALSE	Spur	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
469	Sol Middle	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
470	Sol Middle	FALSE	Spur	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
471	Sol Middle	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
472	Sol Middle	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
473	Sol Middle	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
474	Sol Upper	FALSE	Spur	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
475	Sol Upper	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
476	Sol Upper	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
477	Sol Upper	FALSE	Faceted	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
478	Sol Upper	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
479	Sol Upper	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

480	Sol Upper	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
481	Sol Upper	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
482	Sol Upper	FALSE	Dihedral	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
483	Sol Upper	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
484	Sol Upper	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
485	Sol Upper	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
486	Sol Upper	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
487	Sol Upper	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
488	Sol Upper	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
489	Sol Upper	FALSE	Plain	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE	FALSE
490	Sol Upper	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
491	Sol Upper	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
492	Sol Upper	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
493	Sol Upper	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
494	Sol Upper	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
495	Sol Upper	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
496	Sol Upper	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
497	Sol Upper	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
498	Sol Upper	FALSE	Plain	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
499	Sol Upper	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
500	Sol Upper	FALSE	Plain	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE	FALSE
501	Sol Upper	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
502	Sol Upper	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
503	Sol Upper	FALSE	Faceted	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
504	Sol Upper	FALSE	Cortical	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
505	Sol Upper	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
506	Sol Upper	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

507	Sol Upper	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
508	Sol Upper	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
509	Sol Upper	FALSE	Cortical	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
510	Sol Upper	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
511	Sol Upper	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
512	Sol Upper	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
513	Sol Upper	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
514	Sol Upper	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
515	Sol Upper	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
516	Sol Upper	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
517	Sol Upper	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
518	Sol Upper	FALSE	Cortical	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
519	Sol Upper	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
520	Sol Upper	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
521	Sol Upper	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
522	Sol Upper	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
523	Sol Upper	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
524	Sol Upper	FALSE	Punctiform	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
525	Sol Upper	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
526	Sol Upper	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
527	Sol Upper	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
528	Sol Upper	FALSE	Dihedral	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
529	Sol Upper	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
530	Sol Upper	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
531	Sol Upper	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
532	Sol Upper	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
533	Sol Upper	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

534	Sol Upper	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
535	Sol Upper	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
536	Sol Upper	FALSE	Punctiform	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
537	Sol Upper	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
538	Sol Upper	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
539	Sol Upper	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE
540	Sol Upper	FALSE	Dihedral	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
541	Sol Upper	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
542	Sol Upper	FALSE	Plain	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE	FALSE
543	Sol Upper	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
544	Sol Upper	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
545	Sol Upper	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
546	Sol Upper	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
547	Sol Upper	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
548	Sol Upper	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
549	Sol Upper	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
550	Sol Upper	FALSE	Dihedral	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
551	Sol Upper	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
552	Sol Upper	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
553	Sol Upper	FALSE	Crushed	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
554	Sol Upper	FALSE	Missing	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
555	Sol Upper	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
556	Sol Upper	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
557	Sol Upper	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
558	Sol Upper	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
559	Sol Upper	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
560	Sol Upper	FALSE	Faceted	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

561	Sol Upper	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
562	Sol Upper	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
563	Sol Upper	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
564	Sol Upper	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
565	Sol Upper	FALSE	Plain	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE	FALSE
566	Sol Upper	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
567	Sol Upper	FALSE	Cortical	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
568	Sol Upper	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
569	Sol Upper	FALSE	Cortical	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
570	Sol Upper	FALSE	Spur	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
571	Sol Upper	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
572	Sol Upper	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
573	Sol Upper	FALSE	Winged	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
574	Sol Upper	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
575	Sol Upper	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
576	Sol Upper	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
577	Sol Upper	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE
578	Sol Upper	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
579	Sol Upper	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
580	Sol Upper	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
581	Sol Upper	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
582	Sol Upper	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
583	Sol Upper	FALSE	Crushed	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
584	Magdal	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
585	Magdal	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
586	Magdal	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
587	Magdal	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

588	Magdal	FALSE	Spur	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
589	Magdal	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
590	Magdal	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
591	Magdal	FALSE	Cortical	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
592	Magdal	FALSE	Spur	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE
593	Magdal	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
594	Magdal	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE
595	Magdal	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
596	Magdal	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
597	Magdal	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
598	Magdal	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
599	Magdal	FALSE	Spur	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	TRUE
600	Magdal	FALSE	Plain	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
601	Magdal	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
602	Magdal	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
603	Magdal	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
604	Magdal	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
605	Magdal	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
606	Magdal	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
607	Magdal	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
608	Magdal	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
609	Magdal	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
610	Magdal	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
611	Magdal	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
612	Magdal	FALSE	Dihedral	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
613	Magdal	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE
614	Magdal	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE

