PALEOINDIAN TECHNOLOGY IN BERINGIA—
A TECHNOLOGICAL AND MORPHOLOGICAL ANALYSIS OF THE NORTHERN FLUTED-POINT COMPLEX

A Dissertation

by

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ABSTRACT

This project is the first comprehensive analysis of fluted projectile points found across arctic North America and encompasses three levels of analysis that increase in scope geographically, methodologically, and theoretically. The start of the project served to develop an understanding of the technological organization represented at the first archaeological site to provide a clear radiocarbon record for fluted points in Alaska, Serpentine Hot Springs. The fluted-point collection from Serpentine was then used as a benchmark to compare the greater collection of fluted-points found across northern Alaska and Yukon and understand whether they represent a cohesive complex, and the technological risk and adaptive role associated with fluted-point use in the late Pleistocene Arctic. Finally, an expanded technological and morphological analysis comparing northern fluted points to other fluted-point forms found throughout North America was conducted to investigate whether convergence or cultural transmission was responsible for the presence of fluted-point technology in the far north.

The first phase of the project consisted of an assemblage level analysis of the lithic collection recovered from the Serpentine Fluted-point Site. The site contained buried fluted projectile-point fragments, an associated lithic assemblage, and charcoal-rich cultural features AMS-radiocarbon dated to approximately 12,000 calendar years before present, placing it within a Paleoindian timeframe. Interpretation of the technological organization used by the site's occupants provides a glimpse of a logistical system of mobility practiced by Paleoindian groups in the Arctic.

The second phase of the project consisted of a technological and morphological analysis of 51 northern fluted points that included metric, non-metric, and qualitative variables, which were statistically evaluated and compared to a collection of 46 Folsom artifacts. A new approach to geometric morphometrics was developed to evaluate variability in point outline shape, which allowed the analysis to focus solely on fluted-point basal morphology. Results confirm that northern fluted points represent a cohesive technological strategy and may have served as a risk-management system promoting ease-of-replacement-after-failure to offset transport costs and reduce risk during long-distance travel.

The final phase of the project featured a geometric morphometric shape analysis of 200 fluted points and point fragments, representing the Northern Fluted Complex and fluted points from further south in Canada, the Great Plains, and northeastern United States, to investigate the origin of northern fluted points. Results identified geographic patterns in basal projectile-point morphology and technology suggesting that fluting technology was not independently invented in the north, but originated proximately from the Ice-Free Corridor and ultimately from Clovis. Northern fluted-point technology was culturally transmitted from the south and variability introduced during this process resulted in a distinct arctic variant of Paleoindian fluted-point technology: the Northern Fluted Complex.

This new form of fluted projectile point is unique to the Arctic, yet evident of cultural continuity and a Paleoindian adaptation that spread throughout North America at the end of the last ice age.

DEDICATION

To Mom and Dad,

and

Heath,

for always believing in me.

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CHAPTER I

INTRODUCTION

Northern Alaska encompasses a large part of the late Pleistocene Bering Land Bridge, the last terrestrial connection between the Old and New Worlds and the likely route that humans traversed to reach the American continents. Artifacts found in this region could therefore represent ancestors of the first documented cultural complexes in the New World, such as Clovis and potentially earlier Paleoindian groups (e.g., Antevs 1935; Hibben 1943; Goebel et al. 2008; Waters et al. 2011). One such potentially early artifact from the Bering Land Bridge area is the fluted projectile point. The fluted point is a bifacially flaked stone tool that was affixed to a fore-shaft, and spear or lance, and used as a hunting weapon (Frison 1993; Haynes 1993). Bifacial technology is not unique; it has been documented in the prehistory of both the eastern and western hemispheres. The flute, however, is a distinctive method of thinning the basal portion of a bifacial projectile point to prepare it for attachment to a fore-shaft. Creation of the flute, however, was technologically difficult and often resulted in breakage during the final stages of tool production (Crabtree 1966; Flenniken 1978; Winfrey 1990; but see Ellis and Payne 1995).

Fluted points are widespread in the Americas, but in the Beringian area of north and northwest Alaska and northern Yukon poor contexts and a lack of associated dateable materials have prevented interpretations of their meaning, especially in the context of the peopling of the Americas (Bever 2001a; Goebel and Buvit 2011; Reanier 1995). The proposed research attempts to resolve this problem by addressing the question: What are the culture-historical and adaptive contexts of Alaskan fluted points?

Competing hypotheses regarding the role of Alaskan fluted points in the early settlement of Beringia and the Americas have been discussed at length over the past 60 years. According to Clark (1984), initial discoveries of fluted points in far northwest North America demonstrated the presence of highly anticipated evidence of a Clovis ancestor en route from Asia (Haynes 1969; Hibben 1943; Humphrey 1966; Thompson 1948). None of these initial discoveries, however, provided chronological evidence in support of Clovis ancestry, and alternatively Wormington (1957:109) proposed that Alaskan fluted points represented a "backwash" of Paleoindian technology northward as climatic regimes altered significantly at the end of the Pleistocene and onset of the Holocene (Clark 1984; Clark and Clark 1983). Given associations with later-period artifacts in the north, some researchers also maintained that fluting could have developed independently in both Alaska and mid-continent North America at different times as a result of independent invention (Bowers 1982; Clark 1984; Davis et al. 1981; Gal 1976; Giddings 1964; Hall 1969; West 1981, 1982). Clark and Clark (1983), however, have most recently suggested that fluting may still have developed early in Alaska among bifacially-oriented first Americans and subsequently spread south through the Mackenzie corridor prior to the arrival of microblades associated with Asian-Diuktai traditions. These hypotheses have been largely untestable as Alaskan fluted points have, until recently, been poorly dated.

Previous investigations into the technological activities and organization of early northern Alaskans have suggested that these groups were highly mobile hunters, of presumably bison (Hoffecker 2011; Kunz et al. 2003). These interpretations have been based primarily on findings from late Pleistocene Alaskan sites like Mesa and Sluiceway, which contain lanceolate bifacial points similar to late Paleoindian industries in temperate North America (Kunz and Reanier 1994, 1995; Kunz et al. 2003; Rasic 2008, 2011). Northern Paleoindians at these sites are hypothesized to have utilized an adaptive strategy similar to late Paleoindians of the North American Great Plains, one characterized by a reliance on bifacial technology, bison hunting, schedule-driven mobility, and brief site use (Bever 2006; Cinq-Mars et al. 1991; Hoffecker and Elias 2007; Hoffecker 2011; Kunz and Reanier 1995; Kunz et al. 2003; Rasic 2008, 2011). These studies of Northern Paleoindians, though, have focused on non-fluted bifacial complexes, not sites with fluted points, because of the presence of the former and absence of the latter in dated contexts. Simply put, due to a lack of fluted-point sites from stratigraphically sealed and datable contexts, we have not been able to characterize and explain the overall technology of Alaskan fluted points or interpret settlement and technological organization, the ways people organized their activities with regard to lithic technology within specific environmental contexts, of fluted point makers (Andrefsky 2009; Surovell 2009). Furthermore, we have not been able to address the adaptive role of fluted-points in the Arctic, and how archaeological evidence of this technology came to be present, and widespread across northern Alaska and northern Yukon.

To address these adaptive and culture-historical questions, this dissertation project was conducted in three phases, organized into three levels of analysis that increased in scope geographically, methodologically, and theoretically. The basis of the project is the assemblage from Serpentine Hot Springs, a sealed and dated fluted-point site on the Seward Peninsula, recently excavated by archaeologists from the Center for the Study of the First Americans, Texas A&M University, during the 2009-2011 field seasons. The first phase of dissertation research served to develop an understanding of the technological organization represented at Serpentine, the first archaeological site to provide a clear radiocarbon record for fluted points in Alaska. This portion of the research specifically addressed the question: How can the organization of fluted-point technology from Serpentine Hot Springs inform on northern Paleoindian subsistence and settlement behavior? The technology evident in the fluted-point collection from Serpentine was then used as a benchmark for a technological and morphological comparison of the greater collection of fluted points found across northern Alaska and Yukon to understand whether they represent a homogenous technocomplex, as opposed to a haphazard approach to basal thinning spontaneously used throughout the Holocene by various groups, and the technological risk and adaptive role associated with fluted-point use in the late Pleistocene Arctic. Therefore this portion of the research addressed four questions: How were fluted points made and used? Do they represent a cohesive technological complex? What role did fluted points play in late Pleistocene human adaptations in the Arctic? Why did early northern Alaskan's flute their lanceolate projectile points, especially given the high risk involved in the fluting strategy? The last phase of the project is an expanded technological and morphological analysis comparing northern fluted points to other fluted-point forms found throughout North America to investigate whether independent invention or cultural transmission was responsible for the presence of fluted-point technology in the Arctic. Research questions addressed in the final phase of the project were: What is the origin of fluted points in Alaska? Is there a strong morphological, technological, and geographical association between northern fluted points and the fluted complexes of temperate North America, representing a homologous similarity?

Research Background

A History of Fluted Points in Alaska

In 1933, F. Hibben came across a fluted point for sale in a curio shop in Ketchikan, Alaska, that was reportedly found north of Cook Inlet (Gal 1976; Hibben 1943). The provenience of this find was never determined, but in 1947 the first field-reported Alaskan fluted point was found by E. Sable of the United States Geological Survey (Thompson 1948). It was an isolated find from the surface of a high ridge overlooking the Utukok River (Solecki 1950). Through the 1950s and 1960s additional fluted points were found, chiefly in northern Alaska where they were typically encountered in surface contexts unable to be radiocarbon dated (Humphrey 1966; MacNeish 1956; Reanier 1995; Reger and Reger 1972; Solecki 1951; Solecki and Hackman 1950).

In the early 1970s, archaeological survey conducted along the Trans-Alaska Pipeline resulted in the discovery of the first fluted-point sites in buried contexts (Alexander 1987; Cook 1970; Gal 1976; Hoffecker et al. 1993; Reanier 1995). The first of these was the Girls Hill site, located along the Jim River south of the Brooks Range (Gal 1976). Initial excavations produced a fluted point associated with a microblade core, microblades, and a scraper (Gal 1976; Dumond 1980). Thirty meters to the north, a second locality produced three additional fluted points associated with four non-fluted projectile points and three polyhedral blade cores (Gal 1976). Wedge-shaped cores, thousands of microblades, burin spalls, scrapers, and large bifaces were also recovered from this locality (Dumond 1980). Charcoal was reportedly sparse in the excavation; however, multiple samples from the fluted-point level of the northern locality were combined to produce a radiocarbon date of 4440 ± 190 (GX-4102) ^{14}C years BP (Gal 1976). Bone recovered from the fluted-point locus also produced an apatite date that was even younger, close to 1900 ^{14}C years BP (Gal 1976). Debitage could not be firmly associated with any particular artifact types found at the site (Gal 1976). Problems inherent in bulk-charcoal and apatite-bone dating have led some researchers to tentatively reject these late dates until details of the context and associations are presented and the site is presently considered disturbed (Bever 2001a).

The Putu site was discovered in 1973 and found to contain a buried component comprising of a fluted-point base, four non-fluted lanceolate points, three unifacial scrapers made on blades, nine gravers, 44 burins, cores, and more than 6,000 pieces of debitage including 121 utilized flakes (Alexander 1987; Bever 2000). A second fluted-point base was also found on the surface (Alexander 1987). Radiocarbon analysis yielded four dates associated with the fluted point zone: 11,470 ± 500 (SI-2382), 5700 ± 190 (GaK-4941), 8454 ± 130 (WSU-1318), and 6090 ± 430 (GaK-4939) ^{14}C years BP. The range of dates has suggested to some researchers mixing of geological strata, perhaps even of multiple cultural occupations (Alexander 1987; Bever 2006; Hamilton and Goebel 1999; West 1966). Further investigations were conducted in 1993-1994 by M. Kunz and R. Reanier, who obtained a date of 8810 ± 60 (Beta-69901) ^{14}C years BP from archived material associated with a feature from the fluted-point-bearing component (Reanier 1994, 1996). Although this date complements one of the original dates from the site, Reanier (1996) concluded that unequivocal association of the datable material with the fluted points could not be established. To test for contemporaneity, Reanier (1995) called on obsidian-hydration dating even though a variety of factors limits the dependability of this technology (Clark 1984). Reanier found that one of the fluted points and multiple flakes had simultaneous hydration measures suggesting their contemporaneity. Gal (1976) also assumed direct association between the sites' fluted points and other cultural materials, but Bever (2000) interpreted them as being differently aged. He instead linked the lanceolate Mesa points from the site with the rest of the Putu assemblage.

At the same time as the Pipeline survey, D. Clark and colleagues found a series of at least 16 fluted points in the Batza Tena area of the Koyukuk Lowlands, just south of Hughes, Alaska (Clark and Clark 1993). The area has historically been plagued by forest fires, one of which cleared a significant amount of vegetation in 1968 and exposed a number of archaeological sites (Clark 1972; Clark and Clark 1993). During surveys in 1971, Clark's team discovered fluted points at ten localities, either in surface or buried contexts; these typically were associated with other lithic artifacts (Clark and Clark 1993). According to Clark and Clark (1993), the setting of Batza Tena prevented the accumulation of wind-blown sediments, resulting in little deposition and overlapping palimpsests of various cultural occupations at many sites. Due to the proclivity of forest fires, attempts at obsidian-hydration dating failed to provide confident chronological control of the fluted-point collections (Clark and Clark 1993; Hamilton and Goebel 1999).

As with Girls Hill and Putu, a similar variety of artifacts in association with fluted points has been recovered at Batza Tena. While obsidian from this source has been found in most of northern Alaskan sites including the Mesa site, XRF analysis of obsidian recovered at Serpentine Hot Springs, conducted by Jeff Speakman (National Museum of Natural History, Washington, D.C.), was also found to have originated at Batza Tena. These data confirm a cultural or economic connection between these areas, the adaptive context of which deserves further exploration.

Since the early 1970s, additional fluted points have been recovered in north and northwest Alaska, but again, typically in undated contexts. These include finds from Bonanza Creek, Teshepuk Lake, Iteriak Creek, Lisburn, Kugururok River and Nimiuktuk River (Bowers 1982; Davis et al. 1981; Reanier 1995).

Even the Mesa site, well-known for its lanceolate-point industry dating to 10,300-9700 ^{14}C years BP, produced one projectile point that is not only fluted on both faces, but from both ends (Kunz et al. 2003). Its association with the diagnostic Mesa complex artifacts has been debated (Bever 2000; Hoffecker 2011; Kunz et al. 2003).

Thus despite more than 50 years of searching, no fluted points in Alaska had been found in a securely buried context that could be unequivocally dated, that is, until 2005 when R. Gal and crew discovered a fluted point base at Serpentine Hot Springs (BEN-192) in Bering Land Bridge National Preserve (Goebel and Smith 2011). Initial testing by R. Gal, C. Young, and S. Gilbert-Young in that year led to discovery of a channel flake associated with charcoal dates of 9480 ± 40, 10,250 ± 60, 10,060 ± 40, and 10,250 ± 60 ^{14}C years BP (Young and Gilbert-Young 2007). A team led by T. Goebel returned in 2009-2011 to conduct excavations, uncovering a fluted-point assemblage directly associated with three hearth features. AMS ^{14}C dating of charcoal from these hearths consistently produced dates averaging 10,200-10,000 ^{14}C years BP. Four fluted point bases have been recovered in situ alongside these hearths, and two fluted point bases and a midsection were found in eroded blowouts nearby the buried component (Goebel and Smith 2011). The remaining buried assemblage contains unfluted bifacial points, channel flakes, bifaces, biface fragments, blades, bladelets, scrapers, and thousands of pieces of debitage. Hundreds of pieces of burned and calcined bone were also recovered from within the hearth features and have been identified by Bryan Hockett (Bureau of Land Management, Nevada) as ungulate (Goebel and Smith 2011).

Another significant fluted-point discovery was made in 2007 at the Raven Bluff site, located less than 300 km north of Serpentine Hot Springs in the western foothills of the Brooks Range on the Kivalina River (Hedman 2010). It contained a fluted point as well as a fluted-point preform in a buried context which has produced radiocarbon dates complementary to those from Serpentine Hot Springs—10,200 ^{14}C years BP (Hedman 2010; Rasic 2010). Within the lower cultural horizon, microblades, blade cores, bifaces, and debitage have been recovered along with bones preliminarily identified as caribou (Hedman 2010; Rasic 2010).

This is an exciting time for Paleoindian research in Alaska as two sites have almost simultaneously produced firm evidence of an Alaskan fluted-point complex at the Pleistocene-Holocene transition. Detailed technological and morphological analyses of the collection from Serpentine Hot Springs, along with the comparative analyses of the greater collection of Alaskan fluted points and a sample of Paleoindian fluted points from temperate North America, are used to clarify how fluted points came to be present in the Alaskan cultural record. The analysis is, ultimately, an investigation of northern Paleoindian adaptation and technological organization, and moreover, provides new insight into late Pleistocene human dispersals throughout the Americas.

Research Context: The Culture-Historical and Adaptive Significance of Northern Fluted Points

Culture History Problem. Since their discovery, the presence of fluted points in Alaska has been an inexplicable phenomenon. This has not dampened scholarly interest in the presence of fluting on Beringian stone tools. Hypotheses regarding their role in the prehistory of the American continents began to accumulate shortly after their detection and can ultimately be summarized into three competing ideas: they represent 1) a northerly backwash of technology, 2) a remnant population of Clovis ancestors, 3) a technological element of an Archaic cultural complex, i.e., the product of independent invention.

Wormington's (1957) proposal that Alaskan fluting technology represented a "backwash" was inspired by the idea that fluting developed in the Americas south of the ice sheets among established Paleoindian inhabitants (Beck and Jones 2010; Smith 2010). The backwash hypothesis was also put forth by Krieger (1954), who stressed that no evidence could be found suggesting that Beringian fluted points predate those from the continental United States.

Collins (1963, 1964) and Clark and Clark (1983, 1993), however, maintained the possibility of an ancestral relationship between Alaskan and continental fluted-point makers. According to their hypothesis, as late Pleistocene humans first migrated into Beringia and continued south to eventually deposit evidence of the Clovis cultural complex, a remnant population remained in Beringia and deposited lanceolate and fluted points in the north. It is significant, however, that fluted points are not present in the northeast Asian archaeological record (Hamilton and Goebel 1999). Although the Uptar site, located 40 km north of Magadan, Russia, has been reported to have produced a fluted projectile point (King and Slobodin 1993), the artifact is questionable as to its interpretation as a fluted specimen (Waguespack 2007). Other researchers have interpreted the "flute" on this artifact to represent a deep basal thinning flake or, more likely, impact damage rather than the removal of a channel flake in preparation for hafting (Goebel and Slobodin 1999). Therefore, the origin of fluting technology cannot be assigned to northeast Asia.

The possibility remains that fluted points in Alaska are the result of independent invention, a hypothesis that was put forth by Giddings in 1952. This assessment has been supported by Gal (1976) who suggested that a microblade-producing culture could easily utilize a small blade-making technique to thin the face of a biface. It also helped explain the presence of later-period artifacts (e.g., notched points) in association with fluted points at some shallowly buried sites. Wilson and Burns (1999) also suggested the possibility of independent invention of Paleoindian technology in the north by stressing that the lanceolate biface is the easiest and most logical form to invent; however, they do not directly address the presence of fluting.

As of 2011, however, a model of late Paleoindians moving up the Ice-free Corridor following the receding glacial ecosystem remains the most popular and parsimonious hypothesis to explain the presence of Paleoindian-type points in Alaska (Bever 1999; Dixon 1999; Hoffecker 2011; Reanier 1995; but see Morlan 1977). Research continues to support a southern invention of fluting technology that appears to be correlated with Pleistocene fauna such as mammoth, camel, horse, and bison (*Bison bison antiquus)* who thrived in the Pleistocene ecosystems south of the ice sheets (Beck and Jones 2010; Smith 2010; Wilson and Burns 1999). As the ice-free corridor became biologically viable and late glacial environments crept northward, southerly fauna and fluted-point-wielding humans followed the new biota north.

The undatable context typical of most Alaskan fluted-point locales, however, has continued to fuel debate regarding their origin and chronology. Until recently, the only two instances of fluted points and datable material in buried contexts, Putu and Girls

Hill, produced substantially young dates, and subsequent fluted-point finds failed to improve the situation. With the exception of Serpentine Hot Springs and Raven Bluff, Alaskan fluted-point localities and assemblages have not been found in sealed contexts and cannot be confidently attributed to existing archaeological complexes; however, some assumptions must be made to begin determining if they are coeval. For decades researchers have called for the discovery of new sites with fluted points in datable contexts which would provide an impetus to accelerate research into the northern fluted-point phenomenon and resolve questions regarding their significance in prehistory (Bever 2001a; Morlan and Cinq-Mars 1982; Reanier 1995). Serpentine Hot Springs is such a site, and with it serving as a chronological anchor for investigation, the opportunity finally came to conduct a meaningful comparative analysis of Alaskan fluted points.

Adaptive Context. Similarities between early sites in arctic/subarctic Alaska and northwest Canada (e.g., Mesa, Spein Mountain, Engigstciak, Irwin Sluiceway, Putu, and Bedwell) and the North American Plains have been proposed to represent a widespread American Paleoindian tradition (Bever 2000; Hoffecker 2011; Kunz and Reanier 1995; MacNeish 1963; Rasic 2008, 2011). Inferences of similar land use, subsistence, technology, and chronology have been used to interpret the adaptive context of the northern Paleoindians (Bever 2006; Rasic 2011). Commonalities observed between complexes have led researchers to refer to this tradition as the Northern Paleoindian tradition, which encompasses local complexes such as Mesa and Sluiceway (Bever 2000; Kunz and Reanier 1994; Rasic 2008). Alaskan fluted points have occasionally been lumped into this tradition, primarily because fluting is considered an American phenomenon. The Mesa complex contains the possible association of both point forms. Putu may be one example of fluted biface contemporaneity between fluted points from Serpentine Hot Springs and other non-fluted northern Paleoindian assemblages (Bever 2000; Hoffecker 2011; but see Clark and Clark 1983; Morlan and Cinq-Mars 1982). It should be noted, however, that the formal definition of the Mesa complex does not include fluted points (Bever 2006).

The Northern Paleoindian "adaptation" has been proposed to have focused on hunting bison and caribou (Cinq-Mars et al. 1991; Hoffecker and Elias 2007; Kunz et al. 2003; Rasic 2011). Although little faunal evidence has been recovered from the arctic/subarctic Alaskan and northwestern Canadian sites (e.g., no faunal evidence from the Mesa site can be attributed to bison or caribou), the expansion of grasses during the Younger Dryas suggests that bison suddenly became abundant in Alaska during this short return to glacial conditions (Bigelow and Edwards 2001; Guthrie 1990; Rasic and Matheus 2007). The Mesa complex potentially coincides with these events given its dating to the late Younger Dryas, and this was quickly followed by a decline in bison populations associated with the Holocene spread of tussock tundra indirectly supporting an adaptive reliance on bison hunting by Mesa complex people (Kunz and Reanier 1995; Mann et al. 2001). The window during which bison abundance coincided with the occupation of the Mesa site (10,300-9,500 ^{14}C years B.P.) can also be attributed to other sites included in the Northern Paleoindan tradition, for example Spein Mountain, Engigstciak, Irwin Sluiceway, and possibly Putu (Bever 2001a; Cinq-Mars et al. 1991).

Generally, Northern Paleoindian sites appear to have been repeatedly used for short periods of time, suggesting to researchers that these people were highly mobile and participated in intercept and encounter hunting on a seasonal basis to acquire prey animals migrating through the Brooks Range (Bever 2000). Other site attributes such as the distribution of hearths, activity areas, and flaking debris also demonstrate similar activities occurring at these sites (Bever 2000, 2001a). Such evidence led Bever (2000, 2001a) and Kunz and Reanier (1995) to propose that these sites served as single or repeated short-term hunting camps, a pattern also recognized at Girls Hill (Krasinski 2003). Technological activities at Mesa focused on tool production and maintenance, and toolstone procurement was embedded into a high mobility strategy (Bever 2000; Kunz and Reanier 1995).

Correlations in cultural material centers around Mesa complex projectile points, which have been related to those from Plains Paleoindian complexes like Agate Basin, Hell Gap, Angostura, and Plainview, and provide evidence to support the proposal that these sites represent the northernmost expression of midcontinental Paleoindian peoples (Hoffecker 2011). The assemblages found at each of the sites included in the Mesa complex demonstrate significant overlap in terms of tool type and technological organization (Bever 2001a). Variation in tool-type frequency between assemblages, also evident in the Sluiceway complex, is hypothesized by Rasic (2011) to demonstrate functional differences resulting from seasonal variation in prey availability by mobile groups of foragers.

The sites attributed to the Mesa complex also share a similar setting atop elevated ridges that overlook river valleys where Paleoindians are hypothesized to have awaited passing prey animals (Ackerman 2001; Bever 2001b). The proximity of these sites to riparian zones suggest the strategic placement of these sites near resources such as willow for use as fuel and shelter, toolstone, small game, fish, edible vegetation, and water (Bever 2001a; Kunz et al. 2003; Rasic 2011).

Despite the loose association of Alaskan fluted points with Mesa complex assemblages, Serpentine Hot Springs and Ravens Bluff also date to the Younger Dryas and have therefore been lumped into the Northern Paleoindian tradition (Hoffecker 2011). Kunz et al. (2003) support the possibility that Alaskan fluted points represent the northward movement of Paleoindians, such as Folsom or Agate Basin, which further suggests a relation between Alaskan fluted points and the northern Paleoindian complexes in terms of geographic origin. The most promising evidence for the inclusion of Alaskan fluted points in the Mesa complex is the discovery of a fluted point at the Mesa site itself (Kunz et al. 2003).

The great majority of research into the adaptive context of arctic/subarctic Paleoindians has focused primarily on the Mesa site. Evidence for bison hunting consists of the correlation of time of occupation at Mesa and the window of Younger Dryas-grassland expansion that would have supported small herds of bison in northern Alaska before their disappearance at the end of the Younger Dryas (Bigelow and Edwards 2001; Guthrie 1990; Kunz and Reanier 1995; Mann et al. 2001; Rasic and Matheus 2007). Researchers (Kunz et al. 2003; Kunz and Reanier 1995) also hypothesize that the similarity of artifact style between Mesa and the North American Plains, such as lanceolate bifaces, reflects a corresponding mobile hunting system focused on bison despite a lack of identifiable faunal remains at the Mesa site. Specifically, the points from Mesa have often been favorably compared to later Paleoindian points, such as those from the Agate Basin site in Wyoming (Bever 2001a; Dumond 2001, 2011; Goebel and Buvit 2011; Hoffecker 2011; Kunz and Reanier 1994, 1995). In reporting the Mesa site, Kunz and Reanier (1995) included a morphological and technological comparison of Mesa and Agate Basin points using data published by Frison and Stanford (1982) and effectively established correlations between the two point forms.

To date, however, no further analysis has been conducted to investigate relationships between the adaptive systems of Alaskan and Plains groups of Paleoindians. Certainly, no analysis of Alaskan fluted-point assemblages has been conducted in terms of adaptation in the sense of Bever's (2000, 2001b) analysis of the Mesa complex sites or Rasic's (2008) analysis of Sluiceway complex sites. Alaskan fluted points have been provisionally interpreted to represent a Paleoindian mode of adaptation (Bever 2001a). While these models of northern Paleoindian adaptation are highly probable, they are far from proven or sufficiently tested. Often, these kinds of data have not been based on detailed technological or subsistence data, but instead on the "Paleoindianesque" of the northern assemblages and the hypothetical availability of certain prey animals. This investigation tests this model of adaptation using fluted-point assemblages and provides a significant contribution to our understanding of early human adaptation in the Arctic and Subarctic.

Why Analyze Fluted Points?

Fluting is the diagnostic technological attribute of the first well-documented and widespread Paleoindian complex in North America, Clovis. As such, fluted points and associated artifact assemblages can provide important clues for reconstructing the adaptations of the first Americans, an especially significant endeavor given that the late Pleistocene was a time of major climate and environmental change. Research into fluted points in Alaska, however, has failed to place these artifacts in the context of human dispersal across the Americas, and we still know virtually nothing about the adaptive context of fluted points in arctic and subarctic ecosystems. How did fluted projectile points aid early Alaskans in survival? What specific functions did this technological trait serve? Does the presence of fluting in Alaskan archaeology represent the movement of humans across regions, or the transmission of knowledge through social networks already in place across late Pleistocene Beringia? This void in our understanding of early arctic prehistory is largely a result of the inadequate contexts in which Alaskan fluted points have been found, making a thorough analysis of this adaptive signature premature and impossible. The fluted-point assemblage recovered from Serpentine Hot Springs in a secure and datable context, however, finally provides the benchmark needed to evaluate the significance of Alaskan fluted points and the opportunity to confidently investigate their role in Alaskan Paleoindian adaptation.

Research Objectives

The ultimate goal of this dissertation project is to understand the cultural and adaptive contexts of fluted points in Beringia from three perspectives: 1) a specific archaeological site, 2) the northern Alaska-Yukon region, and 3) the North American continent.

Specific Objectives

1) *To characterize technological activities carried out at the Serpentine Fluted-point site.* This analysis utilized assemblage-level data and consists of both lithic debitage and tool analyses. What lithic raw materials were procured near Serpentine Hot Springs, and which were transported from greater distances? Does Serpentine Hot Springs represent a short-term camp/tool refurbishing area? What were the primary activities conducted at the site? What can the assemblage from Serpentine tell us about late Pleistocene mobility and settlement strategies?

2) *To characterize the technology and morphology of fluted points in Alaska and northern Yukon.* This analysis measured morphological and technological variability in northern fluted points, comparing the new Serpentine Hot Springs sample with existing points. How were fluted points manufactured? Do aspects of technology, such as method of manufacture and hafting strategies, conform amongst all fluted specimens in Alaska (e.g., Morlan and Cinq-Mars 1982; Sellet 2001)? Is there significant statistical variability in Alaskan fluted-point morphology, or do they represent a single form? Can an Alaskan fluted-point "style" be defined, in the sense of Sackett (1977, 1982) and Odell (2001)? What was the function of northern fluted points? What can variability in tool design and technology imply about early Northern Paleoindian mobility, land-use, and subsistence (e.g., Nelson 1991; Shott 1986)? How did Beringian fluted-point makers provision themselves with materials needed to survive? Did they rely on local lithic materials to

expediently produce tools and weapons as needs arose? Or did they formally produce tools in advance of use, transporting them great distances?

3) *To investigate the origins of northern fluted points.* Is there a strong morphological and technological association between Alaskan fluted points and any of those from the Ice-free Corridor in western Canada and temperate North America, for example Clovis, Folsom, Barnes, Debert, or Vail? What are the major characteristics of variation in the sample of fluted points from across North America? Is this variability geographically patterned, and does it suggest a source of such variation in the North American fluted-point sample? Does a specific dearth of homogeneity suggest independent invention was responsible for the presence of fluting technology in the Arctic? Was fluted-point technology transmitted culturally between southern and northern human groups and, therefore, represent cultural continuity between other Paleoindian complexes?

Materials

The Serpentine Assemblage

The assemblage recovered from Serpentine Hot Springs is currently housed at Texas A&M University. The collection contains eight fluted points, two unfluted bifacial points, channel flakes, bifaces, biface fragments, blades, bladelets, scrapers, and thousands of pieces of debitage. The fluted-point horizon was sealed by a layer of colluvium that preserved the integrity of the cultural component. Four hearth features were also excavated from this cultural horizon and contained dense concentrations of charcoal and hundreds of pieces of burned and calcined bone. Multiple chronological analyses have produced an average date of 10,200 ^{14}C years BP.

Comparative Fluted Points

The technological and geomorphic morphometric analysis of northern fluted points included eight fluted points from Serpentine Hot Springs, eighteen from Batza Tena, two from Putu, and three from Girls' Hill as well as known isolates from thirteen other Alaskan sites (Alexander 1987; Bowers 1982; Clark and Clark 1993; Davis et al 1981; Gal 1976; Giddings 1964; Humphrey 1966; Reanier 1995; Solecki 1951; Solecki and Hackman 1950; Thompson 1948). Fluted points from outside of Alaska include those from Kikavichik Ridge in the northern Yukon, Charlie Lake Cave and Pink Mountain in British Columbia, Sibbald Creek and Banff National Park in Alberta, as well as isolated points found in surface contexts in Alberta (Fedje 1996; Fladmark 1988, 1996; Gryba 1983; Irving and Cinq-Mars 1974; MacNeish 1956; Payne et al. 2006; Wilson 1996). Also included were a number of points from the Great Lakes and maritime regions of northeastern North America, some of which, although not necessarily so well dated, may represent the first inhabitants of that recently deglaciated landscape and include Thedford II, Crowfield, Parkhill, Debert, Vail, Bullbrook, and Lamb (Deller and Ellis 1988, 1992; Ellis 2004; Gramly 1982, 1999; MacDonald 1985; Witthoft 1954). Folsom fluted points recovered from the North American Great Plains and Rocky Mountains include Hanson, Lindenmeier, Krmpotich, Black Mountain, Agate Basin, Hell Gap, and Barger Gulch (Frison and Bradley 1980; Frison and Stanford 1982; Root 1980; Wilmsen and Roberts 1978). Data on Clovis artifacts include fluted points from Anzick, Blackwater Draw (Locality 1), Cactus Hill, Colby Mammoth, Dent, Domebo, Drake, Jake Bluff, Lehner, Murray Springs, Naco, Paleo-crossing, East Wenachee, Shawnee-Minisink, and Simon (Smith 2010).

Collection of comparative data on northern and other North American fluted points required travel to artifact collections curated at the University of Alaska Museum of the North, National Park Service, and Bureau of Land Management in Fairbanks, National Park Service in Anchorage, National Museum of Natural History in Washington D.C., Frison Institute at the University of Wyoming at Laramie, Royal British Columbia Museum in Victoria, Simon Fraser University in Vancouver, Royal Alberta Museum in Edmonton, Parks Canada in Calgary, Canadian Museum of History (formerly the Canadian Museum of Civilization) in Ottawa, and the University of Western Ontario in London, Ontario.

Organization

The following three chapters present each phase of the project independently and provide details on specific materials and methods used therein. Ultimately, the goal of this project was to understand the adaptive context and origin of fluted points in the North American Arctic.

Chapter 2 presents the results of the lithic analysis conducted on the assemblage recovered from the Serpentine Fluted-point site. I provide a background of the state of research into the Northern Paleoindian Tradition and summarize the results of excavations at the Serpentine Fluted-point site. I discuss the late Pleistocene ecological setting and lithic landscape surrounding Serpentine Hot Springs. The suite of artifacts from Serpentine has never been seen outside of an undateable palimpsest; therefore, details of the fluted-point assemblage and aspects of northern fluted-point manufacturing technology are described. I evaluate patterned variability present in the debitage assemblage between raw-material, typological, and metric attributes. I evaluate formal and expedient tools in terms of frequency of raw-material types, as well as a series of quantitative and qualitative variables to understand function, assemblage formality, and overall life history of the artifacts. I discuss manufacturing activities interpreted from the debitage collection and the formal versus expedient use of tools in the assemblage. While the site provides only a glimpse of an entire cultural system in late Pleistocene Alaska, the information contained in the assemblage allowed me to develop an understanding of an aspect of this group's technological organization and achieve a preliminary understanding of how fluted points were made and used at Serpentine and how organization of technology informed on subsistence and settlement behavior. Evidence for retooling and maintenance of fluted points, and the presence of faunal remains, suggest that the locality served as a place to use weapons in animal dispatch and subsequent technological recovery far from sources of preferred toolstone. Results of the site- and assemblage-level analysis of the Serpentine lithic collection provided evidence that the site may characterize a component of a logistical system of group mobility that may be applicable to the greater collection of fluted points found across northern Alaska and Yukon.

Chapter 3 is a technological and morphological analysis of 51 northern fluted points available across northern Alaska and Yukon meant to establish whether the sample represents a homogeneous technological complex and if they can be ascribed the same age as the Serpentine assemblage. I review the northern fluted-point problem, in terms of recovery and context, and the history of archaeological research. Evaluation of the role fluted points played in late Pleistocene human adaptations in the Arctic and why early northern Alaskan's fluted their lanceolate projectile points given the high risk involved in using a fluting strategy begins with a discussion of risk and risk-management in hunter-gatherer research. I include data from 46 Folsom points from seven archaeological sites in the technological and morphological analyses, and data from 43 Folsom points in the geometric morphometric analyses to facilitate comparison to a known highly standardized technological complex (Frison 1991; Frison and Bradley 1981, 1982). I evaluate nominal technological attributes, metric attributes, and count data to infer manufacturing technique, artifact function, and point typology. Geometric morphometric shape analysis was used to assess morphological variation in fluted-point basal fragments from sites across northern Alaska and Yukon in comparison with Folsom point fragments. A new approach to geometric morphometrics is presented, which Thom DeWitt and I developed to facilitate the analysis to focus solely on fluted-point basal morphology. I describe major characteristics in basal shape present in the samples of northern and Folsom fluted points. I discuss results of univariate and multivariate statistics, which confirm that northern fluted points represent a cohesive technological strategy. I further discuss technological and morphological attributes used to formulate a hypothesis as to the ultimate function of northern fluted points in the Arctic, which may have served as a risk-management system promoting ease-of-replacement-after-failure to offset transport costs and reduce risk during long-distance travel.

