From the Yenisei to the Yukon

Interpreting Lithic Assemblage Variability in Late Pleistocene/Early Holocene Beringia

Edited by Ted Goebel and Ian Buvit

Texas A&M University Press • College Station

First edition

This paper meets the requirements of ANSI/NISO Z39.48-1992 (Permanence of Paper).

Binding materials have been chosen for durability.
∞ ♻

Library of Congress Cataloging-in-Publication Data

<CIP to come>

16. Gaining Momentum

Late Pleistocene and Early Holocene Archaeological Obsidian Source Studies in Interior and Northeastern Beringia

JOSHUA D. REUTHER, NATALIA S. SLOBODINA, JEFF RASIC, JOHN P. COOK, AND ROBERT J. SPEAKMAN

For decades archaeologists have recognized the remarkable value of obsidian for understanding human mobility, migration, exchange networks, and differential access to sources (e.g., Carlson 1994; Close 1999; Eerkens et al. 2007, 2008; Glascock 2002; Renfrew 1969; Shackley 2005). The community of archaeologists who perform and support obsidian provenance studies continues to grow worldwide. Within a region, obsidian research can be conceived of as progressing through a series of stages. The initial stage typically involves the identification, documentation, and characterization of geological sources and the identification of obsidian by sources within archaeological assemblages. The second stage of research tests ideas about human behavior or cultural processes.

Obsidian research in eastern Beringia has had a long history and is at the cusp of the second stage of research. We now know of six geological sources of obsidian that were utilized by prehistoric populations in eastern Beringia,[1] but the chemical signatures for numerous other groups of obsidian with unknown source locations are currently represented by only a few (or a few dozen) archaeological samples each. Despite these limitations, recent research has generated a large database of samples among which patterns can be identified.

In this chapter, we describe the current state of knowledge about obsidian in late Pleistocene and early Holocene archaeological contexts in eastern Beringia, using data derived from the Alaska Archaeological Obsidian Database (AAOD). Our geographic focus is restricted to the northern and interior regions of Alaska and the Yukon.[2] On the basis of this information, we frame a set of proposals about the transport and use of obsidian for the production of flaked-stone tools. There is little agreement among researchers about the causes of variation among lithic assemblages in eastern Beringia during this interval. Some describe discrete and considerable variation (Bever 2001; Hoffecker and Elias 2007; Kunz et al. 2003), whereas others see substantial continuity among late Pleistocene assemblages (Holmes 2001; West 1996). There is not only a lack of consensus concerning the causes of interassemblage variation but also a lack of agreement on how variation is (or can be) measured. Certainly there is no simple answer or single cause. One set of variables that is recognized as having an important influence on lithic assemblage content, however, is that which relates to lithic raw materials.

A discussion of variability among lithic technologies must address such fundamental issues in the organization of technologies (sensu Nelson 1991) as landscape knowledge (e.g., geological sources), access to and acquisition of raw materials, raw material package size and shape, and mechanisms available for transporting and distributing goods (e.g., trade and exchange, water transport, canine traction, pedestrian movement). The strategies people used to procure raw materials and the design, transport, and maintenance of stone tools are important factors that condition variation in lithic assemblages. In turn, these strategies are strongly influenced by the character and distribution of lithic raw materials (Andrefsky 1994a, 1994b; Bamforth 1990; Kuhn 1991, 1995). From this perspective, obsidian studies can provide unique insights into prehistoric technological and land use systems, since obsidian is available in relatively restricted geological areas, can be pinpointed with geochemical analyses to precise geographic locations, and is of relatively uniform flintknapping quality.

A Brief History of Obsidian-Sourcing Research in Eastern Beringia

This short history of obsidian-sourcing studies in eastern Beringia focuses on geochemical analyses conducted on samples from archaeological sites and geological sources located in interior and northern regions. Several equally important archaeological and geological studies of obsidian sources for coastal Alaska and British Columbia, including Carlson (1994), Erlandson et al. (1992), Moss and Erlandson (2001), and Nelson et al. (1975), have been published since the 1970s, but these are outside the scope of our research.

Provenance studies of eastern Beringian archaeological obsidian using geochemical analytical techniques began in the late 1960s. Early on, Cook (1969) and Griffin et al. (1969) began using neutron activation analysis (NAA) to characterize obsidian artifacts recovered from Alaskan archaeological sites, such as Healy Lake and Onion Portage. These two studies used ratios of sodium to manganese to discriminate among potential sources. Griffin et al. (1969) defined four geochemical varieties (A–D) of obsidian based an analysis of 103 artifacts recovered from eleven different locales/sites in northwestern Alaska, including artifacts excavated from the Onion Portage site by Giddings (1962).[3] However, they were unable to assign the Onion Portage artifacts to any of the geological sources known to them at that time.

Cook (1969:75–79) submitted several artifacts and geological source samples to the University of Michigan for NAA. The Village and Garden sites situated on the shores of Healy Lake were among those included in this research. Several of the samples from these two sites matched Griffin et al.'s geochemical varieties A and B. Based on these data, Cook (1969:78) argued that the two chemical groups indicated the existence of two different groups of people, potential trade relations between Onion Portage and Healy Lake populations, or both.