615	Magdal	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE
616	Magdal	FALSE	Dihedral	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE
617	Magdal	FALSE	Plain	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
618	Magdal	FALSE	Spur	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE
619	Magdal	FALSE	Dihedral	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
620	Magdal	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
621	Magdal	FALSE	Spur	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
622	Magdal	FALSE	Spur	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE
623	Magdal	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
624	Magdal	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
625	Magdal	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
626	Magdal	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE
627	Magdal	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
628	Magdal	FALSE	Spur	FALSE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE
629	Magdal	FALSE	Spur	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE
630	Magdal	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
631	Magdal	FALSE	Spur	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE
632	Magdal	FALSE	Spur	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE
633	Magdal	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
634	Magdal	FALSE	Faceted	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
635	Magdal	FALSE	Spur	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE
636	Magdal	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
637	Magdal	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
638	Magdal	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
639	Magdal	FALSE	Punctiform	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
640	Magdal	FALSE	Crushed	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
641	Magdal	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

642	Magdal	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
643	Magdal	FALSE	Faceted	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
644	Magdal	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
645	Magdal	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
646	Magdal	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
647	Magdal	FALSE	Crushed	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
648	Magdal	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
649	Magdal	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
650	Magdal	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
651	Magdal	FALSE	Linear	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
652	Magdal	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
653	Magdal	FALSE	Plain	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
654	Magdal	FALSE	Dihedral	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
655	Magdal	FALSE	Linear	FALSE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE
656	Magdal	FALSE	Punctiform	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
657	Magdal	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
658	Magdal	FALSE	Dihedral	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
659	Magdal	FALSE	Missing	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

Appendix 3

Raw Data – Blade Termination

ID	Period	Blunt/feathered	Hinged	Plunging	Distal Cortex	Distal CaCo3	Snap
1	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
2	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
3	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
4	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
5	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
6	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
7	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
8	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
9	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
10	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
11	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
12	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
13	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
14	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
15	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
16	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
17	Clovis	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
18	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
19	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
20	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

21	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
22	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
23	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
24	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
25	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
26	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
27	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
28	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
29	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
30	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
31	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
32	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
33	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
34	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
35	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
36	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
37	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
38	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
39	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
40	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
41	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
42	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
43	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
44	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
45	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
46	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
47	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

48	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
49	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
50	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
51	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
52	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
53	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
54	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
55	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
56	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
57	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
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59	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
60	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
61	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
62	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
63	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
64	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
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66	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
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69	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
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72	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
73	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
74	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

75	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
76	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
77	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
78	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
79	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
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83	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
84	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
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86	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
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88	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
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92	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
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100	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
101	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

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217	Sol Lower	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
218	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
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220	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
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222	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
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224	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
225	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
226	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
227	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
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230	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
231	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
232	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
233	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
234	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
235	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
236	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE

237	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
238	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
239	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
240	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
241	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
242	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
243	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
244	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
245	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
246	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
247	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
248	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
249	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
250	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
251	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
252	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
253	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
254	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
255	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
256	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
257	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
258	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
259	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
260	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
261	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
262	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
263	Sol Lower	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

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265	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
266	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
267	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
268	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
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270	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
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273	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
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276	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
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317	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE

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357	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
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361	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
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363	Sol Middle	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
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366	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
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371	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE

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375	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
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396	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
397	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
398	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE

399	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
400	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
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402	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
403	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
404	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
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406	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
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420	Sol Middle	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
421	Sol Middle	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
422	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
423	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
424	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
425	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE

426	Sol Middle	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
427	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
428	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
429	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
430	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
431	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
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434	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
435	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
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450	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
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452	Sol Middle	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

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454	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
455	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
456	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
457	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
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463	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
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471	Sol Middle	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
472	Sol Middle	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
473	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
474	Sol Upper	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
475	Sol Upper	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
476	Sol Upper	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
477	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
478	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
479	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE

480	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
481	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
482	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
483	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
484	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
485	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
486	Sol Upper	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
487	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
488	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
489	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
490	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
491	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
492	Sol Upper	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
493	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
494	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
495	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
496	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
497	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
498	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
499	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
500	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
501	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
502	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
503	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
504	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
505	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
506	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE

507	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
508	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
509	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
510	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
511	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
512	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
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514	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
515	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
516	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
517	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
518	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
519	Sol Upper	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
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521	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
522	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
523	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
524	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
525	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
526	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
527	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
528	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
529	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
530	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
531	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
532	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
533	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE

534	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
535	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
536	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
537	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
538	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
539	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
540	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
541	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
542	Sol Upper	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
543	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
544	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
545	Sol Upper	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
546	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
547	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
548	Sol Upper	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
549	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
550	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
551	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
552	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
553	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
554	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
555	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
556	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
557	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
558	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
559	Sol Upper	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
560	Sol Upper	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

561	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
562	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
563	Sol Upper	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
564	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
565	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
566	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
567	Sol Upper	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
568	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
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570	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
571	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
572	Sol Upper	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
573	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
574	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
575	Sol Upper	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
576	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
577	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
578	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
579	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
580	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
581	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
582	Sol Upper	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
583	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
584	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
585	Magdal	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
586	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
587	Magdal	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

588	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
589	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
590	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
591	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
592	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
593	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
594	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
595	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
596	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
597	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
598	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
599	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
600	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
601	Magdal	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
602	Magdal	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
603	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
604	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
605	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
606	Magdal	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
607	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
608	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
609	Magdal	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
610	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
611	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
612	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
613	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
614	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE

615	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
616	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
617	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
618	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
619	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
620	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
621	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
622	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
623	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
624	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
625	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
626	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
627	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
628	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
629	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
630	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
631	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
632	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
633	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
634	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
635	Magdal	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
636	Magdal	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
637	Magdal	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
638	Magdal	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
639	Magdal	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
640	Magdal	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
641	Magdal	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

642	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
643	Magdal	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
644	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
645	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
646	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
647	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
648	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
649	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
650	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
651	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
652	Magdal	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
653	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
654	Magdal	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
655	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
656	Magdal	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
657	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
658	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
659	Magdal	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE

Appendix 4

Raw Data – Blade scar pattern and notes

ID	Period	Unidirectional	Asymmetrically opposed	Opposed	Crossed	Multidirectional	Dorsal Cortex	Dorsal CaCo3	Notes
1	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
2	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
3	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Primary Blade, Lipped platform, linear facet
4	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	Primary Blade
5	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Primary Blade
6	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	Cortex to base
7	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	Some CaCo3
8	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
9	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	Primary Blade
10	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Blade-like Flake?
11	Clovis	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	Linear facet on platform
12	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
13	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Crested Bifacial fragment
14	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	Primary Blade
15	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Primary

16	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Corner Blade
17	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	
18	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner Blade
19	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner Blade?
20	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Hinge (See Lindsey PIT 1269-30)
21	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True Blade
22	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Corner Blade (cortex)
23	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner Blade (cortex)
24	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True Blade
25	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	True Blade
26	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
27	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
28	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True Blade
29	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Corner Blade
30	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Crested Blade
31	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True Blade
32	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
33	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Too much CaCo3 build up
34	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Heavy battering
35	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
36	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner Blade
37	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner Blade
38	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
39	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
40	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True Blade
41	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Truncated
42	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner Blade

43	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Lateral retouch
44	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
45	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	Crested Blade fragment
46	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	True Blade
47	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
48	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	True Blade
49	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Corner Blade
50	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	Lateral Retouch
51	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	Lateral retouch
52	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Lateral plat retouch, Partial semi-abrupt retouch
53	Clovis	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	Polish (awl?)
54	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	Snap (hinge from opposite direction)
55	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
56	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner
57	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner Blade
58	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
59	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	True Blade
60	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner Blade
61	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
62	Clovis	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	Fragment
63	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner
64	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
65	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True Blade
66	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Primary Blade
67	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	True Blade
68	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	True Blade
69	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	

70	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True Blade
71	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	Linear facet
72	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
73	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Endscraper
74	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Heavy cortex deep hinge
75	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Distinct style
76	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	Similar Distinct style
77	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	CaCo3
78	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True Blade
79	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner blade, Linear facet
80	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner blade 'chapeau de gendarme'
81	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
82	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
83	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True Blade
84	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Distinct type
85	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Heavy Cortex
86	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True Blade
87	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True Blade
88	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Distinct Type
89	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Linear Facet
90	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True Blade
91	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	partial semi-abrupt retouch
92	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
93	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner blade
94	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
95	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Distinct type
96	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner Blade

97	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
98	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True blade
99	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True blade
100	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner blade
101	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner Blade
102	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
103	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner Blade
104	Clovis	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	
105	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner
106	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
107	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
108	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	True blade
109	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner Blade
110	Clovis	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	
111	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	
112	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Crested Blade
113	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner Blade
114	Clovis	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	
115	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True Blade
116	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True Blade
117	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Awl
118	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True Blade
119	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner Blade
120	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
121	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Blade snapped in half AFTER excavation, measurement and weight given represent WHOLE blade, individual components length 89.9 and 18.8
122	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	CaCo3