Chapter 4 presents the expanded morphological and technological analysis of northern fluted points to include fluted points from across Canada and the United States to evaluate the origin of northern fluted-point technology. I discuss the implications of fluted point forms found in archaeological contexts across North America and the history of questions regarding how Alaskan fluted points relate to other, more southerly, fluted-point complexes. I evaluate trends in morphological and technological characteristics in the context of cultural transmission (CT) theory, discussing how concepts of both evolutionary theory and behavioral ecology inform on the evaluation of cultural continuity and adaptive similarity. I discuss concepts organized by Eerkens and Lipo (2007), content and context, which I used to evaluate whether fluted-point technology was culturally transmitted northward to the Arctic. I used geometric morphometrics and multivariate statistics to identify variability in basal morphology in a sample of 200 fluted points, and found evidence of similar point morphology between the northern fluted points, Clovis, and a sample of early fluted points from the ice-free corridor. I evaluate three major technological characteristics to explore patterns of technological affinity between these samples, which may complement the results of the morphological analysis. I concluded that Alaskan and northern Yukon fluted points were not invented independently of the southern fluted-point complexes. Fluted-point technology appears to have been transmitted culturally from northern-most Clovis groups to Ice-free Corridor and Northern Fluted Complex groups via a form of transmission that introduced variability into the technology by the time it reached the North American Arctic.

The concluding chapter provides a synopsis of the project. I summarize the conclusions of each phase of research and discuss the Northern Fluted-point complex in the greater context of the peopling of the Americas. The research is presented to serve as a contribution to the study of fluted-point technology, as well as Beringian and Paleoindian adaptation, and to stimulate further research of the first human groups to spread throughout the Western Hemisphere.

CHAPTER II

FLUTED POINTS ON THE BERING LAND BRIDGE: LITHIC TECHNOLOGICAL ORGANIZATION AT SERPENTINE HOT SPRINGS, ALASKA*

Fluting, one of many methods used by prehistoric humans to thin the base of a bifacial projectile point, is technologically distinctive and restricted to the American continents, where it serves as a diagnostic signature of the first widespread technological complex recognized in the New World: Clovis (Crabtree 1966; Frison 1993; Haynes 1993; Jennings and Waters 2014; Sellet 2004). Archaeological evidence of a northeast Asian ancestry for the first peoples to flute bifacial projectile points has been strengthened by recent genetic evidence (Rasmussen *et al*. 2014), returning attention to Beringia as the initial point of human entry into the Americas during the late Pleistocene. Archaeologists have searched Alaska for artifacts indicating the first human crossing of the Bering Land Bridge for over half a century, and specifically, for fluted points that could represent ancestors of the first documented cultural complexes in the New World (e.g., Antevs 1935; Clark 1984; de Laguna 1936; Dixon 2013; Hibben 1943; Wormington 1953). Fluted technology was indeed found in Alaska; however, poor contexts, in the form of disturbed stratigraphic deposits, surface and near-surface

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*At the time of writing, this paper is accepted and in press from ‘Fluted Points on the Bering Land Bridge: Lithic Technological Organization at Serpentine Hot Springs, Alaska’ by Heather Smith, Journal of Field Archaeology, by Maney Publishing.

palimpsests containing mixed cultural components, and the absence of unequivocally associated dateable material repeatedly prevented the development of secure chronology and obscured interpretations of the meaning of fluted points in the north, especially in the context of the peopling of the Americas (Bever 2001; Goebel and Buvit 2011; Reanier 1995).

Since 2005, two sites in northwest Alaska, Serpentine Hot Springs and Raven Bluff, have been found to contain fluted points in a buried context and associated with dateable materials. These provide the first opportunity to understand both the chronology and adaptive significance of fluted technology in an arctic ecosystem (Goebel *et al*. 2013; Hedman 2010). The focus of this paper, the Serpentine fluted-point site (BEN-192), is located in Bering Land Bridge National Preserve, Alaska, and was found to contain fluted points in a buried deposit associated with a lithic assemblage and dateable charcoal from features interpreted as hearths. AMS-radiocarbon dating suggested that fluted projectile-point technology at Serpentine dates to about 12,400-9900 calendar years before present (cal B.P.) (Goebel *et al*. 2013), coeval with preliminary dates from deposits at Raven Bluff (Hedman 2010). Both postdate initial colonization of the New World and development of fluting technology in temperate North America by a millennium or more. Therefore, fluting technology in northwest Alaska does not represent Clovis ancestry, but either a northward movement of Paleoindian technology during the latest Pleistocene (Wormington 1953, 1957), or independent invention (Bowers 1982; Davis et al. 1981; Giddings 1964). While its appearance in the Arctic remains unclear, fluting technology played a key role in the terminal Pleistocene cultural system of northernmost Beringia, referred to by some as the Northern Paleoindian Tradition (Kunz and Reanier 1994; Reanier 1995).

The artifacts from Serpentine provide our first opportunity to look beyond the question of chronology surrounding fluted points in Alaska and consider how fluted-point technology can inform on mobility patterns and planning, concepts important to our understanding of northern Paleoindian adaptive strategies (*sensu* Bamforth and Bleed 1997; Binford 1977, 1980; Bousman 1993; Brantingham 2006; Kelly 1988; Rasic 2011; Sellet 2013; Shott 1986). This paper presents an analysis of the Serpentine lithic assemblage, discusses how fluted points were made and used in the Arctic, and how the organization of fluted-point technology at Serpentine informs on Northern Paleoindian subsistence and settlement behavior.

Background

The Northern Paleoindian Tradition

Late Pleistocene archaeological sites containing lanceolate bifacial points occur across northern Alaska and have provided our first insights into an arctic adaptive strategy similar to late Paleoindians of the North American Plains—one characterized by bifacial technology, large-mammal hunting, schedule-driven mobility, and brief site use (Bever 2006; Cinq-Mars *et al*. 1991; Hoffecker and Elias 2007; Kunz and Reanier 1995; Kunz *et al*. 2003; Rasic 2011, see also de Laguna 1936; Rainey 1939; Wormington 1957) (Figure 2.1). Technological analyses of lithic assemblages have shed light on behavioral patterns of tool and landscape use and have framed how we interpret the Northern Paleoindian Tradition, and have been based primarily on investigations of two complexes: Mesa and Sluiceway.

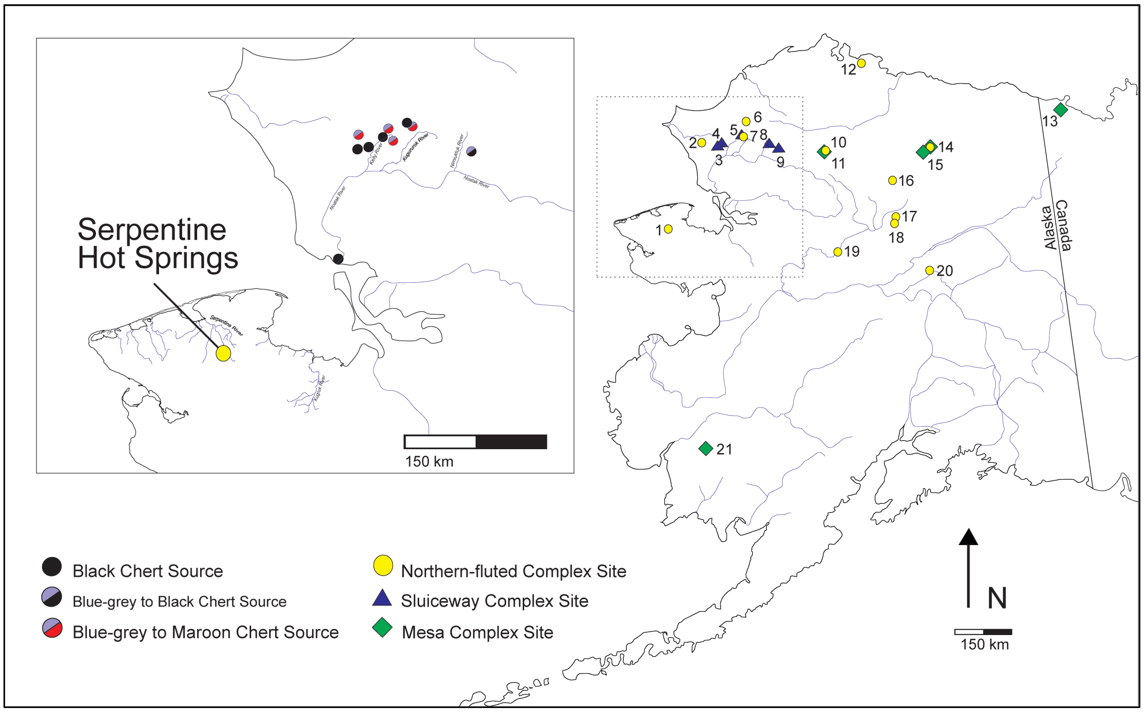


Figure 2.1. The location of the Serpentine fluted-point site and other sites mentioned in the text organized by archaeological complex: (1) Serpentine Hot Springs; (2) Raven Bluff; (3) DEL-185; (4) Tuluaq Hill; (5) Caribou Crossing; (6) Driftwood Creek; (7) Kugururok River; (8) Nat Pass; (9) Irwin-Sluiceway; (10) Lisburne; (11) Mesa; (12) Teshekpuk Lake; (13) Engigstciak; (14) Putu and Bedwell; (15) Hilltop; (16) Redstar Creek; (17) Girls Hill; (18) The Island; (19) Batza Téna; (20) Hank's Hill; (21) Spein Mountain; and lithic raw material sources identified by Malyk-Selivanova *et al*. 1998.

Clear radiocarbon dates placing three specific and widespread bifacial assemblages of northern Alaska into a Paleoindian timeframe were first obtained from the Mesa site located in the central Brooks Range (Bever 2000, 2008; Kunz *et al*. 2003;

Reanier 1982). Mesa contained numerous hearth features and more than 150 Mesa projectile points that became the diagnostic artifact of the Mesa Complex (Bever 2000; Kunz *et al*. 2003). With similar points and assemblages, sites including Spein Mountain (Ackerman 2001), Putu and Bedwell (Alexander 1987; Bever 2006; von Krogh 1973), Hilltop (Bever 1999, 2000; Reanier 1995), Engigstciak (Cinq-Mars *et al*. 1991; Mackay *et al*. 1961; MacNeish 2000), and possibly Lisburne (Bowers 1982) also have been assigned to the complex (Hoffecker and Elias 2007). Bever (2000) determined that Mesa technological organization represented seasonal and schedule-driven subsistence activities involving an embedded procurement system, encounter-hunting strategies, high residential mobility between short-term campsites, and a reliable bifacial technology that prevented failure in the face of uncertain subsistence returns.

Bifacial points representing the Sluiceway Complex were first discovered at the Irwin-Sluiceway site in northwest Alaska (Rasic 2008, 2011). Sluiceway points now serve as a cultural marker associated with early archaeological assemblages from the western Brooks Range (Rasic 2011), including Tuluaq Hill (Rasic 2008), NR-5 (Anderson 1972), Caribou Crossing I and II (Rasic 2008), Nat Pass (Rasic 2008), and DEL-185 (Potter *et al*. 2000). Sluiceway complex sites are variable in terms of site function, raw-material availability, and tool maintenance, suggesting to Rasic (2011) that they represent a seasonal pattern of land use, specifically fall/spring intercept-hunting localities in the Brooks Range or summer encounter-hunting localities in the Arctic Foothills.

The Mesa and Sluiceway complexes are associated with radiocarbon ages that range from approximately 13,200 to 10,000 cal B.P. They seem to be geographically segregated in different areas of the Brooks Range, Mesa in the east and Sluiceway in the west. Respective bifacial points are typologically and technologically homogeneous within each complex, and studies of technological activities show that most Mesa and Sluiceway sites functioned as lookout locations (Bever 2000; Kunz *et al*. 2003; Rasic 2011; Reanier 1995). Technological assessments are not profoundly different, and the two point forms have been found together in some contexts (Smith *et al*. 2013).

However, technological organization characteristics suggested to Rasic (2008) that Sluiceway hunter-gatherers utilized a logistical procurement system, evident in potential for intercept-hunting strategies, brief site-use, variable site types including special-purpose task stations and observation localities, and evidence for gearing-up behavior. Whereas Bever (2000) hypothesized that projectile point production in the Mesa complex facilitated immediate use, encounter-hunting strategies, and unpredictable resource availability, suggesting high residential mobility characteristic of a more Forager-based system; despite analogous characteristics in both complexes such as variability in site use, recurrent site use, and planned re-occupation of sites. As a result, Rasic (2011) recently proposed that both belong to the same complex, preferring a “label-free” approach to research on variability in subsistence activities, habitat use, and lithic assemblages as a means to investigate regional economic patterns that may vary, not as a result of individual cultural behavior, but due to conditioning by regional variation in ecological structures (see also Potter 2008). Rasic’s approach reflects new appreciation in hunter-gatherer mobility research for variability in land-use strategies representing adjustments to changing resource composition and distribution due to seasonality on a small scale, and climate change on a larger scale (Breslawski and Byers 2015; French 2015; Johnson 2014; Kuhn and Clark 2015; Pinar and Rodriguez 2015). Explaining archaeological evidence for various dimensions of mobility now involves the combination and re-organization of previously defined procurement strategies (*sensu* Binford 1978; 1980).

Adding to the complexity of arctic Alaska's Paleoindian record is a third complex—Northern Fluted (Smith *et al.* 2013). Interestingly, the first of the Northern Paleoindian bifacial points to be recognized were fluted points found in 1947 near the Utukok River (Solecki 1950; Thompson 1948). Through the 1950s and 1960s additional fluted points were found, chiefly in northern Alaska, where they were typically encountered in surface contexts associated with no dateable materials (Humphrey 1966; Reanier 1995; Reger and Reger 1972; Solecki 1951). In the early 1970s, the first buried fluted points were discovered at Girls Hill, Putu, and Batza Téna (Alexander 1987; Hoffecker *et al.* 1993; Reanier 1995). Radiocarbon dates obtained for each site were problematic and suggested mixing of geological strata and even cultural occupations (Bever 2000, 2006a,b; Clark and Clark 1993; Hamilton and Goebel 1999; Reanier 1994, 1995). Additional fluted points were recovered in north and northwest Alaska at the Island, Teshekpuk Lake, Redstar Creek, Lisburne, Kugururok River, and Hank's Hill sites (Bowers 1982; Davis *et al.* 1981; Reanier 1995). After more than 50 years of exploration, however, no fluted points in Alaska had been found in secure, buried contexts that could be confidently dated, until 2005 when R. Gal and crew discovered the Serpentine fluted-point site (BEN-192) (Goebel *et al*. 2013; Young and Gilbert-Young 2007), and again in 2007, when J. Rasic and B. Hedman began excavations at the Raven Bluff site in the western Brooks Range (Hedman 2010). Until then, the unknown age of Alaskan fluted projectile points prevented their inclusion within the Northern Paleoindian tradition and hampered comprehensive study of their adaptive significance in late Pleistocene Alaska (Bever 2006; Dixon 1993; Reanier 1995).

The Serpentine Fluted-Point Site

The following summary of excavations at the Serpentine fluted-point site is based on Goebel et al. (2013). Serpentine is located in the interior of the Seward Peninsula, northwest Alaska, an area once located in the central Bering Land Bridge and now forms an exposed shelf projecting more than 300 km into the Bering Sea since the post-LGM inundation of the land bridge (Figure 2.1). The site is situated on a southeast-facing granite ridge that provides an expansive view of the surrounding valley tundra.

Formal excavations included a 21-m^2 block aligned along a north-south axis which paralleled the ridge, a 1-m wide geological trench that extended 9 m west from the block, and two solitary 1-m^2 test units (Figure 2.2). Cultural remains, including fluted points, channel flakes, thousands of burned and calcined bone fragments and a few teeth (some ungulate), occurred primarily in a deposit of aeolian silt with gruss (stratum 2), which was below a colluvial deposit of silty gruss (Figure 2.3). Five features of abundant charcoal and dark-gray to black silt were exposed in the excavation, all in stratum 2, and contained charcoal, faunal, and lithic evidence; the spatial distribution of

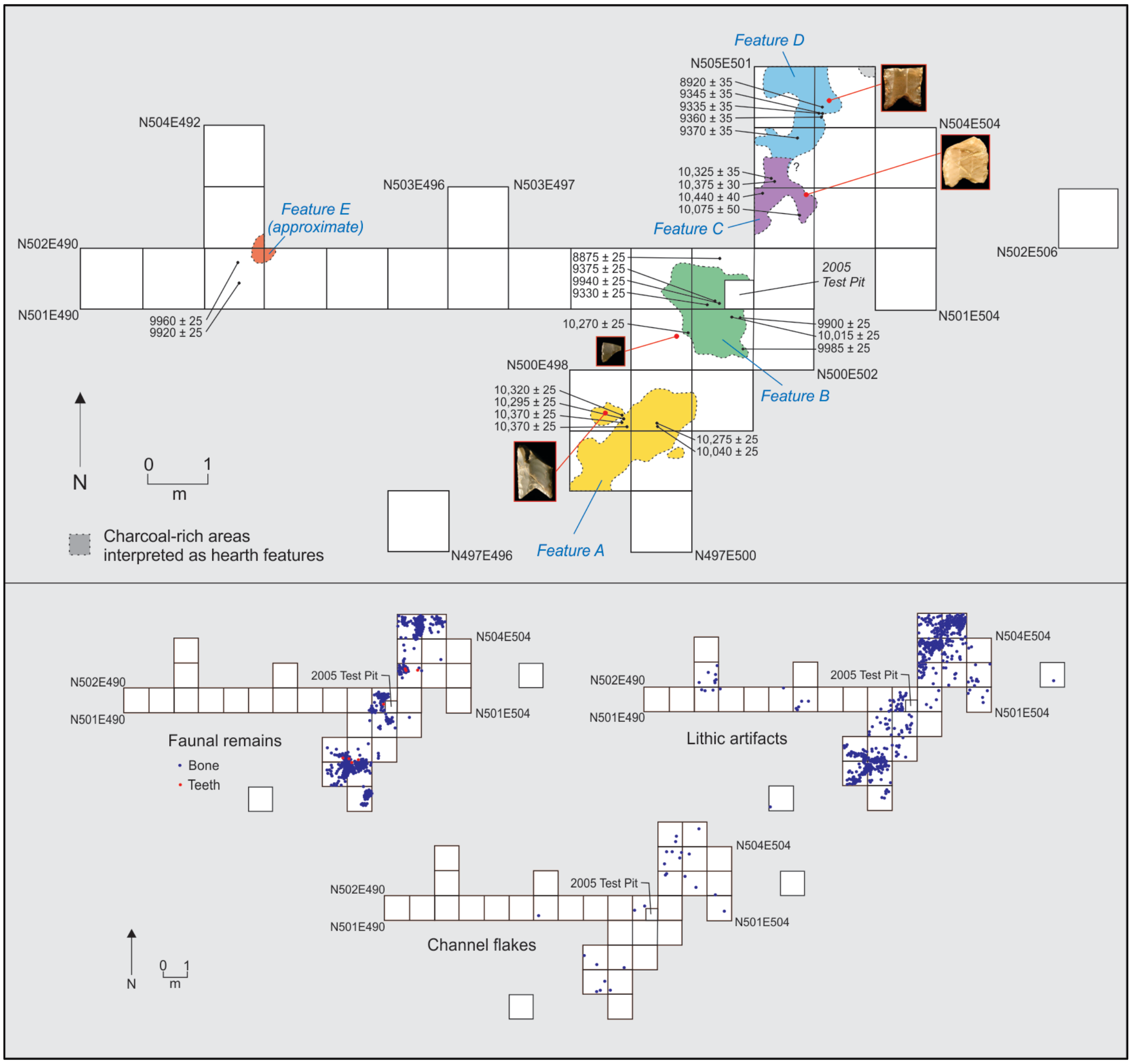


Figure 2.2. Planview of 2005-2011 excavations at the Serpentine fluted-point site: top, provenience of radiocarbon-dated material, cultural features, and fluted-point fragments found in situ; bottom, spatial distribution of the charcoal, faunal, and lithic evidence sealed in strata 2 and 3 of the Serpentine fluted-point site (modified from Goebel *et al*. 2013:Figure 6).

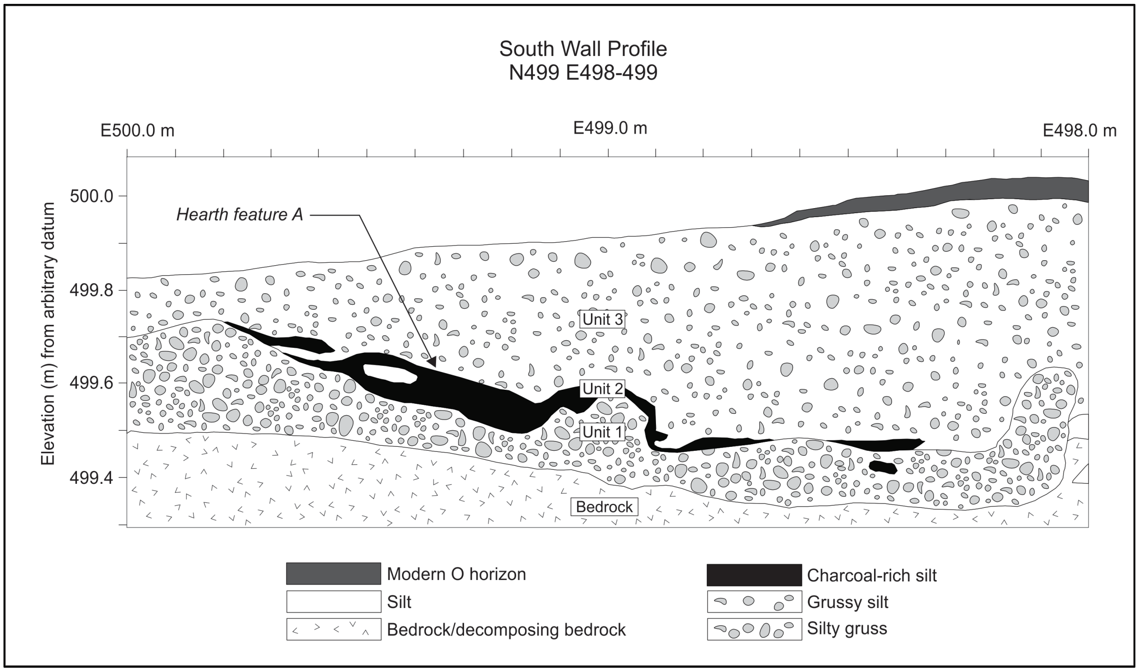


Figure 2.3. Illustration of a stratigraphic profile from the excavation featuring the sealed component of charcoal and gray-to-black stained silt (modified from Goebel *et al*. 2013:Figure 4).

which formed five concentrations indicative of activity areas. Four were aligned parallel to the overlook edge (A-D) and a fifth (E) was separated from the others by about 9 m.

Wood charcoal, consisting of birch (*Betula* sp.), presumably shrub birch, willow (*Salix* sp.) and Ericaceae, was collected from every feature, and 24 samples provided chronological control for the cultural deposits (Figure 2.2). The complete suite of radiocarbon dates suggests that cultural materials were deposited between 12,400 and 9900 cal B.P. (Goebel *et al*. 2013:Table 1); however, the time span indicated solely by willow charcoal, ethnographically known to have been used as fuel rather than shrub birch or Ericaceae (but see Hoffecker *et al*. 2014), suggested to Goebel *et al*. (2013) a restricted range of occupation of 12,400-12,000 cal B.P., consistent with dates from

Raven Bluff (Hedman 2010). While the non-willow dates are not excluded from the analysis, their spatial segregation to feature areas B and D, notably closer to the apex of the ridge, may suggest recurrent cultural activity, similar hearth placement, and re-use of the site by fluted-point using groups. Willow grows in moist soils, such as riverine settings, and would not have naturally occurred on the elevated ridge, the burned willow charcoal recovered from the excavation provides evidence of humans actively bringing the material to the ridge; while the later dating *Ericaceae*, which did grow on the ridge, could have resulted from wildfire. Therefore we consider the human activity associated with willow to better represent the range of occupation.

While most of the lithic assemblage (75.18%), consisting of flakes and tool fragments, occurred in stratum 2 and was associated with the charcoal features, debitage was also collected from overlying stratum 3 (16.67%) where solifluction affected the deposit, moving some artifacts up in the profile. Spatial correlations of clusters of raw material type and flake typology between strata suggest that the assemblage recovered from strata 2 and 3 of the block excavation represent a related component. The research presented here focuses on tool fragments and debitage recovered from this context only.

Closer to the ridge's edge and north of the block excavation, deflation has exposed stratum one and bedrock, exposing artifacts on the surface. We hypothesize that wind has blown many of these exposed artifacts back onto the surface of the intact sediment, therefore, the surface collection (6.86%) and the small percentage of artifacts incorporated into the O-horizon (1.29%) are in secondary deposits. This analysis was limited to artifacts in primary context, allowing for only centimeters worth of vertical displacement into stratum 3, which remained spatially separated from artifacts in secondary context in the O-horizon and on the site's surface.

Ecological Setting

The late Pleistocene environment surrounding Serpentine Hot Springs consisted of species of grasses and forbs supporting migrating herds of large fauna, and distinctly lacking in woody plants except along streams. The Seward Peninsula was largely ice-free and available for human and animal habitation during the late Pleistocene (Hopkins 1963; Kaufman and Hopkins 1986; Kaufman and Manley 2004). By 12,000 cal B.P., seawater had begun to flood the Bering Land Bridge, separating Asia and America (Elias *et al.* 1996). Data obtained from regional pollen records and entomological remains suggest that the terminal Pleistocene landscape was a mosaic of open shrub tundra with willow and birch supporting bison, caribou, horse, and musk oxen (Abbott *et al.* 2010; Edwards and Barker 1994; Elias and Crocker 2008; Elias *et al*. 2000; Mann *et al*. 2001, 2013; Rasic and Matheus 2007). However, like today, the late Pleistocene Arctic experienced extreme seasonal fluctuations in resource distribution and availability, as well as low biotic diversity, requiring the use of correspondingly organized mobility strategies by human groups (Lie and Paasche 2006; Mann et al. 2001; Rasic 2008).

Lithic Landscape

During field seasons, we surveyed the area immediately surrounding the hot springs and fluted-point site and did not identify a local source for any of the cryptocrystalline silicates that make up nearly all of the artifact assemblage. The area is composed of granite and biotite-bearing schists (Sainsbury 1986; Thurston 1985), outcropping as tors protruding meters above the ground. Other local stones include quartz-rich gneiss, which mantles the now exposed granite intrusions. Diabase and gabbro reportedly occur in large dike swarms associated with gneiss domes in the mountains to the south.

Elsewhere on the Seward Peninsula, fine-grained raw materials are rare. Sainsbury and colleagues (1971) described small dark chert nodules near the York Mountains south of Serpentine, and green to tawny-colored chert fragments in the Kugruk River gravels (Sainsbury 1986). These possible chert sources are over 100 km from Serpentine and not available locally. There are also no known sources of obsidian on the peninsula, the closest being Batza Téna more than 400 km to the east.

Few raw-material sourcing studies have been conducted in the greater area of northwest Alaska. Malyk-Selivanova and colleagues (1998) maintain that there are no sources for quality toolstone on the Seward Peninsula or the adjacent Kobuk River basin; however, the Noatak River basin, the mouth of which is located more than 150 km north of Serpentine, across Kotzebue Sound, contains a variety of chert sources (Mull 1995). There, black chert occurs in the De Long Mountains and Lisburne Hills, red and gray chert in the Upper Kelly River and Upper Kugururok chert quarries, and gray-black mottled chert in the Otuk Formation (Malyk-Selivanova *et al*. 1998). Secondary deposits of chert that originated at these sources, in the form of pebbles or cobbles, have also been documented in the deltaic gravels at the mouth of the Noatak River and this material has been found in archaeological sites throughout the region (see Malyk-Selivanova *et al*. 1998, and references therein). These chert formations stretch east across the Brooks Range and also were available in drainages and chert-bearing sediments hundreds of km to the northeast (Mull 1995). Possibly, some of these cherts make up the Serpentine assemblage and, like sources to the south of Serpentine, would have been transported more than 100 km to arrive at the site.

Materials and Methods

Artifact Assemblage

This report focuses on the buried lithic assemblage recovered from strata 2 and 3 of the Serpentine fluted-point site. This assemblage includes 1530 lithic pieces; however, 47% of these are medial, distal, or lateral flake fragments excluded from the analysis to focus on technological evidence present on or near the striking platforms, remove false indications of flake size, and avoid redundancy. The remaining data-set includes tools, tool fragments, and complete and proximal debitage fragments. The tool assemblage is discussed in detail in the Supporting Material, which includes descriptions of all seven fluted-point fragments found at BEN-192 (Figure 2.4), 16 additional biface fragments (Figure 2.5A-G), 29 utilized flakes, a multiple-spurred graver (Figure 2.5H), four cobble tools (Figure 2.6), and a culturally modified piece of quartz. Three of the fluted-point fragments were found on the site's surface and therefore not included in statistical analyses.

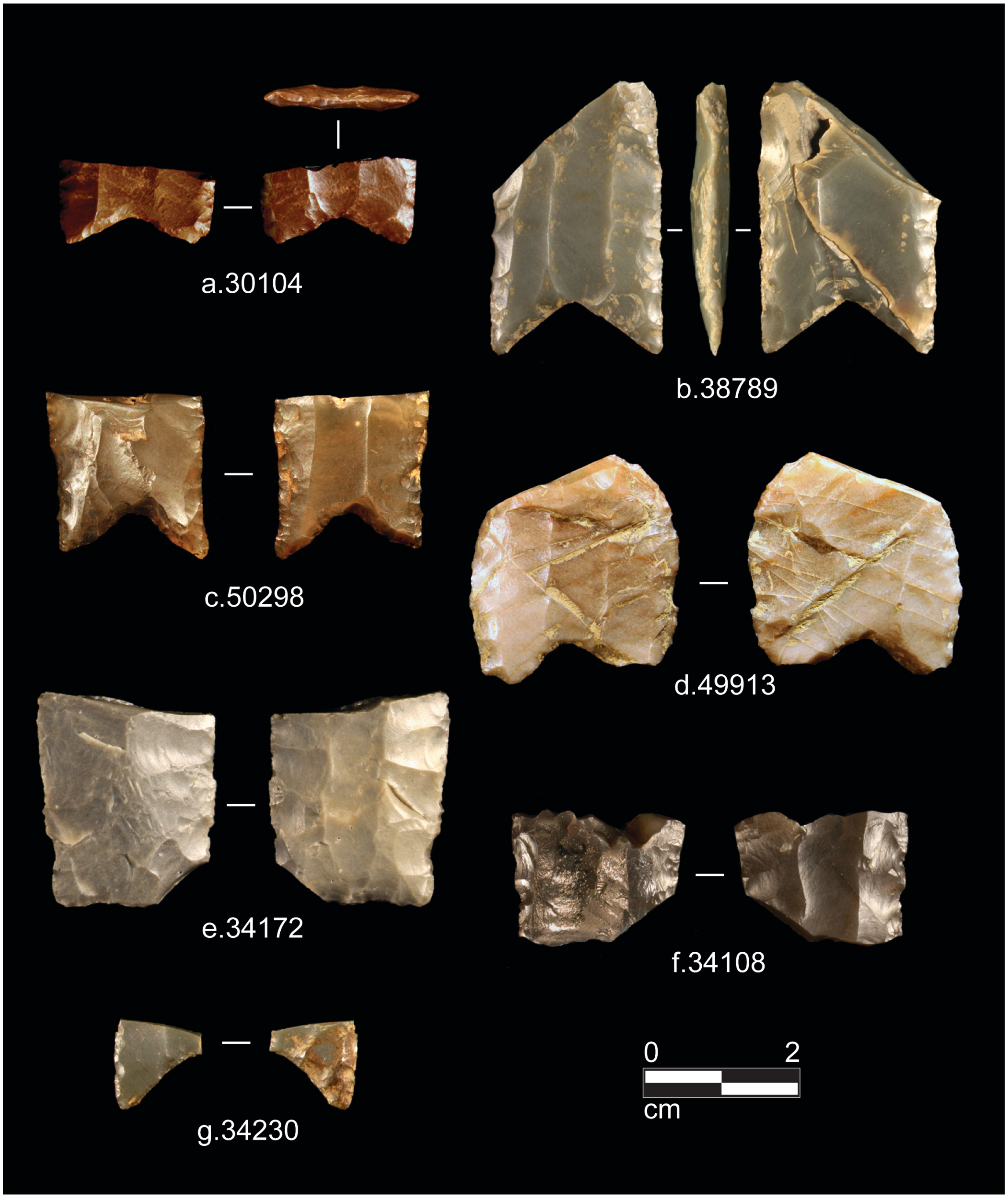


Figure 2.4. The fluted-point collection from the Serpentine fluted-point site.

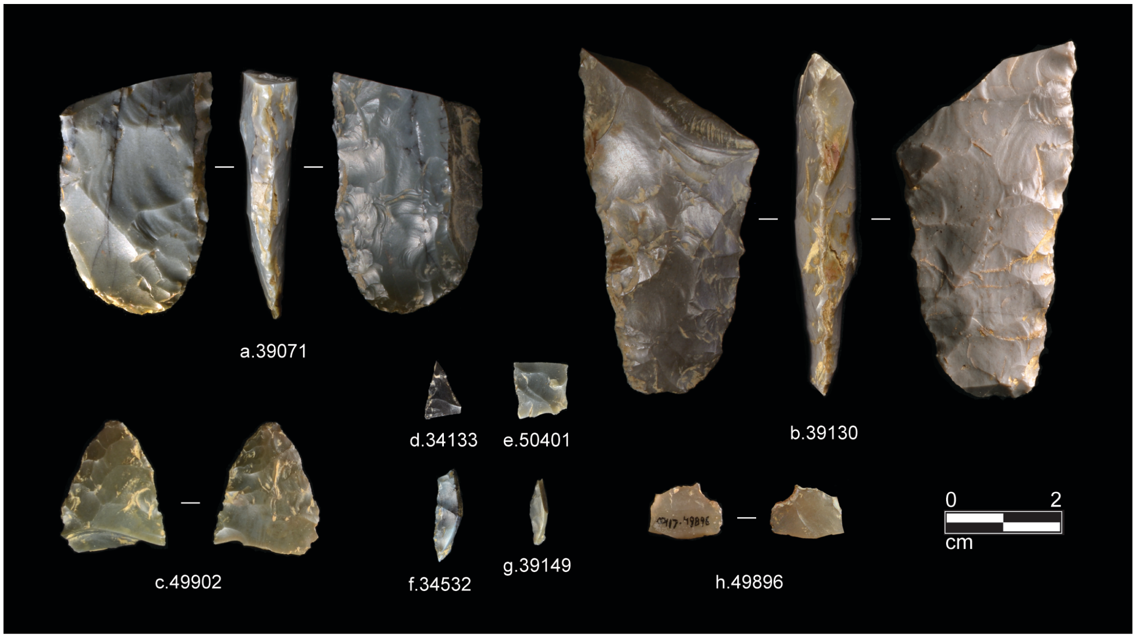


Figure 2.5. Biface and graver fragments recovered from the excavation.