In 1970, Patton and Miller (1970) submitted to Griffin nine geological source samples from a bedrock outcrop situated on Indian Mountain, located along the Indian River, a tributary of the Koyukuk River. A majority of the artifacts analyzed by Griffin et al. (1969) fell within the range of the chemical composition of the samples submitted by Patton and Miller (1970), indicating that the Indian River source materials were used by the occupants of Onion Portage.

In the 1970s, Clark (1972) and McFadyen Clark began an extensive geological and archaeological survey of the region surrounding the Indian Mountain obsidian source (see Clark and McFadyen Clark [1993] for the comprehensive description of their research on this source). Wheeler and Clark (1977) analyzed 74 samples using atomic absorption spectrophotometry from archaeological and geological contexts from the Indian Mountain and Koyukuk River regions. Their analysis resulted in the identification of three distinct groups (1–3), two of which were similar to the results of Griffin et al. (1969) and Patton and Miller (1970). Clark's reference to the Indian Mountain source as Batza Téna—a Koyukon word meaning "obsidian hill"—is now the generally accepted name for the location.

Cook (1995) published on the geochemical characterization and distribution of about six hundred archaeological and geological obsidian samples from locations throughout Alaska, the Yukon, British Columbia, and northeast Siberia. His study distinguished more than thirty geochemically distinct obsidian groups, of which only five could be related to specific geological sources. He identified several potential trade networks focused on sources located in interior and northern Alaska (i.e., Batza Téna and Wiki Peak), the Aleutians, and northeast Siberia. Cook's obsidian research continued throughout the 1990s in partnership with the Missouri University Research Reactor (MURR), where an additional 450 archaeological and geological samples were analyzed by NAA. In addition, the MURR laboratory incorporated all of Cook's earlier analyses into a larger database that is being developed further in the research described here.

Analytical Techniques and Sample Selection

The AAOD is being developed as a joint effort of the Smithsonian's Museum Conservation Institute, the National Park Service, and the University of Alaska Museum of the North. A main goal of the project is to create a clearinghouse that facilitates data sharing and encourages consistent methods and terminology. A database currently is being compiled from extant published and unpublished research (e.g., Cook 1995) and recent work by our team (Slobodina et al. 2008). Our ultimate goal is to provide a database that other researchers can freely access and contribute to, for cooperation among all is needed to build the baseline data to address significant behavioral questions.

The AAOD incorporates analyses conducted over a period of at least twenty years from many research projects (Cook 1995; Glascock, Cook et al. 2004; Speakman et al. 2007) and a wide variety of analytical techniques—including NAA, X-ray fluorescence (XRF), and laser ablation inductively coupled plasma mass spectroscopy (LA-ICP-MS). More than three thousand artifacts from over 360 sites from Alaska, Yukon, British Columbia, and northeast Asia have been analyzed, and the resulting data

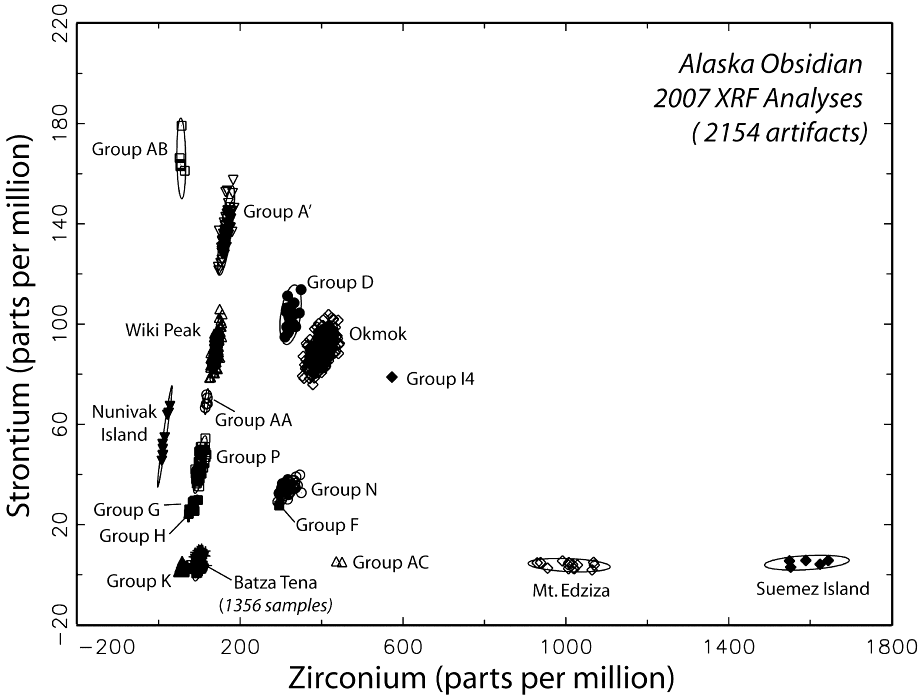


Figure 16.1. Plot of zirconium and strontium concentrations for obsidian artifacts analyzed by portable-XRF. Ellipses represent the 95% confidence interval for group membership. Unassigned specimens are not plotted. Zirconium and strontium are particularly useful elements for discriminating sources because these large ions are incompatible with crystallizing solids; as magmas evolve, the concentrations of incompatible elements are different for each source.

are being incorporated into the AAOD, including the work of Cook (1995) and Glascock, Cook et al. (2004). At least 960 sites in Alaska alone are known to contain obsidian, meaning that we have sampled less than 40% of these sites.