123	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
124	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	
125	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
126	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner Blade
127	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Corner Blade Distinct type (partially)
128	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Fragment
129	Clovis	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	Initial Blade
130	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Crested Blade
131	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
132	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	
133	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Partial Crest Corner Blade
134	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner Blade
135	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	Corner Blade
136	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Corner Blade
137	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Crested Blade
138	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
139	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True Blade
140	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
141	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True Blade
142	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Distinct Type
143	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	
144	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
145	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
146	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Crested
147	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	Burin
148	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	Endscraper corner blade
149	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Lateral retouch

150	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	Corner blade
151	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	Along one edge
152	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Endscraper
153	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	heavily modified
154	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Endscraper lateral retouch
155	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	Endscraper proximal end
156	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Lateral retouch
157	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True Blade endscraper
158	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Lateral retouch
159	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Lateral retouch
160	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Endscraper parallel lateral retouch
161	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Endscraper
162	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	slight crest with flaking from back of core to front
163	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	deep hinge
164	Clovis	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	rejuvenation recovery flake
165	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	SEE NOTES rejuvenation flake
166	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	Opposed recovery blade
167	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	True blade, retouched like a point au face plan
168	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	SEE NOTES 42F-5
169	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
170	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
171	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
172	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	repair blade
173	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
174	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
175	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
176	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	

177	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
178	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
179	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
180	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
181	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
182	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
183	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
184	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
185	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
186	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
187	Clovis	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	
188	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
189	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
190	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
191	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
192	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
193	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
194	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
195	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
196	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
197	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
198	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
199	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
200	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	
201	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
202	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
203	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	

204	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
205	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
206	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	CAST
207	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
208	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
209	OTC	TRUE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	partial crest on distal end
210	OTC	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	square edge with one cortical side
211	OTC	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	slight front ground
212	OTC	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	unidirectional scar with flakes struck from arris
213	OTC	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
214	OTC	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
215	OTC	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	remnants of cresting on left lateral edge
216	OTC	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	retouch bottom edge slight front ground
217	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
218	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
219	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
220	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
221	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
222	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
223	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
224	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	

225	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
226	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
227	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
228	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
229	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
230	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
231	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
232	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
233	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
234	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
235	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
236	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
237	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
238	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
239	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	

240	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
241	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
242	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
243	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
244	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
245	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
246	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
247	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
248	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	bidirectional refit with next blade
249	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	Bidirectional refit with previous blade (B1976)
250	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
251	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
252	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
253	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
254	Sol Lower	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	crested from ridge

255	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
256	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
257	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
258	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
259	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
260	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
261	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
262	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
263	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
264	Sol Lower	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	
265	Sol Lower	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
266	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
267	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
268	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
269	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	

270	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	BIG eraillure
271	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
272	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
273	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
274	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
275	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
276	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	backed blade
277	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	point au face plan
278	Sol Lower	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	bifacially crested from ridge
279	Sol Lower	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	unifacial crest from ridge
280	Sol Lower	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	bifacially crested from ridge
281	Sol Lower	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	unifacial from ridge
282	Sol Lower	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	unifacial crest from ridge
283	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	unifacial from ridge
284	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	unifacial from ridge

285	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
286	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
287	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
288	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
289	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
290	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
291	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
292	Sol Lower	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
293	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
294	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
295	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
296	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
297	Sol Lower	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
298	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
299	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	

300	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
301	Sol Lower	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	
302	Sol Lower	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	
303	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
304	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
305	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
306	Sol Lower	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	
307	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
308	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
309	Sol Lower	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
310	Sol Lower	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	repair of face
311	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
312	Sol Lower	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	opposed scars with crossed scars to form crest flaked from back, also front ground
313	Sol Lower	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	front ground
314	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	removed hinge

315	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
316	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
317	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
318	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
319	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
320	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
321	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
322	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
323	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Front ground
324	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	front ground
325	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
326	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
327	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
328	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
329	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	removed a hinge from the opposite pf

330	Sol Lower	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	removed full length blade scar from opposite platform
331	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
332	Sol Middle	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	
333	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
334	Sol Middle	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	
335	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
336	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Removed a hinge from the face of the core
337	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
338	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
339	Sol Middle	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	
340	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	repair blade removed a hinge
341	Sol Middle	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
342	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
343	Sol Middle	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	fractured distal end shows working from opposite end of core
344	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Took part of core base