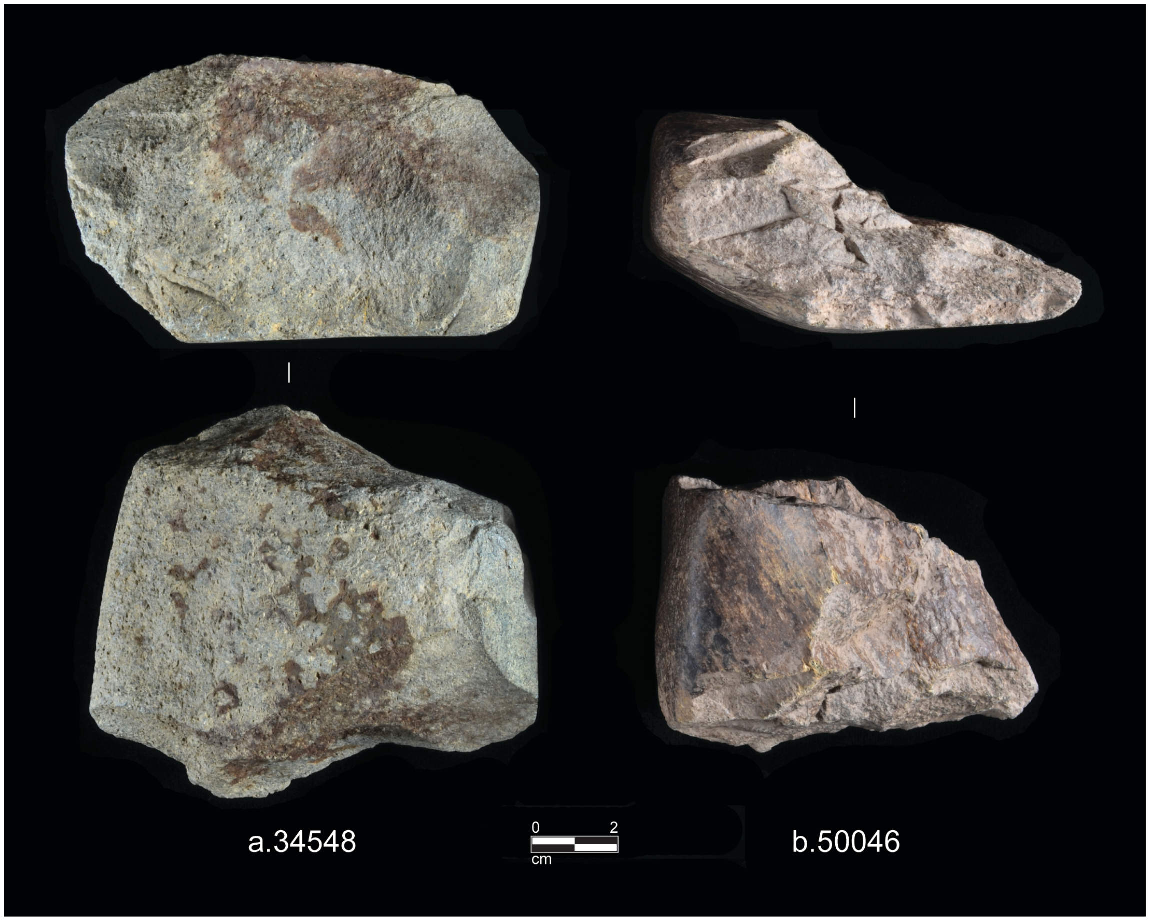


Figure 2.6. Two examples of the plano-convex cobble tools recovered from the excavation.

Excluded from this analysis are 133 surface and near-surface finds presumed to be in secondary context. We also excluded a small collection of bladelets, microblades, and debitage (n=51) found near the west end of the trench (feature E). Artifacts from this concentration are described in Supporting Material. The association of this cluster with the fluted-point assemblage is ambiguous, and moreover, it lacks fluted points and channel flakes and is spatially separated from the four charcoal features and fluted-point assemblage by 7 m of nearly culturally-sterile sediment. While this cluster may reflect an episode of bladelet manufacture 7 m to the west, this ambiguous separation prevents lumping these artifacts with the fluted-point assemblage that is unified spatially, technologically, chronologically, stratigraphically, and pattern of faunal association.

The analyzed assemblage, as a result, contains a total of 749 lithic pieces, 617 of which were recovered in association with features A-D encased in the silt of stratum 2, while the remaining 132 were recovered immediately above in the silty-gruss of stratum 3.

Data Acquisition

Each artifact was analyzed with regard to raw material to provide information on toolstone procurement and selection. Laboratory analysis of artifacts included metric data (length, width, thickness) collected with digital calipers. Other variables, such as number of flute scars and raw-material type, were gathered via visual inspection. In the case of raw material identification, obsidian was identified directly by XRF analysis, whereas cryptocrystalline silicates and other igneous rocks, such as gabbro, were visually identified according to grain size and texture, comparison to reference collections, and informed by local lithic-material availability and geology (Malyk-Selivanova et al. 1998; Sainsbury 1986; Thurston 1985).

The data-set includes 55 tools which were typologically indexed following Goebel et al. (1991). Tools were further evaluated in terms of condition (complete/fragmentary), presence of cortex, presence of edge abrasion (grinding), base shape, and incidence and directionality of flaking to inform on function, use-life, and assemblage formality (following Bradley 1993; Kuhn 1994; Smallwood 2010; Surovell

2009). Degree and type of basal thinning, presence of fluting, number and width of flute scars, extent of edge abrasion, crushing or polishing on faces, as well as breakage patterns were recorded to provide evidence of hafting methods, functionality, resharpening/refurbishing practices, and overall life history of each artifact (following Ahler and Geib 2000; Andrefsky 2005, 2009).

The 694 lithic pieces that make up the debitage assemblage were organized into technological/typological categories by indexing a suite of variables such as platform type, size class, amount of cortex, and thickness (following Andrefsky 2005; Bradbury and Carr 1999; Goebel 2007; Rasic and Andrefsky 2001). These attributes served to provide evidence of reduction strategy, stages of reduction practiced, and artifact type produced (Amick *et al*. 1988; Andrefsky 2001, 2005; Carr and Bradbury 2001; Shott 1994). The term microblade is used here to metrically describe small blades that are < 10 mm wide and have dorsal scars parallel to the long axis; however, determining whether these pieces represent the presence of a formal microblade technology, the end of bladelet-core reduction, or tertiary channel flakes remains equivocal.

Due to sample-size limitations, expected cell counts were too low for dependable chi-square analysis, but observed frequencies of raw material and technological variables informed on the technological organization used by the inhabitants of the site. Patterns of reduction within raw-material categories were determined by non-parametric statistical analysis of thickness using Kruskal-Wallis analysis.

Results

Raw Materials

Seventy-five percent of the assemblage is made up of cherts, 17.76% is chalcedony, 2.00% is quartzite, 1.60% is obsidian, 1.47% is diabase, 1.07% is gneiss, 0.93% is quartz, and 0.27% is rhyolite (Figure 2.7a). A variety (~10) of chert compared to other materials was brought to the site. The only raw materials from the Serpentine lithic assemblage that we are presently able to source using XRF analysis are a few pieces of obsidian found to originate 400 km to the east at Batza Téna; demonstrating the magnitude of distances raw materials were carried to reach the site (Goebel *et al*. 2013). The remaining high-quality raw materials are cryptocrystalline silicates (CCS) presently unable to be sourced specifically; however, consideration of other variables such as percentage of cortex is useful to model distance from source (Andrefsky 2005; Holdaway et al. 2010). Only 0.42% of CCS artifacts have cortex remaining (Figure 2.7b). Of the low-quality materials, 18.18% of diabase, 42.86% of quartz, and 87.50% of gneiss, have cortex remaining on both tools and debitage. The significantly lower incidence of cortex on CCS than on low-quality raw materials suggests that the CCSs were transported greater distances to reach the site. These findings match those of our lithic-landscape survey. As noted above, the closest documented sources of CCS are more than 100 km away, while low-quality toolstones (diabase, gneiss, quartz) outcrop nearby in the Serpentine valley.

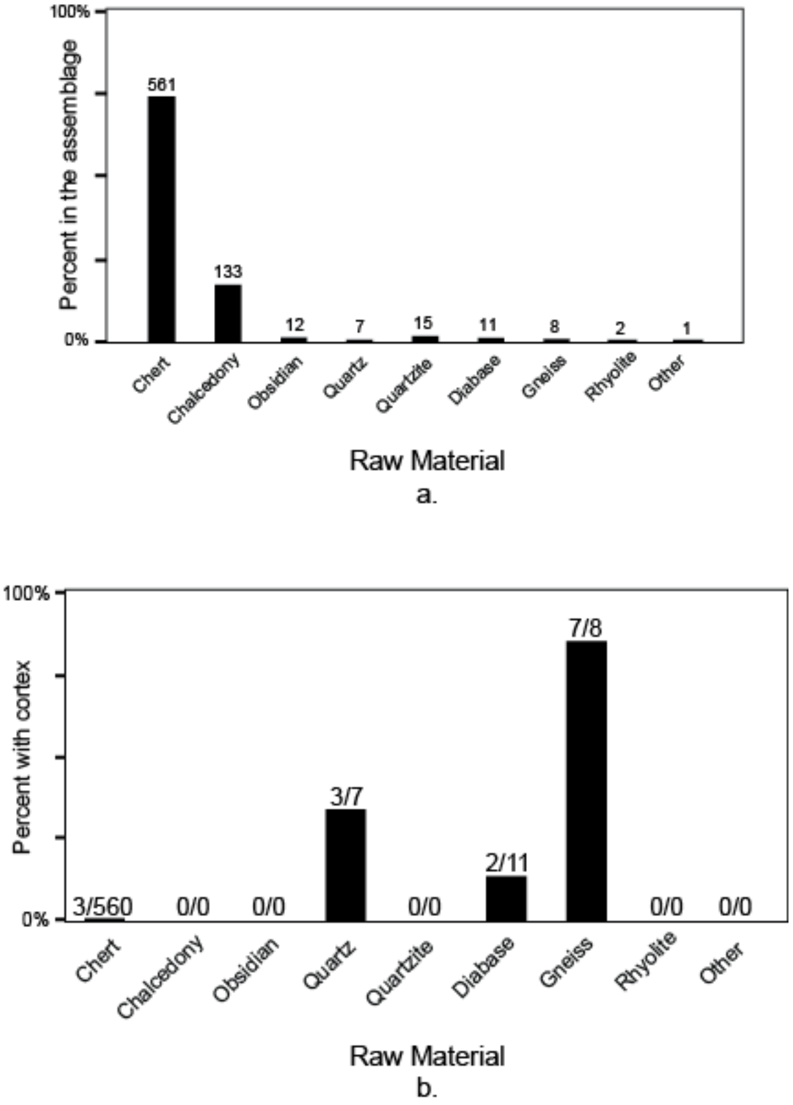


Figure 2.7. Frequencies of lithic raw materials and remaining cortex in the assemblage from the excavation: (a) counts of lithic raw materials; (b) sub-sample of artifacts in each raw-material category with cortex remaining.

The Tool Assemblage

Four fluted-point fragments (BELA-38789/ BELA-38788, BELA-50298, BELA-49913, BELA-34230) were found *in situ* and are briefly described below. Measurements of biface length, width, and thickness, including fluted-point fragments recovered from the surface, are presented in Table 2.1 (see Appendix A for detailed descriptions). The fluted-basal fragments average 23.80 mm in width and 5.53 mm in thickness.

Table 2.1. Measurements of Length, Width, and Thickness of the Fluted-Point Collection and Other Hafted Bifaces from the Serpentine Fluted-Point Site.

Artifact number	Length (mm)	Width (mm)	Thickness (mm)
30104	11.50*	20.31	3.69
38789/38788	35.58*	24.00	5.72
50298	21.53*	20.53	4.93
49913	27.70*	26.86	5.96
34172	28.07*	23.29	7.09
34108	17.71*	22.50	6.68
34230	11.74*	11.33*	2.73
39130	64.73*	32.41	12.47
39071	45.66*	27.90*	9.98
49902	23.42*	10.26	4.98

*Measurement taken on a fragment.

The first fluted point, made from bluish-gray, translucent chert, consists of two fragments, a primary basal fragment (BELA-38789) and spall (BELA-38788) that removed a portion of the reverse face (Figure 2.4b, right). The distal break is a transverse fracture at a 45° angle to the long axis, which truncates three parallel channel-flake scars on each face. Straight lateral edges were refined with fine pressure flaking and ground after fluting occurred. The basal concavity is V-shaped.

Fluted-point BELA-50298 is made from brown chalcedony. An impact scar hinges over the distal snap and terminates on the obverse face (Figure 2.4c, left). Three channel-flake scars thin each face. Fine pressure flaking and heavy edge abrasion, occurred on lateral margins and within the V-shaped basal concavity post-fluting.

Fluted-point BELA-49913 is made of beige-to-tawny chert, and striations cross three flute scars on each face (Figure 2.4d). The distal snap occurred along one of these planes. Convex lateral margins were trimmed with fine pressure flaking after fluting, yet edge abrasion is not present on the lateral margins or V-shaped basal concavity.

The fluted-point corner fragment BELA-34230, of a once V-shaped basal concavity, is made of greenish-gray chert (Figure 2.4g). Two channel-flake removals, the left lateral flute and half of the center flute, are present on the reverse face (right). Post-fluting pressure flaking and edge abrasion is present along the lateral and basal edges. Snap fractures form the distal and medial breaks. Overall, notable characteristics include a V-shaped basal concavity, straight lateral edges, multiple flute scars, marginal pressure retouch after fluting, and edge abrasion.

Two biface fragments are distinctly robust in terms of average width, 30.16 mm, and thickness, 11.23 mm, which are markedly larger than the fluted-point fragments (see Table 2.1). The fragments still have flake scars possibly evident of early-stage bifacial shaping using percussion flaking, large removals with negative scars denoting prominent bulbs of force, a few of which reached across the face of the artifacts (Crabtree 1968; Cotterell and Kamminga 1979). These are over-flaked along the margins by irregular clusters of smaller pressure-flake removals, which together form an uneven central ridge down the long axis and a diamond-shaped cross-section.

Table 2.2. Frequencies of Tools and Debitage Recovered from Strata 2 and 3 of the Serpentine Fluted-Point Site Organized by Formal and Expedient Tools and Raw Material.

Description	Chert	Chalcedony	Obsidian	Quartz	Quartzite	Diabase	Gneiss	Rhyolite	Gabbro	Totals
Formal Tools										**21**
Fluted-point*	3	1	0	0	0	0	0	0	0	4
Biface tip*	1	0	0	0	0	0	0	0	0	1
Robust biface*	2	0	0	0	0	0	0	0	0	2
Biface frag.*	12	0	1	0	0	0	0	0	0	13
Expedient Tools										**34**
Cobble tool	0	0	0	0	0	1	3	0	0	4
Worked piece	0	0	0	1	0	0	0	0	0	1
Utilized flake	20	6	3	0	0	0	0	0	0	29
Spurred graver*	0	1	0	0	0	0	0	0	0	1
Total Tool	38	8	4	1	0	1	3	0	0	**55**
Total Debitage	522	125	8	6	15	10	5	2	1	**694**
Totals	**560**	**133**	**12**	**7**	**15**	**11**	**8**	**2**	**1**	**749**

*Artifact is fragment.

The robust biface BELA-39071 is made of bluish-gray chert with dark striations. A transverse snap forms the distal break (Figure 2.5a). Lateral edges are convex and not ground. The proximal edge is convex and neither thinned nor ground.

Lateral flaking on the second (BELA-39130) gray-chert robust biface consists mostly of the larger, possibly percussion, removals that meet at the midline of the artifact and create an irregular mid-line ridge (Figure 2.5b). Clusters of pressure-flake removals are also present, and lateral-edge abrasion occurs in the medial area only. The distal break forms a longitudinal macrofracture that hinged over the distal edge and terminates in a step fracture. The proximal end is convex and not basally thinned.

A distal biface fragment (BELA-49902) has an overshot hinge termination forming the proximal break, and its lateral flake scars create a medial ridge on both faces

(Figure 2.5c). Thirteen additional biface fragments are deficient in diagnostic characteristics (Figure 2.5d-g); however, an average thickness of 4.38 mm and a regular pattern of fine flake scars suggest that they were once part of late-stage or even hafted bifaces.

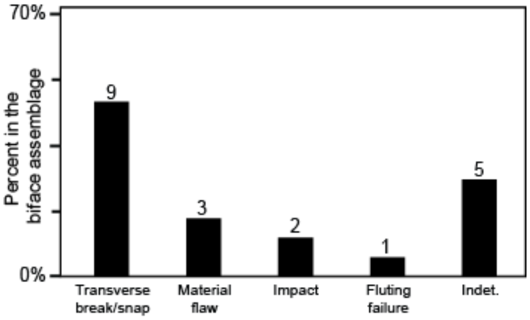
Thirty-five unifaces are in the buried assemblage and include 29 utilized flakes made on high-quality toolstone, a double-spurred graver (BELA-49896) made on chalcedony (Figure 2.5h), and a culturally modified piece of white quartz. Four plano-convex cobble tools (BELA-34548, BELA-50359, BELA-50046, and BELA-50544) have gouged flake removal scars that form a working edge (following Goebel *et al.* 1991:56) (Figure 2.6).

The frequency of raw-material types among formal and expedient tools is presented in Table 2.2. Formal tools, such as biface fragments and the graver, represent 38.18% of the tools and are made entirely on high-quality raw materials. The remaining 61.81% of the tools found at Serpentine represent expedient tools including four plano-convex cobble tools made on low-quality gneiss (n=3) and diabase (n=1), one modified piece of quartz, and 29 utilized flakes. All of the utilized flakes are made on CCS and obsidian. Three are distal fragments that lack platforms, but the remaining 26 were produced during biface reduction, 18 having complex platforms and 8 crushed platforms. Despite their expedient use as tools, they represent a component of a curated biface technology. In this respect 90.91% of the tool assemblage is related to formal-tool production.

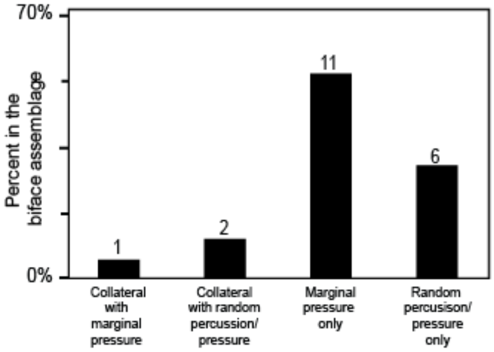
Every biface in the collection is fragmentary and represents late or finished stages of manufacture. Transverse breaks/snaps occur on 45% of the biface fragments and include bending snap fractures on the fluted-point fragments (Figure 2.8a). Impact fractures that hinge over the distal break and terminate in a heavy step fracture are present on 10% of the bifaces, including two fluted-points and one robust biface fragment. Distal fragment BELA-49902 has a hinge fracture resulting from fluting failure, three bifaces broke along a raw-material flaw, and five fractures were unable to be categorized. Flake scars on the biface fragments and graver resulted from small pressure-flake removals along the margins, although the robust bifaces have larger removals and intermittent clusters of small pressure-flake removals (Figure 2.8b). All basal fluted-point fragments but one (BELA-49913) have marginal-edge abrasion, but of the non-diagnostic biface fragments, 33.33% have evidence of hafting wear (Figure 2.8c).

Of the flake tools, 6 utilized flakes and the graver have bending-snap fractures; terminations on the remaining 23 are obscured by retouch. The cobble tools and worked piece of quartz are considered complete. There is no evidence of hafting wear on any of the unifacial tools.

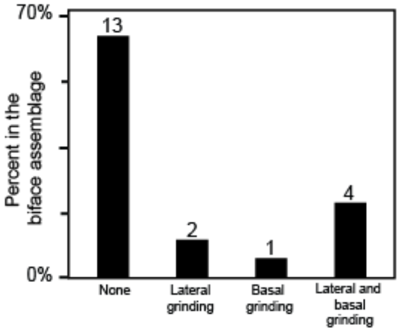
Potlids on three utilized flakes and thermal fractures on two non-diagnostic biface fragments are the only instances of thermal alteration and do not suggest intentional thermal pre-treatment, but discard near or in hearths (Mercieca and Hiscock 2008). The fragmentary nature of the formal-tool assemblage suggests that complete and functioning tools may have been curated pieces that were brought to and removed from the site by the occupants.



Fracture Type
a.



Flake Scar Pattern
b.



Hafting Wear
c.

Figure 2.8. Frequencies of attributes scored on bifaces in the assemblage from the excavation: (a) fracture type; (b) flake scar pattern; (c) hafting wear.

The Debitage Assemblage

Due to sample-size limitations, expected cell counts were too low for dependable chi-square analysis, but patterned variability between raw material, degree of cortex, flake size, thickness, platform condition, and flake type was observed (Table 2.3).

Table 2.3. Frequencies of Cortex Percentage, Flake Size, and Platform Surface on Debitage Recovered from Strata 2 and 3 of the Serpentine Fluted-Point Site Organized by Raw Material Type.

Description	Chert	Chalcedony	Obsidian	Quartz	Quartzite	Diabase	Gneiss	Rhyolite	Gabbro	Totals
Percentage cortex										
0%	519	125	8	4	15	9	1	2	1	684
0-25%	1	0	0	0	0	0	0	0	0	1
25-50%	0	0	0	1	0	1	3	0	0	5
50-75%	0	0	0	1	0	0	0	0	0	1
100%	2	0	0	0	0	0	1	0	0	3
Flake size										
<1 cm	331	70	2	1	8	0	1	2	0	415
1-3cm	190	55	6	3	7	1	2	0	1	265
3-5cm	1	0	0	2	0	5	1	0	0	9
>5cm	0	0	0	0	0	4	1	0	0	5
Platform surface										
Complex	402	88	5	2	14	0	0	1	1	513
Flat	13	10	1	1	0	3	0	0	0	28
Cortical	1	0	0	2	0	2	5	0	0	10
Crushed	100	27	2	0	1	0	0	1	0	131
Unknown	6	0	0	1	0	5	0	0	0	12
Total/raw material	**522**	**125**	**8**	**6**	**15**	**10**	**5**	**2**	**1**	**694**

The collection of lithic debris (n=694, 92.66% of the analyzed assemblage) primarily consists of the same types of toolstone that make up the tools, with the addition of two pieces of rhyolite and one piece of what appears to be gabbro. Cortex is present on only 1.44% of the debitage assemblage—four pieces of gneiss, three pieces of chert, two pieces of quartz, and one piece of diabase. Cortical spalls consist of local low-quality raw materials, except for two pieces of opaque-brown chert and one piece of green chert.

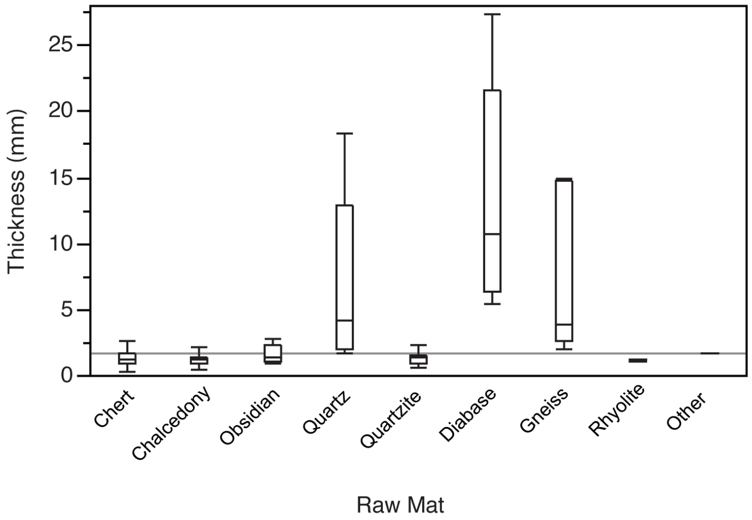


Figure 2.9. Box-plot showing results of Kruskal-Wallis analysis of debitage according to raw material type and thickness.

The collection is dominated by small flakes (>1 to 3 cm diameter), which make up 97.98% of the debitage, and 99% of these are chert, chalcedony, obsidian, and quartzite (see Table 2.3). Large flakes (3 to >5 cm in diameter) represent 2.02% of the collection and consist of low-quality raw materials: quartz, diabase, and gneiss. A non-parametric Kruskal-Wallis test found a significant difference (X^2=59.85, DF=8, p=<0.0001) in thickness driven by flakes made from CCS and obsidian versus low-quality raw materials (Figure 2.9).

Typologically, the collection includes bifacial (90.78%) and unifacial (7.20%) reduction flakes, cortical flakes (1.44%), shatter (proximal flake fragments shattered by thermal fracture, 0.29%), and a possible microblade (0.14%) and bladelet (0.14%) (Figure 2.10a,b) (Table 2.4).

Figure 2.10. Debitage from the excavation included in analysis and specifically referred to in the text: (a) microblade; (b) bladelet; (c-g) primary channel flakes; (h-i) secondary channel flakes; (j-k) tertiary channel flakes.

No formal cores or core fragments occur in the assemblage. Intact platforms are present on 79.39% of the analyzed debitage, including cortical (1.44%), flat (4.03%), and complex (73.92%) platforms (see Table 2.3). The remaining 20.60% are crushed and damaged platforms. Flakes made on non-local raw materials have mostly complex platforms (75.92%). Crushed platforms, which may have resulted from soft-billet percussion flaking or instrument-assisted pressure flaking (see Pelegrin and Inizan 2013), account for 19.16% of the flakes made on high-quality raw materials. Nine of ten flakes with cortical platforms are made of local gneiss and diabase, while one is made on chert. Flat platforms are present in both high-quality (85.72%) and low-quality (14.28%) raw-material classes. The cortical and flat platforms in the low-quality class appear to represent preparation and rejuvenation of the plano-convex cobble tools. Within the non-local, high-quality class of raw materials, 41.66% of flakes (n=10) with flat platforms are made of chalcedony. Of flat-platform flakes, 46.43% are made from chert (n=13) and 3.57% from obsidian (n=1), and many correspond to non-bifacial reduction methods (see Morrow 1997) or could represent small single-faceted platforms removed from bifaces. Thirteen flakes (1.73%) have damaged platforms that do not conform to the crushed category and were not typologically distinctive.

Table 2.4. Frequencies of Debitage Type Recovered from Strata 2 and 3 of the Serpentine Fluted-Point Site Organized by Raw Material.

Description	Chert	Chalcedony	Obsidian	Quartz	Quartzite	Diabase	Gneiss	Rhyolite	Gabbro	Totals
Flake	27	5	3	5	1	8	1	0	0	50
Cortical flake	3	0	0	1	0	2	4	0	0	10
BTF > 10 mm	168	31	1	0	5	0	0	0	1	206
BTF < 10 mm	320	89	4	0	9	0	0	2	0	424
Shatter	2	0	0	0	0	0	0	0	0	2
Blade/Bladelet	1	0	0	0	0	0	0	0	0	1
Microblade	1	0	0	0	0	0	0	0	0	1
Totals	522	125	8	6	15	10	5	2	1	694

Bifacial Thinning Flakes (BTF) are Separated into Large and Small Size Fractions.

Among biface-thinning flakes, nine channel flakes were identified, six made on chert and three on chalcedony (Figure 2.10c-k). Primary channel flakes (n=5) have a dorsal-scar pattern that consists of lateral flaking forming a medial ridge down the long axis of the flake. Dorsal faces of secondary channel flakes (n=2) have lateral scars that are perpendicular to a previous channel-flake removal scar. Tertiary channel flakes (n=2) have two parallel arises aligned with the long axis of the dorsal surface resulting from previous guide-flake removals (following Loebel 2009).

Variability in flake type, representing variation in reduction technique, is driven by the predominance of biface-thinning flakes (90.77%) in the high-quality raw-material category versus the remaining 7.20% of flat-platform flakes and 1.44% of cortical flakes possibly representing core reduction. When only very small (<10 mm in diameter) biface-thinning flakes are considered, chert and chalcedony is specifically dominated by products of late-stage bifacial reduction (see Table 2.4).

The low degree of cortex, dominance of small flakes with complex platforms made on high-quality raw materials, and number and variety of channel flakes suggest that late-stage fluted-point manufacturing activities produced the majority of the debitage assemblage in the buried component.

Discussion

Analysis of the buried lithic assemblage from the Serpentine fluted-point site demonstrates an instance of long-distance movement of high-quality raw material for use as formal tools, restricted expedient use of low-quality local raw materials, and a focus on late-stage fluted-point manufacture. While the site provides only a glimpse of an entire late Pleistocene cultural system in place on the Seward Peninsula, the information contained in the assemblage allows us to develop an understanding of an aspect of this group's technological organization. To this end, we can achieve some appreciation of how fluted points were made and used at Serpentine and how organization of the technology informs on subsistence and settlement behavior, which possibly represents one facet of a combination of season-dependent procurement strategies (Grove 2009).

Raw-Material Procurement and Technological Organization

Evidence for tool refurbishing and the presence of faunal remains suggest that the Serpentine Hot Springs area was a place to use weapons in animal dispatch and BEN-192 served as a place for subsequent technological recovery far from sources of preferred toolstone. As tools and previously prepared lithic materials were predominantly brought from distant sources to the site, environmental conditioning was low (see Kuhn 1994), i.e., inhabitants were not limited to only using resources available in the vicinity of the hot springs (see Chatters 1987).

The dominance of small flakes (<1 to 3 cm in diameter) with complex and crushed platforms suggests a focus on late-stage bifacial retouch (Crabtree 1968; Pelegrin and Inizan 2013). Low numbers of large debitage pieces, cortical spalls, and the absence of cores suggest a dearth of primary production, and minimal focus on local raw materials (see Surovell 2009). Tools such as blades, gravers, and utilized flakes were made from the same high-quality raw materials transported to the site. These tools could have been involved in resetting and binding points within a haft or animal processing. The robust plano-convex cobble tools represent the use of local raw materials in expedient tool manufacture and possible production of animal-processing tools.

Activities at the Site: Tool Manufacture and Use

A variety of attributes observed on the tool fragments shed light on the manufacturing activities at the Serpentine fluted-point site. Multiple finished bifaces were refurbished and fluted there. Tools made on a variety of high-quality lithic materials appear to have been carried back to the site while still in the haft before binding was removed to free broken fragments for replacement or repair. The biface fragments, including the fluted points, and the graver, are dominated by marginal, fine-pressure flaking consistent with tool refurbishing and resharpening. The bifacial tip fragment (BELA-49902), detached from its base by a failed fluting attempt, along with nine channel flakes, demonstrate the prominence of fluting late-stage bifaces or re-fluting broken fluted-point fragments. The two robust bifacial base fragments, however, appear to demonstrate a random combination of percussion and pressure flake removals that form an uneven central ridge down the long axis and diamond-shaped cross-section. This may represent remnant scar patterns of earlier production stages. Similarity in raw material and stratigraphic association suggests that the robust bifaces are part of the fluted-point assemblage. The combination of abrasion in the medial area of the lateral edges of robust biface BELA-39130 and the morphology of the distal macrofracture suggests that the artifact may represent a hafted tool, however, location of edge abrasion does not suggest that the artifact served as a projectile point and, ultimately, its precise function is unknown. The utilized flakes were exclusively made from non-local high-quality raw materials and may attest to flexible use of the robust bifaces, which could have served as bifacial cores, tool blanks, or hafted implements as part of the transported tool kit.

The overall fragmentary nature of the biface collection appears to be a result of mechanical failure during use. The majority of breakage types, visible mostly on the fluted-point fragments, are transverse or bending-snap fractures, demonstrated, experimentally, to result from heavy impact (Collins 1993; Frison 1989), while only one fluted-point base and one robust-biface base have hinge-fractures suggestive of impact. There is evidence of thermal fracturing in the form of potlid scars on three of the bifaces, which likely occurred after broken fragments were discarded in or near hearths. The graver is also snapped; whether this occurred during manufacture or use is unknown.

Fluted-Point Technology and Function at Serpentine. Evidence of the full continuum of biface manufacture is distinctly lacking at Serpentine, as there are no artifacts exhibiting characteristics unequivocally evident of early-stage production. Attributes of the discarded fluted-point fragments, such as flake-removal sequence, metrics at discard, nature of flake scars, and breakage patterns, in addition to the results from debitage analyses, however, provide some indication of the final stages of reduction and a glimpse at one segment of a reduction continuum (see Appendix B).

Blank form is difficult to assess; however, the extreme thinness of the fluted-point fragments, and a few instances of curvature present on some, suggest that manufacture began with flake blanks. Regularly spaced flake-scar patterns (5-10 mm in scar width) visible on fragments BELA-34172 and BELA-49902 suggest that to-the-mid-line flake removals were used to initially shape toolstones into lanceolate forms.

The points from Serpentine suggest that fluting was used to thin, not only the medial axis of the point base, but also across the entire face. Typically, three flutes were removed from each face. As more flutes were imposed on the points, creation and removal of the fluting platforms resulted in repeated raw-material removal from the base, deepening the cavity, which was in turn retouched and specifically shaped into an inverted ‘V’. Fine-pressure retouch along both lateral margins and within the basal concavity took place after fluting.

Evidence for hafting is present on almost all of the fluted-point fragments. Firstly, fluting is a method of basal thinning to prepare a projectile point for the hafting element. Edge-grinding, or abrasion, evident of hafting wear, is visible along the basal edges and lateral margins of the proximal fragments.

The combination of the V-shaped basal concavity, straight lateral edges, adjacent flute scars, and edge abrasion, represents a formal design meant for insertion into a prepared haft (see Ahler and Geib 2000). The fragmentary nature of the points further demonstrates that basal fragments were protected by binding and carried to the ridge for release and discard (see Keeley 1982). Impact damage suggests that they functioned as projectile weapons. Likewise, no distal fragments, which broke as a result of impact, are present in the collection, suggesting their use off-site in ‘turbulent’ activities (see Flenniken 1991). The only distal biface fragments recovered appear to have broken during manufacture, specifically during fluting, suggesting, along with the primary channel flakes, that the occupants had maintained a reserve of bifacial blanks that required fluting prior to use. The lack of cortical spalls and the multitude of fine bifacial retouch flakes suggest that replacement points arrived at the site in late stages of manufacture and could be finished with fine pressure retouch and fluting, which would have required a narrow instrument, such as an antler tine. Such a tool would have been necessary for fluting within the points' deep basal concavity.

Non-Fluted Biface Manufacture. The robust bifaces may represent a reduction strategy different from the fluted points. Both bifacial-base fragments have a series of uniform pressure flake removals along one lateral margin whereas the opposite margins' pressure flakes are irregularly interspersed with older and larger scars. Both have a protrusion of raw material on the reverse face (see Figure 2.6a,b, right) of their bases that may represent original spall platforms. Ultimately, the sheer size and thickness of the robust biface fragments suggest that these tools began as bifacial cores or nodules, but the possibility that they may have been manufactured from large spalls cannot be dismissed.

Subsistence and Settlement Behavior

Aspects of settlement organization become apparent when considering variables such as assemblage structure and diversity of features and resources (Amick 1996; Binford 1977, 1979; Carlson 1979; Chatters 1987; Surovell 2009). Aside from the utilized flakes, bifacial fragments dominate the Serpentine tool assemblage; the low number of other tool forms indicates low tool-assemblage diversity. The absence of early-stage and middle-stage bifaces and dominance of exhausted and discarded points produced a high point-to-preform ratio, a pattern occurring when reserve points and point blanks were manufactured beforehand at lithic sources (Amick 1996). Likewise, the absence of cores in the assemblage demonstrates an extremely high biface-to-core ratio, considered by some researchers to represent high mobility, or at least, short stays at the site (Jennings *et al*. 2010; Parry and Kelly 1987). Feature diversity is also low and consists of only hearths and associated artifact concentrations but no caches, dwelling structures, storage pits, etc. Together, these data indicate that the site served as a short-term camp visited by highly mobile hunters.

Only a few tasks were undertaken at the site, primarily weapons maintenance and limited processing of animal carcasses. No evidence of extensive faunal processing is present in the form of specialized task areas, additional butchering tools, or spatial organization of variable faunal remains. There are no scraping tools in the assemblage, and, besides the utilized flakes, the plano-convex cobble tools potentially represent the only tool associated with carcass processing; that is if we assume the gouged flake removals and corresponding step terminations resulted from smashing bone or joint tissue. In addition to some ungulate tooth fragments recovered, the faunal assemblage consists of thousands of tiny (≤ 1 cm) fragments of burned and calcined bone (Goebel *et al*. 2013). They may indicate use of bone as hearth fuel and/or extraction of grease for binding materials (see Outram 2001; Stiner *et al*. 1995). The combination of faunal and lithic evidence suggests that mobile hunters maintained weapons and dispatched animals somewhere in the vicinity of the ridge near Serpentine Hot Springs, and brought parts of the animal back to the ridge to cook or use as fuel.

Conclusion

As a whole, the evidence suggests that BEN-192 at Serpentine Hot Springs was a specialized field station where hunters looked for caribou and maintained weapons as they did so. These activities may represent the practice of an intercept-hunting strategy at a geothermal feature that attracted a variety of animals within the logistical radius of a residential base or field camp (Ashley et al. 2011; Binford 1978,1980; Guthrie 1983; Sheehan 1994). As such, the evidence from the site may characterize a component of a logistical system of mobility (Binford 1980; Carlson 1979; Grove 2009; Guthrie 1983).