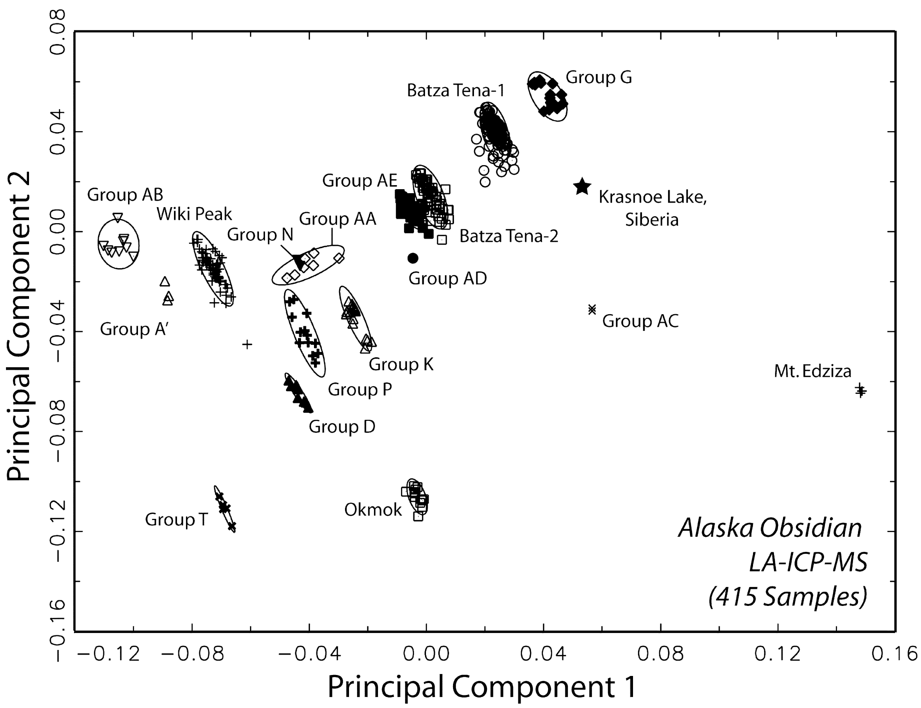
In addition to chemical data, artifact attributes recorded in the AAOD include weight, maximum dimension, artifact/tool type designation, presence of cortex, and completeness of the specimen. These attributes are designed to be applicable to a variety of research problems and to permit easy access to researchers who wish to contribute new information to the database.

In all cases, NAA was performed at MURR.[4] Many of the earlier XRF analyses (e.g., Cook 1995) were conducted at the Advanced Instrumentation Lab at the Department of Geology and Geophysics, University of Alaska, Fairbanks. More recent analyses using XRF and LA-ICP-MS were conducted at MURR and at the Smithsonian's Museum Conservation Institute (Speakman 2007). Detailed discussions of these analytical methods can be found in Cecil et al. (2007), Glascock and Neff (2003), Glascock et al. (1998, 2007), Speakman and Neff (2005), and Speakman et al. (2007).

NAA is a destructive analytical technique, whereas XRF and LA-ICP-MS are nondestructive or less damaging to artifacts. However, NAA has a higher degree of analytical precision for a wider range of elements and has continued to be used on all geological source samples. We have used NAA data from geological and archaeological samples to calibrate XRF and ICP-MS instruments for increased analytic precision and comparability with extant sourcing data. Source identification and grouping methods, based on bivariate and 3-D plots as well as cluster and discriminant classification analyses, were applied to indicate within a 95% or greater probability that the major geochemical groups reflect distinct sources of obsidian and that samples are correctly assigned to their compositional groups (figures 16.1, 16.2; Glascock et al. 1998).

NAA has, until recently, been the most widely used analytical technique for sourcing Alaskan obsidian artifacts. Because of its destructive nature, previous researchers have been hesitant, for good reason, to subject formal tools to such analyses. Consequently, most previous studies have been based primarily on the analysis of debitage and thus have limited analytical and interpretive value. The nondestructive nature of XRF and the minimally invasive nature of LA-ICP-MS have allowed contributors to the AAOD to focus on the analysis of a wide array of artifacts, from formal tools to debitage, covering a large spectrum of size distributions and artifact classes. Portable-XRF (PXRF) spectrometers can be efficiently transported to curation facilities to analyze large numbers of artifacts in a relatively brief period of time (upwards of 50–100 samples per day). A key benefit of PXRF is that, by bringing the instrument to the artifact, it is possible to analyze all samples, nondestructively, from a given site or group of

Figure 16.2. Plot of principal components 1 and 2 based on variance-covariance matrix of the 415-specimen LA-ICP-MS obsidian dataset. Ellipses represent the 95% confidence interval for group membership. Unassigned specimens are not plotted. The statistical routines used to interpret LA-ICP-MS data generated for this project are described extensively in Neff (1994, 2001) and Glascock (1992; Glascock, Neff et al. 2004).



sites without having to go through what is often a cumbersome process of obtaining permission to remove the artifacts from the curation facility to a laboratory for analysis.