345	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
346	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
347	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
348	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
349	Sol Middle	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	
350	Sol Middle	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	unidirectional on 2 arises with scars from back to front along one side
351	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
352	Sol Middle	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	
353	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
354	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
355	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
356	Sol Middle	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
357	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	corner with flake struck from ridge
358	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
359	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	

360	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
361	Sol Middle	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
362	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
363	Sol Middle	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	
364	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	scar struck from ridge
365	Sol Middle	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	unidirectional one side of ridge, struck too the ridge on the other side
366	Sol Middle	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	partially crested struck from ridge
367	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
368	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	
369	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
370	Sol Middle	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	struck to crest
371	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
372	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
373	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
374	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	retouched

375	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
376	Sol Middle	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	
377	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	GROUND ON FRONT
378	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	ground to front, retouch
379	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	ground to front
380	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
381	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	pf retouched
382	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
383	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	ground to front
384	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	ground to front
385	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	scrapper ground to front
386	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	crest worked from crest back
387	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
388	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
389	Sol Middle	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Ground front

390	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
391	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
392	Sol Middle	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
393	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
394	Sol Middle	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
395	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
396	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
397	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
398	Sol Middle	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	Ground to front
399	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
400	Sol Middle	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	removed a hinge struck from the distal end repair
401	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
402	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
403	Sol Middle	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	flake scars removed towards ridge
404	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	

405	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
406	Sol Middle	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	crested from ridge
407	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
408	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
409	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
410	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
411	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
412	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
413	Sol Middle	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	see notes corner frag medial
414	Sol Middle	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
415	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
416	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
417	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
418	Sol Middle	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
419	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	

420	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
421	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
422	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
423	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
424	Sol Middle	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	partial crested
425	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
426	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
427	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
428	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	ground front
429	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	ground front
430	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
431	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
432	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
433	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
434	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	

435	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
436	Sol Middle	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	repair, Front ground
437	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
438	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
439	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
440	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
441	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
442	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
443	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
444	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
445	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
446	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
447	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
448	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
449	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground

450	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
451	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	oblique truncated
452	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
453	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
454	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
455	Sol Middle	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
456	Sol Middle	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	repair
457	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
458	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
459	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
460	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	repair removed partial hinge
461	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
462	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
463	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
464	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	

465	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
466	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
467	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
468	Sol Middle	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	Crest from ridge
469	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
470	Sol Middle	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
471	Sol Middle	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	repair or rejuvenation preparation
472	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
473	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
474	Sol Upper	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	
475	Sol Upper	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	double end scraper
476	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
477	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
478	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	burinated
479	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	

480	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
481	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
482	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
483	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	hinge removal from base
484	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
485	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
486	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
487	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
488	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
489	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	removed 2 hinges
490	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
491	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
492	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	removed base
493	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
494	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	

495	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
496	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
497	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	removed hinge from top
498	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
499	Sol Upper	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	removed a hinge
500	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
501	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
502	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
503	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
504	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
505	Sol Upper	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
506	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
507	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
508	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
509	Sol Upper	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	

510	Sol Upper	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
511	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
512	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
513	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
514	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
515	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
516	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
517	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
518	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
519	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
520	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
521	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
522	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
523	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
524	Sol Upper	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	

525	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
526	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
527	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
528	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
529	Sol Upper	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
530	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
531	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
532	Sol Upper	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
533	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
534	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
535	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
536	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Front ground
537	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
538	Sol Upper	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
539	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	

540	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
541	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
542	Sol Upper	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
543	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	languette fracture
544	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
545	Sol Upper	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	retouched platform
546	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
547	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
548	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
549	Sol Upper	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	removed hinge
550	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
551	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
552	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
553	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
554	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	

555	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	burinated unifacial point, composite tool
556	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
557	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
558	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
559	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
560	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
561	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
562	Sol Upper	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
563	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
564	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
565	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
566	Sol Upper	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	secondary stage cresting from back of core to blade face
567	Sol Upper	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	
568	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
569	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	

570	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
571	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
572	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
573	Sol Upper	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	
574	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
575	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
576	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
577	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
578	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
579	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
580	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
581	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
582	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
583	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
584	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
585	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground

586	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
587	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	Side scraper
588	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	burin on spur pf
589	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
590	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
591	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
592	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
593	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
594	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
595	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
596	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
597	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
598	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
599	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
600	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
601	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
602	Magdal	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	from back
603	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
604	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
605	Magdal	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	to crest from back
606	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
607	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
608	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
609	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
610	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
611	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
612	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	