Further support for this conclusion requires knowledge of exactly how far people would have travelled from a residential base or field camp, to reach BEN-192 at Serpentine. Ethnographic evidence suggests that a corresponding field camp would often have foraging radii of only 6-10 km (Kelly 1995) and ethnography specific to the Arctic predicts a base camp could be located as much as 70 km away especially given the high level of resource dispersal in the Arctic (Binford 1980, 1983). Some raw materials, however, appear to have been carried more than 300 km to reach Serpentine. While logistical parties certainly could have travelled such distances to arrive at this specific geothermal feature, the long-distance transport of raw material suggests the potential for high residential mobility (see Lovis *et al*. 2005; Smith and Kielhoferb 2011). The evidence under consideration suggests that the Serpentine fluted-point makers were scheduling mobility between predictable, yet distant and seasonally available, patches of resources. The hot springs may have been the magnet, attractive to both animals and humans, especially during late fall and early spring when hot spring water exceeding 140° F staved frost and snow. This assumes that patterns of animal migration in the late Pleistocene were predictable and dependable, as they were known to have been ethnographically (Bever 2000; Binford 1979; Gordon 2005; Sheehan 1994). More detailed lithic-provenance studies and survey in the Serpentine area are needed to determine the sources of toolstones, distances moved, and relationship of the Serpentine fluted-point station to hypothetical field and base camps, which could be located near Serpentine or many km away.

For now, analysis of the evidence from the Serpentine fluted-point site demonstrates that tool maintenance/refurbishing/reloading were the primary activities practiced on the ridge. The presence of ephemeral hearth features, concentrations of lithic debris, and variety of raw materials suggest that this pattern of behavior was predicated upon repeated use of this location. This suggests a degree of preparation for the next task or planned move involving the refurbishment of a maintainable toolkit. In their range of movement, this group appears to have included the hot springs along the upper Serpentine River and lithic sources in the Brooks Range, which are predictive, or reliable, resources. These would have been key variables in the group's depth of planning and imposed little risk of arriving at a location to find such resources unavailable. It is also possible that hot springs served to attract game animals, providing opportunities for intercept-hunting strategies (Churchill 1993; Sheehan 1994). Fluted-projectile technology may also have been selected to offset technological risk involved with highly mobile procurement systems, and further inquiry into the technological traits that characterize the collection of northern fluted-points will shed light on their adaptive role in the late Pleistocene Arctic.

CHAPTER III

THE NORTHERN FLUTED POINT COMPLEX: TECHNOLOGY, ADAPTATION, AND RISK IN THE LATE PLEISTOCENE ARCTIC

Introduction

The indisputable trademark of Paleoindian technology is the fluted point, the earliest examples of which are found south of the late Pleistocene ice sheets of North America in archaeological sites dating to as early as 13,200 calibrated years before present (cal B.P.) (Waters and Stafford 2007) and possibly earlier (Haynes et al. 2007). Many researchers consider fluted-point production to have been a highly risky method of thinning the bases of lanceolate projectile points, citing high rates of production failure in both archaeological and experimental contexts (Flenniken 1978; Gryba 1988; Judge 1973; Sellet 2004; Sollberger 1985; Winfrey 1990; but see Ellis and Payne 1995). Clovis and other fluted-point forms, however, were highly standardized, both morphologically and technologically, forming homogenous types throughout the Paleoindian era. The prevalence of fluting-failure has been described as technological risk because of the high potential for such failure to waste valuable toolstone (Torrence 1989). Various hypotheses have been developed to understand why Paleoindian groups prioritized production of fluted points including ease of hafting (Judge 1973; Wilmsen 1974; Wilmsen and Roberts 1978), improved penetration and lethality (Crabtree 1966), increased durability (Hutchings 1997), and predictive failure (Bleed 1986) (see also Ahler and Geib 2000). Analyses of fluted-point technology and Paleoindian technological risk have been further used to interpret mobility patterns and planning depth to better understand Paleoindian adaptive behavior across mid-continental North America (Bamforth and Bleed 1997; Binford 1977, 1980; Bousman 1993; Brantingham 2006; Ellis 2008; Kelly and Todd 1988; Rasic 2011; Sellet 2013; Shott 1986; Torrence 1989).

Although fluted points have been found in arctic North America for over 50 years, studies of fluted-point technology and its adaptive role in the North have been impossible to conduct due to a lack of reliable radiocarbon data for these artifacts and an inability to define their cohesiveness as a technocomplex. However, AMS-radiocarbon dates on organic material associated with fluted-point assemblages at two new sites in northwest Alaska, Serpentine and Raven Bluff, indicate that fluted points were used in the Arctic between 12,400 and 12,000 cal B.P. (Goebel et al. 2013; Hedman 2010; Smith et al. 2013). The evidence recovered at these sites serves as a benchmark establishing the chronological context for the greater collection of northern fluted points allowing us to begin to investigate why early Beringians chose such a risky means of thinning the bases of their lanceolate projectile points in the late Pleistocene Arctic, as their Paleoindian counterparts in the Great Plains did. The goal of this paper is to determine whether the technology and morphology of northern fluted points found across Alaska and northern Yukon represent a homogenous technological adaptation meant to reduce technological risk in the late Pleistocene Arctic. To this end, a combination of technological and morphological analyses of northern fluted points is presented, with variables being statistically evaluated and compared to a collection of Folsom artifacts that serve as a reference for a known technologically cohesive complex, similar in chronology and geographic spread to the northern sample (Frison and Bradley 1981, 1982). A new approach to geometric morphometrics was used that facilitated a focus solely on the basal morphology of complete as well as fragmented fluted points.

The Northern Fluted-Point Problem

The historic difficulty of finding northern fluted-point sites in dateable contexts is very much a consequence of northern Alaskan and Yukon environments, their past depositional histories, and contemporary sampling biases. Sites frequently consist of surface or shallowly buried palimpsests that resulted from a lack of windblown-sediment deposition or, in the case of prominent landforms and exposed settings, periodic or even permanent deflation (Clark and Clark 1993; Desrosiers 2007). Conversely, in buried contexts, moisture caused episodic solifluction throughout the Holocene, often resulting in mixed stratigraphy (Mann et al. 2002). Additionally, a record of recurring forest fires often led to the incorporation of natural charcoal into archaeological components, or re-setting of obsidian-hydration rims on artifacts (Clark and Clark 1993). Compounding this is the remoteness of northern Alaska and Yukon, making access to these areas challenging and expensive. As a result, fluted-point sites were often found during government-sponsored geological surveys, or in conjunction with road or oil-pipeline construction projects. Frozen ground and snow cover allow for only short field seasons, and during summer months, the growing season is accelerated by 24 hours of sunlight, quickly limiting ground visibility with thick tundra and boreal vegetation (Dixon 1993; Mann et al. 2002).

Not surprisingly, therefore, the first Alaskan fluted point was found in 1947 on the surface of a high ridge by E. Sable during an expedition sponsored by the U.S. Geological Survey (Thompson 1948). The ridge overlooked the Utukok River and was associated with no other cultural materials (Solecki 1950). Two more fluted points were soon found along the Kugururok and Kokolik rivers; they, too, were discovered in surface contexts on a mountain pass of the Brooks Range (Solecki 1951). Other early fluted-point surface finds included a distal tip from Anaktuvuk Pass in association with artifacts assigned to the late Holocene Denbigh flint complex (Solecki 1951; Solecki and Hackman 1951), and a basal fragment on a hill near the confluence of the Utukok River and Driftwood Creek, in association with what were thought to be fluted-point blanks, channel flakes, and a large "blade industry", which Humphrey (1966:587) organized into the "Driftwood Creek Complex".

In the 1970s, an archaeological survey along the proposed Trans-Alaska Pipeline led to the discovery of the first buried fluted-point sites (Cook 1971; Hoffecker et al. 1993; Reanier 1995). The first of these was the Putu Site, where a fluted-point base was recovered on the surface of a high knoll overlooking the Sagavanirktok River valley. In 1973, Alexander (1987) conducted excavations at Putu, revealing a buried assemblage with a second fluted-point base, non-fluted lanceolate points, unifacial scrapers on blades, gravers, burins, utilized flakes, cores, and more than 7,000 pieces of debitage. Radiocarbon dates associated with the fluted-point zone ranged from 12,751 to 6718 cal

B.P., suggesting that the cultural horizons were mixed (Alexander 1987; Bever 2006; Hamilton and Goebel 1999). Reanier (1994,1996) returned to Putu in 1993 and obtained a radiocarbon date of 10,158-9631 cal B.P., but this could not be associated with the fluted points. Soon thereafter, the Island site was discovered by C. Holmes on a knoll overlooking the Bonanza Creek valley. Shallow deposits produced multiple artifacts including six lanceolate projectile-point bases, two of which were fluted, but no associated dateable material (Holmes 1971; Reanier 1995). Similarly, at Girls Hill, located along the Jim River in the southern foothills of the Brooks Range, R. Gal found multiple fluted points in two localities, along with artifacts representing an array of time periods and no reliable chronological control (Dumond 1980; Gal 1976).

At about the same time as the pipeline surveys, more than 18 fluted points, preforms, and manufacturing rejects were recovered from the Batza Téna obsidian source at the head of the Koyukuk Lowlands near Hughes (Clark and Clark 1980, 1983, 1993). D. Clark and crew discovered these at ten localities in either surface or shallowly buried contexts along with debitage and artifacts that ranged from late Pleistocene to historic in age, obviously in mixed palimpsests that could not be radiocarbon dated (Clark 1972; Clark and Clark 1993). Obsidian-hydration analysis also failed to provide usable chronological information (Hamilton and Goebel 1999).

Other, more recently discovered, surface finds include several fluted points from surface exposures near Teshekpuk Lake and Iteriak Creek in the National Petroleum Reserve (Davis et al. 1981), and the mid-section of a fluted point in a buried context at the Lisburne site (Bowers 1982). Like earlier finds ages of these points could not be established. In the early 1990s, R. Gal found three more fluted points on the surface near the Kugururok, Nimiuktuk, and Koyukuk rivers (Reanier 1995).

Fluted points have been found in the northern Yukon Territory as well. These include single fluted-basal fragments from the surface of Kikavichik Ridge, which overlooks the Old Crow plain (Irving and Cinq-Mars 1974), and the nearby Dog Creek site (Esdale et al. 2001). Dateable material could not be confidently associated with the fluted fragments at either site. At the Engigstciak site, located along the Firth River, a lanceolate point with a flute on one face was reported, but radiocarbon dates from the site were not clearly tied to the point (Cinq-Mars et al. 1991; MacNeish 1956), and the artifact no longer exists in the collection at the Canadian Museum of History.

Thus, despite 50 years of searching by the turn of the last century, no fluted-point site had been found in the Arctic that could be dated, and the poor contexts made defining a complex of archaeological assemblages impossible. There were, however, several unifying characteristics of northern fluted-point finds. First, they were repeatedly found on promontory settings providing commanding views of watersheds and mountain passes (Ackerman 2001). Second, geographically, they were restricted to northern Alaska, ranging from near the Chuchki Sea coast to the Yukon Territory (Smith et al. 2013). Third, of course, they all came from problematic contexts.

This all changed in 2005, when R. Gal and crew discovered a fluted-point base near Serpentine Hot Springs on the Seward Peninsula, Bering Land Bridge National Preserve. Initial testing led to the discovery of a channel flake associated with four radiocarbon dates on charcoal ranging from 12,376 to 11,353 cal B.P. (Young and

Gilbert-Young 2007). A team led by T. Goebel returned in 2009-2011 to conduct block excavations, uncovering a buried fluted-point assemblage associated with charcoal-rich features that contained hundreds of pieces of burned and calcined bone, identified as ungulate, and likely represents caribou (Goebel et al. 2013). Radiocarbon (AMS) dating of charcoal produced a series of dates ranging from 12,400 to 9900 cal B.P., and when considering only willow charcoal (ethnographically preferred as firewood instead of shrub birch or Ericaceae (Stefansson 1919; cited in Alix 2013)), an age of 12,400-12,000 cal B.P. was inferred for the cultural deposit. Four fluted-point bases were recovered in situ in association with the dated features, and two fluted-point bases and a midsection were found in eroded blowouts nearby the buried component (Goebel et al 2013). A fluted distal fragment was also recovered from the surface of a knoll, designated as BEN-170, approximately 1.5 km south of the Serpentine fluted-point site.

A second significant fluted-point discovery was made in 2007 at the Raven Bluff site, located along the Kivalina River in the western foothills of the Brooks Range (Hedman 2010). Eight radiocarbon dates between 12,131 and 11,102 cal B.P. from a buried cultural layer bracket a fluted point and associated materials that include faunal remains of primarily caribou (Smith et al. 2013), replicating the Serpentine finds. Analyses of archaeological materials are in progress, but they include both a fluted point and a fluted-point preform.

With the evidence from Serpentine and Raven Bluff, we now know that northern fluted points are late Paleoindian in age, dating to the end of the Younger Dryas and beginning of the Holocene. During this time, human groups in the Arctic contended with dynamic seasonal extremes, a mosaic of ecological settings exaggerated by variable terrain and proximity to retreating mountain glaciers, rising sea levels, and thinly dispersed resources with intermittent availability (Abbott et al. 2010; Anderson and Brubaker 1994; Edwards et al. 2000; Elias et al. 2000; Lie and Paasche 2006; Mann et al. 2001; Oswalde et al. 2003; see also Graf and Bigelow 2011). The Serpentine site represents a specialized field camp where weapons maintenance and intercept-hunting took place as part of a logistical foraging system (Goebel et al. 2013). Local raw materials make up less than 4% of the assemblage and the remainder includes non-local, high-quality toolstones that originated hundreds of km away. Some of the lithic materials from Raven Bluff are made on similar raw materials, which are available locally in the Kivalina River as it passes below the site's prominent setting (W. Hedman, personal communication 2010).

Despite the encouraging information learned from Serpentine and Raven Bluff, we still do not know if all of the fluted points found in northern Alaska and Yukon truly form part of a cohesive technological complex and whether they can be ascribed the same age range. We also do not understand the role fluted points played in late Pleistocene human adaptations in the Arctic, i.e., why early northern Alaskan's fluted some of their lanceolate projectile points, especially given the high risk involved in the fluting strategy.

Paleoindians and Technological Risk

A promising avenue of inquiry regarding the explanation of fluted-projectile point use in the late Pleistocene is assessment of risk and risk-management (Ahler and

Geib 2000; Amick 1996; Bamforth and Bleed 1997; Binford 1977; Ellis and Payne 1995; Sellet 2004; Torrence 1989, 2001). Discussions of risk in hunter-gatherer research generally concern the possibility of groups encountering unpredictable problems (often in, but not limited to, subsistence pursuits) and degree of negative outcomes, which serve as a measure of "cost" (Bamforth and Bleed 1997; Torrence 1989). Bamforth and Bleed (1997) point out that heuristically, risk and risk-management can be translated into concepts of "predictability" and "reliability" (Bamforth 1988; Hayden 1981; Lee 1968; Wilmsen 1973), with predictability serving as a key variable in group planning depth and mobility scheduling ("gearing up" or "tool maintenance/retooling/reloading" strategies), social relationships, and food storage (Binford 1977; Bousman 1993; Jodry 1999; Sellet 2004, 2013; Smith and Boyd 1990; Torrence 1989; Wiessner 1982). Reliability in technology reduces risk of tool failure, especially when such failure would accrue high costs in terms of tool breakage at times when repair or replacement is difficult or a subsistence opportunity is lost (Bamforth and Bleed 1997).

But what makes a tool reliable? Bleed (1986) suggests it is the ability to forecast or manipulate a tool's use-life by designing it to have high stress limits and, ultimately, guard against failure (i.e., breakage). Ahler and Geib (2000) suggest, however, that a maintainable tool is simultaneously reliable because it facilitates anticipated failure rates, fracture management, and rejuvenation protocol, so that the tool can be *reliably* returned to functionality in the event of failure (see also Odell 2001). The production cost of both maintainable and reliable tools is the same, requiring similar raw-material reduction, transport, and time expenditures, but production and rejuvenation schedules vary.

Ultimately the ability to control this schedule is a form of risk-management. Early in tool production, risk can be reduced by making optimal technological choices, which can be determined if factors are known, for example prey type, encounter strategy, terrain type, armature type, and the distance from a raw-material source that a tool is intended to be used and/or repaired. Therefore, the question is, was fluting an optimal choice given specific factors experienced by Paleoindian groups?

Technological Choice in the Late Pleistocene Arctic

During the terminal Pleistocene of Alaska and northern Yukon, contemporaneous groups utilized variable weapon systems that involved slotted osseous and microblade technologies as well as lithic bifacial technology. The different technological schemes and risk-management strategies possibly resulted from different cultural groups, but other factors of variability may have included the arrangement of prey type, encounter strategy, terrain type, and raw-material availability experienced by different groups or during different seasons, as well as and successive adaptive responses to alteration in resource distribution resulting from climate change (Dixon 1985; Dumond 2001; Goebel et al. 1991; Hoffecker 2001; Holmes 2001; Kunz et al. 2003; Potter 2011; Powers and Hoffecker 1989; Rasic 2011; Wygal 2011). In northern Alaska and Yukon, bifacial projectile-point industries were characterized by non-fluted lanceolate varieties known as Mesa and Sluiceway. Research conducted by Bever (2000) and Rasic (2008) provided the first comprehensive studies of these complexes. Bever noted that Mesa sites were often located near sources of high-quality raw materials and contained abundant evidence of bifacial-core production but simultaneously a high degree of tool maintenance in the form of lateral-edge rejuvenation. From this evidence, he inferred high residential mobility and logistical gearing-up strategies to combat unpredictability of faunal resources during encounter hunting (see also Bever 2008). This tactic reflects a replace-before-failure, or reliable, strategy of risk-management that may have ensured adequate performance when failure-to-procure costs were high (Bamforth and Bleed 1997; Kuhn 1989; Torrence 2001). Likewise, Rasic (2008) found that Sluiceway sites, were often located near sources of high-quality toolstone, but they functioned as places of gearing-up for intercept hunting, with weapons maintenance often consisting of resharpening. According to Rasic (2008), risk-management strategies associated with the Sluiceway complex include communal involvement in intercept hunting, the production and transport of preforms, and, again, complementary to Mesa, a reliable tool morphology.

Unlike Mesa and Sluiceway, late Pleistocene hunters at Serpentine focused maintenance efforts on fluting projectile points hundreds of km away from sources of high-quality knappable materials, whereas at Raven Bluff, sources for quality toolstone were nearby and behaviors there include preform manufacture (Goebel et al. 2013; Smith et al. 2013). Since fluting is a method of basal thinning classically touted as a high-risk endeavor, with failure rates during production ranging from 30-50% in both experimentation (Flenniken 1978; Gryba 1988; Sollberger 1985; Winfrey 1990) and archaeological contexts (Judge 1973; Sellet 2004; Winfrey 1990; but see Ellis and Payne 1995), hypothesized risk-management solutions have involved easy access to raw materials, existence of specialist producers, lowered transport costs, or risky production taking place only at the very beginning or end of a recycling system (Bamforth and Bleed 1997; Sellet 2004).

The sample of known fluted points from Alaska and Yukon combined with the assemblage-level evidence from Serpentine presents a unique opportunity to investigate risk involved in using fluting technology in the late Pleistocene Arctic by evaluating evidence for the above-mentioned risk-management solutions in northern fluted-point technology, morphology, and provenance. Set within a technological-organization context, the analysis presented here considers whether extreme effectiveness, maintainability, and transportability incorporated into the Alaskan fluted-point production system may have outweighed anticipated failure rates and transport costs (Ahler and Geib 2000; Bleed 1986; Guthrie 1983). Alternatively, it is possible that modern perceptions of risk from fluting failure are ill-conceived, as we project situational bias in the form of our own difficulties in fluting experiments, or misinterpret archaeological evidence regarding the actual impact of fluting failure on technological costs (Ahler and Geib 2000; Crabtree 1966; Ellis and Payne 1995). With this in mind, the hypothesis tested here is two-fold: (1) northern fluted points comprise a cohesive point form, technologically representing a single reduction strategy that was (2) used to create a maintainable tool that minimized risk of tool-failure far from raw-material sources in the late Pleistocene Arctic.

Materials and Methods

The technological and morphological analyses presented here were performed on 51 fluted artifacts from 17 Alaskan/Yukon sites and consisting of basal, medial, distal, and corner fragments, as well as whole fluted points (Table 3.1a, Figures 3.1 and 3.2). Nineteen of the 51 fluted points/fragments were suitable for geometric morphometric shape analysis. Data from 46 Folsom points from seven archaeological sites were included in the technological and morphological analyses, and data from 43 Folsom points were added to the geometric morphometric analyses to facilitate comparison to a known highly standardized technological complex (Frison 1991; Frison and Bradley 1981, 1982) (Table 3.1b, Figure 3.1). Due to dissimilar breakage patterns, no specimen was eligible for all analytical procedures, but each contributed to the analysis in some way.

Nominal technological attributes and count data included raw-material type, presence/absence of fluting, number of flute scars per face, fluting sequence, flake-scar pattern, frequency of marginal retouch after fluting, edge grinding, breakage pattern/fracture type, and cross-section shape (following Ahler and Geib 2000; Andrefsky 2005, 2009; Gryba 2006; Jennings 2013; Miller and Smallwood 2012; Titmus and Woods 1986). Two-dimensional high-resolution digital photographs of each artifact in planview were also taken with a Nikon D5100, for use in geometric morphometric shape analysis.

Table 3.1. Artifacts included in the analysis: (a) Northern fluted points and point fragments; (b) Folsom complex points and point fragments.

Site	Artifact	Fragment type
a. Northern Fluted		
Serpentine Fluted-point site	BELA-34166	distal
Serpentine Fluted-point site	BELA-30104	proximal
Serpentine Fluted-point site	BELA-34172	proximal
Serpentine Fluted-point site	BELA-38788/89*	proximal
Serpentine Fluted-point site	BELA-34108	medial
Serpentine Fluted-point site	BELA-50298*	proximal
Serpentine Fluted-point site	BELA-49913*	proximal
Serpentine Fluted-point site	BELA-34230	corner
BEN-170	BELA-34561	distal
Batza Téna	RkIg-43:1	proximal
Batza Téna	RkIg-29:16*	proximal
Batza Téna	RkIg-10:36	proximal
Batza Téna	RkIg-01:49	medial
Batza Téna	RkIg-47:13	proximal
Batza Téna	RkIg-31:120*	proximal
Batza Téna	RkIg-31:15*	proximal
Batza Téna	RkIg-31:60*	whole
Batza Téna	RkIg-31:119	medial
Batza Téna	RkIg-30:42	proximal
Batza Téna	RkIg-30:160	lateral margin
Batza Téna	RkIg-30:254	lateral margin
Batza Téna	RkIg-30-321	proximal
Batza Téna	RkIg-30:323	corner
Batza Téna	RkIg-30:247	distal
Girls Hill	UA74-027-0228*	proximal
Girls Hill	UA74-027-1256	whole
Girls Hill	UA74-027-6485*	whole
Hank's Hill	UA76-203-0001	proximal
Lisburne	UA78-080-0633	medial
Teshekpuk Lake	UA78-224-1*	proximal
Teshekpuk Lake	UA78-224-9*	corner
Itkillik Lake	UA76-307-0001	distal
Caribou Mountain South	UA2006-084-0001	proximal
Raven Bluff	UA2009-136-121*	proximal
Raven Bluff	UA2010-100-001	proximal
Raven Bluff	UA2010-100-002	medial
Raven Bluff	US2010-100-003	distal
Putu	UA70-84-74*	proximal
Putu	UA70-84-73*	proximal
Kipmik Lake	GAAR-4120	lateral
Red Star Creek	GAAR4063*	distal
Tinayguk River	GAAR4072	proximal
Island Site	UA71-083-0373	whole
Island Site	UA71-83-564	proximal
Upper Noatak	NOAT 23286*	proximal
Upper Noatak	NOAT 2588	proximal
Driftwood Creek (Utukok River)	391806*	proximal
Driftwood Creek (Utukok River)	423535*	whole
Driftwood Creek (Utukok River)	423534*	proximal
Driftwood Creek (Utukok River)	“#A”	proximal
Kikavichic Ridge‡	70K-A4-1	proximal

Table 3.1. Continued.

Site	Artifact	Fragment type
b. Folsom		
Agate Basin	OA093*	proximal
Agate Basin	"refits 96506, 96508, 96509, OA285	proximal
Agate Basin	96507*	whole
Agate Basin	OA085	whole
Agate Basin	OA059*	whole
Agate Basin	OA112*	whole
Agate Basin	96533	proximal
Agate Basin	OA175	proximal
Agate Basin	refits 96544, OA016	distal
Agate Basin	OA020	proximal
Hanson	refit 95290, 9528*	proximal
Hanson	refit 95267, 95268	proximal
Hanson	95424*	proximal
Hanson	refit 95461, 95450*	proximal
Hanson	95456*	proximal
Hanson	95478	proximal
Barger Gulch	LJ490-17-126*	proximal
Barger Gulch	no number*	proximal
Barger Gulch	LI490-5-387*	proximal
Barger Gulch	no number*	proximal
Barger Gulch	no number*	proximal
Barger Gulch	refit LI490-3-167, LJ490-14-67*	proximal
Barger Gulch	Li490-4-44*	proximal
Barger Gulch	LJ487-3-2*	proximal
Barger Gulch	LJ490-24-472	proximal
Barger Gulch	LJ488-3-68*	proximal
Barger Gulch	LJ490-24-334	proximal
Barger Gulch	LI490-4-343*	proximal
Barger Gulch	LI491-2-82*	proximal
Barger Gulch	LJ490-23-169*	proximal
Krmpotich	48SW9826-13*	proximal
Krmpotich	48SW9826-4*	proximal
Krmpotich	48SW9826-6*	proximal
Krmpotich	48SW9826-7	proximal
Krmpotich	48SW9826-1	proximal
Krmpotich	refit 48SW9826-3, 48SW9826-2*	proximal
Krmpotich	A576745*	proximal
Hell Gap	A6258*	proximal
Hell Gap	47195*	proximal
Hell Gap	47192*	proximal
Hell Gap	46606	proximal
Hell Gap	47196*	proximal
Hell Gap	47193*	proximal
Hell Gap	46530*	proximal
Hell Gap	UWI-342	proximal
Hell Gap	46531	distal
Lindenmeier	440281†	proximal
Lindenmeier	440420†	whole
Lindenmeier	441017†	proximal
Lindenmeier	441560†	proximal
Lindenmeier	442795†	whole
Lindenmeier	442839†	proximal
Lindenmeier	443437†	proximal
Lindenmeier	443844†	proximal
Lindenmeier	A576741†	whole
Lindenmeier	A576742†	whole
Lindenmeier	A576743†	whole
Lindenmeier	440777†	whole

*Artifact also used in geometric morphometric analysis, ‡ Site located in northern Yukon, Canada, † Artifact only used in geometric morphometrics. analysis.

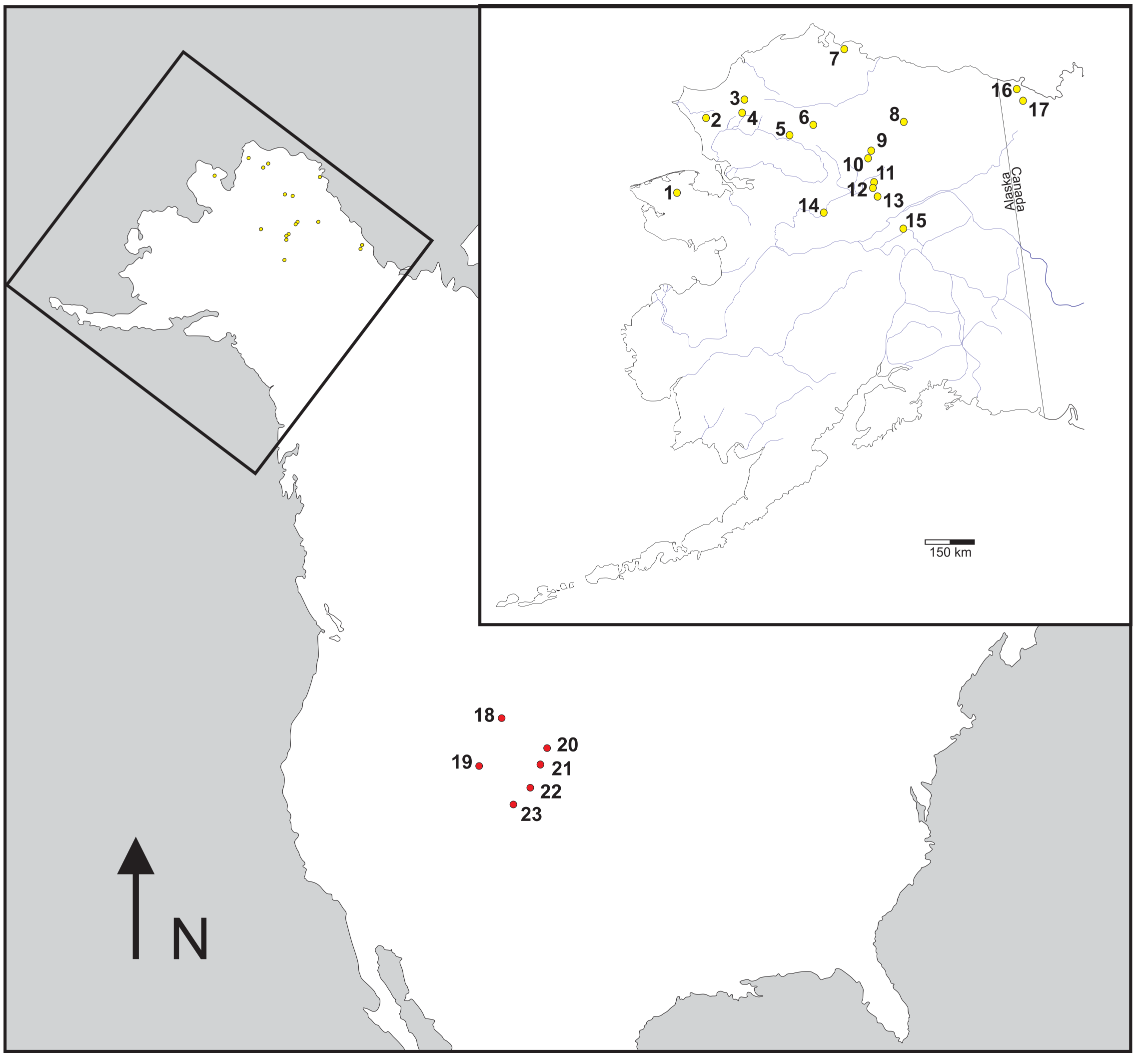


Figure 3.1. Map showing the location of northern fluted-point and Folsom sites mentioned in text: (1) Serpentine Hot Springs (BEN-192 and BEN-170); (2) Raven Bluff; (3) Driftwood Creek (Utukok River); (4) Upper Noatak; (5) Kipmik Lake; (6) Lisburne; (7) Teshekpuk Lake; (8) Putu and Bedwell; (9) Redstar Creek; (10) Tinayguk River; (11) Girls Hill; (12) The Island; (13) Caribou Mountain South; (14) Batza Téna; (15) Hank's Hill; (16) Engigstciak; (17) Kikavichik Ridge; (18) Hanson; (19) Krmpotich; (20) Agate Basin; (21) Hell Gap; (22) Lindenmeier; (23) Barger Gulch.

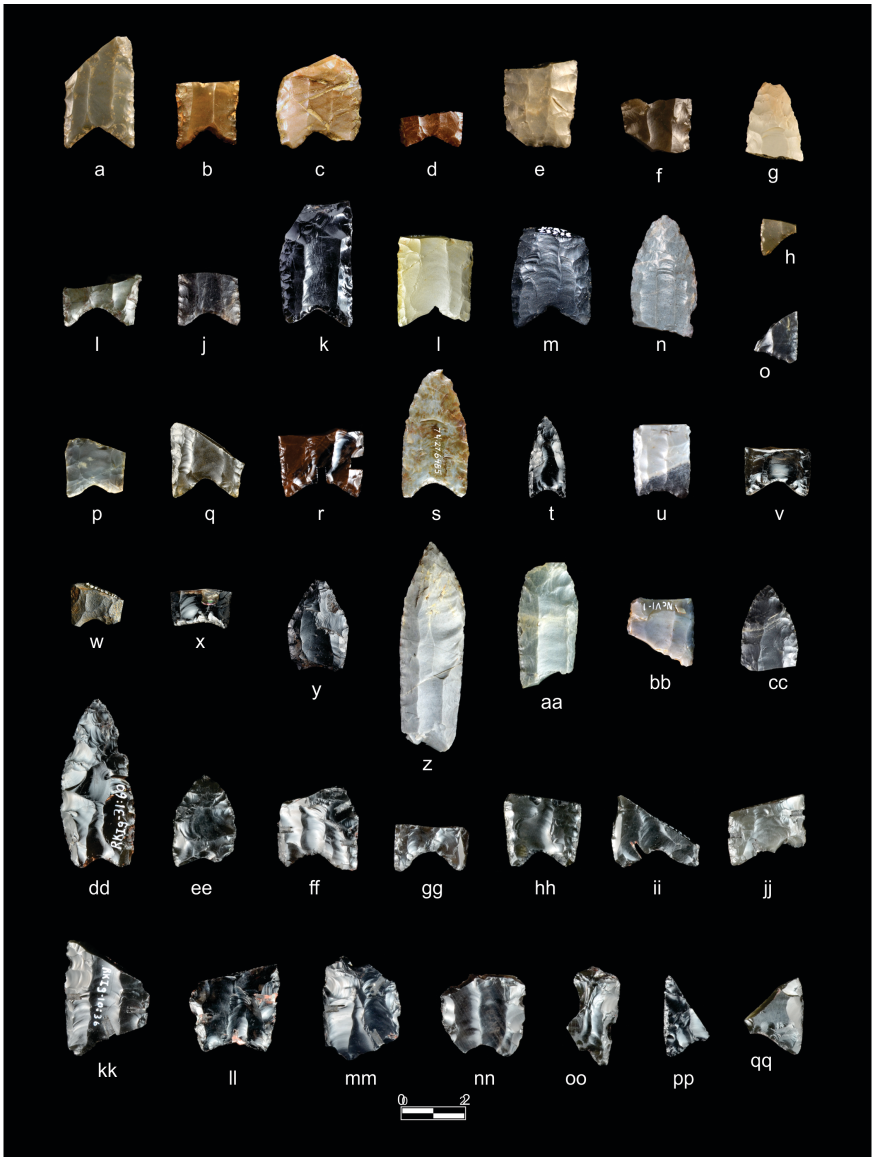


Figure 3.2. Fluted points from Alaska and the Northern Yukon included in the analysis, Serpentine Fluted-point site: (a) BELA-38788/89; (b) BELA-50298; (c) BELA-49913; (d) BELA-30104; (e) BELA-34172; (f) BELA-34108; (g) BELA-39071 (BEN-170); (h) BELA-34230; Raven Bluff: (i) UA2010-100-001; (j) UA2009-136-121; Putu: (k) UA70-84-74; (l) UA70-84-73; Upper Noatak: (m) NOAT 23286; (n) NOAT 2588; Teshekpuk Lake: (o) UA78-224-9; Caribou Mountain South: (p) UA2006-084-0001; Hank's Hill: (q) UA76-203-0001; Red Star Creek: (r) GAAR4063; Girls Hills: (s) UA74-027-6485; (t) UA74-027-1256; (u) UA74-027-0228; (v) Teshekpuk Lake: UA78-224-1; Island Site: (w) UA71-83-564; (x) UA71-083-0373; Tinayguk River: (y) GAAR4072; Itkillik Lake: (z) UA76-307-0001; Lisburn: (aa) UA78-080-0633; Kikavichic Ridge: (bb) 70K-A4-1; (cc) Kipmik Lake: GAAR-4120; BatzaTena: (dd) RKIg-31:60; (ee) RKIg-47:13; (ff) RKIg-29:16; (gg) RKIg-43:1; (hh) RKIg-31:120; (ii) RKIg-30:321; (jj) RKIg-30:42; (kk) RKIg-10:36; (ll) RKIg-31:15; (mm) RKIg-01:49; (nn) RKIg-31:119; (oo) RKIg-30:254; (pp) RKIg-30:323; (qq) RKIg-30:160.