Obsidian Groups and Sources in Eastern Beringia

In the entire AAOD, thirty-two obsidian groups have been defined based on differences in the geochemical compositions of artifacts and geological source materials (table 16.1). We use the term *source* to indicate a geochemical group that has also been identified in a geological context (primary or secondary). We use the term *group* to refer to distinct clusters of geochemically similar obsidian materials found in archaeological contexts but whose original geological physical location or locations are unknown. Groups are given letters as a naming convention, following the work of Cook (1995) and Glascock, Cook et al. (2004). Cook's (1995) obsidian group designations have been refined based on the work outlined here. Of the thirty-two obsidian groups thus far identified, nine (28%) have known geological source locations. However, only seven of the nine known sources were utilized by prehistoric populations as raw materials for making chipped stone tools. One of these is the Mount Kankaren/Krasnoe Lake (Group S) source, located along the Anadyr' River on the Chukotka Peninsula, Russia. It has been found in late Holocene archaeological contexts in Alaska. Two relevant sources in Canada are Mount Edziza (Group E: Cook 1995; Fladmark 1985) in British Columbia and the Airdrop Lake/Hoodoo Mountain source in the Yukon (Group M). Batza Téna is located in the middle Koyukuk River drainage in northern interior Alaska (Groups B and B′: Clark and McFadyen Clark 1993; Cook 1995; Kunz et al. 2001; Patton and Miller 1970). Wiki Peak (Group A) is located in the Nutzotin Mountains, an eastern subrange of the Alaska Range. Okmok Caldera (Group I) is located on the northeastern end of Umnak Island in the Aleutians in southwestern Alaska. Suemez Island (Group Z) is located in the Alexander Archipelago in southeast Alaska, just west of Prince of Wales Island (Erlandson et al. 1992; Moss and Erlandson 2001).

For the purpose of this chapter, we selected artifacts from components of the northern and interior regions of eastern Beringian sites that are reported in the literature as representing terminal Pleistocene and early Holocene occupations (figure 16.3). We have included sites in the AAOD that are within the timeframe 14,000–8800 cal BP (12,000–8000 ^{14}C BP).[5] Collection accessibility was an important factor in the sites we considered in this study, and we do not claim to have covered the entire range of sites from this time period exhaustively. Several of the sites have secure dates (e.g., Broken Mammoth, Dry Creek, Gerstle River, Healy Lake, Mesa Site, Moose Creek, Swan Point, Walker Road), but for other sites the dates are less secure. Age assignments were based on radiocarbon dating as well as typological comparisons with assemblages

Table 16.1. Obsidian Sources and Groups Identified in Terminal Pleistocene/Early Holocene Eastern Beringia

Groups	*Source Name*	*Earliest Use (cal BP)*	*Longest Distance from Source during LP/EH (km)*	*Longest Distance from Source (km)*
A	*Wiki Peak*	*13,300*	*465*	*480*
A′	–	*13,180*	–	–
B	*Batza Téna*	*13,300*	*500*	*930*
C	Letter not used by Cook			
D	–	8750	–	–
E	*Mount Edziza*	*11,600*	*260*	*1,200*
F	–	5040	–	–
G	–	5750	–	–
H	–	*13,940*	–	–
I	*Okmok Caldera*	*9000*	*70*	*970*
J	–	3250	–	–
K	–	*11,100*	–	–
L	–	undetermined	–	–
M	Airdrop Lake/Hoodoo Mountain	3250	–	460
N	–	6660	–	–
O	Source sample not yet found in archaeological context			
P	–	*11,070*	–	–
Q	Source sample not yet found in archaeological context			
R	–	undetermined	–	–
S	Mount Kankaren/Krasnoe Lake, Chukotka	2700	–	1,150
T	–	930	–	–
U	–	undetermined	–	–
V	–	undetermined	–	–
W	–	730	–	–
X	–	undetermined	–	–
Y	–	undetermined	–	–
Z	*Suemez Island*	*11,600*	*260*	*260*
AA	–	930	–	–
AB	–	undetermined	–	–
AC	–	undetermined	–	–
AD	–	undetermined	–	–
AE	–	5040	–	–

Italics indicates sources and groups found in archaeological contexts.

from independently dated sites. A total of 139 artifacts from eighteen archaeological components and fifteen sites are included in this analysis (table 16.2).

Batza Téna obsidian is the most geographically widespread source in the terminal Pleistocene and early Holocene archaeological assemblages, and Wiki Peak is the second most widespread. Wiki Peak obsidian was documented in ten of eighteen (56%) components, and Batza Téna was identified in eight (44%) components. Groups A′, H, K, and P and three samples from two distinct but "unknown" sources represent the remaining obsidian varieties identified. Group H was found in two components (11%), and Groups A′, K, and P were identified in one (6% each) component each.