613	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
614	Magdal	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	crested from ridge
615	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
616	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
617	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
618	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
619	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
620	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
621	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
622	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
623	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
624	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
625	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
626	Magdal	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	to crest from back
627	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
628	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
629	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
630	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
631	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
632	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
633	Magdal	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	
634	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
635	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	en eperon
636	Magdal	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	unifacial from crest to back retouched
637	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
638	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
639	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	

640	Magdal	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	crested from ridge
641	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
642	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	front ground
643	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
644	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
645	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
646	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
647	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
648	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
649	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
650	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
651	Magdal	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	scars from back to face
652	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
653	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
654	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
655	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
656	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
657	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
658	Magdal	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	
659	Magdal	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	

Appendix 5

Raw Data – Blade Core data, core state and notes

ID	Site	Entity	Lot	Specimen	Period	Exhausted	Battered	Platform Crushed	Notes
1	Laugerie Haute East	C854			Sol Middle	TRUE	FALSE	FALSE	Exhausted lost correct of angle 2 linear removals across top to try to recorrect angles but did not work
2	Laugerie Haute East	B1147			Sol Middle	TRUE	FALSE	FALSE	exhausted core almost conical core shaped with ridge
3	Laugerie Haute East	T950			Sol Middle	TRUE	FALSE	FALSE	exhausted (bladelet core) some cortex retention on back
4	Laugerie Haute East	A1405			Sol Middle	TRUE	FALSE	FALSE	exhausted wedge shaped core step angle removed
5	Laugerie Haute East	G1 579			Sol Middle	TRUE	FALSE	FALSE	see notes
6	Laugerie Haute East				Sol Middle	TRUE	TRUE	FALSE	extremely battered worked well beyond and good blades see notes core 1000
7	Laugerie Haute East				Sol Middle	TRUE	TRUE	FALSE	See notes core K281
8	Laugerie Haute East	A1047			Sol Upper	TRUE	FALSE	FALSE	wedge core see notes
9	Laugerie Haute East	A1402			Sol Upper	TRUE	FALSE	FALSE	lost angle from pf

10	Laugerie Haute East	F394			Sol Upper	TRUE	TRUE	FALSE	crest on back runs horizontally
11	Laugerie Haute East				Sol Upper	TRUE	TRUE	FALSE	Exhausted wedge discarded due to lost pf angle
12	Laugerie Haute East	J491			Sol Lower	FALSE	FALSE	FALSE	see notes
13	Laugerie Haute East	B840			Mag/Bad	TRUE	FALSE	FALSE	See notes
14	Laugerie Haute East	A318			Mag 2	TRUE	FALSE	FALSE	pf lost
15	Laugerie Haute East	B200			Mag 2	TRUE	FALSE	FALSE	bidirectional core
16	Laugerie Haute East	D1			Mag 2	TRUE	FALSE	FALSE	flat plain pf
17	Laugerie Haute East	A128			Mag 2	TRUE	FALSE	FALSE	flat plain pf
18	Laugerie Haute East	A172			Mag 2	TRUE	FALSE	FALSE	flat pf cortical back
19	Laugerie Haute East	B183			Mag 2	TRUE	FALSE	FALSE	flat pf ridged see notes
20	Laugerie Haute East	21-32			Mag 2	TRUE	FALSE	FALSE	cortex flat see notes
21	Laugerie Haute East	A196				TRUE	FALSE	FALSE	See notes
22	Laugerie Haute East	A197			Mag 2	TRUE	FALSE	FALSE	see notes
23	Laugerie Haute East	A185			Mag 2	TRUE	FALSE	FALSE	see notes
24	Laugerie Haute East	B427				TRUE	FALSE	FALSE	see notes