A variety of metric attributes and ratios were recorded for each specimen to infer manufacturing technique, artifact function, and point typology. These included maximum length, width, and thickness, width and thickness at 5-mm intervals from the proximal edge (FPE), basal-concavity depth, maximum fluted area width, edge angle, and width of dominant flute in 5-mm intervals FPE (Andrefsky 2005; Beck and Jones 2007; Bettinger and Eerkens 1997, 1999; Morrow 1995; Morrow and Morrow 1999; O'Brien et al. 2001). Dominant flute width was defined as the most unobstructed channel scar on each face, which was usually from the last flute removed and often the medial flute.

Statistical Analyses

Frequencies of qualitative data (i.e., raw-material type, fluting presence and number of flutes, cross-section shape, presence of edge grinding, presence of marginal retouch after fluting, breakage pattern) and quantitative data (i.e., average edge angle per fragment type) were used to asses trends in technology used to create northern fluted points. To test the hypothesis that northern fluted points represent a cohesive and standardized technological complex, this analysis also considered coefficient of variance (CV) in a series of metric variables, including fragment length, width and thickness, both overall and in 5-mm increments, basal concavity depth, pooled standard deviation of dominant flute width in 5-mm increments, and ratio of basal concavity depth to basal width. As a unit of measure, CV can efficiently evaluate standardization of artifact morphology between samples with unequal sizes (Eerkens 1998, 2000; Eerkens and Bettinger 2001; Okumura and Aroujo 2014), and when taken at uniform locations on artifacts, CV can inform on whether specimens were created to adhere to strict morphological or metric parameters, i.e., a pre-made hafting mechanism and/or normative morphology. Given that CV's report distributions around means, they can be compared on an attribute-by-attribute basis and assessed for magnitude in a comparative framework, in this case between northern and Folsom fluted points. DA'D statistics were generated for each comparison to demonstrate significant differences in variation as comparisons for CV, which can be sensitive to magnitude or mean (following Eerkens and Bettinger 2001).

For both northern and Folsom fluted points, linear regression was used to identify correlations between basal concavity depth and fragment width, thickness, and average fluted-area width. Nonparametric Kruskal-Wallis analysis was used to identify morphological patterns in point thickness measured in 5-mm increments, and thickness of proximal and distal fragments.

Geometric Morphometric Analyses

Geometric morphometric shape analysis was used to assess morphological variation in fluted-point basal fragments from sites across northern Alaska and Yukon in comparison with Folsom point fragments.

The use of only basal fragments posed a new challenge to outline evaluation using a landmark-based approach to geometry. Previous analyses of outline shape using landmarks were limited to whole artifacts with three major landmarks—the distal tip and two basal corners—which served as homologous landmarks in Procrustes superimposition to align specimens horizontally along the X-axis in a Cartesian coordinate system (Buchanan 2006; Buchanan and Collard 2007, 2010; Buchanan et al. 2011; Gonzalez-Jose and Charlin 2012; Smith 2010; Smith et al. 2014; Thulman 2012). Procrustes superimposition rotates, aligns, and centers each configuration of an artifact's landmark data in a common coordinate system to facilitate geometric morphometric analysis and remove nuisance variation that results from differences in artifact orientation, location, and scale in the original photographs, or scans (Bookstein 1991; Rohlf and Slice 1990; Zelditch et al. 2004).

Without the distal end to serve as the third uniform landmark to align the data in Procrustes superimposition, basal fragments must instead be aligned along the X-axis by a different means. We accomplished this by digitizing tools positioned horizontally with basal margin to the left in digital photographs with tpsDig2 (v. 2.12) to place a constellation of semi-landmarks along each artifact's perimeter (Rohlf 2008a). Semi-landmarks along the distal break were then deleted. To produce horizontal alignment of the broken outlines, we performed a sequential balancing procedure as follows. First, a regression line was fit to the semi-landmarks assigned to the top lateral margin. Outlines were then rotated to the regression angle to achieve a more horizontal position. The regression angles of the top and bottom lateral margins were then calculated and the outline was rotated to the average angle. I found that two rotations were enough to produce homogeneous slopes for the lateral edges, so that further iterations of rotation made only vanishingly small differences in final outline orientations. To standardize the length of the top and bottom lateral edges, the outlines were restricted to 13 mm FPE and points in excess of this were deleted. Finally, landmark constellations were reduced to a suite of 120 type II semi-landmarks that consisted of outlines made of 30 equidistant type II semi-landmarks assigned to each lateral margin, and 60 equidistant type II semi-landmarks assigned to the basal margin. The resulting semi-landmark density was more than sufficiently saturated to capture tool shape differences. The excess of shape information was reduced by calculating principal components and discarding minor and null vectors. Five principal components were found to summarize 93.36% of total variation in the Alaska/Yukon points, six PCs summarized 95.33% in the Folsom points, and seven PCs summarized 95.90% in the combined northern and Folsom point dataset.

A landmark-based approach was desired in this analysis because it allowed the analyst to define the location of each landmark to be compared to the mean location of its corresponding landmark on each artifact in the sample. For example, while no mechanically meaningful positions were identifiable along the lateral margin of projectile points in this sample, important variance in lateral margin shape was recorded by placing a uniform number of equidistant landmarks between the topologically proximal- and distal-most points on the lateral margins of each artifact (see Appendix C). The location and number of each landmark was discrete in that each represents a location that explains shape at a relative percentage of the length of the margin from the uniform topological position on each specimen (e.g., point #10 counting towards the distal represents 33.33% of the lateral margin) and corresponds to a point at the same location (33.33% of the lateral margin) on all comparative specimens resulting in equal proportional intervals. This method was preferred to sliding semi-landmarks, where landmark positions are adjusted to match the positions of corresponding landmarks on a reference specimen, which in the case of a curve, may result in landmark-placement error (Adams et al. 2004). This analysis took specific advantage of the proportionally equidistant placement of semi-landmarks to describe the curve of an artifact's margin.

Generalized least squares Procrustes superimposition (Generalized Procrustes analysis) was conducted in tpsRelw (v. 1.45, Rohlf 2008b) to superimpose the constellations of corresponding semi-landmarks (Rohlf and Slice 1990), translating each semi-landmark constellation to the same centroid, scaling each constellation to the same centroid size, and iteratively rotating each constellation until the summed squared distances between the semi-landmarks and mean semi-landmark position is minimized (Bookstein 1991; Mitteroecker et al. 2013; Rohlf 1999). Superimposed semi-landmark constellations (Procrustes shape coordinates) were subjected to principal component (PC) analysis, and resulting PC scores summarizing 93-96% of total variation were used to represent shape of the basal fragments (Adams et al. 2004, 2013; Bookstein 1991; Mitteroecker et al. 2013). Centroid size, the square root of the summed squared distances between all landmarks to their common centroid, serves as an ideal size variable for use in multivariate analysis, as it can be set as an independent variable to analyze shape and as a dependent variable with shape factors for analyses of form (Bookstein 1991; de Ruiter et al. 2013; Smith et al. 2014).

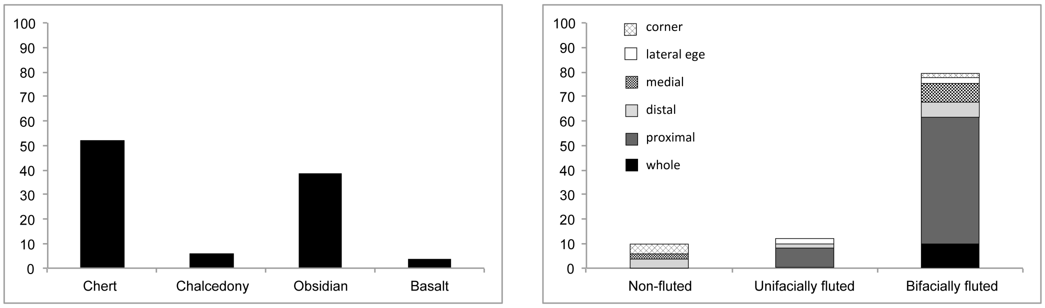
Principal components of shape variation were also used to visualize shape characteristics that represent the major factors of variability in the sample of northern fluted and Folsom-point basal fragments, and the combined samples of northern fluted and Folsom point fragments. Multivariate analysis of variance (MANOVA) was used to test models of morphological homogeneity by testing variance in shape and form among artifacts organized by sites/regions (with solitary contexts of northern fluted-point finds being consolidated into larger regions), complexes, and gradients of latitude and longitude.

To evaluate whether northern fluted-point technology served to minimize risk in the late Pleistocene Arctic, qualities of reliability and maintainability were determined by assessing point function and patterns of rejuvenation and resharpenting. Fluted-point function was observed, specifically, by assessing fracture type, variability in fragment metrics, and hafting evidence in terms of edge-grinding and cross-section shape. Patterns of rejuvenation and resharpening were evaluated by identifying patterns of flute- and flake-scar removal according to fragment type, and variability in basal concavity shape and depth. Characteristics of site type and proximity to Brooks Range resources in general were also considered during evaluation of potential risk factors and risk-management solutions. All statistical analyses were conducted using JMP software version 10 (SAS Inst. Inc., Cary, NC).

Results

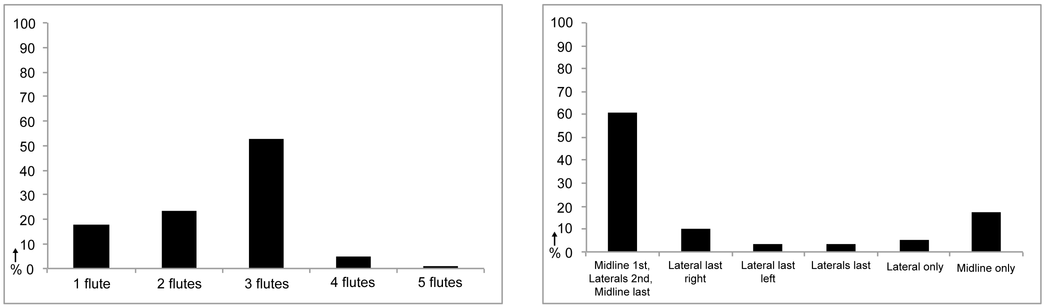
Non-Metric Results

Frequency diagrams of observational data are provided in Figure 3.2. The northern sample is dominated by chert and obsidian, although there are three artifacts made from chalcedony and two from basalt (Figure 3.3a). Overall, the northern fluted-



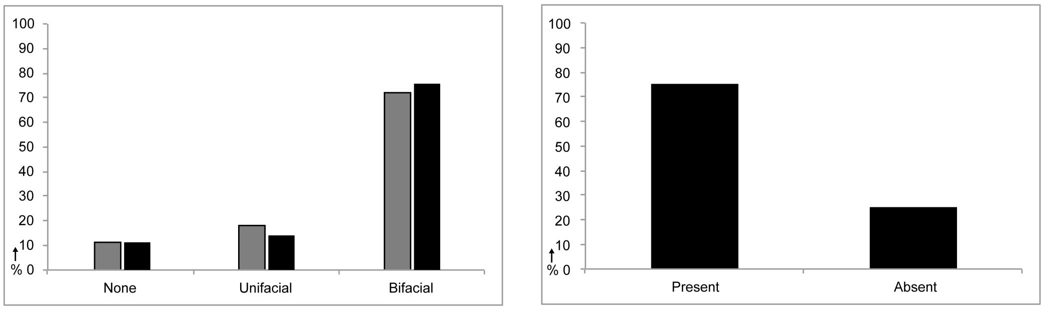
a. Frequency (%) of fluted-point raw material (n=51).

b. Frequency (%) of unifacially and bifacially fluted points .



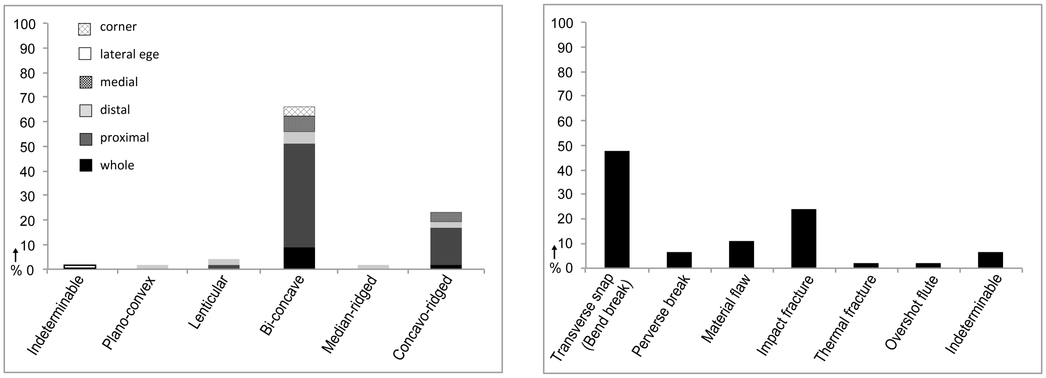
c. Frequency (%) of number of flutes on (n=85) fluted-point faces.

d. Frequency of flute removal sequences (n=81 faces).



e. Frequency of lateral (gray, n=45) and basal (black, n=37) margin retouch after fluting.

f. Frequency of edge grinding (n=51).



g. Frequency of cross-section shape (n=47).

h. Frequency of fracture type (n=47).

Figure 3.3. Frequency diagrams of qualitative data.

point sample is made of only high-quality, fine-grained raw materials. Forty-six of fifty point fragments are fluted on at least one face, and the four lacking flutes on one side include a reworked lateral fragment, one distal fragment, and two corner fragments (Figure 3.3b). If complete, all of these could have been fluted bifacially. Among the northern fluted point specimens, 53% of faces had three adjacent flute-removal scars followed by 24% with two adjacent flute-removal scars (Figure 3.3c). Seventeen percent of flute faces have a single flute scar down the midline of the long axis. It should be noted that five of the nine single-fluted artifacts are distal and medial fragments. Sequence of flute-scar removals was observable on 81 artifact faces, and in over 60% a primary medial (along the midline of the long axis) flute was removed first, followed by two lateral flutes and then a final medial flute was removed, and in 22% a lateral flute was removed at the end of the flute-removal sequence (Figure 3.3d).

Eighty-seven percent of northern fluted-point fragments have evidence of some degree of marginal retouch after fluting (Figure 3.3e). No marginal retouch after fluting was recorded on seven fragments, four of which are distal fragments, and one is a "preform" found at the Raven Bluff site. Eighty percent of fragments have marginal grinding in the proximal area suggesting preparation for hafting (Figure 3.3f).

Cross-section shape demonstrates two major types of face preparation: bi-concave, resulting from flute-scar removals predominantly on basal fragments, and medial ridges remaining on one or both artifact faces creating shapes such as concavo-ridged, median-ridged, and lenticular, predominantly on distal fragments and whole points (Figure 3.3g). The difference in cross-section shape between the base and the blade portion of the northern artifacts was a noticeable pattern. However, three basal fragments from Girls Hill (UA-74-27-228), Batza Téna (RkIg-31:15), and the Upper Noatak River (Noat 2588) have lenticular to median-ridged cross-sections, flute-removals from only one face, and relatively shallow basal concavities, which are atypical of the remaining 26 proximal fragments included in the analysis.

Breakage patterns were also observed on all non-corner fragments (Figure 3.3h). Almost 50% of the collection broke as a result of a transverse snap or bend break fracture, followed by 24% that have evidence of impact fractures. Only 11% broke along planes of raw-material impurities, and 9% consist of one thermally fractured artifact, one distal fragment that was detached by a hinge fracture from a failed fluting attempt, and three artifacts with indeterminable fractures.

Univariate Metric Results

Comparing Distributions of Width and Thickness. A subsample (n=29) of proximal fragments was used to observe relative variability in tool dimensions of northern fluted points (Table 3.2). There was little variability in maximum thickness and width measurements, with standard deviations notably less (thickness CV=17.15%, width CV=10.95%) than mean length (CV=31.97%). Mean length was measured to compare width and thickness to a presumably more random factor, which represents points, both fragmented and whole at time of discard, with variable breakage patterns. A similar pattern is apparent in CV generated for these variables in the Folsom sample (n=44). When considering basal fragments only variability around mean length decreased slightly in both samples, yet according to the DA'D statistic variability significantly increased in Folsom relative to northern points (p=0.03), which may suggest a variable breakage pattern due to hafting differences between the two assemblages.

Width and thickness were measured in 5-mm increments from the proximal edge (FPE) requiring a reduction in the sample as the analysis progressed to 25 mm FPE.

Table 3.2. Relative Variability in Tool Dimensions Measured on Northern Fluted and Folsom Points and Point Fragments.

Variable	NFC CV	Folsom CV	NFC Mean	Folsom Mean	NFC Std. Dev.	Folsom Std. Dev.	NFC N	Folsom N	D'AD p-value
Thickness (max)	17.15	16.92	4.79	4.72	0.82	0.80	23	43	0.96
Width (max)	10.95	15.95	22.78	23.85	2.49	3.81	23	43	0.06
Length (max)	31.97	50.60	23.00	37.28	7.35	18.86	25	44	0.05
Length (bases only)	31.63	50.12	24.40	34.52	7.72	17.30	30	39	0.03
Basal Width	37.21	8.63	18.31	18.36	6.81	1.58	19	38	0.00
Width 5mm FPE	11.34	8.74	21.30	19.75	2.41	1.73	25	40	0.16
Width 10mm FPE	9.84	9.10	21.80	21.15	2.15	1.93	24	42	0.67
Width 15mm FPE	12.52	9.71	22.17	22.31	2.78	2.17	20	38	0.19
Width 20mm FPE	17.01	11.26	21.19	23.29	3.60	2.62	17	29	0.06
Width 25mm FPE	31.01	14.81	17.88	23.56	5.54	3.48	9	22	0.01
Basal Thickness	20.62	18.35	1.49	1.36	0.31	0.24	25	39	0.39
Thickness 5mm FPE	18.70	15.33	3.39	2.74	0.63	0.42	27	40	0.29
Thickness 10mm FPE	15.08	12.16	4.39	3.77	0.66	0.46	27	40	0.24
Thickness 15mm FPE	15.84	11.16	4.80	4.28	0.76	0.48	24	36	0.07
Thickness 20mm FPE	15.81	12.43	5.16	4.47	0.82	0.55	18	27	0.24
Thickness 25mm FPE	21.28	10.06	5.21	4.64	1.11	0.47	13	21	0.00
Basal concavity depth	39.90	41.05	4.39	4.13	1.75	1.70	29	40	0.87
Basal depth/Basal W	25.96	36.16	0.23	0.22	0.06	0.08	22	36	0.14
Pooled std. dev. of dominant flute	27.41	22.48	1.05	1.10	0.29	0.25	29	29	0.33
Edge Angle 5mm FPE	16.46	19.39	63.62	57.91	10.47	11.23	73	91	0.01
Edge Angle 10mm FPE	17.49	21.31	61.64	58.09	10.78	12.38	74	92	0.00
Edge Angle 15mm FPE	19.72	20.61	62.16	57.53	12.26	11.86	65	87	0.00
Edge Angle 20mm FPE	20.42	21.88	63.36	56.23	12.94	12.30	47	61	0.00
Edge Angle 25mm FPE	24.09	22.26	57.52	56.88	13.86	12.66	27	48	0.01

Variance around mean width at 0 mm FPE (effectively the base of the point) was 37.21%, significantly more variable than in the Folsom sample (8.63%, p=0.00). In the Folsom sample, variability around mean width between 5 and 20 FPE ranged from

(8.74-11.26%) and remained fairly constant to 25 mm FPE (14.81%). Relative standard deviations around the mean remained relatively low from 5-20 mm FPE in the northern sample as well (11.34%, n=25; 9.84%, n=24; 12.52%, n=20; 17.01%, n=17, respectively), but at 25 mm FPE variability in width increased (31.01%), being driven primarily by the whole points from Tinayguk River and Batza Téna (artifact number RkIg-47:13), the blade edges of which begin to contract between 20-25 mm from the base. This is a significant departure from the uniformity on the Folsom sample that remained after 20 mm FPE (p=0.01). Therefore, basal width is much more variable around the mean in the northern than the Folsom samples. Moreover, metrics in width begin to vary considerably in the northern sample after 20 mm FPE, whereas in the Folsom sample variability around mean width remains constant from 5-25 mm FPE.

Thickness at base (0 mm FPE) was measured on 64 fragments (at least those with one corner remaining) (Table 3.2), but two of them were broken just beyond 15 mm FPE and could not be included in the 20 and 25 mm analyses. Variance in thicknesses FPE around means was relatively low among all points from 0-20 mm FPE, only fluctuating between 11.16-18.70% of the mean. In the northern sample, however, variability around mean thickness significantly increased at 25 mm FPE, while it remained constant in Folsom (p=0.00). Therefore, in the northern fluted points, basal thickness FPE was metrically uniform from the base to 20 mm FPE but increased in variability by 25 mm FPE, whereas in the Folsom sample, variation around mean thickness was constant from the base to 25 mm FPE.

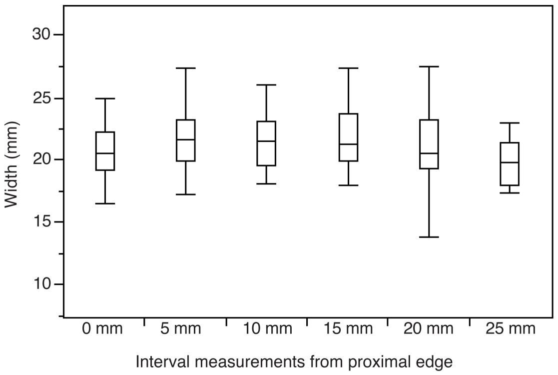


Figure 3.4. Box plot showing results of Kruskal-Wallis analysis of width measured on northern fluted points from 5-25 mm (X^2=7.43, p=0.19).

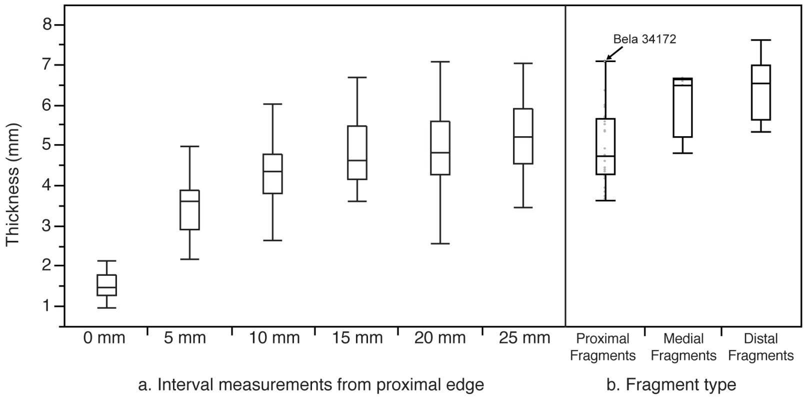


Figure 3.5. Box plot showing results of Kruskal-Wallis analysis of thickness measured on northern fluted points: (a) Variability in thickness from 5-25 mm (X^2=88.69, p=<0.0001); (b) Variability in mean thickness between proximal and distal fragments (X^2=13.27, p=0.0041). Artifact BELA-34172 represents the fragment from Serpentine with only a single flute on one face.

Kruskal-Wallis tests were used to identify whether the uniform patterns of width and thickness increased, decreased, or remained constant among northern fluted points. Results demonstrated no significant variability in mean width among 5-mm intervals (X^2=7.43, p=0.19) suggesting that widths remained relatively uniform for the first 20 mm FPE (Figure 3.4). Thickness, however, varied significantly, steadily increasing from

5 to 20 mm FPE, suggesting a gradient increase (X^2=88.69, p<0.0001) (Figure 3.5a). Thus, northern points have straight lateral margins in planview, and their profile shape is similar to a wedge with a very acute angle. Kruskal-Wallis analysis also found a significant difference in mean thickness between proximal and distal fragments (X^2=13.27, p=0.0041) (Figure 3.5b). Not only are points consistent in profile shape, they uniformly increase in thickness from the base at a constant rate, reflecting a 20-mm long wedge-shaped profile, with distal fragments being significantly thicker than basal fragments in the northern fluted point sample.

Basal-Concavity Depth. Basal-concavity depth was fairly variable around the mean (39.90%, n=29); however, this variability dropped 15% when considered relative to width (25.96%, n=22) (see Table 3.2). Folsom basal-concavity depths were similarly variable (41.05%), and still highly variable even when indexed against basal width (36.16%) (Table 3.2). There were moderate correlations between basal-concavity depth and maximum width and average fluted-area width in the northern fluted-point sample, but no such correlations in the Folsom sample (see Figure 3.6a,b). This may indicate a greater degree of control of basal concavity design in the northern sample.

Channel-Scar Metrics. To compare uniformity in flute metrics standard deviations of dominant flute widths measured in 5-mm intervals on each point face in the northern fluted sample were pooled and generated a CV of 27.41%, which is relatively more variable than measures of width and thickness intervals, as well as CVs of pooled fluted-interval widths for Folsom points (22.48%, n=29) (Table 3.2). Similarly, no correlation was found in flute widths between faces of proximal fragments

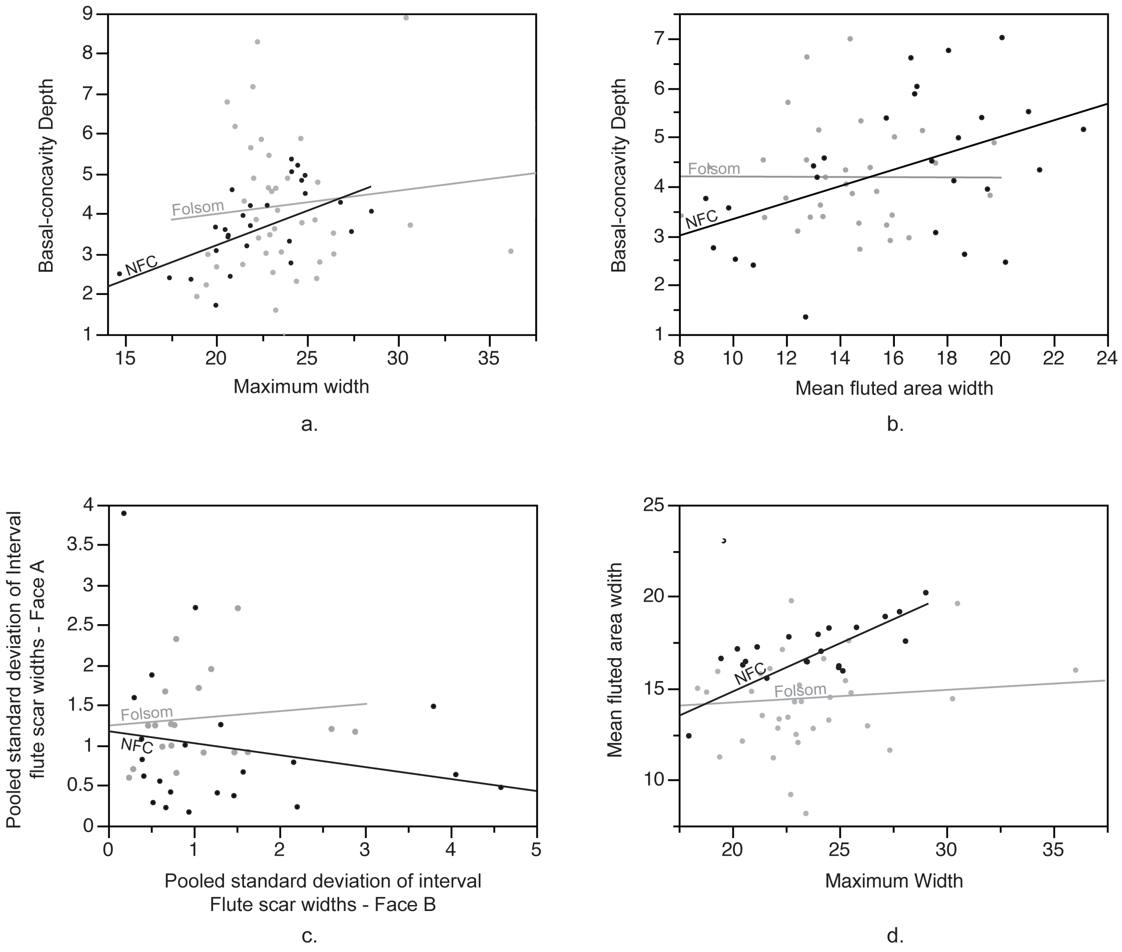


Figure 3.6. Regression coefficients describing Northern Fluted (NFC) and Folsom points (gray=northern fluted points and black=Folsom points): (a) basal-concavity depth and maximum width (NFC: r^2=0.24, p=0.0089; Folsom: r^2=0.01, p=0.48); (b) basal-concavity depth and average fluted-area width (NFC: r^2=0.21, p=0.019; Folsom: r^2=0.00, p=0.98); (c) correlation between pooled standard deviations of three width measurements per dominant flute on each face (NFC: r^2=0.04, p=0.35; Folsom: r^2=0.01, p=0.68); (d) correlation between mean flute area width and maximum width (NFC: r^2=0.54, p=<0.0001; Folsom: r^2=0.00, p=0.63).

for either the northern sample (r^2=0.04, p=0.35) or the Folsom sample (r^2=0.01, p=0.63) (Figure 3.6c). The width of the entire fluted area on each artifact face, however, did correlate with maximum basal-fragment width in the northern sample (R^2=0.54, p=<0.0001), suggesting that the points were thinned across the entire face. This correlation was not present in the Folsom sample (R^2=.00, p=<0.89) (Figure 3.6d).

Edge Angle. Edge angle measured on both edges in 5-mm intervals between 5 and 20 mm FPE on 35 northern-fluted basal fragments averaged 63.70°. On 20 specimens long enough for measurement at 25 mm FPE, average edge angle decreased to 57.52° (Table 3.2). This difference in edge angle is uniform throughout the sample providing evidence of lowered edge angles in the distal portions. Conversely, edge angle measured in 5-mm intervals between 5 and 20 mm FPE on 46 Folsom points averaged 57.44°, and remained fairly constant by 25 mm FPE (average 56.88°). Results of DA'D analyses suggest that variability around mean edge angle is significantly lower for northern than Folsom points, suggesting that, unlike Folsom, northern point's edge angles were consistently manufactured to a uniform angle, which was a wider angle in the proximal portions than the distal portions.

Results of the DA'D test were able to demonstrate that northern and Folsom fluted points are roughly equivalent in degree of variation suggesting that both samples were manufactured to specific parameters. The northern sample was more variable in basal width, width at 25 mm FPE, and thickness as 25 mm FPE and less variable in fragment length than Folsom, which may have ultimately resulted from differing hafting strategies. Edge angle from 5-20 mm FPE was also significantly more variable in Folsom than the northern sample, attesting to a specific uniformity in the first 20 mm in the northern points.

Additional variables, such as basal-concavity depth demonstrate a degree of flexibility in base shape, which was more pronounced in Folsom and less dependent on width, suggesting higher standard of uniformity in the northern points. Technological flexibility, however, was greater in the production of flute scars in the northern sample, which, given correlation with maximum width, appears to demonstrate a different goal of fluting in the north: to thin points across the entire face.

Multivariate Shape Analysis Results

Northern Fluted PC Analysis. The first five principal components were found to explain 93.36% of variability in the northern-fluted point data-set (n=19). Figure 3.7 demonstrates the shape characteristics expressed at each end of the PC axes. Each dimension of shape (each PC) in the Alaskan dataset describes a deep basal concavity that is predominantly V-shaped with triangular basal corners. Lateral margins are straight in almost every dimension as well, except for the PC2 axis that describes instances of basal lateral margins that are relatively more rounded (-PC2) or slightly more flaring (+PC2). A degree of asymmetry is expressed in each PC too, which is appropriate given the fragmentary nature of the dataset. This asymmetry likely explains a degree of variability in the sample.

Northern Fluted Distribution of Variance. The Alaskan fluted points could not be organized by archaeological site because many represent solitary surface finds; therefore, the main grouping of spatial variation was by region: Northern Coastal Plain, Seward Peninsula, Western Brooks Range, and the Central Brooks Range. Statistical analysis of the major trends identified in the PC analysis confirmed that no significant variability in morphology is present within the northern fluted-point data-set when organized into regions (Table 3.3a). Models of latitude and longitude were also used to identify variability in the dataset along a geographic gradient. Tests of both shape and form found no significant variability along the latitude and longitude gradients, and the interaction between longitude and latitude. Results of this analysis suggest that the shape of northern fluted-point basal fragments in this sample represent a morphologically homogenous point design.

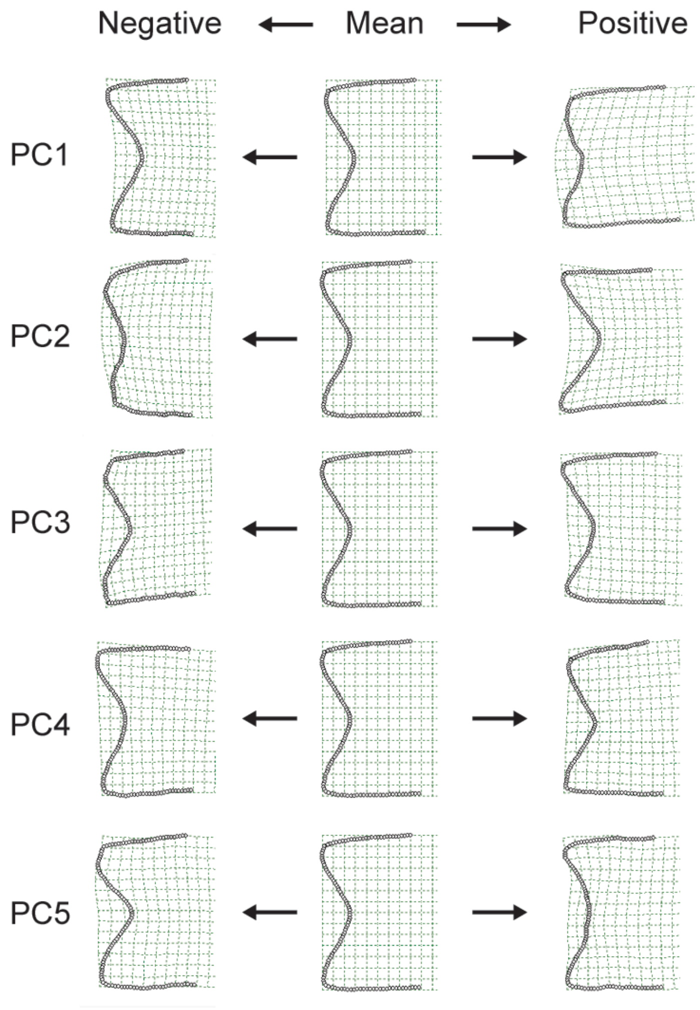


Figure 3.7. Graphical depictions of the first five principal components, which explain 93.36% of variability in the northern fluted-point sample (n=19).

Table 3.3. MANOVA results for Shape and Form for geographic and complex models: (a) Northern Fluted-Point Complex only; (b) Combined Northern Fluted-Point and Folsom Complexes.

		Shape			**Form**	
Model	*F*	df_n/df_d	*P*	*F*	df_n/df_d	*P*
a. Northern Fluted Points						
Region	0.65	15/19.73	0.80	0.71	18/28.77	0.78
Latitude	0.77	5/10	0.59	0.66	6/10	0.68
Longitude	0.70	5/10	0.63	0.59	6/10	0.73
Latitude*Longitude	0.64	5/10	0.67	0.59	6/10	0.73
b. Folsom Points						
Site	1.60	30/126	0.04	1.72	35/132.84	0.02
Latitude	0.48	6/33	0.81	1.02	7/33	0.44
Longitude	1.68	6/33	0.16	2.22	7/33	0.06
Latitude*Longitude	0.08	6/33	0.86	1.56	7/33	0.18
c. Northern Fluted and Folsom Points						
Complex	15.06	6/46	<0.0001	17.70	7/46	0.0001
Latitude	5.64	6/52	<0.0001	5.04	7/52	0.0002
Longitude	0.38	6/52	<0.0086	3.06	7/52	0.0092
Latitude*Longitude	0.36	6/52	<0.0106	3.01	7/52	0.0098

Folsom PC Analysis. The first six PCs explain 95.33% of shape variability present in Folsom sample. The “Folsomoid” basal-concavity shape is angular, with fairly straight interior edges, pronounced basal ears, and straight lateral margins that contract toward the proximal end (see O’Brien et al. 2001:1127). These shape characteristics are represented along every PC axis illustrated in Figure 3.8. Negative loadings of PC2 and PC4, and positive loadings of PC3, PC5, and PC6 describe a small curve along the apex of the basal concavity, which represents remnants of the characteristic Folsom “nipple” platform (Crabtree 1966; Frison 1991).