Distribution of Obsidian in Assemblages

14,000–13,000 cal BP

Swan Point cultural zone (CZ) 4, Broken Mammoth CZ 4, Walker Road component 1, and Moose Creek component 1 are the earliest well-dated components of interior eastern

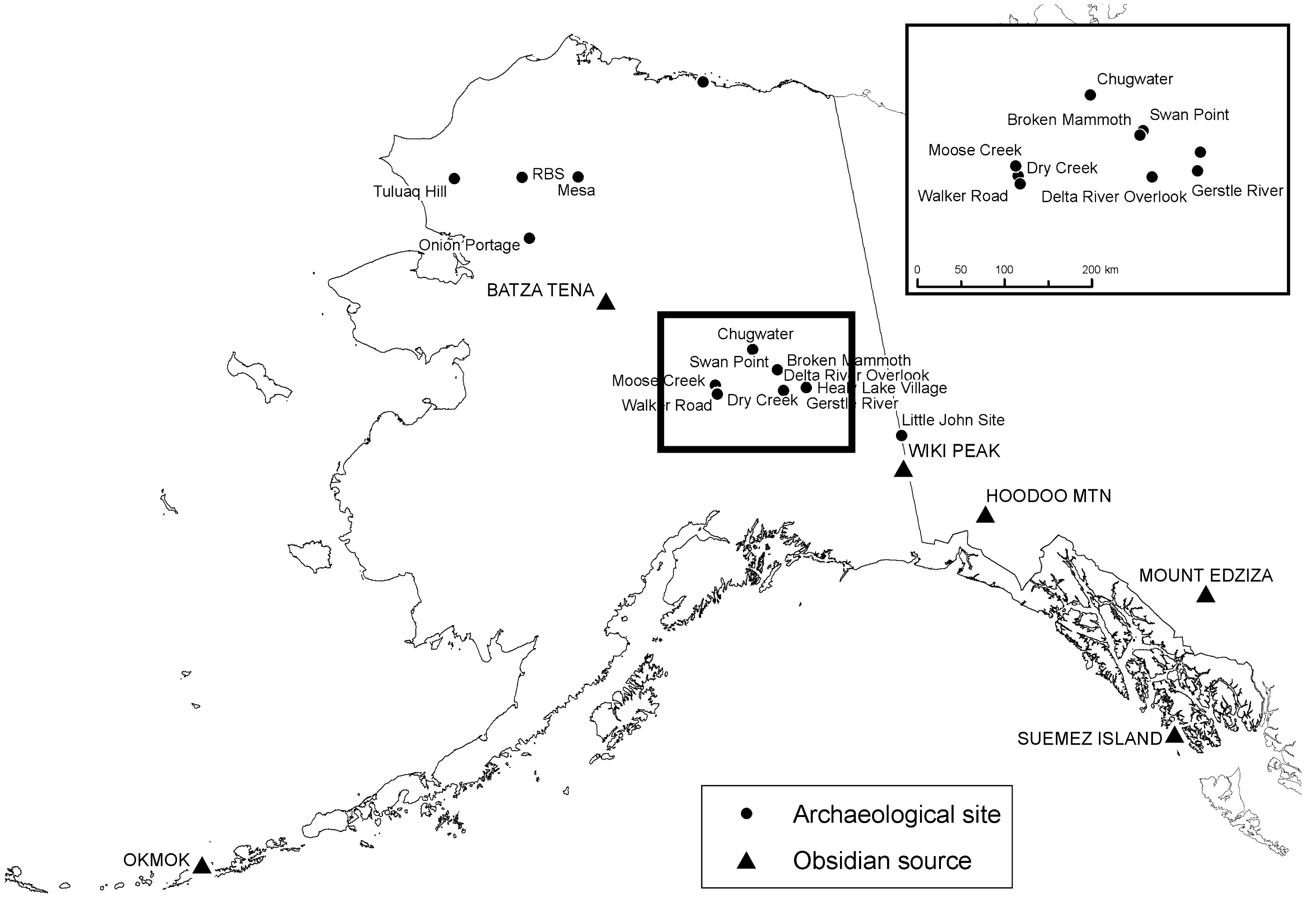


Figure 16.3. Eastern Beringian obsidian sources and late Pleistocene/early Holocene sites discussed in the text.

Beringia containing obsidian. The earliest use of obsidian in Alaska is in CZ 4 at Swan Point, dated to around 14,000 cal BP. Occupants utilized Group H obsidian (Speakman et al. 2007). At Broken Mammoth, occupants of the earliest component (CZ 4), dated to around 13,400 cal BP, used Wiki Peak obsidian. Wiki Peak obsidian also was recovered from component 1 at Walker Road, dating to 13,080–13,190 cal BP, along with Group A′ (sometimes alternatively referred to as the "Ringling group") obsidian (Goebel et al. 2008). Batza Téna and Wiki Peak obsidian also was used by the earliest occupants of Moose Creek (component 1), dated to about 13,060–13,180 cal BP.