25	Laugerie Haute East	C632			Mag 2	TRUE	FALSE	FALSE	see notes
26	Laugerie Haute East	D147			Mag 2	TRUE	FALSE	FALSE	see notes
27	Laugerie Haute East	B248			Mag 2	TRUE	FALSE	FALSE	see notes
28	Laugerie Haute East	A164			Mag 2	TRUE	FALSE	FALSE	bi directional
1	Gault	UT	2060	5	Clovis	TRUE	FALSE	FALSE	Repairs from base
2	Gault		2608	1	Clovis	TRUE	FALSE	TRUE	
3	Gault		2391	8	Clovis	TRUE	FALSE	TRUE	
4	Gault		2385	2	Clovis	TRUE	TRUE	FALSE	Re-worked and heavy battering. CaCO3 deposits
5	Gault	BB	2122	1	Clovis	TRUE	TRUE	TRUE	Two platforms
6	Gault	BB	2100	18	Clovis	TRUE	FALSE	TRUE	Exhausted core fragment
7	Gault	UT	1497	3	Clovis	TRUE	TRUE	TRUE	See notes
8	Gault	BY	110	1	Clovis	TRUE	TRUE	TRUE	Two Platforms, Novice core
9	Gault	BB	2072	1	Clovis	FALSE	FALSE	FALSE	Natural?
10	Gault	NH	1107	1	Clovis	TRUE	FALSE	TRUE	
11	Gault	UT	4448	58	Clovis	TRUE	FALSE	TRUE	Right lateral CaCo3
12	Gault		3542	5	Clovis	TRUE	FALSE	FALSE	
13	Gault		3317	14	Clovis	TRUE	TRUE	TRUE	Flat, heavily worked no lateral edge to note
14	Gault		4469	16	Clovis	TRUE	TRUE	FALSE	
15	Gault		4693	21	Clovis	TRUE	TRUE	TRUE	Exhausted and Battered
16	Gault		3166	7	Clovis	FALSE	FALSE	TRUE	See Notes
17	Gault	UT	4722	1	Clovis	TRUE	FALSE	TRUE	Unidirectional Core
18	Gault	UT	4556	15	Clovis	TRUE	TRUE	TRUE	Crest remnants on base. Unidirect core
19	Gault	UT	4416	26	Clovis	TRUE	TRUE	TRUE	Left lateral heavily battered, re-use as scraper
20	Gault	UT	4416	20	Clovis	TRUE	FALSE	FALSE	Right Lateral natural flat

21	Gault	UT	4230	6	Clovis	TRUE	FALSE	FALSE	Opposite use of platform to shape back
22	Gault	UT	4110	7	Clovis	TRUE	TRUE	FALSE	Fragment
23	Gault	UT	3152	5	Clovis	FALSE	TRUE	FALSE	
24	Gault	UT	3027	6	Clovis	TRUE	TRUE	FALSE	Novice core
25	Gault	UT	2911	2	Clovis	TRUE	FALSE	FALSE	
26	Gault	UT	2695	1	Clovis	FALSE	FALSE	FALSE	Crested for blade removal but no blades removed due to flaw
27	Gault	UT	4660	7	Clovis	TRUE	FALSE	TRUE	Offset back crest
28	Gault	UT	4554	47	Clovis	TRUE	FALSE	TRUE	
29	Gault	UT	4509	4	Clovis	TRUE	FALSE	FALSE	
30	Gault	UT	4505	1	Clovis	TRUE	TRUE	FALSE	
31	Gault	UT	4061	18	Clovis	TRUE	FALSE	TRUE	Right Lateral Battered.
32	Pavo Real	66G-1			Clovis	TRUE	TRUE	FALSE	PAVO REAL SEE NOTES
33	Pavo Real	126P2-21			Clovis	TRUE	FALSE	FALSE	PAVO REAL SEE NOTES
34	Pavo Real	128P2-83			Clovis	TRUE	FALSE	FALSE	PAVO REAL SEE NOTES
35	Gault	OTC	6314	50	OTC	FALSE	FALSE	FALSE	Flat back heavily prepared platform with hinges. One deep hinge perpendicular to platform. Heavily curved final blade removal. Platform angle approaching 90 deg and possible reason for discard. Plat prep conducted from blade scars towards blade back
36	Gault	OTC	6424	2	OTC	TRUE	FALSE	FALSE	Single platform wedge shaped one large plunging blade removal. Platform is small irregular. Flat back
37	Gault	OTC	6409	1	OTC	FALSE	FALSE	FALSE	Single plat semi circumference flaking. Flat back due to large perpendicular flake. Some cortex retained. Core tablet possibly removed some prep from blade scar into core plat flake from core back to front hinge.

Appendix 6

Raw Data – Blade Core data, core back morphology

ID	Site	Period	Uni-laterally flat	Bi-laterally flat	Multidirectional Flat	Unifacial Crest	Bifacial Crest	Cortex	CaCo3
1	Laugerie Haute East	Sol Middle	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
2	Laugerie Haute East	Sol Middle	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
3	Laugerie Haute East	Sol Middle	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
4	Laugerie Haute East	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
5	Laugerie Haute East	Sol Middle	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
6	Laugerie Haute East	Sol Middle	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
7	Laugerie Haute East	Sol Middle	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
8	Laugerie Haute East	Sol Upper	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
9	Laugerie Haute East	Sol Upper	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
10	Laugerie Haute East	Sol Upper	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
11	Laugerie Haute East	Sol Upper	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
12	Laugerie Haute East	Sol Lower	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
13	Laugerie Haute East	Mag/Bad	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
14	Laugerie Haute East	Mag 2	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
15	Laugerie Haute East	Mag 2	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
16	Laugerie Haute East	Mag 2	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
17	Laugerie Haute East	Mag 2	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
18	Laugerie Haute East	Mag 2	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
19	Laugerie Haute East	Mag 2	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
20	Laugerie Haute East	Mag 2	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE

21	Laugerie Haute East		FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
22	Laugerie Haute East	Mag 2	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
23	Laugerie Haute East	Mag 2	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
24	Laugerie Haute East		FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
25	Laugerie Haute East	Mag 2	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
26	Laugerie Haute East	Mag 2	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
27	Laugerie Haute East	Mag 2	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
28	Laugerie Haute East	Mag 2	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
1	Gault	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
2	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
5	Gault	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
6	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
8	Gault	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
9	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
11	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
12	Gault	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
13	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
14	Gault	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
15	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
16	Gault	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
17	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
18	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
19	Gault	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE

20	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
21	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
22	Gault	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
23	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
24	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
25	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
26	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
27	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
28	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
29	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
30	Gault	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
31	Gault	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
32	Pavo Real	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
33	Pavo Real	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
34	Pavo Real	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
35	Gault	OTC	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
36	Gault	OTC	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
37	Gault	OTC	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

Appendix 7

Raw Data – Blade Core data, left lateral margin scar pattern

ID	Site	Period	LSP Unidirectional	LSP Bidirectional	LSP Opposed	LSP Asymmetrically opposed	LSP Crossed	LSP Multidirectional	LSP Cortex	LSP CaCo3
1	Laugerie Haute East	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	Laugerie Haute East	Sol Middle	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	Laugerie Haute East	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	Laugerie Haute East	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	Laugerie Haute East	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	Laugerie Haute East	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
7	Laugerie Haute East	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	Laugerie Haute East	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	Laugerie Haute East	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	Laugerie Haute East	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
11	Laugerie Haute East	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
12	Laugerie Haute East	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
13	Laugerie Haute East	Mag/Bad	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
14	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
15	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

16	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
17	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
18	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
19	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
20	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
21	Laugerie Haute East		FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
22	Laugerie Haute East	Mag 2	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
23	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
24	Laugerie Haute East		FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
25	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
26	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
27	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
28	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
1	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
4	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
5	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
8	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	Gault	Clovis	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
10	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
11	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
12	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
13	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
14	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

15	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
16	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
17	Gault	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
18	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
19	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
20	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
21	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
22	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
23	Gault	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
24	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
25	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
26	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
27	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
28	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
29	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
30	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
31	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
32	Pavo Real	Clovis	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
33	Pavo Real	Clovis	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
34	Pavo Real	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
35	Gault	OTC	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
36	Gault	OTC	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
37	Gault	OTC	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

Appendix 8

Raw Data – Blade Core data, right lateral margin scar pattern

ID	Site	Period	RSP Unidirectional	RSP Bidirectional	RSP Opposed	RSP Asymmetrically Opposed	RSP Crossed	RSP Multidirectional	RSP Cortex	RSP CaCo3
1	Laugerie Haute East	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	Laugerie Haute East	Sol Middle	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
3	Laugerie Haute East	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	Laugerie Haute East	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
5	Laugerie Haute East	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	Laugerie Haute East	Sol Middle	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	Laugerie Haute East	Sol Middle	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
8	Laugerie Haute East	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	Laugerie Haute East	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	Laugerie Haute East	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
11	Laugerie Haute East	Sol Upper	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
12	Laugerie Haute East	Sol Lower	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
13	Laugerie Haute East	Mag/Bad	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
14	Laugerie Haute East	Mag 2	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
15	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
16	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

17	Laugerie Haute East	Mag 2	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
18	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
19	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
20	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
21	Laugerie Haute East		FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
22	Laugerie Haute East	Mag 2	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
23	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
24	Laugerie Haute East		TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
25	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
26	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
27	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
28	Laugerie Haute East	Mag 2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
1	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
2	Gault	Clovis	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
3	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
4	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
5	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
6	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
7	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
8	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
9	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
10	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
11	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
12	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
13	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
14	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
15	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

16	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
17	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
18	Gault	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
19	Gault	Clovis	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
20	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
21	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
22	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
23	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
24	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
25	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
26	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
27	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
28	Gault	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
29	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
30	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
31	Gault	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
32	Pavo Real	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
33	Pavo Real	Clovis	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
34	Pavo Real	Clovis	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
35	Gault	OTC	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
36	Gault	OTC	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
37	Gault	OTC	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE

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