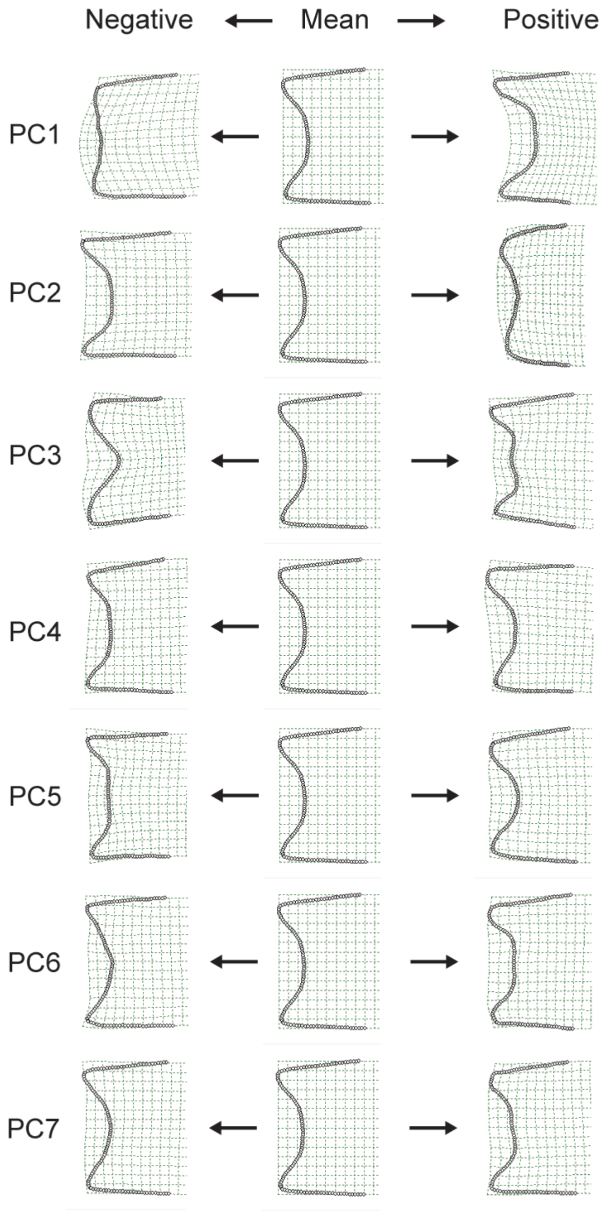


Figure 3.8. Graphical depictions of the first six principal components, which explain 95.33% of variability in the sample considering Folsom (n=43) fluted points.

Folsom Distribution of Variance. Models of variation were organized by site and gradients of latitude and longitude (Table 3.3b). Geographical models testing shape and form did not find significant variability on either latitude or longitude gradients, or the interaction between longitude and latitude. Analysis of variance for shape and form, however, found that PCs describing the Folsom point sample produced significant amounts of variability at the site level (at 95% confidence). Thus, there is some degree of geographic variability present in the Folsom sample. PC loadings reflect more parallel lateral margins in points from Lindenmeier and Agate Basin points relative to expanding lateral point margins in the remaining sites, deeper basal concavities at Krmpotich and Lindenmeier, and more prominent nipple platforms on Hanson and Barger Gulch points. Thus even in Folsom there is a range of variability, despite being considered a highly standardized technological complex.

Comparing Northern Fluted and Folsom Complexes. Significant variability in morphology was present in the sample of northern and Folsom fluted points. The first seven PCs explain more than 95.90% of the variability present point morphology. Shape characteristics specific to each collection are identifiable in the series of seven PCs generated for the combined sample (Figure 3.9a). Least squares means of actual PC loadings for each complex are charted in Figure 3.9b. The first PC describes variability in basal concavity depth, with Folsomoid basal-concavity shape being expressed predominantly in the positive loadings of PC1 and PC3, and to a lesser extent in the negative loading of PC4 and PC5 and positive loadings of PC6 and PC7. These feature Folsom-point characteristics such as angular basal concavity shape, pronounced basal ears, straight lateral margins, and the classically described fluting platform at the apex of the basal concavity. Alaskan shape characteristics are primarily expressed on negative PC1 and PC3, and less so on positive PC4 and PC5 and negative PC6 and PC7.

Combination Distribution of Variance. Models of variation were organized by complex and gradients of latitude and longitude (Table 3.3c). Tests of both shape and form found highly significant variability between complex assignments, as well as geographical gradients, with a specifically higher F-statistic in the model testing for latitude. Such significant variability between typology and geography suggest that they indeed represent two cohesive complexes, with the range of variation within the northern fluted points being comparable to that of the chronologically and technologically well-defined Folsom complex. The northern points, in other words, represent a morphologically homogeneous group separated in shape space from Folsom points (Figure 3.10). Results illustrated as canonical centroid plots, in which least squares means are given in canonical space explaining among group differences standardized to the within group differences, demonstrate that the northern sample is somewhat more variable than the Folsom, but are clearly separated in canonical shape space. While greater variability observed in the northern sample may be an artifact of sample size, this trend was also observed in four of the CV's generated for the northern sample, that produced significant DA'D statistics suggesting greater variability relative to Folsom fluted points in basal fragment length, basal width, and width and thickness at 25 mm FPE.

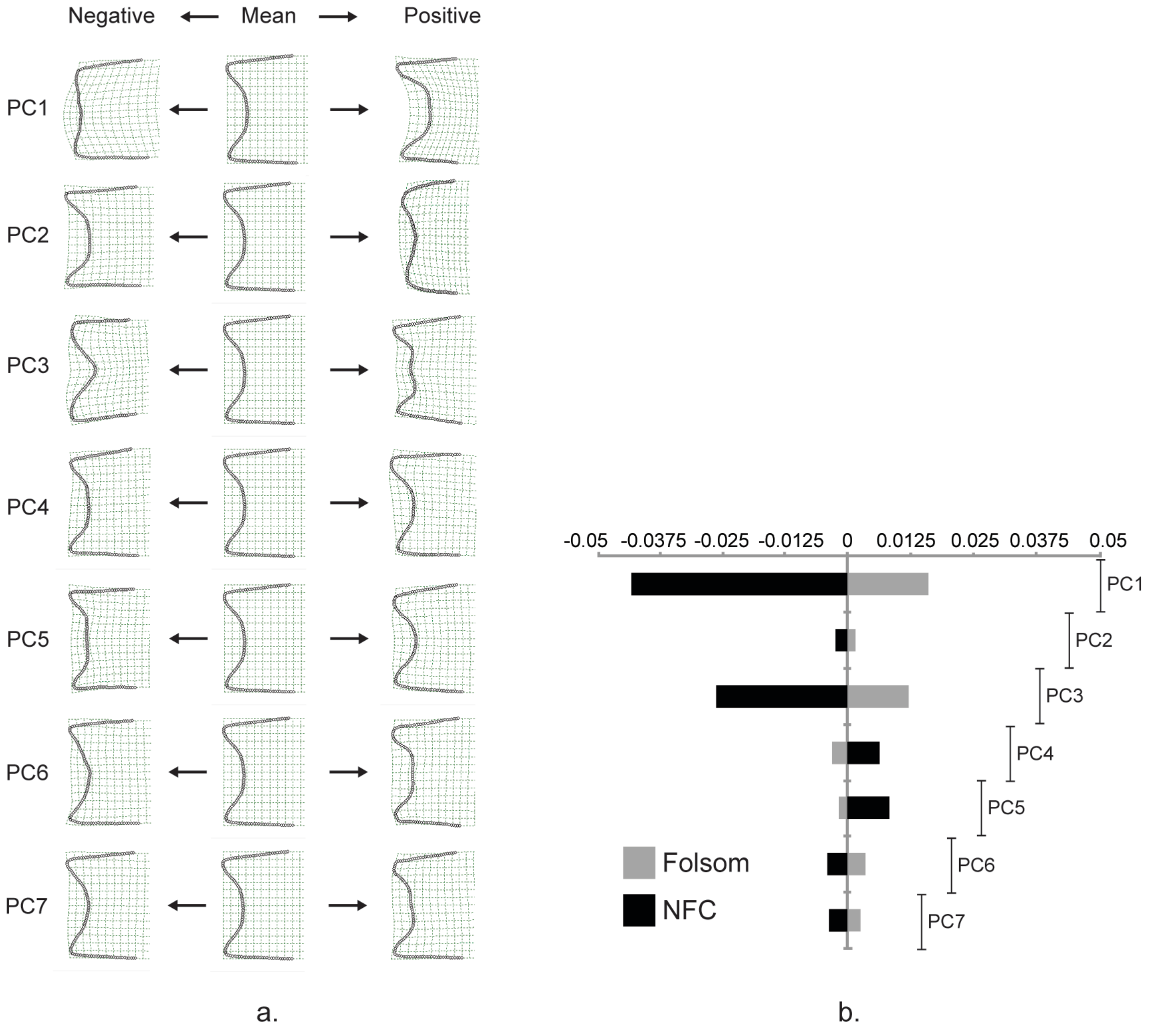


Figure 3.9. Principal component analytical results: (a) Illustrations of the first seven principal components which explain 95.81% of variability in the data-set considering both northern (n=19) and Folsom (n=43) fluted points; (b) Least Squares Means of principal component loadings for Northern-fluted (black) and Folsom (gray) datasets.

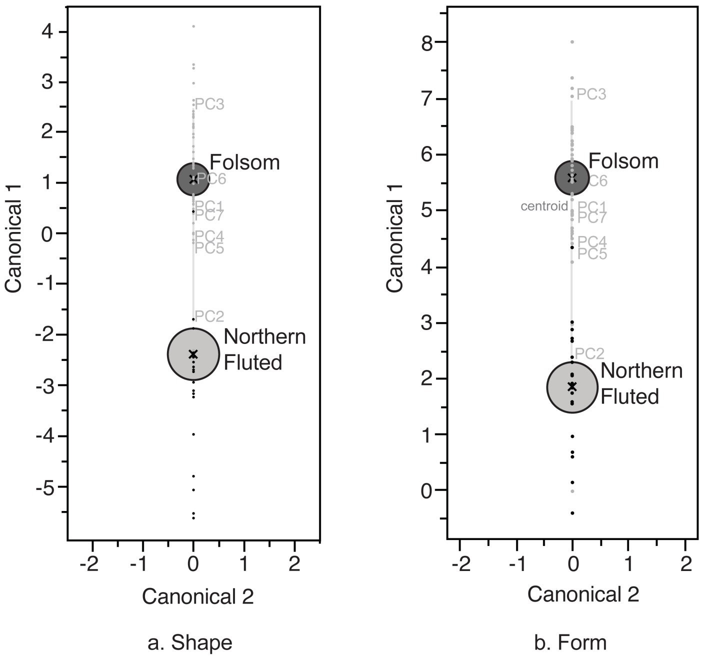


Figure 3.10. Canonical centroid plot for (a) Shape and (b) Form showing separation of the northern fluted-point sample from the Folsom complex.

Discussion

Defining the Northern-Fluted Projectile Point

Morphology. Homogeneity in haft-area metrics was indicated by low variability around mean width and thickness for the first 20 mm FPE, with mean width staying constant and mean thickness increasing uniformly. Results of MANOVA found no significant variability in fluted-point basal morphology between regions in Alaska, suggesting that the northern fluted points in this data-set were manufactured to meet a uniform morphological standard. Moreover, shape variables described by PC axes did not demonstrate a broad range of variability within the data-set. Each PC generated for the northern-fluted point sample describes the deep V-shaped basal concavity that varies slightly from a more angular to a more curved apex, straight lateral margins, and triangular basal corners. Likewise, MANOVA found that the northern fluted-point series is separated in shape space from artifacts representing the Folsom complex, suggesting that the fluted points found across northern Alaska and Yukon form a morphologically homogenous projectile-point type.

Technology. While this study has focused on finished points and point fragments and not associated debitage or early-stage biface assemblages, much information regarding northern raw-material preference, pre-fluting and flute production, and morphological state at terminal use-life was indicated by the materials in the dataset. In the production of northern-fluted points, raw-material choice was limited to high-quality, fine-grained toolstone; and, despite a single proximal fragment from Serpentine fluted on only one face, it appears that all northern-fluted points were meant to have multiple flute scars on each face in the proximal area. Channel-scar metrics found significant variability in width along the dominant channel flake, suggesting some laxness on the part of the producer in terms flute uniformity. However, the width of the entire fluted area significantly correlated with fragment width, suggesting that multiple flutes served to thin the entire face. Outside edges of lateral channel scars were over-flaked by marginal thinning, creating an average edge angle of 63.7° between 5 and 20 mm FPE, and were then edge ground. At 25 mm FPE, average edge angle decreased to 57.5°, likely representing the edge angle imposed prior to fluting and completion of the manufacturing process, or the differently shaped edges of the base and blade elements.

Despite these apparent regularities in northern fluted point production and form, there are some irregularities as well. One the one hand, dominant flute-scar widths and basal concavities differed among points. On the other hand, the total fluted area was more regularly controlled, and mean basal concavity depth seems to have been scaled to point width, with wider points having deeper basal concavities. Moreover, the basal margin became more concave as channel flakes and marginal-retouch flakes were removed from the proximal edge, eventually forming the inverted V-shape. The variation present in flute-scar width and basal concavity depth suggests allowance for flexibility during production or reworking, possibly attesting to less risk when fluting than previous hypotheses have noted, and even allowing for knappers at different skill levels to successfully flute basal margins.

Overall, fluting was used exclusively to thin the base, which facilitated the gradient increase in thickness. The Kruskall-Wallis test also found a significant difference in thickness between proximal and distal fragments. Blade portions of the fluted points were flaked to the longitudinal midline to produce a median-ridged to lenticular cross-section. This medial ridge was likely present on preforms as well, prior to fluting, and used to guide the first flute removal. The lateral arises that remained after the first flute were likely used to guide subsequent lateral flute removals.

Function. The presence of marginal grinding and fluting provides important evidence that northern-fluted points were prepared for hafting to another technological element, such as a fore-shaft. Distal damage, resulting from impact, is present on two of seven distal fragments from the sample, which attests to their use as projectile weapon tips. Nearly 75% of basal fragments have transverse snaps, or bend breaks, a fracture type noted to occur in high frequencies in fluted-point collections from the North American High Plains and northeastern U.S., and found, experimentally, to result from heavy impact (Collins 1993; Frison 1989). Without question, northern fluted points functioned as hafted projectiles that impacted targets at high velocities.

Fluted Technology as an Adaptation in the Late Pleistocene Arctic

The homogeneity in morphological and technological features documented here supports the hypothesis that northern fluted points form a cohesive complex, or point type, technologically representing a single manufacturing and reduction strategy. Results of this analysis have identified patterns of northern fluted-point form, technology, and function, which may suggest whether they served as a component of a reliable or maintainable system to facilitate risk-management solutions. This hypothesis can be further explored by accounting the effects of northern fluted-point technological and morphological characteristics.

Why Flute? Projectile-point bases can be thinned in a variety of ways, and hypotheses addressing why many Paleoindians preferred fluting include (see Ahler and Geib 2000) weight reduction, enhanced bleeding, more cutting-edge exposure (Crabtree 1966), potential for thicker, more durable, hafting material (Hutchings 1997), and Bleed’s (1986) suggestion that fluting promoted predicted failure to increase maintainability. Further, Judge (1973) suggested that fluting facilitated interchangeability of projectile points within a still-usable foreshaft, and Wilmsen (1974; Wilmsen and Roberts 1978) suggested that the texture of a fluted surface increased friction and bonding, thus serving to secure the point in the absence of adhesive materials. Perhaps multiple and parallel flute scars on northern fluted points provided increased texture and stabilization of the point within the haft.

Fluting also facilitated the low-gradient increase in thickness FPE, providing northern fluted points with a long wedge in profile, which may have served as another mechanical advantage in terms of stability within the haft. While other non-fluted forms of lanceolate projectile points (e.g., Sluiceway) in northern Alaska possess this wedge-like quality, they have an overall shorter, high-angle wedge, making them laterally unstable in a split-shaft and, therefore, require significant efforts in binding (Figure 3.11). The ability to stabilize a projectile tip with help from the mechanics of the fluted point itself likely decreased the amount of time and supplies required to bind and maintain a point (Keeley 1982; Wadley et al. 2009; see also Weedman 2006).

Figure 3.11. Photograph showing the wedge-like quality of Northern Fluted Complex (left) and Sluiceway (right) projectile-point profile and the difference in wedge angle.

Why a Deep Basal Concavity? Flenniken (1978) noted that most of his experimental projectile points failed beyond repair when one of the corners snapped because the points became loose within the haft. Likewise, Odell and Cowan (1986) found that symmetry in point positioning within the haft was key to successful penetration through the hide of prey animals. Deep basal concavities like those seen on the northern fluted points facilitate the presence of pronounced proximal corners to stabilize a point laterally, thereby increasing symmetry in the hafting element.

The characteristics of the Alaskan sample of fluted basal fragments presented here are similar to characteristics identified by Collins (1993), who found that most basal fragments of Angostura points were 20 mm long, suffered from bend-break fractures, and had basal-flaking patterns suggestive of reworking the proximal ends of distal fragments, not resharpening of blades still in a haft. This evidence suggested to Collins that these points were possibly designed to break at approximately 20 mm FPE to facilitate the rehafting of a considerable amount of material remaining on distal fragments (see also Musil 1988). Among the northern sample, it is possible that once a corner broke during use, hunters snapped broken bases on purpose to fashion new ears and flutes on distal fragments (see Ellis 2004), explaining the common FPE breakage at approximately 20 mm and high incidence of transverse snaps, or bend breaks, as well as a high number of channel flakes recovered at Serpentine (Goebel et al. 2013).

Why Variable Flaking Patterns? Blades on northern fluted points were median-ridged to diamond-shaped in cross-section, a durable shape for a projectile point (Chechier and Kelly 2006). Moreover, this form would have facilitated preservation of enough raw material after breaking from a fragile base to re-flute. The presence of the medial ridge would also serve to guide new flute removals from a fresh snap. Chechier and Kelly (2006) suggest that point durability increases as more of the point is protected within the haft (i.e., Folsom); however, metric patterns in the Alaskan sample demonstrate a preference for a short hafting element, ~20 mm long, implying that blade durability, not basal durability, was the quality desired by these fluted-point makers. This strategy allowed point-makers to control how much usable material remained after failure (see Ahler and Geib 2000). One caveat, of course, is that distal fragments would have had to have been retrieved from the carcass or procurement site before rebasing.

Mobility, Land Use, and Risk-Management Solutions. Northern fluted points are rarely found associated with high artifact densities and evidence of "gearing up" activities, such as those found at most non-fluted Paleoindian sites in northern Alaska (i.e., Mesa and Sluiceway) (Bever 2000; Kunz et al. 2003; Rasic 2011). Fluted-point site contexts were often in overlook settings, at further distances from raw-material sources, and not associated with clearly-related, high-density cultural deposits. The functional advantage of this projectile-point design potentially allowed for maximum portability and maintainability in terms of ease of removal and replacement, lowering transport costs in terms of risk-management because they did not require high investment in gearing up (Bousman 2005; Eerkens 1998; Judge 1973; Torrence 1989).

Many studies have pointed out that risk increased with distance from raw-material sources (e.g., Bamforth 1986; Bleed 2002), but risk of not having adequate lithic material on hand when needed may have been coupled with not having the organic supplies and time to repair, or recreate, hafting elements (see Chechier and Kelly 2006). The maintainable northern fluted-point system may have offset high costs involved with accessing toolstone and hafting materials. Northern fluted-point locales are geographically widespread across northern Alaska and Yukon, and often, not near Brooks Range sources for toolstone. In an embedded procurement system, as groups travelled between locations intended for intercept hunting or toolstone acquisition (i.e., predictable resources), opportunities for encounter hunting would arise (i.e., unpredictable resources). The maintainable fluted-point system would have provided portable yet effective hunting tools to reduce risk during unpredictable events, after which tool maintenance would be more costly because access to raw materials was decreased.

Higher expenditures of hafting effort were required when using a point with a high-angle wedge in profile and without basal corners which (1) decreased the point's own ability to contribute to stabilization within the haft while (2) increasing the point's potential to resist breakage. In this scenario, risk increased as groups became less able to expend time and materials *if* the hafted area required repair (see Bousman 1993; Kuhn 1994). One way to reduce risk if basal damage occurred was to ensure that it *would* occur, if rebasing protocol was meant to *quickly* create an effective refurbished weapon. The multitude of channel flakes removed from northern fluted points, evidence of fluting far away from sources of lithic materials at intermediate stages of a recycling system, and lack of uniformity in channel flake metrics suggests that fluting may not have been a high-risk task as commonly thought. Instead, fluting provided security, serving as a reliable method of weapons maintenance by eliminating time and energy expenditures in haft maintenance and minimizing expenditures on rebasing, resharpening, and reinsertion into the haft (following Boldurian et al. 1986; Ellis 2008). Blade resharpening, however, likely still occurred on northern fluted points; however, unlike some Paleoindian technologies, this may have been a rejuvenation procedure used sparingly.

Conclusion

The analyses presented here support the hypothesis that Alaskan and northern Yukon fluted points represent a cohesive technological strategy and can be termed the Northern Fluted-point complex, and places northern fluted projectile weaponry in the role of a portable hunting weapon within a cultural system adapted to moving great distances. The technological organization of northern fluted-point makers suggests the ability to make future-oriented decisions and manage risk by lowering transport costs. Fluted-point use in the north, therefore, reflects a risk-management strategy promoting ease-of-replacement-after-failure which may have ensured that effective tools could be quickly recovered when high mobility meant maintenance costs were high (Bamforth and Bleed 1997; Kuhn 1989; Torrence 2001).

This assessment is supported by significant homogeneity in fluted-point technology and basal-fragment morphology which conveys an overall artifact “style”, in the sense of Wiessner (1985) and Rick (1996). However functionality appears to have played a significantly influential role in the form of northern fluted points (Meltzer 2003; Sackett 1982; but see Bettinger et al. 2003), which served to laterally stabilize the point within the haft, break at a specified length, preserve the distal portion for rebasing, and be facilitated by removing flutes to re-thin the base. Thus, this technology was effective, maintainable, and transportable—the result of a production and maintenance system that specifically offset transport costs and reduced risk during long-distance travel.

CHAPTER IV

THE ORIGINS OF FLUTED-POINT TECHNOLOGY IN BERINGIA: A GEOMETRIC MORPHOMETRIC ASSESSMENT

The earliest well-dated fluted-point form, diagnostic of the Clovis technocomplex, occurs predominantly in the continental United States (Bradley et al. 2010) in contexts dating to between 13,125 and 12,925 calendar years ago (cal B.P.), coeval with rising temperatures of the Allerød interstadial (Holliday and Miller 2013; Waters and Stafford 2007). By the onset of the Younger Dryas cooling event (12,850 and 11,700 cal B.P.), fluted points had spread geographically throughout the Western hemisphere, but their forms became quite variable in both morphology and technology. Examples in North America include Folsom in the Rocky Mountains and Plains, Barnes in the Great Lakes region, and Cumberland in the Southeast; and in South America, Fishtail points were also often fluted (Anderson 2012; Bradley 2015; Ellis 2008; Morrow and Morrow 1999; Politis 1991; Smallwood 2012; Sellet 2004). From Alaska and northern Yukon (Canada), we can add the Northern Fluted complex, now independently dated to the end of the Pleistocene at two archaeological sites (Smith et al. 2013).

Fluted points across the Western Hemisphere appear to represent rapid human dispersal and successful adaptation to a variety of environments, including recently deglaciated and recovering landscapes as well as newly reorganized terminal Pleistocene plant and animal communities (Anderson and Faught 1998; Ellis 2004; Kelly and Todd 1988; Morrow and Morrow 1999). In these contexts, although projectile-point form and technology was often altered, the practice of fluting was maintained as a method for thinning the point’s proximal area. As such, the unique practice of fluting serves as a proxy for investigating technological continuity as Paleoindian groups spread throughout the Americas (Eerkens and Lipo 2005; Lycett 2011; O’Brien et al. 2010). In this light, this paper presents the results of a geometric morphometric analysis of fluted projectile points from Alaska and northern Yukon — the Northern Fluted Complex (NFC) — as well as points from southern Canada, the Great Plains, and eastern United States to explain the appearance of fluted-point technology in Beringia. I employ cultural transmission (CT) theory, which considers concepts of both evolutionary theory and behavioral ecology, to evaluate potential cultural relatedness and adaptive similarity of artifact morphologies (Bentley and Shannen 2003; Boyd and Richerson 1985; Eerkens and Lipo 2007). Frequencies of technological attributes were also considered to further investigate patterns of trait distribution.

Background

While much research has addressed the spread of fluted-point technology in North America (Buchanan and Hamilton 2009; Morrow and Morrow 1999; O’Brien et al. 2001; Smith et al. 2014; Thulman 2012), our understanding of its appearance in Beringia remains poor, due largely to deficits in archaeological data for regions above

50° N latitude. When fluted points were first found in Alaska in 1947 (Thompson 1948), early researchers (Clark and Clark 1983; Giddings 1964; Haynes 1964; Hibben 1943; Krieger 1954; Wilmsen 1964; Wormington 1953) questioned their presence in the North and how they related to Clovis and other later fluted variants. Did Alaskan fluted-point technology represent an adaptation similar to other Paleoindian groups, and did it represent the ancestral condition of Clovis on the Bering Land Bridge?

Addressing these and related questions has always been stymied because, until recently, Alaskan fluted points had never been found in discretely buried contexts with unequivocally associated datable material (Clark and Clark 1983; Reanier 1995). With no chronological control, competing hypotheses of when, how, and why fluting technology emerged in the North could not be tested. If pre-Allerød in age, they could represent Clovis antecedents en route from Asia (Clark and Clark 1983); if post-Allerød in age, they could represent either temperate North American Paleoindian technology spreading northward back to the land bridge (Wormington 1953), or simply an independent Arctic invention (Gal 1976; Giddings 1964). The buried cultural components preserved at two archaeological sites in northwest Alaska, Serpentine and Raven Bluff, recently have provided the first clear AMS-radiocarbon dates for northern fluted-point technology, demonstrating that they were used in the Arctic during post-Clovis times, between approximately 12,700 and 10,700 cal B.P., coeval with the Younger Dryas and earliest Holocene (Goebel et al. 2013; Hedman 2010; Smith et al. 2013), like other late Paleoindian complexes in temperate North America and South

America. As a result we can reject the hypothesis that the NFC represents a Clovis antecedent, and turn our attention fully to address the alternatives.

Paleoindian Dispersal Research: A Problem of Context

While it took a half-century to achieve basic chronological understanding of northern fluted points, other shortcomings have stymied the study of Paleoindian dispersal elsewhere in the New World. Recent studies focusing on fluted points have attempted to track homologous stylistic attributes, concluding that morphological and technological evolution through stylistic, or cultural, drift led to regionally unique forms as groups dispersed into previously unoccupied territories (Buchanan et al. 2013; Morrow and Morrow 1999; O'Brien et al. 2001; Smith et al. 2014). Some of these studies, however, interpret the dispersal of fluted-points to have progressed from the western U.S. to the east (Buchanan and Hamilton 2009; O'Brien et al. 2001; Smallwood 2012; Smith et al. 2014), while others have countered that fluted-point technology originated and spread from the east to the west (Anderson and Faught 1998; Beck and Jones 2010; Mason 1962; Stanford and Bradley 2012). Similarly, explanations of the presence of fluted-point technology in South America have varied, with some scholars considering similarities between Clovis and Latin American Fishtail fluted points as representing either analogy — that Fishtail points were independently invented by pre-existing South American populations (Dillehay 1997), or homology — that they represent the end Pleistocene dispersal of northern Paleoindians into the South American continent (Bradley 2015; Morrow and Morrow 1999). Some of these differences in opinion eventually may be resolved with further chronological evidence, but the inferred dispersal events may have occurred too quickly to be registered by radiocarbon dating, making it critical that we consider other lines of evidence to track the spread of fluting technology from the Arctic to the Sub-Antarctic.

The most common counter-argument used to deport Paleoindian dispersal hypotheses is that human groups had already inhabited the Americas long before the invention of the first Clovis fluted point. This may have been the case in some areas (e.g., Texas and Oregon) (Gilbert et al. 2008; Waters et al. 2011), but in others it certainly was not (e.g., the recently deglaciated landscapes of the northern Great Lakes and northeastern U.S.) (Ellis 2004; Spiess et al. 1998). In Alaska, there is no question of the presence of human groups prior to the appearance of fluted-point technology, complicating explanations of how fluted points entered the archaeological record of Arctic North America (Hamilton and Goebel 1999; Holmes 2011; Rasic 2011). The pre-Clovis presence of humans in Alaska certainly means that the later appearance of fluted-point technology in the North could have involved independent invention, northward migration and cultural drift, or various other processes of cultural transmission.

With an appreciation of the potential complexity of this process, this paper serves as a first step in the investigation of the origins of northern fluted points by testing the hypothesis that independent invention was not responsible for the presence of fluting technology in the Arctic (i.e., northern fluted points are *analogously* similar to other Paleoindian points), but rather, that fluted technology was transmitted culturally from southern to northern human groups (hence, representing a *homologous* similarity to other Paleoindian complexes) (see O’Brien et al. 2014). Is there a strong homologous morphological relationship between the northern fluted complex (NFC) and the fluted complexes of temperate North America, which can be supported geographically and chronologically by the archaeological record? And if so, which temperate complexes best represent the immediate and ultimate antecedents?

Cultural Transmission Theory and the Spread of Fluted Points

This study aims to determine if NFC points were the product of cultural transmission using geometric morphometrics. If so, the groundwork is established for later studies to explore the nature of that transmission. Geographic and chronological patterns in fluted-point morphology and technology, suggestive of cultural continuity, have inspired a body of cultural-transmission (CT) research, such as those mentioned above, grounded in evolutionary archaeology and human behavioral ecology (Buchanan and Collard 2007; Kuhn 2004; Lyman et al. 2008; MacDonald 1998; O'Brien 2005). Evolutionary archaeological principles are based on the assumption that homogeneity in specific artifact traits represents heritability, or continuity, amongst variable traits that were altered from ancestral states by invention, innovation, or copying-errors (Eerkens and Lipo 2007; Henrich 2010; O'Brien 2005). Assumptions rooted in human behavioral ecology predict that a trait is favored, or selected for transmission, when it is fitness-related or maximizes energy extraction (Shennan 2008), so that it becomes adaptive in a particular ecological and/or social setting (Henrich and Gil-White 2001; O'Brien and Bentley 2011). As such, the study of variation in material culture, in this case fluted points, is particularly suited to contexts outlined in CT theory, allowing us to evaluate the nature of similarity and potential for technological continuity (Eerkens and Lipo

2007). To understand the potential for information transmission in the North, i.e., whether fluted-point technology was transmitted northward from temperate North America, we must establish which traits were favored, as well as the adaptive context—ecological and behavioral—which provided a venue for the traits' transmission. These are concepts organized by Eerkens and Lipo (2007) as *content* and *context*.

In terms of content, fluted points from Alaska and the northern Yukon have morphological and technological traits similar to a variety of more southerly fluted forms, and these may represent favored traits. Although the most obvious retained (or favored) trait in the NFC is fluting itself, which may have been maintained for either functional or aesthetic purposes (see Lycett 2015), other such traits may become identifiable through analysis. In this study, transmitted content was assessed by observing trends in fluted-point basal morphology identified by geometric morphometrics. Resulting patterns are discussed in light of ecological and social contexts to understand the source of NFC fluted-point information.

Materials

To evaluate major factors of variability in fluted projectile-point morphology in northern fluted points and those from temperate North America, a geometric morphometric dataset was generated of 200 fluted-point fragments representing fluted forms from northern Alaska, the Ice-free Corridor, the Northeast and Great Lakes regions, Great Plains Folsom, and Clovis sites from across North America (Table 4.1,

Figure 4.1). Frequencies of technological traits are also presented to carry the discussion beyond just morphology.

Table 4.1. Sites and Number of Points Included in the Analysis.

Complex or Region Site	Number of points included in analysis	Primary references
NFC		
Serpentine Fluted-point	3	Goebel et al. 2013; Smith in *prep*
Raven Bluff	1	Hedman 2010
Batza Téna	4	Clark and Clark 1993
Teshekpuk Lake	2	Davis et al. 1981
Redstar Creek	1	Kunz 1985, 1986
Girls Hill	2	Gal 1976
Putu	2	Alexander 1987
Upper Noatak	1	Reanier 1995
Driftwood Creek	3	Solecki 1951; Solecki 1951; Thompson 1948
The Ice-free Corridor (Western Canada)		
Charlie Lake Cave	1	Fladmark et al. 1988
Lake Minnewanka	3	Landals 2008
Sibbald Creek	3	Gryba 1983
Clearwater Pass	1	Vivian 1993
Pink Mountain	2	Wilson 1989
Wally's Beach	5	Kooyman et al. 2001; Waters et al. 2015
Alberta surface collection	7	Gryba 1983; J. Ives, pers. comm. 2014
Canadian Maritime		
Vail	14	Gramly 1982, 1984, Gramly and Rutledge 1981
Debert	7	MacDonald 1966, 1968
Bullbrook	5	Byers 1954
Lamb	5	Gramly 1999
Great Lakes		
Parkhill	10	Ellis and Deller 2000
Thedford II	5	Deller and Ellis 1992
Crowfield	10	Deller and Ellis 2011
Folsom		
Agate Basin	4	Frison and Stanford 1982
Barger Gulch	12	Surovell et al. 2005
Black Mountain	3	Jodry et al. 1996
Hanson	4	Frison and Bradley 1980
Hell Gap	6	Irwin-Williams et al. 1973
Krmpotich	5	Kornfeld et al. 1999
Lindenmeier	12	Bryan and Ray 1940; Crabtree 1966
Clovis		
Anzick	5	Lahren and Bonnichsen 1974; Wilke et al. 1991
East Wenachee	5	Gramly 1993
Drake	12	Stanford and Jodry 1988
Jake Bluff	3	Bement and Carter 2010
Lehner	8	Haury et al. 1959
Naco	6	Haury 1953
Murray Springs	4	Haynes and Hemmings 1968
Blackwater Draw	4	Hester 1972; Warnica 1966
Colby	4	Frison and Todd 1986
Cactus Hill	4	McAvoy and McAvoy 19997
Dent	2	Brunswig and Fisher 1993, Figgins 1933

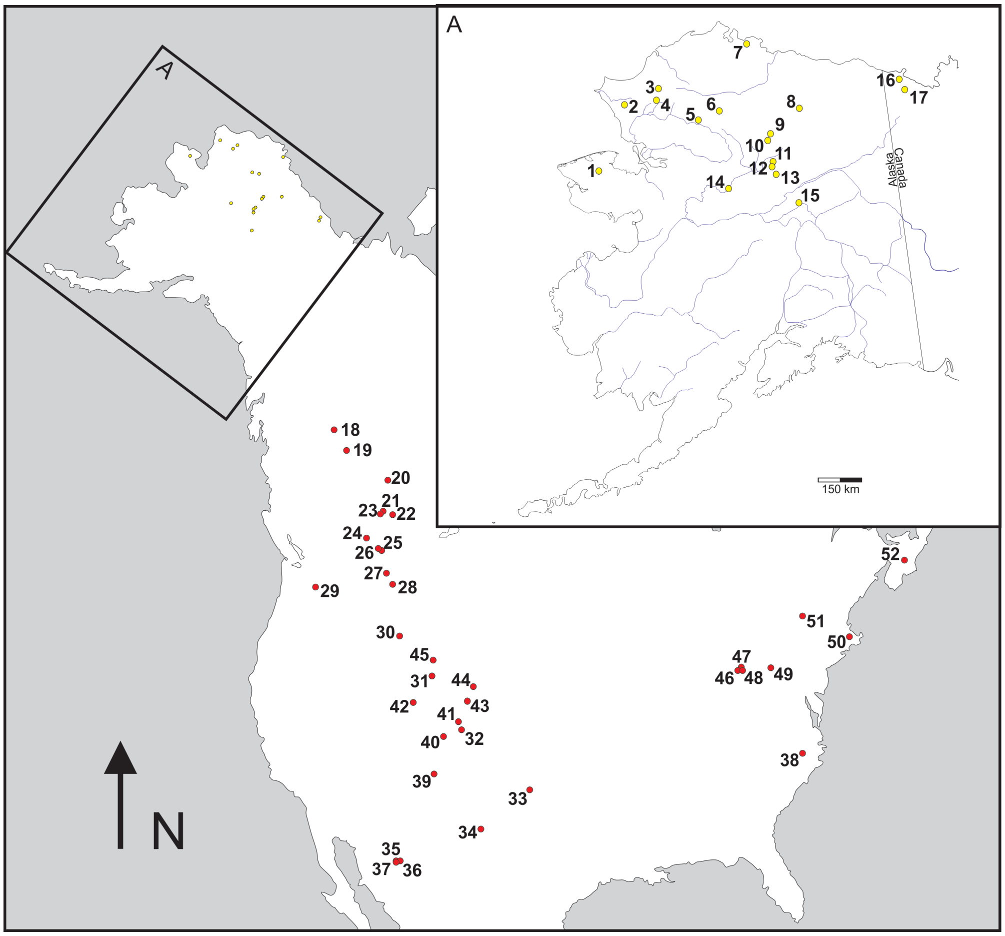


Figure 4.1. Map showing the location of fluted-point sites and isolated surface finds included in the analysis: (1) Serpentine Hot Springs (BEN-192 and BEN-170); (2) Raven Bluff; (3) Driftwood Creek (Utukok River); (4) Upper Noatak; (5) Kipmik Lake; (6) Lisburne; (7) Teshekpuk Lake; (8) Putu and Bedwell; (9) Redstar Creek; (10) Tinayguk River; (11) Girls Hill; (12) The Island; (13) Caribou Mountain South; (14) Batza Téna; (15) Hank's Hill; (16) Engigstciak; (17) Kikavichik Ridge; (18) Pink Mountain; (19) Charlie Lake Cave; (20) Surface isolate; (21) H06; (22) H90; (23) Surface isolate; (24) Clearwater Pass; (25) Sibbald Creek; (26) Lake Minnewanka; (27) DkPj38; (28) Wally's Beach; (29) East Wenatchee; (30) Anzick; (31) Colby; (32) Drake; (33) Jake Bluff; (34) Blackwater Draw; (35) Murray Springs; (36) Lehner; (37) Naco; (38) Cactus Hill; (39) Black Mountain; (40) Barger Gulch; (41) Lindenmeier; (42) Krmpotich; (43) Hell Gap; (44) Agate Basin; (45) Hanson; (46) Thedford II; (47) Parkhill; (48) Crowfield; (49) Lamb; (50) Bull Brook; (51) Vail; (52) Debert.