Between roughly 14,000 and 13,000 cal BP, Batza Téna obsidian was acquired from distances up to 400 km from the source (figure 16.4).[6] Wiki Peak obsidian was acquired from nearly 460 km from the source. The distribution of Group A′ is centralized to one site, Walker Road (figure 16.5). The distributions of Batza Téna, Wiki Peak, and Groups H and K obsidians overlap within the middle Tanana Valley (figures 16.4–16.6), but Group H obsidian is primarily limited to sites north of the Alaska Range within the middle Tanana Valley and does not appear to have been utilized by early occupants of the Nenana Valley (figure 16.6).

During this period, a unique assemblage with an unusually high ratio of usable stone tools to debitage was deposited at the Nogahabara I site in western interior Alaska (Odess and Rasic 2007). The assemblage contains 269 flaked stone tools, 267 of which are obsidian. Only eight have been geochemically characterized, but they all derive from the Batza Téna source approximately 140 km to the west (Odess and Rasic 2007). Batza Téna obsidian is also found as far northwest as the Tuluaq Hill site (13,000 cal BP), approximately 450 km from the source, in the Noatak River drainage, northwestern Alaska (Rasic and Gal 2000). One sample from Tuluaq Hill has a unique geochemical signature that could not be assigned to any known group.

Table 16.2. Terminal Pleistocene/Early Holocene Components with Obsidian Samples Included in the AAOD

Site/Component	*Approx. Estimated Average cal BP (¹⁴C BP) Age*	*Number of Obsidian Artifacts Analyzed*	*Obsidian Sources/Groups Identified (Distance from Source, km)*	*Artifact Types Analyzed*	*References*
Swan Point, CZ 4	13,960–13,780 (12,003 ± 22)*	3	Group H	microblades	Holmes et al. 1996; Holmes 2004
Broken Mammoth, CZ 4	13,420–13,200 (11,443 ± 60)*	19	Wiki Peak (360)	debitage	Holmes 1996
Walker Road, component 1	13,260–12,940 (11,220 ± 92)*	2	Wiki Peak (460), Group A′	debitage	Goebel et al. 1996
Moose Creek, component 1	13,210–12,960 (11,190 ± 60)*	2	Batza Téna (315), Wiki Peak (465)	debitage	Pearson 1999
Tuluaq Hill	13,110–12,970 (ca. 11,150)	14	Batza Téna (450), Unknown Group	debitage	Rasic and Gal 2000
Nogahabara I	13,760–12,800 (11,815–10,780)	8	Batza Téna (140)	flake tools	Odess and Rasic 2007
Little John site (KdVo-6), Nenana complex component	>11,600–11,340 (>10,000)	10	Wiki Peak (80), Unknown Group	blade, flake tools, debitage	Easton et al., this volume
Swan Point, CZ 3	11,960–11,400 (10079 ± 42)*	2	Batza Téna (420)	microblades, debitage	Holmes et al. 1996
Mesa site, Mesa complex component	11,600–11,340 (ca. 10,000)	6	Batza Téna (290)	debitage	Kunz et al. 2003
Healy Lake Village, Chindadn levels (6–10)	11,190–11,140 (ca. 9700)	7	Group H, Batza Téna (500), Wiki Peak (290)	debitage	Cook 1996
Dry Creek, component 2	11,190–10,800 (9657 ± 31)*	47	Group K, Batza Téna (330)	microblades, core tablet, burin spall, point base, biface fragment, debitage	Powers et al. 1983; Bigelow and Powers 1994
Little John site (KdVo-6), Denali complex component	11,070–10,740 (ca. 9550)	10	Wiki Peak (80), Group P, Unknown Source	debitage	Easton et al., this volume
Chugwater, component 1	10,750–10,670 (>9460)	1	Wiki Peak (430)	Chindadn point	Lively 1996
Gerstle River, component 3	10,160–9910 (8882 ± 17)*	1	Wiki Peak (260)	debitage	Potter 2005
Delta River Overlook	9530–9490 (ca. 8500)	1	Wiki Peak (300)	debitage	Bacon and Holmes 1980; Holmes 2001
Onion Portage, Kobuk level	9260–8790 (8200–8000)	2	Batza Téna (230)	scraper	Anderson 1988
Gerstle River, component 5	9280–9010 (8174 ± 55)*	1	Wiki Peak (260)	debitage	Potter 2005
RBS Site	9090–9020 (8130)	3	Batza Téna (350)	microblade, projectile point	Esdale and Rasic 2003
	Total	139			