Methods

Geometric Morphometrics

Landmark-based Outline Analysis of Projectile-Point Proximal Fragments. Geometric morphometric analysis comparing the NFC sample to the greater collection of North American fluted points posed a new challenge to outline evaluation using a landmark-based approach to geometry in that the majority of the small collection from the north was fragmentary. Out of 51 NFC specimens available for analysis, only 14 proximal fragments and five whole points were suitable for geometric morphometric analysis. Basal morphology was best suited for the analysis, allowing for more specimens to be included and a specific focus on basal morphology, which typically was maintained throughout episodes of distal resharpening (Shott and Ballenger 2007). Original digital photographs of each artifact were taken perpendicular to each point's planview with a Nikon D5100 to ensure quality and uniformity.

Previous analyses of outline shape using landmarks were limited to whole artifacts with three major landmarks—the distal tip and two basal corners—which served as homologous landmarks in Procrustes superimposition to align specimens horizontally along the an X-axis in a Cartesian coordinate system (Buchanan 2006; Buchanan and Collard 2007, 2010; Buchanan et al. 2011; Gonzalez-Jose and Charlin 2012; Smith 2010; Smith et al. 2014; Thulman 2012). Without the distal end to serve as the third uniform landmark to align the data in Procrustes superimposition, basal fragments must instead be aligned along the X-axis by a different means.

A new approach to produce horizontal alignment of segmented outlines (generated in tpsDig2 (Rohlf 2008a)) was used to analyze only basal morphology. Generalized least squares Procrustes superimposition (Generalized Procrustes analysis) was conducted in tpsRelw (v. 1.45, Rohlf 2008b) to superimpose the constellations of corresponding semi-landmarks (Rohlf and Slice 1990), translating each semi-landmark constellation to the same centroid, scaling each constellation to the same centroid size, and iteratively rotating each constellation until the summed squared distances between the semi-landmarks and mean semi-landmark position is minimized (Bookstein 1991; Mitteroecker et al. 2013; Rohlf 1999). Superimposed semi-landmark constellations (Procrustes shape coordinates) were subjected to principal component (PC) analysis, and resulting PC scores summarizing 95.57% of total variation were used to represent shape of the basal fragments (Adams et al. 2004, 2013; Bookstein 1991; Mitteroecker et al. 2013). Centroid size, the square root of the summed squared distances between all landmarks to their common centroid, serves as an ideal size variable for use in multivariate analysis, as it can be set as an independent variable to analyze *shape* and as a dependent variable with shape factors for analyses of *form* (Bookstein 1991; Smith et al. 2014). Principal components of shape variation were also used to visualize shape characteristics that represent the major factors of variability in the sample of North American fluted points and point fragments.

Technological Attributes

Technological attributes considered include four that represent key characteristics of the NFC complex. These include multiple fluting, pressure retouch after fluting on proximal and lateral margins, and a specific sequence of flute removal in which a medial flute is removed first, followed by two lateral flutes, and then completed by a second medial flute removed last.

Statistical Procedures

Statistical analyses were conducted using JMP software version 10 (SAS Inst. Inc., Cary, NC). Analyses were conducted for both tool shape and form. Multivariate analysis of variance was used to evaluate three main models. The first, a chronological model testing variability according to mean radiocarbon date (when available), was used to identify temporal variation in tool shape. Next, variability in basal shape was evaluated according to seven categories representing typological complex or regional categories: NFC, Clovis, Clovis Caches, Ice-free Corridor, Folsom, Great Lakes (Parkhill, Thedford II, and Crowfield sites), and Northeast (Vail, Debert, Lamb, and Bullbrook sites). Lastly, models of geographical gradients using latitude and longitude and their interaction were used to identify geographic variation. To further explore geographic patterns in variability, typological and regional category assignment was further evaluated heuristically by observing affinity between individual points and regions with linear discriminant function analysis (DFA), using the seven typological/regional categories as grouping variables.

Results

Principal Components Analysis

Over 95% of variability in shape in the whole dataset is expressed in the first five PC axes shown in Figure 4.2a, and least squares means of PC loadings for each complex/region are reported in Table 4.2 and shown graphically in Figure 4.2b. NFC points are predominantly explained by the negative axes of PC3 and PC4, which together describe deep, V-shaped basal concavities as well as variation in lateral margins being either expanding or contracting towards the base. Most shape information for the Ice-free Corridor points is explained by positive PC2, which describes shallow, angular basal concavities and convex lateral margins; as well as negative PC3 and PC4, which represent point forms similar to the northern fluted points. The contrasting shape information in this combination of PCs suggests a large degree of variability is present in the corridor sample, which is likely made up of a variety of typological specimens possibly ranging over 2,000 years of fluted-point use (Anderson and Faught 1998; Fiedel 1999). Folsom loadings are expressed, firstly, by negative PC2's deep basal concavities, proximal flaring just inside the basal ears, and slightly excurvate lateral margins; and secondly, by the positive loading of PC4, which appears to represent a classic "Folsomoid" shape with angular basal ears, angular medium-depth basal concavity, and a remnant fluting platform at the apex of the basal concavity. Northeast points are described predominantly by the deep, rounded, basal concavities of positive PC1, in

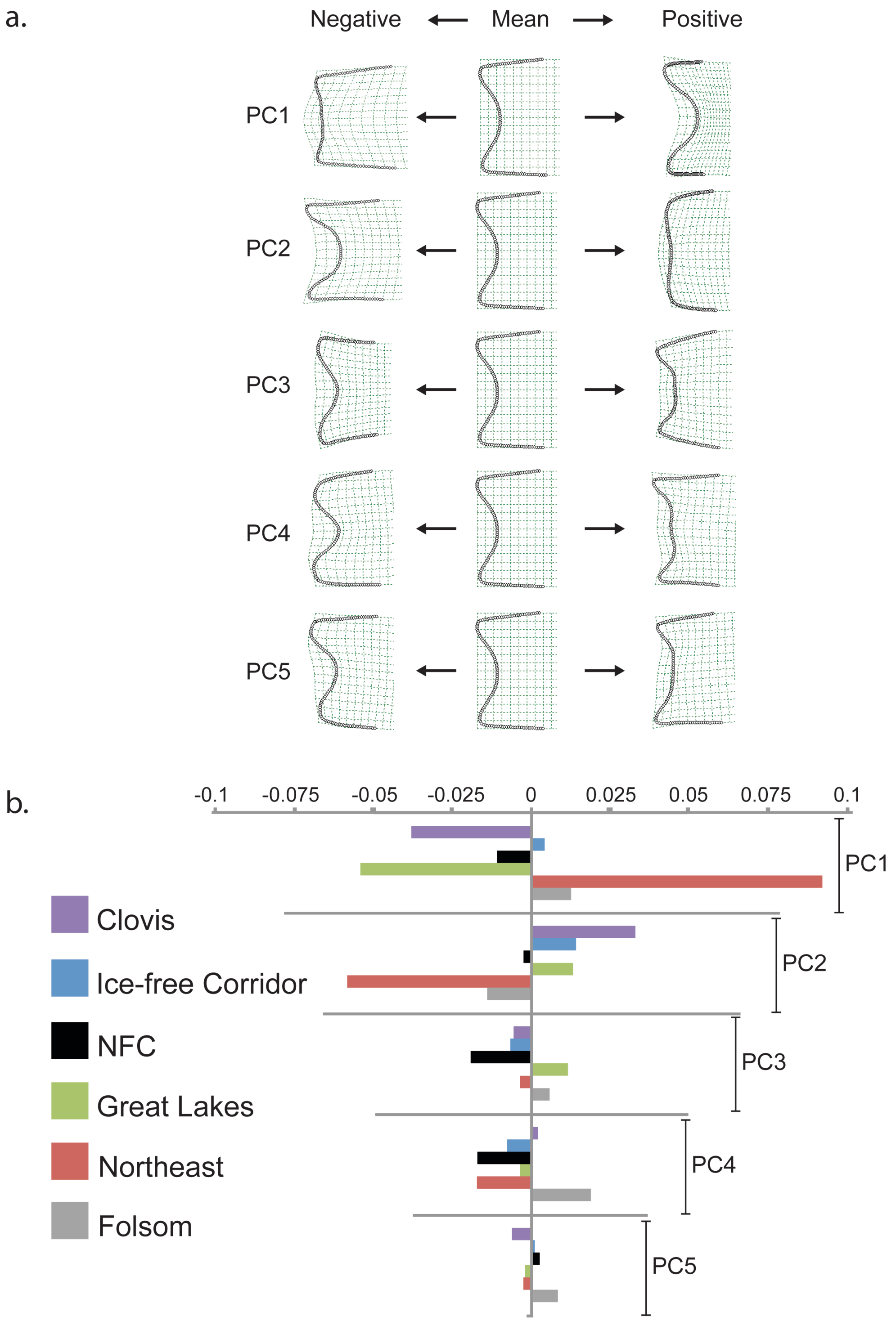


Figure 4.2. Graphical depiction of the first 5 principal component axes generated with geometric morphometrics: (a) illustrations of fluted-point basal shape described on each axis; (b) bar chart of least squares means of principal component loadings for each fluted-point group.

Table 4.2. Least Squares Means of PC-Loadings for Each Complex/Region.

Complex	PC1 LSM	PC2 LSM	PC3 LSM	PC4 LSM	PC5 LSM
Clovis	-0.037724136	0.032549412	-0.005011703	0.001623603	-0.005613684
Ice-free Corridor	0.003595721	0.013837606	-0.006260833	-0.00748865	0.000178056
Northeast	0.09174222	-0.057616396	-0.003126098	-0.017201363	-0.001682178
Great Lakes	-0.053306862	0.012940087	0.010778339	-0.003359458	-0.001967949
Folsom	0.012101925	-0.013938699	0.005502153	0.018383451	0.007994704
NFC	-0.010413017	-0.002330484	-0.019161754	-0.016897517	0.002295721

addition to negative PC2, which emphasizes the deep basal concavities in the dataset, as well as slight proximal flaring of basal corners and slightly excurvate lateral margins. The Great Lakes sample is described mostly by negative PC1, which reflects very shallow but angular basal concavities and slightly contracting lateral margins. Positive PC2 and PC3 also describe point shapes in the Great Lakes area, though to a much lesser degree, with positive PC2 reemphasizing shallow, angular basal concavities and slightly contracting but convex lateral margins, and positive PC3 describing deeper basal concavities and strongly contracting lateral margins, the former representing the Barnes point form and the latter, Crowfield. The Clovis sample is characterized by negative PC1 and positive PC2 reflecting this point form's shallow basal concavity, variation in angular to rounded corners, and slightly contracting but sometimes convex lateral margins.

Statistical Analysis of Form and Shape

For shape, F-statistics indicated significant relationships with radiocarbon age, complex/region assignments, longitude, and the relationship between longitude and latitude (Table 4.3). MANOVA, however, did not identify significant variability in shape along the latitude gradient. For form, all of these relationships were also significant, in addition to latitude. Overall, temporally and geographically, there was significant variability in the overall sample, however results suggest some morphological affinity exists between regions in the north and south.

Table 4.3. MANOVA Results for Shape (Left) and Form (Right).

	Shape				Form			
Model	***F***	df_{num}	df_{denom}	***P***	***F***	df_{num}	df_{denom}	***P***
Radiocarbon Date	2.49	95	457	<.0001	8.10	120	655	<.0001
Sites[Complex]	3.17	130	830	<.0001	3.70	156	958	<.0001
Latitude	2.24	5	189	<.0519	3.38	6	191	<.0034
Longitude	12.28	5	189	<.0001	11.88	6	191	<.0001
Latitude*Longitude	17.62	5	189	<.0001	9.04	6	191	<.0001

Discriminant Function Analysis

To investigate regional shape organization heuristically, DFA employed seven divisions of typological and regional categories: NFC, Clovis, Clovis Caches, Ice-free Corridor, Folsom, Great Lakes, and Northeast (see e.g., Figures 4.3 and 4.4). Results of DFA led to misclassifications of 37.5% of the dataset (Table 4.4). Northeast and Folsom points were the most accurately assigned, 83% and 76% respectively. Clovis Cache points were also classified accurately, with 91% assigned as Clovis Cache and another 9% classified as Clovis. These represent the most homogeneous groups in the data-set.

Great Lakes and Clovis points were not so accurately classified in the DFA. Only 64% of Great Lakes points were assigned correctly, while 16% were misclassified as

Folsom and 12% as NFC points, presumably because some of these points have angular basal concavities similar to Folsom, or deep V-shaped concavities and slight proximal flaring just inside the basal corners. For Clovis points, of which only 40% classified correctly, misclassifications were assigned to every category except for Folsom, but mostly to the Ice-free Corridor (20%), Great Lakes (17%), and Clovis Cache (14%). The assignments to Clovis Cache are not surprising, and the assignments to Great Lakes points may be a reflection of some Clovis points having deeper basal concavities like Barnes points. The misclassification of Clovis with the Ice-free Corridor group is more difficult to interpret, but likely reflects the presence of Clovis in the corridor (Anderson and Faught 1998).

Table 4.4. Results of DFA Employing Seven Divisions of Typological and Regional Categories: NFC, Clovis, Clovis Caches, Folsom, Ice-Free Corridor, Great Lakes, and Northeast as Grouping Variables.

(Predicted) (Actual)	Clovis	Clovis Cache	Ice-free Corridor	North-east	Great Lakes	Folsom	NFC	Total
Clovis	14	5	7	1	6	0	2	35
Clovis Cache	2	20	0	0	0	0	0	22
Ice-free Corridor	7	1	5	2	5	0	2	22
Northeast	0	1	3	25	0	1	1	31
Great Lakes	1	0	1	0	16	4	3	25
Folsom	1	0	2	1	5	35	2	46
NFC	2	0	5	1	1	0	10	19

37.5% misclassified, actual classifications are in rows and predicted classifications are in columns.

Figure 4.3. Photographs of examples of fluted points included in the analysis from: (a) the Northern Fluted complex; (b) the Northeast; (c) Folsom; (d) Clovis and Clovis caches; (e) the Great Lakes.

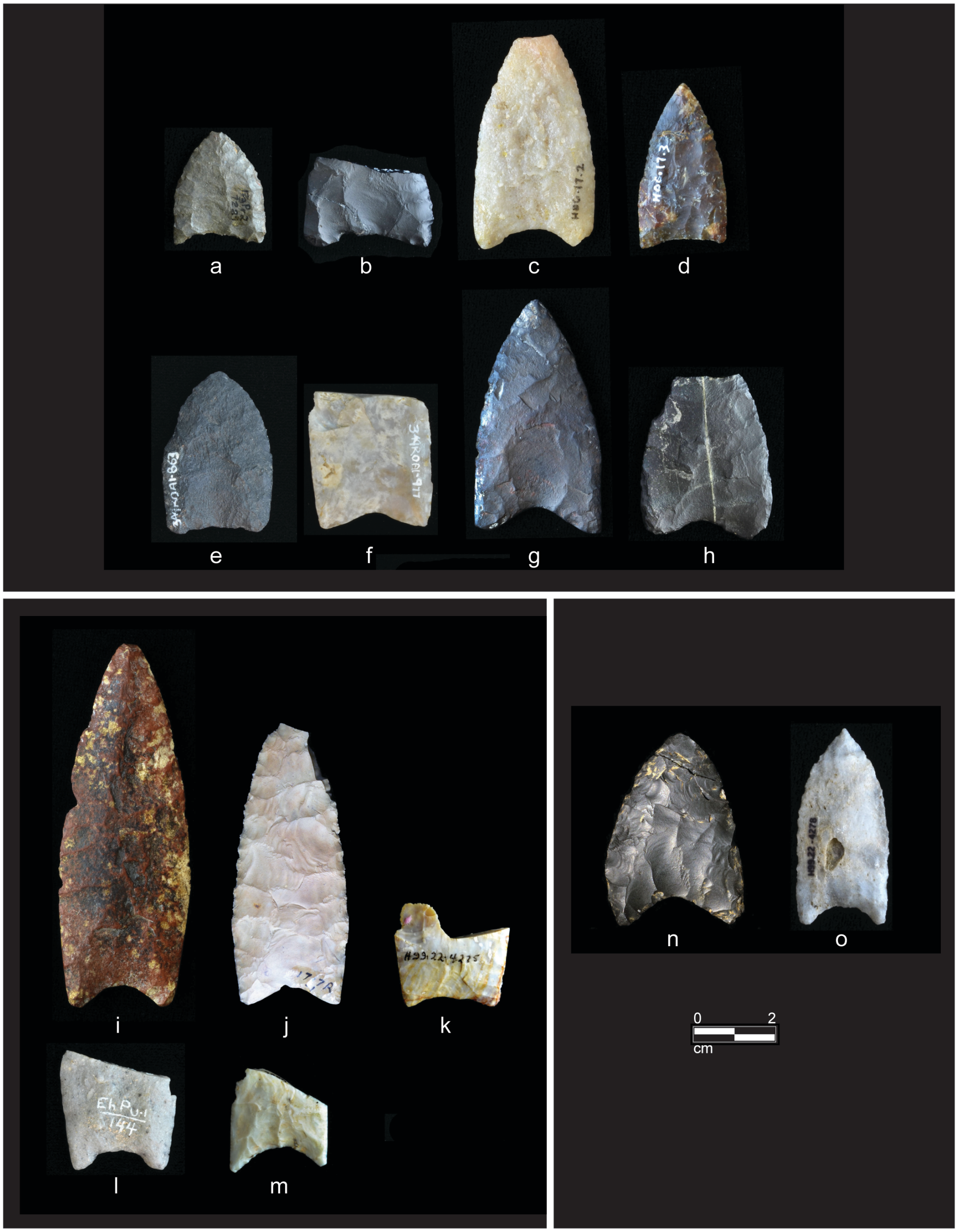


Figure 4.4. Examples of fluted points from the Ice-free Corridor that were assigned by DFA to Clovis: top, (a-b) Sibbald Creek (EgPr2-8385, EgPr2-7229); (c-d) H06 (H06-17-2, H06-17-3); (e-f) Lake Minnewanka (ROA1-863, ROA1-977); (g) DkPj38-170; (h) H67-354-4; correctly to the Ice-free Corridor: bottom left, (i) H90-142-1; (j) Clearwater Pass (1717R1A-1); (k) Wally's Beach (H99-22-4275); (l) Lake Minnewanka (EhPu-1-144); (m) Sibbald Creek (EgPr2-6886); and to the Northern Fluted complex: bottom right, (n) Charlie Lake Cave; (o) Wally's Beach (H99-22-4278).

Only 23% of Ice-free Corridor points were classified correctly, indicating that significant variability is present in the sample. These specimens have variably shaped bases, with either deeply curved concavities with straight lateral margins, or shallow concavities and convex lateral margins (PC2 positive loading; PC3 and PC4 negative loadings). Some of the Ice-free Corridor points (32%) misclassified as Clovis, further indicating the presence of morphologically Clovis-like points in western Canada; and another 23% were assigned to the Great Lakes group, suggesting the additional presence of Barnes-like forms there. Specifically, artifacts from the Ice-free Corridor that misclassified as Clovis were six points from Sibbald Creek (EgPr2-8385, EgPr2-7229), H06 (H06-17-2, H06-17-3), and Lake Minnewanka (ROA1-863, ROA1-977), and two isolated points designated as DkPj38-170 and H67-354-4 (Figure 4.4a-h). The artifacts from the Ice-free Corridor that misclassified as NFC were Charlie Lake Cave and a single point from the Wally's Beach site (H99-22-4278) (Figure 4.4n,o). The artifacts from the Ice-free Corridor that classified correctly were individual points from Sibbald Creek (EgPr2-6886), Lake Minnewanka (EhPu-1-144), Wally's Beach (H99-22-4275), Clearwater Pass (1717R1A-1), and a surface find designated as H90-142-1, interestingly, from three of the same sites that misclassified as Clovis and NFC points.

NFC points, finally, were moderately well-attributed in the DFA, with 53% classifying correctly. An additional 26% were assigned to the Ice-free Corridor group, due to shared deep, rounded basal concavities (expressed in positive PC1), a clear sign of overlap between the two regions.

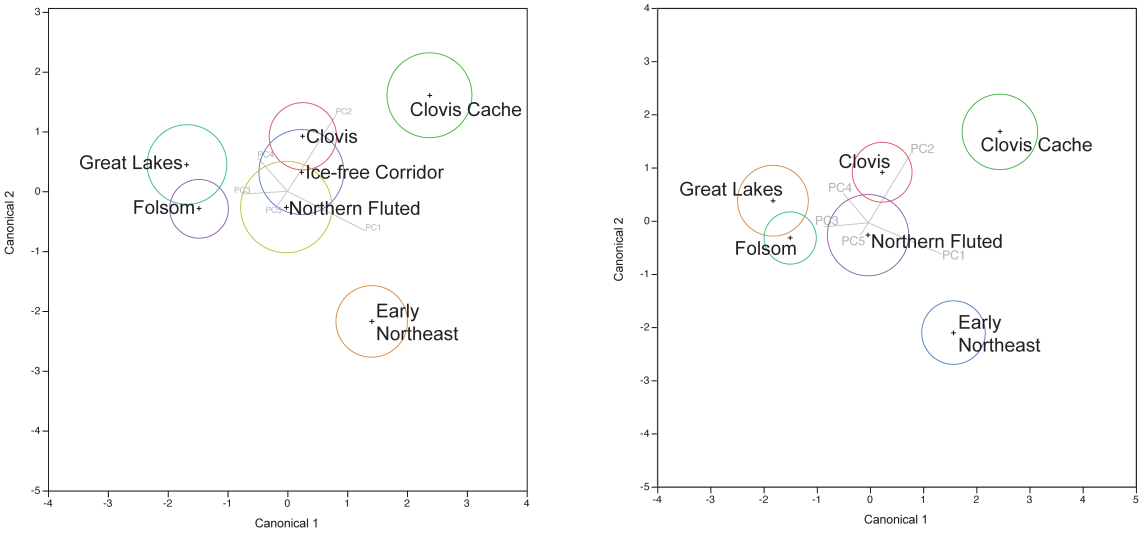
In a DFA generated without the points from the Ice-free Corridor, only 28.65% of specimens misclassified (Table 4.5). Affinity between Clovis and Clovis Cache points remained, while three Northeast points previously assigned to the Ice-free Corridor were reassigned to Clovis. The most Clovis misclassifications remained assigned to the Great Lakes region (20%) emphasizing an overlap between Clovis and Barnes specimens. The overlap between Great Lakes and Folsom also remained; however, Great Lakes points previously assigned to the Ice-free Corridor were instead misclassified as NFC. Five (26%) NFC points were assigned to Clovis, and two (11%) to the Great Lakes. These results further imply that the Corridor points are drawn in two directions in the analysis, some toward Clovis/Barnes, and the other toward the NFC.

Table 4.5. Results of DFA Employing Six Divisions of Typological and Regional Categories: NFC, Clovis, Clovis Caches, Folsom, Great Lakes, and Northeast as Grouping Variables.

(Predicted) (Actual)	**Clovis**	**Clovis Cache**	**Northeast**	**Great Lakes**	**Folsom**	**NFC**	**Total**
Clovis	20	5	1	7	0	2	35
Clovis Cache	2	20	0	0	0	0	22
Northeast	3	1	25	0	1	1	31
Great Lakes	1	0	0	16	5	3	25
Folsom	2	0	0	5	36	3	46
NFC	5	0	1	2	1	10	19

28.5% misclassified, actual classifications are in rows and predicted classifications are in columns.

The Canonical centroid plot of the first two canonical axes (Figure 4.5a), which describe the most variance in the model by explaining among group differences standardize to the within group differences, identified two main clusters separated along the first canonical axis, one including the Great Lakes and Folsom groups, and the other representing Clovis, NFC, and Ice-free Corridor groups. The overlap between Clovis, NFC, and the Ice-free Corridor again emphasizes similarities in shape within these groups over that of the other clusters. The pattern remains in a second canonical centroid plot generated from the DFA without the Ice-free Corridor sample (Figure 4.5b); it emphasizes more overlap between Clovis and NFC than with any other groups.



a.

b.

Figure 4.5. Canonical centroid plot of the first two canonical axes describing the majority of shape variation in the dataset: (a) Model includes all seven typological and regional groups (37.5% misclassified); (b) Model includes all but the Ice-free corridor sample (28.5% misclassified).

Technological Characteristics

As indicated above, groups of points with the most morphological affinity with NFC points are the Ice-free Corridor group and Clovis, followed by Great Lakes points from the Parkhill and Thedford II sites. These morphological trends were further evaluated by comparing frequencies of technological attributes that best characterize the NFC points (Figure 4.6).

	Multiple Fluting	Proximal Marginal Retouch after Fluting	Lateral Marginal Retouch after Fluting	Midline- -Laterals- -Midline flute removal sequence
NFC	●	●	●	◕
Ice-free Corridor Missclassified	●	●	◕	◑
Ice-free Corridor	◕	◕	◑	◑
Clovis	◑	◕	◑	◑
Great Lakes	◕	◕	◑	◔
Early Northeast	●	◕	◑	○
Folsom	○	◕	◑	○

○ >10% ◔ 10-25% ◑ 25-50% ◕ 50-75% ● >75%

Figure 4.6. Frequencies of technological characteristics in percentage of samples in each complex.

Three or more flutes denoting multiple fluting, which was dominant in the NFC, was also prevalent in the subsample of misclassified Ice-free Corridor points and Northeast points, and somewhat prevalent in the remaining Ice-free Corridor sample. Multiple fluting was less frequent in Clovis and rare in Folsom (<10%). Marginal retouch along the proximal edge after fluting was another prevalent characteristic of the NFC, and also found to be prevalent in the Ice-free Corridor misclassified sub-sample, but also common in all other groups. Likewise, marginal retouch after fluting on lateral edges was found to be prevalent on NFC points, as well as the sub-sample of Ice-free Corridor points, but infrequent on points in the remaining samples. The sequence of fluting predominant in the NFC sample (a medial flute removed first, followed by two lateral flutes, and then another medial flute removed last) was also prevalent in the Ice-free Corridor and Clovis groups, infrequent in the Great Lakes sample, and rare in the Northeast and Folsom samples. Thus, technologically, NFC points appear most similar to points from the Ice-free Corridor, followed by Clovis, except for the lower frequency of multiple fluting in the latter. These technological similarities, in a general sense, match the pattern found in the shape analysis.

Discussion and Conclusions

Content: Morphology and Technology

Fluting itself, which may have been maintained for either functional or aesthetic purposes (see Lycett 2015), is the basic unit of content and the basis of this study. However, results demonstrate that patterns in morphological and technological traits represent content differentially selected for among groups leading to variability in fluted-point forms. The first 5 PCs generated for the geometric morphometric dataset demonstrated a range of variability present in North American fluted-point basal morphology. Results of MANOVA and DFA demonstrated the greatest morphological affinity between NFC points, a selection of fluted points from the Ice-free Corridor representing Charlie Lake Cave, Sibbald Creek, Lake Minnewanka, Wally's Beach, Clearwater Pass, and additional surface finds, and Clovis. All four technological characteristics that dominate the NFC are otherwise most common in the Ice-free Corridor, followed by the Clovis sample, and present in the other fluted-point samples in variable frequencies, suggesting that technological affinities may complement the morphological continuum identified in the geometric morphometric analysis. While many of the Corridor points are not associated with radiocarbon dates, two of the Corridor sites, Charlie Lake Cave (12,510-12,200 cal B.P.) and Lake Minnewanka (13,150-11,300 cal B.P.) have been dated to just prior to, or coeval with, the NFC (Driver et al. 1996; Fladmark et al. 1988; Landals 2008; Waters and Stafford 2013). Ultimately, morphological affinity, in combination with this chronological ordering and geographic proximity of NFC and the Ice-free Corridor points, which shared the northern recesses of the northwestern Clovis landscape, indicate that fluting technology was not independently invented in the north. The transmission of morphological and technological information likely occurred between the Ice-free Corridor and Alaska, and more distantly, between Clovis and Alaska.

Interestingly, there were few misclassifications between NFC and Folsom, suggesting that the homologous characteristics shared between NFC and Clovis points represent information brought to the Canadian Plains and into the Ice-free Corridor prior to the development of Folsom in the American Great Plains and Rocky Mountain Front. Additionally, Paleoindian groups of the northern Great Lakes, likely representing Clovis descendants manufacturing Barnes points, may have dispersed northwestward along the edge of the retreating Laurentide ice sheet, also transmitting fluting information into the

Corridor. According to the shape analysis, however, while some Corridor points were assigned to the Great Lakes group, only 4% of Great Lakes points (n=1) were assigned to the Corridor, possibly suggesting unidirectional transmission. With this better understanding of content, i.e., favored morphological traits of northern late Paleoindian groups, we can explore this further in a discussion of the adaptive context for trait transmission.

Context: Ecology and Behavior

Paleoenvironmental Setting. Environmental context influences the type, distribution, and availability of floral, faunal, and lithic resources, as well as group-mobility strategies, setting the adaptive context that could host cultural transmission. Rising temperatures and fluctuations in effective moisture during the Bølling-Allerød interstadial (14.6-12.9 cal B.P.) led to reorganization of biomes across North America (Williams et al. 2004), and it was during this environmentally transitional period that fluted-point technology developed, most likely, south of the diminishing Cordilleran and Laurentide ice sheets (Holliday and Miller 2013; Ives et al. 2013; Smith 2010; Waters and Stafford 2007). In this context, fluting appears to have developed in a mosaic of open-spruce parkland, piñon-juniper woodlands, distinct riparian zones, and grasslands dominated by C4 grasses, ultimately supporting large grazers such as mammoth and bison (Ballenger 2010; Hall 2005; Haynes 1991; Mann and Meltzer 2007).

The post-Clovis proliferation of fluted-point technology accompanied the onset of the Younger Dryas (YD) chronozone (12,900-11,700 cal B.P.) and continued ecological reorganization (Strauss and Goebel 2011). In northern Yukon and northeast

Alaska, dwarf birch and high-tussock tundra had become abundant among patches of diminishing steppe, while more xeric herb communities existed in northwest Alaska (Anderson and Brubaker 1994; Eisner and Colinvaux 1990; Mann et al. 2002). Northern clades of bison still occupied the region (Shapiro et al. 2004; Mann et al. 2013), but caribou were better suited to the westward-edging tussock-tundra communities (Guthrie 1990; Klein 1996, 1999). Not surprisingly, the remains of such ungulates occur in the dated fluted-point assemblages at Serpentine and Raven Bluff in northwest Alaska (Goebel et al. 2013; Hedman 2010). Similar environments were present in the Ice-free Corridor, which, during the terminal Pleistocene, increasingly connected eastern Beringia to the Canadian interior, where shrub-sedge tundra met northward-shifting spruce forests and wetland lakes and marshes dotted the periglacial zone (Burns 2010; Dyke 2004; Guthrie 2006; Shapiro et al. 2004). Near the Great Lakes, open spruce parklands and pine woodlands were also bordered by periglacial shrub-tundra and sedge-filled wetlands attracting migratory caribou populations (Ellis et al. 2011; Holliday et al. 2002; Lothrop et al. 2011; Newby et al. 2005; Pelletier and Robinson 2005; Shuman et al. 2002; Swayze and McGhee 2011). Grassland expansion throughout the Plains, which supported bison populations and the development of Folsom fluting technology, was unlike the shrub-tundra of the North, and the temperate deciduous forests of the Midwest and Eastern U.S. were equally different (Anderson et al. 2011; Ballenger et al. 2011; Meltzer and Holliday 2010; Morrow and Morrow 1999; Williams et al. 2004). It is apparent that YD environmental reorganization across North America was variable in degree and schedule (Meltzer and Holliday 2010), and potentially influenced the diversification of Paleoindian fluted-point forms and adaptive behavior.

Behavioral Setting. While a coherent understanding of early Paleoindian social dynamics is impossible given the minimal archaeological record at our disposal, research on the technological organization of early groups provides some context for understanding the potential for transmittal of information (Perreault and Brantingham 2011). Recent investigations into NFC technological organization have identified the use and transport of high-quality lithic raw materials, often hundreds of km from geologic sources, as well as a logistical strategy embedded into long-distance seasonal rounds. Paleoindians in the mid-continent were also highly mobile, with range and organization decreasing through time from residential to more logistical strategies, and with fluted-point makers continuing to exploit high-quality lithic resources through embedded procurement strategies (Amick 1996; Anderson et al. 2011; Ellis 2008; Elston and Zeanah, 2002; Kelly and Todd 1988; MacDonald 1998). Subsistence pursuits across the continent generally focused on large mammals, with minimal evidence for intense plant processing (Bonnichsen et al. 1987; Gingerich 2011; Waguespack and Surovell 2003). This was especially the case in the north, where caribou and bison continued to serve as important prey for late Paleoindians (Cinq-Mars et al. 1991; Driver 1996; Haile et a. 2009; Ives et al. 2013; Mann et al. 2013; MacNeish 2000; Newby et al. 2005; Pelletier and Robinson 1995; Spies et al. 1998).

Consensus: The Potential for Information Transmission

The lack of overlap between Folsom and the NFC suggests that Clovis groups were in the Corridor before the development of Folsom. Environmentally, NFC, the Ice-free Corridor and Clovis groups occurred in similarly structured biomes supporting migrating herds of, at least, bison and caribou. Some Clovis groups, or descendent Clovis groups, appear to have dispersed into the shrub-tundra environments that formed during post-glacial recovery; the presence of these recovering landscapes "pulled" groups northward and beyond the Plains' grasslands (Anthony 1990). Bison, not caribou, however, occurred in the early deposit at Charlie Lake Cave, in the Corridor, and at Engigstciak, in northern Yukon; however, these bison clades were a genetically unique northern variety different from those hunted by Folsom groups in the south (Shapiro et al. 2004). Importantly, though, genetic investigations identified both northern and southern clades of bison at Charlie Lake Cave, demonstrating a connection between Arctic and southern populations (Shapiro et al. 2004; Wilson et al. 2009). An analogous process of bidirectional human movement and interaction is plausible.

Degree of group mobility and technological organization played an important role in the context of cultural transmission of fluted-point technology (Perreault and Brantingham 2011). Clovis groups were highly mobile and covered long distances across North America, evident in the caching of raw materials and tools hundreds of km from their lithic sources, as well as the continent-wide spread of this single point form within a few hundred years (Kelly and Todd 1988; Kilby 2008; Sholts et al. 2012; Waters and Stafford 2007). This level of mobility allowed Clovis groups to enact long-distance migrations into the northern Ice-free Corridor, too, during which foraging parties would have become familiar with the landscape in years prior to the arrival of dispersing groups. Conversely, groups in the Great Lakes are hypothesized to have decreased mobility by the onset of the Younger Dryas (Ellis 2008), lowering their behavioral potential to be a source population. Clovis-point morphology is present in the early deposits of the central Corridor suggesting that Clovis groups were likely the first to move into the region and transmit fluted-point technological information further north toward the Yukon and Alaska. Clovis fluted-point information was not transmitted to the North through Folsom or another late Paleoindian complex of temperate North America.

Thus, similarity in content and context between the NFC, Ice-free Corridor, and Clovis represents historical and adaptive relatedness. Based on the findings presented here, we can deduce the following conclusions:

- Fluted-point technology was not independently invented in the Far North, but was introduced via cultural transmission from the south.
- Different traits present in Clovis fluted-point technology were selected by human groups in different ecological settings, leading to regional variations in late Paleoindian projectile-point morphology and technology.
- NFC morphology and technology, originated proximately from the Ice-Free Corridor and ultimately from Clovis and not some other temperate North American late Paleoindian complex.

Technological characteristics associated with Clovis and post-Clovis basal morphology, then, were adaptively suited to ecological settings experienced in the Ice-free Corridor, encouraging their transmission farther north into northern Yukon and Alaska. Still unresolved, however, are whether discrete patterns in the variation of fluted-point technology can provide evidence of directional or disruptive change, or stabilization in traits (see Kuhn 2013; Lycett 2015), to investigate whether the NFC represents the *vertical transmission* of cultural traits northward via migration into Alaska, or, a mode of *biased transmission* of cultural traits from the Ice-free Corridor to an autochthonous northern population.

CHAPTER V

CONCLUSION

Shortly after the earliest discoveries of fluted-point technology associated with extinct megafauna occurred in the North American Plains, researchers began searching for fluted points in Alaska as evidence of the first peoples to cross the Bering Land Bridge from Northeast Asia. Results of this project confirm, however, that fluted points in eastern Beringia do not represent the ancestors of Clovis, nor do they represent a distinctly Arctic adaptation, but rather a northern expression of Paleoindian adaptation. Therefore, initial assessments of fluted-point technology in the North were not wholly inaccurate. The removal of long channel flakes from a biface's proximal edge parallel to the long axis continues to represent the archetypical characteristic of the first, widespread human adaptation to late Pleistocene and earliest Holocene ecology in the American continents and indicates such in the North as well. The results of this dissertation confirm that in the North, fluted-point technology can serve as a proxy in following the northward spread of this adaptation. While evidence of similarity between the Arctic bifacial industries and Paleoindians of the Plains (schedule-driven mobility, brief site use, subsistence focus on large mammals, and a reliance on bifacial technology) originated during investigations of the Mesa and Sluiceway complexes (Bever 2000; Kunz and Reanier 1994, 1995; Kunz et al. 2003; Rasic 2008, 2011), Alaskan fluted projectile points represent the first complex to be empirically associated with the Paleoindian tradition of the mid-continent (Bever 2006; Dixon 1993; Reanier 1995).

After more than 50 years of undated fluted-point discoveries in Alaska delayed comprehensive research of the adaptive role fluting technology played in the Arctic, the buried fluted-point component at the Serpentine fluted-point site, Bering Land Bridge National Preserve, Alaska, was found to contain charcoal associated with the fluted-points AMS-radiocarbon dated to approximately 12,400-12,000 calendar years before present. In Chapter II, results of metric and attribute-based analyses determined that, at this time, a hunter-gatherer group occupied the ridge at Serpentine Hot Springs and repaired broken fluted projectile-points. The technological organization represented by the lithic assemblage demonstrates that these early Beringian groups were moving great distances across northern Alaska and Yukon, as well as north and south of the Brooks Range. They likely practiced a logistical system of mobility, and Serpentine Hot Springs was one of an unknown number of stops in the annual rounds of this group. We do know that, in addition to Hot Spring resources on the Seward Peninsula, fluted-point groups visited predictable, or reliable, sources of toolstone in the western Brooks Range, which would have been seasonally available. This implies that northern groups were practicing schedule-driven mobility with significant depths of planning to safely traverse great distances over variable terrain.

Therefore, the adaptive role of northern fluted points, hypothesized in Chapter III, would have been particularly suitable for northern Paleoindian mobility schemes. In that chapter, technological and morphological analyses of northern fluted points, using a new approach to geometric morphometrics, confirmed that they represent a cohesive technological strategy and can be termed the Northern Fluted-point complex. Fluting, as a method used to thin the base of bifacial projectile points, was not found to represent a high-risk technological choice. This is suggested by evidence of the fluting procedure taking place at sites, such as Serpentine Hot Springs, which are far from sources of quality raw materials and consist of cultural components with low-artifact densities. Conversely, northern-fluted projectile weaponry is hypothesized to represent a risk-management strategy that served as a portable hunting weapon capable of lowering transport costs. This risk-management strategy can be described as ease-of-replacement-after-failure, ensuring that effective tools could be quickly recovered when high mobility meant maintenance costs were high, and was specifically facilitated by fluting the basal portion of projectile points. Fluting served not only to thin the base in preparation for the haft, which shaped the points' profile into a low-angle wedge, but remove raw material from the proximal edge resulting in a deep basal concavity that formed pronounced triangular corners, or ears. These characteristics worked to stabilize the point in a split-shaft and potentially required less supplies and effort to bind the point in the haft. Proximal fragments were found to be predominantly 20 mm long, and significantly less variable than Folsom point fragments, and increase in variability around mean width and thickness between 20 and 25 mm from the proximal edge, while Folsom points did not. This implies that different rejuvenation protocols were used in each technocomplex. While Folsom points were made to remain in the haft so that only the distal end needed to the resharpened or reshaped (Ahler and Geib 2000), NFC points may have been made to strategically break at approximately 20 mm from the base, while the thicker, more durable, distal piece remained intact. Evidence presented in Chapter II confirmed that early Arctic Paleoindians were fluting bifaces at Serpentine, many of which were likely bifacial preforms. However, the distal ends that became separated from their fluted bases would have also served as preforms ready to be rebased and reinserted into split-shafts with minimum effort needed to stabilize the point in the haft with excess binding material.

Similar hypotheses, in addition to an array of others, have been formulated to explain the use of fluted-point technology across the Western Hemisphere. While this particular hypothesized strategy may have been confined to the Arctic, other adaptive characteristics were reportedly shared between the NFC and Paleoindian groups from the mid-continent in Chapter IV. Geometric morphometric analysis of fluted projectile-point basal shape representing points from the NFC, Ice-free Corridor, Great Lakes, Northeast, Folsom and Clovis identified significant variability in shape characteristics throughout the continent. The greatest morphological affinity was found between the NFC, fifteen Ice-free Corridor points, and Clovis, suggesting that NFC was not independently invented in the North, but was transmitted northward by Clovis groups, initially to the Ice-free Corridor, and proximally to northern Yukon and Alaska. These three groups shared a similar adaptive context that included a similar mosaic of shrub and steppe-tundra biomes, a subsistence focus on large grazing mammals, and, at least between Clovis and the NFC, high levels of group mobility. Dominant NFC technological traits, identified in Chapter III, were found in the highest frequencies in the Ice-free Corridor subsample and Clovis groups, but were present in lesser and variable frequencies in all fluted-point complexes; which suggests that traits present in Clovis fluted-point technology were selected by human groups in different ecological settings, leading to regional variations in late Paleoindian projectile-point morphology and technology.

The implication that fluted-point technological was developed as an adaptation to a specific ecosystem, which was, in particularly, similar to that in the Ice-free Corridor and northern Alaska and Yukon, presents a role for northern fluted-points in the greater context of the peopling of the Americas. To reiterate, the transmission northward from a Clovis antecedent group was associated with the shrub/steppe-tundra biome, which appeared in the Southern Plains and Southwest during the environmental reorganization of the Allerød interstadial in North America. This biotic structure was also associated with the peri-glacial zone in the Ice-free Corridor during the Younger Dryas, and may have also existed near the peri-glacial zone along the southern edge of the Cordilleran and Laurentide ice-sheets during the Bølling interstadial. This time period corresponds to some of the earliest hypothesized, non-fluted-point, sites in the New World, currently referred to as pre-Clovis (Waters et al. 2015). There, proximity to the peri-glacial zone and proclivity for large, now extinct, grazing megafauna may imply an adaptation to shrub- and steppe- tundra biomes amongst open-forest habitats. Moreover, recent genetic evidence has confirmed that direct ancestry of the earliest American occupants was in Northeast Asian groups who lived in South-central Siberia throughout the LGM (Raghaven et al. 2014; Rasmussen et al. 2014) in a mosaic landscape of tundra-steppes, meadow-steppes and forest-steppes (Khenzykhenova 2008). Such correlation in biota suggests that, while the NFC complex cannot provide evidence of a route taken by Clovis ancestors to reach mid-continent North America, it can potentially inform on the adaptive context of the First Americans.

The results of this dissertation project, however, conclude that the Northern Fluted-point complex represents a cohesive technology made exclusively from high-quality raw materials that were transported long distances across northern Alaska and Yukon. Therefore, these early Arctic groups practiced a subsistence strategy that included high and schedule-driven mobility, potentially organized into seasonal rounds. The evidence from Serpentine Hot Springs suggests that the occupation there represents a field-camp that served as part of a larger logistical system. Morphologically and technologically, fluted-point use in the North was not highly risky, but functioned as part of a risk-management system that reduced technological costs at their level of mobility. Northern fluted points were not an independent Arctic invention or the ancestors of the earliest groups using fluted points in the New World, but ultimately, represent the northernmost expression of early Paleoindian adaptation in the Western Hemisphere.

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APPENDIX A

THE FLUTED-POINT ASSEMBLAGE FROM SERPENTINE HOT SPRINGS: ARTIFACT DESCRIPTIONS

The Fluted-Point Collection

Details on the fluted points are provided here because until now, no clear fluted-point assemblage from a dated context has been presented. Seven fluted-point fragments occur in the Serpentine assemblage. Four were found *in situ*; three were found on the site's surface. Measurements of length, width, and thickness are presented in Table 1 on the main text. Evidence of hafting, such as edge grinding, breakage patterns, and other morphological indications suggest that these tools functioned as projectile points. Corresponding figures are located in the main text.

BELA-30104. This bifacial fluted-point base is made from maroon-colored chert (5YR 2/2) and was found on the ground surface by NPS archaeologists in 2005 (Figure 2.4a). Artifact damage consists of a transverse snap that removed the distal half of the point. Three channel-flake (flute) scars are visible on each face, and fine bifacial pressure flaking along the lateral edges and base occurred after the artifact was fluted. The degree of ripple curvatures within the flute scars and the shape of the flute scars on the obverse face (left) suggest that these channel-flake removals likely originated near the present location of the basal cavity, although the proximal ends of the flute scars are obscured by retouch. Flute scars on the reverse face (right) are wider at the basal cavity, and ripples have less curvature that those on the obverse face, suggesting that the reverse face's channel flakes were removed prior to those on the obverse. The proximal ends of the reverse face's flutes are also obscured by retouch. On both faces, center flute scars appear to have been removed last, after creation of the two lateral flutes. Terminations of all six flutes are missing. The base is V-shaped with a concavity depth of 4.12 mm. Lateral edges are straight and imply that the point may have been lanceolate in planview earlier in its uselife. The lateral edges and basal concavity are lightly edge-ground suggesting that the piece was hafted, although the basal left corner is minimally damaged, or retouched, which removed some of the ground edge. There is no notable polish on the arises of either face. No impact scars are present on the transverse snap, which caused the distal break; breakage could have occurred as a result of either impact or rejuvenation. No flaking is evident on the broken edges, suggesting rejuvenation was not attempted after the break occurred, and no trampling occurred after discard.

BELA-38789/BELA-38788. This fluted-point base consists of two fragments, a primary basal fragment (*BELA*-38789) and spall (*BELA*-38788) that removed a portion of the surface from the reverse face (Figure 2.4b, right). The distal break consists of a transverse fracture that is at a 45° angle to the long axis. The fragments were recovered *in situ* during excavations in 2010, associated with Feature A in the south block, and were articulated in the ground suggesting the artifact has remained in primary context since burial. The fragment is made from a bluish-gray, translucent chert (Munsell color N4), although the material is opaque-black within the spall fracture. There are three channel-flake scars on each face, and their distal terminations were truncated by a distal break. On both faces, the two lateral flutes appear to have been removed first, followed by removal of the center flutes. Flutes on the reverse face are very wide at the basal cavity and have a low degree of ripple curvature relative to those on the obverse face, suggesting that these channel flakes were removed prior to those on the obverse. The point is fluted across the entire face, and fine pressure flaking was used to retouch the lateral edges and base after the channel flakes were removed, except for the center flute of the obverse face, whose original platform appears to have been at the apex of the basal cavity and lacks any retouch after its removal. Therefore, this flute was the last to be implemented and may represent thinning during episodes of rejuvenation later in use-life. The point has a V-shaped basal concavity that is 7.02 mm deep. Straight, lateral edges are lightly ground or abraded and refined by fine pressure flaking that removed flake arises along the lateral edges. Lateral edge angles are between 70-80° in the fluted area of the base. Edge grinding ceases before the distal break, suggesting the extent of haft binding. Within the basal concavity, only one-half of the edge is ground. There are no signs of aris-polish on either face. Straight lateral edges suggest that the point was lanceolate in planview earlier in its use-life. Although the distal break is at an angle rather than perpendicular to the long-axis, ripple marks in the break suggest a snap resulting from a bending fracture, and there are no complementary longitudinal macrofractures confirming impact damage (see Dockall 1997). No flaking is evident on the broken edges, suggesting rejuvenation was not attempted after this break, and no trampling occurred after discard. The lateral edges appear to twist in profile implying that a flake may have served as the original blank during initial stages of manufacture (see Pitblado 2003).

BELA-50298. This fluted-point base was recovered *in situ* during excavations in 2011 and was associated with Feature D (Figure 2.4c) (correction to Goebel et al. 2013:Figure 6a). The fragment is made from brown chalcedony (10YR 2/2) and suffered a transverse snap that removed the distal end. There is an impact scar that hinges from the distal break and terminates in a step-fracture on the obverse face (Figure 2.4c, left). A raw-material flaw is visible on the reverse face (right-center) at the break suggesting a weakness in the stone that may have prompted a fracture. There are three channel-flake removals that thin the entirety of each face; however, the left flute on the obverse face is greatly obscured by lateral retouch. The left margin of the obverse face is relatively sinuous, and invasive lateral retouch suggests more recent rejuvenation. The fluting pattern on each face appears to be skewed to the left (observation left), and basal retouch is more invasive in the concavity's right interior causing the base to be slightly beveled. The right lateral flute on the obverse face is wider than the center flute and has a lower degree of ripple curvature, suggesting that it was created earlier in the tool's use-life than the center flute of this face, the production energy of which skirted around the right flute's left aris. Chip removals along the aris between these two flutes suggest there was a need to reduce this contact and level the surface topography of the face. All three flute scars on the reverse face are wider, seemingly more uniform, and have lower degrees of ripple curvature relative to flutes on the obverse face, suggesting that this face was thinned first. On both faces, lateral flutes were removed first, followed by the removal of the center flute. Fine pressure flaking occured on all edges post-fluting. Overall, the basal concavity is V-shaped, although the interior edge of the basal ears is slightly convex, not straight as in the other fluted fragments, and it indents 6.03 mm from the corner tips. In planview, the lateral edges are straight for 10-12 mm from the proximal edge but expand slightly as they approach the distal break. Heavy grinding occurs along both lateral and basal edges, with the exception of the small area in the apex of the basal concavity. Edge-polish is also visible in some areas providing further evidence of its hafting. Grinding of the lateral edges ceases where they begin to expand near the distal break, although beyond this point they were refined by removing flake arises along the edge. The edges, however, are somewhat sinuous compared to the other fluted-point fragments, suggesting recent rejuvenation prior to the last episode of edge refinement. Thickness and slight curvature in the point’s profile suggest that the original blank may have been a spall.

BELA-49913. This chert fluted-point proximal fragment was associated with Feature C (correction to Goebel et al. 2013: Figure 6), and was found in a vertical position at the soliflucted contact of strata 2 and 1 (Figure 2.4d). Raw material is beige to tawny in color (5Y 6/1 fades to 5YR 6/4) and has a series of striations that cross each other diagonally on each face. These flaws create weak points in the raw material, and flake scars, including channel-flake removals, terminate at these striations. The distal snap also occurred along one of these planes. There are three flute scars on each face. The center flute on the obverse face (left) was forced to skirt around and then terminate at one of the more pronounced diagonal striations. The flutes on the obverse face have a fairly high angle-of-ripple curvature at their proximal ends, suggesting that they were made earlier in the tool's uselife. Channel scars on the reverse face (right) are straight and fairly uniform, and large flute widths and angle-of-ripple curvatures suggest that this face was not re-fluted during more recent episodes of rejuvenation. The flute scars on the reverse face terminate in a step-fracture below a large protrusion of raw material that prevented the face from being completely thinned. Random pressure-flaking scars originate at the top left of the obverse face and travel along the protrusion, suggesting that a struggle to remove it may have resulted in accidental breakage of the tool. Lateral flutes appear to have been made prior to the center flute removals on each face. The basal concavity is V-shaped and indents 4.34 mm from the proximal tips. Both basal ears are broken; however, the right ear of the obverse face (left) has fine flaking around it from a potential attempt to rejuvenate the base. The left basal tip of the obverse face has a small impact fracture that hinges from the break and terminates in a tiny step. Lateral edges are convex in planview and very straight in profile. The point was likely lanceolate in planview when functional. The left lateral margin of the obverse face is more sinuous than the right, and scarring appears more recent on the left lateral margin. Edge trimming in the form of fine pressure flakes is present on both lateral and basal edges and occurred post-fluting. No edge-grinding is present along the lateral edges or basal cavity. This piece was once likely hafted and functioned as a projectile point; however, flake scars not followed by edge refinement and grinding suggest that the artifact underwent a last attempt at rejuvenation prior to discard.

BELA-34172. This fluted-point fragment is made from gray chert (N4) and was recovered from the site's surface in 2009 (Figure 2.4e). Chert color is lighter on the obverse face (left), suggesting patination from surface exposure. A transverse snap hinges over into a longitudinal macrofracture that terminates in a step 5 mm down the reverse face (right). There is only a single flute that stretches up the medial axis on the obverse face, the proximal end of which is obscured by basal retouch. Two smaller scars flank the proximal end of the medial flute, both of which are truncated and partially covered by invasive lateral flaking. Wide ripple curvatures in these scars suggest that these may represent quite older flutes that served to thin a basal portion that is now missing. Lateral edges are straight in both planview and profile, and lateral flake scars, while suggestive of pressure retouch, appear less refined than those of other fluted fragments in the collection. Metrically, they are larger overall, especially where they meet the lateral edge, and form intervals that are less regular and evenly spaced than those visible on the other fluted basal fragments which laterally truncate flute scars. Lateral edges are not fully edge-ground, but arises between lateral flaking scars have been removed. No lateral retouch occurred after the single flute was created. The only grinding present is in two small areas on the right lateral margin near the distal break and just before the basal tip. This fragment is flat across the base with no indentation. Basal retouch has formed a beveled edge that angles toward the reverse face. Flake scars on the reverse face demonstrate a manufacturing strategy where pressure flaking along the lateral margins meets at the mid-line to form a medial ridge along the axis of the point. The left corner is missing and a flake scar bends around the corner and terminates in a step suggesting possible impact damage or manufacture failure. Furthermore, two possible impact fractures and lack of edge grinding suggest that this artifact may represent a distal fragment of a once-functioning projectile point that was discarded during an attempt to rebase it.

BELA-34108. This artifact is a fluted-point medial fragment recovered from the site's surface in 2009 (Figure 2.4f). The piece is made from brown chalcedony (10YR 2/2). Parallel fracture planes travel horizontally through the point, and the distal break occurred along one of these planes. As a result, the edge of the distal break is jagged like the fracture planes. The break at the proximal end of the fragment shows evidence of two different points of impact suggesting that a transverse snap may have occurred on initial impact, and that the fragment suffered further damage while still within the haft. The left half of the obverse face (left) is dramatically thicker than the right. This left edge of the obverse face is well ground, whereas only intermittent grinding on the right edge suggests that it underwent more recent retouch. There are three flute scars on the obverse face and two on the reverse face (right), and marginal retouch occurred after fluting only on the obverse face, suggesting that channel-flake removals on the reverse face may have been created after those on the obverse.

BELA-34230. This fluted-point corner fragment is made of greenish-gray chert (5G 4/1) and was recovered *in situ* in association with Feature B in 2009 (Figure 2.4g). Two vertical flake scars on the obverse face (left) are likely what remains of fluting scars or fairly invasive basal thinning scars. Two definite channel-flake removals, the left lateral flute and half of the center flute, are present on the reverse face (right). What is preserved of the basal concavity is V-shaped, although the interior edge is slightly concave and demonstrates a concavity no less that 5.3 mm deep. Tiny pressure flaking is present along the lateral and basal edges that occurred after the original point was fluted. Both edges are also ground. Tiny micro-chipping is present on the interior of the lateral break and likely represents fragments crushing against each other during breakage while still in the haft.

Other Hafted Biface Fragments

Three distinctive biface fragments are also in the assemblage and require detailed description. Two are basal fragments of bifaces that are distinctly more robust than any of the fluted points in terms of width, thickness, and flake-scar size, and the third is a distal fragment of a biface which may represent a fluted point broken during manufacture. Table 1 presents the metrics of these artifacts.

BELA-39071. The robust biface fragment was recovered in association with Feature C (Figure 2.5a). It is made from a bluish-gray chert (~5B 5/1 and fades into 5GY 2/1) with dark gray to black striations. Lateral flaking consists of mainly percussion scars, some of which reach across the face of the artifact. These create an irregular pattern yet preserve a plano-convex cross-section that may indicate that manufacture began with a large spall. Clusters of pressure flake scars intermittently placed along the lateral edges are also present. Lateral edges are shaped into slightly convex outlines but not refined or edge ground. Likewise, the proximal edge is convex and neither basally thinned nor ground. The distal break is a transverse snap that is at a slight angle. There is no obvious impact fracture except for a small scar that hinges off the distal break and terminates in a step 2.5 mm down the reverse face (right). A quarter of the right lateral margin of the obverse face (left) is missing and appears to have snapped off along a natural vein in the raw material.

BELA-39130. The second of two similar chert biface proximal fragments is made from gray chert (N4) (Figure 2.5b). Lateral flaking consists mostly of percussion removals that meet at the midline of the artifact but create an irregular (not straight) mid-line ridge. In places along the lateral edges, these are followed by irregular clusters of pressure-flake removals that do not refine the entire edge of either lateral margin. There is some edge-grinding present on the lateral margins located in the medial area, but the proximal and basal margins of the artifact are not edge-ground. The proximal end, or base, of the artifact is rounded and convex and bears no evidence of basal thinning. The distal break may have resulted from impact creating a longitudinal macrofracture that hinged over the distal edge. It has very pronounced radial fissures and a series of dramatically acute ripples, and terminates in a step fracture 11.13 mm down the obverse face (left). The artifact appears to have been discarded with a significant amount of raw material still available for rejuvenation. The presence of lateral edge-grinding suggests it may have been hafted; however, the location of grinding suggests that it was either not hafted in the same fashion as the fluted points or that all proximal grinding was removed during retouch prior to discard.

BELA-49902. This green chert (5Y 3/2) projectile-point distal fragment was recovered in association with Feature C (Figure 2.5c). The proximal break is a hinge termination that resulted from an overshot fluting failure (see Frison and Bradley 1980;

Gryba 1988). A series of pressure-flake removals shaped the lateral edges; however, these are wider and more invasive than the fine pressure retouch that is present on the fluted basal fragments. Resulting edges are sharp, neither ground nor finely retouched, and fairly straight in profile, yet they remain somewhat sinuous, similar to the flaking around the lateral edges of point *BELA*-34172. Overall, lateral flake scars meet at the midline of both faces, creating a medial ridge and lenticular cross-section. The distal point is not finished, and a series of steppe terminations and a bulb of excess raw material just below the tip suggest that the piece was discarded prior to the final stage of production. Significantly, two similar distal fragments with obvious hinge fractures from failed fluting attempts were recovered on the site's surface.

Additional Biface Fragments

Thirteen additional biface fragments occur in the buried assemblage (Figure 2.5d-g). Ten on cherts of various colors: gray (5GY 4/1), dark-gray (5Y 4/1), light-gray translucent with gray striations (5B 5/1 with N2 striations), opaque brown in darker and lighter shades (~5Y 4/1), brownish gray (N3), red (5YR 3/2), and green (5YR 3/2) to black (N4), as well as yellowish chalcedony (10YR 4/2) and gray obsidian (10YR 2/2). Four are bifacial corner fragments (e.g., Figure 2.5e), similar in morphology to point 34230. These corner fragments could be portions of concave bases, but the question remains whether their basal flake scars represent channel-flake removals. Only one of these fragments is edge-ground. Likely they represent fragmented points carried back to the site within hafts and then discarded when removed from binding. Eight fragments are biface-edge fragments that range from 7.94 to 25.52 mm long, 3.43 to 22.32 mm, wide and 3 to 8.94 mm thick (e.g., Figure 2.5f-g). Five of these have some edge grinding suggesting they too were components of the hafted portions of functioning projectile points. Although they are deficient in diagnostic characteristics, sizes and regularity of lateral flake scars, and thicknesses of the fragments suggest that they were once part of late-stage or even hafted bifaces.

Unifacial Tools

Thirty-five unifaces are in the buried assemblage, 29 of which are utilized flakes.

BELA-49896. This artifact is a double-spurred graver made from yellowish chalcedony (10YR 4/2) recovered in association with Feature C (Figure 2.5h). It measures 9.69 x 13.63 mm and is 2.5 mm thick. The tool appears to be manufactured from a flake fragment; however its platform is missing. Marginal retouch in the form of pressure flaking occurs along the entire distal perimeter and was used to isolate two spurs.

Cobble Tools

BELA-34548, BELA-50359, BELA-50046, and BELA-50544. Four tools are made from local raw materials, three from gneiss and one from diabase, and represent expedient artifacts found at Serpentine (Figure 2.6). Two were recovered from Feature D, one (diabase) from a test pit east of the excavation (N502 E506), and one from Feature A. The artifacts are classified as plano-convex cobble tools (following Goebel et al. 1991:56). Irregular percussion flaking on the dorsal face suggests that the original cobbles could have served as cores. Smooth cortex consistently remains on the ventral face, which meets very steep stepping on the dorsal face. These are the result of gouged flake removals that originate on the ventral face and form the working edge. Metrically, the cobble tools are between 60.52 x 134.62 mm and 33.84 x 94.61 mm in length and width, and between 33.46 and 59.63 mm in maximum thickness. It is uncertain whether these artifacts served as planes or cores, but none of the flakes in the debitage collection made of these raw materials have evidence of retouching, suggesting they did not serve as cores. There is no evidence of hafting wear on these artifacts.

A single amorphous piece of white quartz (BELA-*50540*) reminiscent of the type eroding from the granite tors was also found. Flakes appear to have been removed from this piece; however, there is no directionality to the scarring, or identifiable fronts or platforms. As a result the item can only be described as culturally modified.

Utilized Flakes

Twenty-nine utilized flakes are present in the collection, all of which are made on high-quality fine-grained toolstone. Evidence of expedient use consists of scarring patterns described as use-wear or marginal nibbling visible with a 10x hand lens. On 25 utilized flakes, this wear was present along one margin of the distal end. On four, it occurred along one lateral margin.

Collection Associated with Feature E

Tools from this concentration include one brown chert core tablet, which appears to represent a conical bladelet core, and a yellow chalcedony biface fragment. Five proximal fragments interpreted as microblades occur, too, four on the same brown chert as the core tablet and a fifth on translucent-gray chert. Two medial microblade fragments and two proximal bladelet fragments are also made on brown chert. The remaining debitage includes biface-thinning flakes, blade-like flake fragments, and a cortical spall.

APPENDIX B

NORTHERN FLUTED-POINT REDUCTION CONTINUUM

There are no early- or middle-stage bifaces in the assemblage from Serpentine; therefore, blank form is difficult to assess. The extreme thinness of the fluted-point fragments, and a few instances of curvature present on some fragments, however, suggest that fluted-point manufacture began with flake blanks. Collections from fluted-point localities at Batza Téna include a variety of amorphous flake cores and large flake blanks that exceed the minimum metric requirements for the fragmentary forms from Serpentine (personal observation; see also Clark and Clark 1980).

Regularly spaced flake-scar patterns (5-10 mm in scar width) visible on fragments BELA-34172 and BELA-49902 suggest that to-the-mid-line flake removals, using anything from hard-hammer billet direct percussion to antler-tine indirect-percussion, were used to initially shape toolstones into lanceolate forms (see Pelegrin and Inizan 2013). The points from Serpentine suggest that fluting was used to thin not only the medial axis of the point base, but also the entire face from edge to edge, which resulted in a flat lateral edge, perpendicular to the point face. Typically, more than three flutes were removed from each face. It appears that a medial flute was removed first, as suggested by the primary channel flakes at the site. Next, two lateral flutes were removed from either side of the initial removal, to both thin the entire face and remove arises left by the first flute. This step resulted in a variety of secondary channel flakes. A second medial flute was then removed to possibly smooth the medial arises left by the interior edges of the lateral flutes. This second medial flute overlaps the lateral flutes on almost every point fragment, and could not have produced flakes with dorsal-scar patterns like those visible on the primary channel flakes. The channel flake that resulted from this removal could represent a tertiary channel flake with two parallel ridges on the dorsal face (see Plumet and Lebel 1997). This flake is difficult to identify, as it would not have distinct lateral flaking as earlier channel flakes and would be trapezoidal in profile. These attributes, in addition to a platform shape that is similar to flakes removed from an isolated complex platform, are present on "microblade" BELA-34398; therefore, there is potential for this microblade to actually be a tertiary channel flake. Remnants of previous flute removals are still apparent on the point fragments, suggesting that these pieces were repeatedly fluted during rejuvenation attempts or basic finishing protocol.

As more flutes were imposed on the points, creation and removal of the channel-flake platforms resulted in repeated raw-material removal from the base, deepening the cavity, which was in turn retouched and specifically shaped into an inverted 'V' with straight edges. Basal concavity depths on the three excavated fragments are 4.34, 6.03, and 7.02 mm, and 4.12 on the surface find (BELA-30104). Except for one fragment—fine-pressure retouch along both lateral margins and within the basal concavity took place after fluting on each of the fluted-point bases.

APPENDIX C

GEOMETRIC MORPHOMETRIC METHOD

A New Approach to Geometric Morphometrics

Specimen Imaging. Original digital photographs were taken of all tools and casts, even for tools with published images, to minimize variation by standardizing camera angle and artifact orientation. Specimens were photographed at high (16.2 megapixel) resolution at focal lengths to fit specimens in frame. The camera was fixed to a copy stand with the lens normal to specimens placed on a light table, which provided high contrast silhouettes of the artifact relative to the background. If necessary image contrast was increased using graphics software (Adobe Photoshop version CS5). Artifact outlines were digitized from images using tpsDig software (Rohlf 2008a).

Obtaining basal-shape outline coordinates. The use of only basal fragments posed a new challenge to outline evaluation using a landmark-based approach to geometry. Previous analyses of outline shape using landmarks were limited to whole artifacts with three major landmarks—the distal tip and two basal corners—which served as homologous landmarks in Procrustes superimposition to align specimens horizontally along the an X-axis in a Cartesian coordinate system (Buchanan 2006; Buchanan and Collard 2007, 2010; Buchanan et al. 2011; Gonzalez-Jose and Charlin 2012; Smith 2010; Smith et al. 2014; Thulman 2012). Procrustes superimposition rotates, aligns, and centers each configuration of an artifact's landmark data in a common coordinate system to facilitate geometric morphometric analysis and remove nuisance variation that results from differences in artifact orientation, location, and scale in the original photographs, or scans (Bookstein 1991; Rohlf and Slice 1990; Zelditch et al. 2004).

Without the distal end to serve as the third uniform landmark to align the data in Procrustes superimposition, basal fragments must instead be aligned along the X-axis by a different means. I accomplished this by digitizing tools positioned horizontally with basal margin to the left in digital photographs with tpsDig2 (v. 2.12) to place a constellation of semi-landmarks along each artifact's perimeter (Rohlf 2008a). To incorporate basal fragments in this analysis, a series of adjacent semi-landmarks consisted of approximately 500 to over 5000 points, depending on the size of the artifact, were first assigned to the perimeter of each artifact, positioned horizontally with proximal area left, in standardized digitial photographs in tpsDig2 to form a constellation of semi-landmarks (Rohlf 2008a) (all original photographs were used in this analysis to ensure quality and uniformity and taken perpendicular to point planview with a Nikon D5100). Semi-landmarks placed along the distal break were then deleted so that shape information describing the distal end was uniform and analyses of variability would only describe information from the proximal end.

To produce horizontal alignment of the broken outlines, I performed a sequential balancing procedure as follows. First, a regression line was fit to the semi-landmarks assigned to the top lateral margin. Outlines were then rotated to the regression angle to achieve a more horizontal position. The regression angles of the top and bottom lateral margins were then calculated and the outline was rotated to the average angle. We found that two rotations was enough to produce homogeneous slopes for the lateral edges, so that further iterations of rotation made only vanishingly small differences in final outline orientations.

The coordinate constellations were then used to locate the proximal-most point on the lateral margins of each artifact, which also served as the basal corner landmarks and the lateral limits of the basal margin. The proximal-most point on the lateral margin was located by rotating the tool outline 45 degrees clockwise and locating the coordinate with highest y-value. Outlines were then rotated 90 degrees counter-clockwise to locate the coordinate with lowest y-value.

To standardize the length of the top and bottom lateral edges, the outlines were restricted to 13 mm FPE and points in excess of this were deleted. Therefore, in effect, the variability in slope of each artifact's lateral margin, either expanding from or contracting toward the x-axis is minimized. Original landmark constellations were then reduced to a suite of 120 type II semi-landmarks that consisted outlines made of 30 equidistant type II semi-landmarks assigned to each lateral margin, and 60 equidistant type II semi-landmarks assigned to the basal margin. The resulting semi-landmark density was more than sufficiently saturated to capture tool shape differences. The excess of shape information was reduced by calculating principal components and discarding minor and null vectors.

A landmark-based approach was desired in this analysis because it allows the analyst to define the location of each landmark to be compared to the mean location its corresponding landmark on each artifact in the sample. For example, while no mechanically meaningful positions are identifiable along the lateral margin of projectile points in this sample, important variance in lateral margin shape was recorded by placing a uniform number of equidistant landmarks between the topologically proximal- and distal-most points on the lateral margins. The location and number of each landmark is discrete in that each represents a location that explains shape at a relative percentage of the length of the margin from the uniform topological position on each specimen (e.g. point #10 counting towards the distal represents 33.33% of the lateral margin) and corresponds to a point at the same location (33.33% of the lateral margin) on all comparative specimens resulting in equal proportional intervals. This method is preferred to sliding semi-landmarks, where landmark positions are adjusted to match the positions of corresponding landmarks on a reference specimen and in the case of a curve, may result in landmark-placement error (Adams et al. 2004). This analysis takes specific advantage of the equidistant placement of semi-landmarks to describe the curve of an artifact's margin.

Procrustes Superimposition. Generalized Least Squares Procrustes Superimposition (Generalized Procrustes Analysis) was conducted in tpsRelw (Rohlf 2008b) to superimpose the constellations of corresponding semi-landmarks (Rohlf and Slice 1990), which translates each semi-landmark constellation to the same centroid, scales each constellation to the same centroid size, and iteratively rotates each constellation until the summed squared distances between the semi-landmarks and mean semi-landmark position is minimized (Bookstein 1991; Mitteroecker et al. 2013; Rohlf 1999; Slice et al. 1996). Superimposed semi-landmark constellations (Procrustes shape coordinates) were used to measure variability in shape between each constellation (approximated by the Euclidean distance between the superimposed semi-landmarks), and projected onto a deformation grids to generate relative warps for visualization (see Bookstein 1991) and subjected to principal components analysis and resulting PC scores summarizing >90% of total variation were used to represent shape of the basal fragments (Adams et al. 2004, 2013; Bookstein 1991; Mitteroecker et al. 2013). Centroid size, calculated during Generalized Procrustes Analysis (the square root of the summed squared distances between all landmarks to their common centroid), is uncorrelated with shape and serves as an ideal size variable for use in multivariate analysis as it can be set as an independent variable to analyze Shape, independent of size, and as a dependent variable for analyses of Form, simultaneous observation of both size and shape (Bookstein 1991; Smith 2010; Smith et al. 2014).