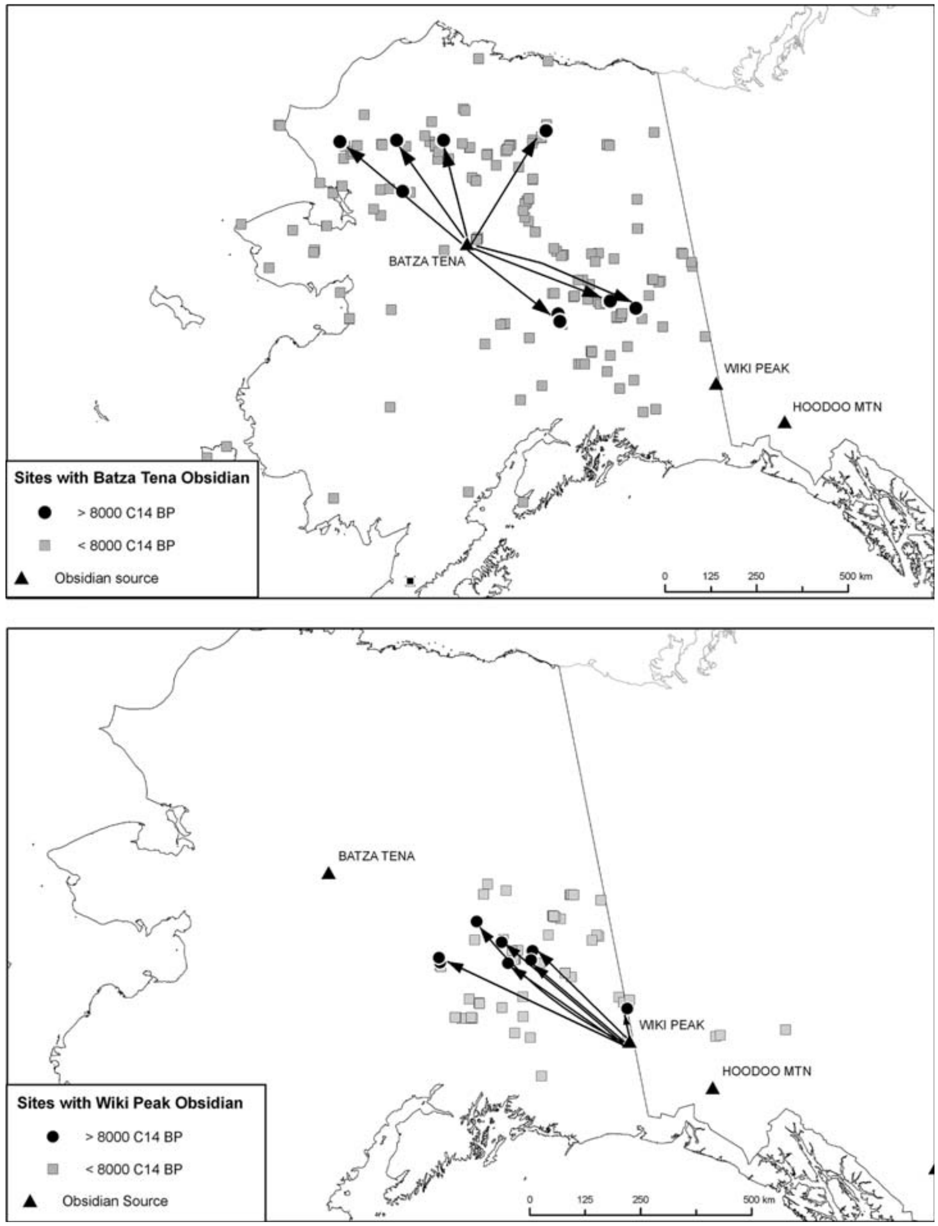
*Averages from Potter (2008).

13,000–11,600 cal BP

Only three northern and interior Alaskan assemblages that contain obsidian and date to the period 13,000–11,600 cal BP are included in this analysis. In the middle Tanana Valley, Swan Point CZ 3 dates to about 11,600–11,300 cal BP and contains artifacts made of Batza Téna obsidian, the earliest use at this site. The Mesa site, located in the northern foothills of the Brooks Range, could date earlier than this period, but the majority of the dates from the site average 11,600–11,300 cal BP (Kunz et al. 2003). Small pressure flakes of Batza Téna obsidian were found here, approximately 200 km north of the source.

In the Yukon, at the Little John site, Wiki Peak and one

Figure 16.4. Distribution of Batza Téna and Wiki Peak obsidians.



unassigned obsidian artifact were found in the lowest, yet undated component, which has artifacts stylistically similar to the Nenana/Chindadn complex (Easton et al., this volume). However, an overlying date of about 11,070–10,740 cal BP on the Denali complex component at this site provides a minimum age for the underlying Nenana component. The single unassigned obsidian artifact has yet to be recognized in any other assemblage, regardless of age, in Alaska, Yukon Territory, or British Columbia.

11,600–10,200 cal BP

Four assemblages in our sample date between 11,600 and 10,200 cal BP: Dry Creek component 2, Healy Lake Village (Chindadn levels), Chugwater component 1, and the Denali component at the Little John site. The Dry Creek site is situated along a glacial outwash terrace within the Nenana River valley in the north-central foothills of the Alaska Range (Powers et al. 1983). The average age for Dry Creek component 2 is 11,170–10,890 cal BP (Potter 2008), and this site contains the largest sample of obsidian artifacts from a single component included in this analysis. Dry Creek component 2 occupants used two varieties of obsidian, Batza Téna and Group K. Although Cook (1995) had reported artifacts of Wiki Peak (Group A) obsidian in component 2, provenience information contained in the collection documentation at the University of Alaska

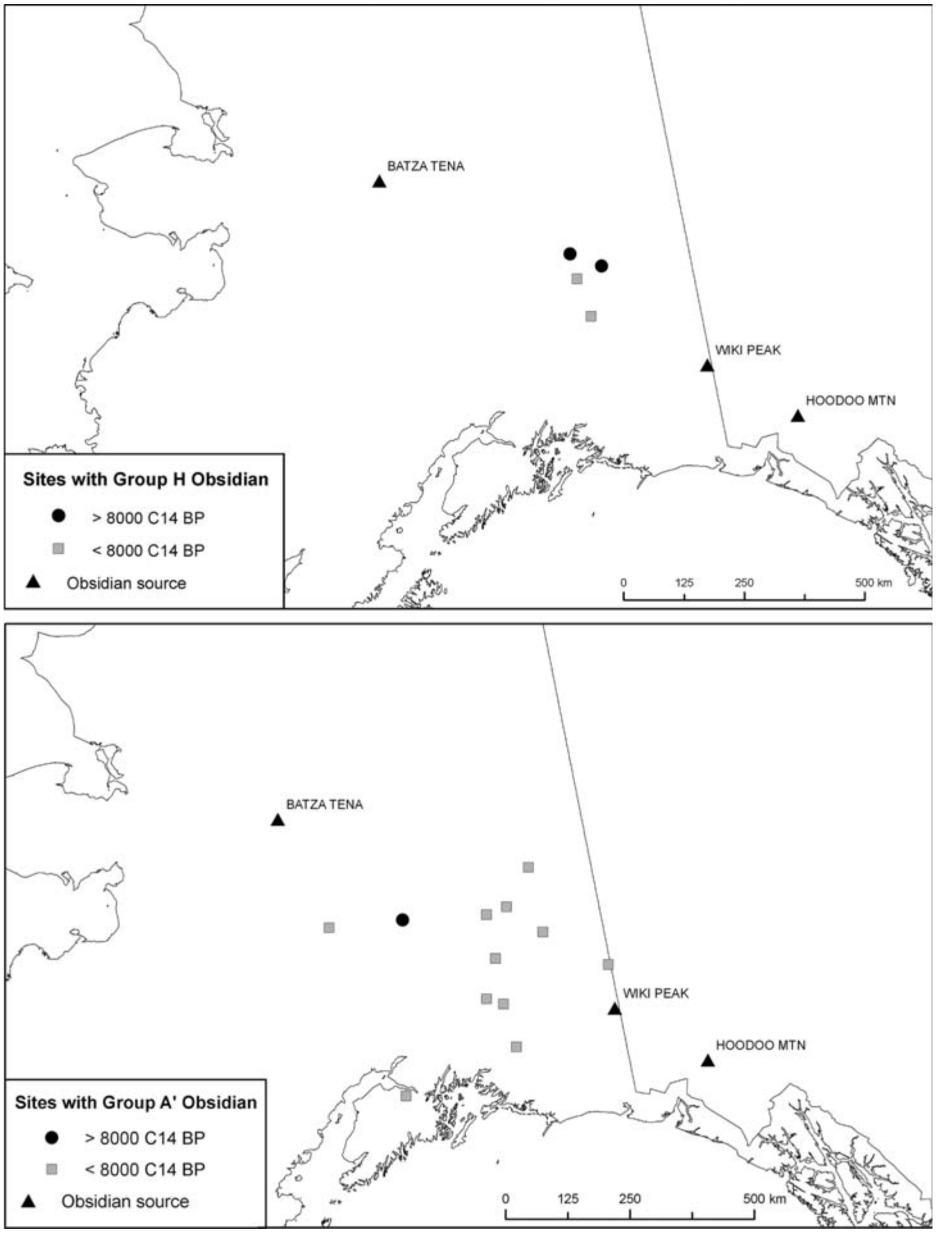


Figure 16.5. Distribution of Group A′ and Group H obsidians.

Museum indicates that those samples were recovered from the more recent component 4. We further discuss the procurement and use of obsidian below.

The earliest component or components at the Healy Lake Village site (levels 6–10), located within the upper Tanana River valley, have an average age of 11,140–11,200 cal BP (Cook 1996), although combining these levels may effectively lump multiple occupations and components spanning 13,000–10,200 ^{14}C BP (Erlandson et al. 1991). The early occupation(s) at the Healy Lake Village site obtained obsidian from several sources, including Batza Téna, Wiki Peak, and Group H. Later in the Holocene, sites near Healy Lake continued to use a diverse array of obsidian groups, including material from Mount Edziza, located nearly 1,000 km southwest of the area (Cook 1995). Healy Lake's centralized setting adjacent to a large lake in a broad lowland east-west trending valley and its access to upland trade routes made it a prime location for exchange of goods from many parts of Alaska. Component 1 at the Chugwater site, situated on Moose Creek Bluff in the middle Tanana River valley, is inferred to date within this time period, and possibly earlier, based on a date of 10,670–10,750 cal BP from an overlying component and similarities with artifacts from other Nenana

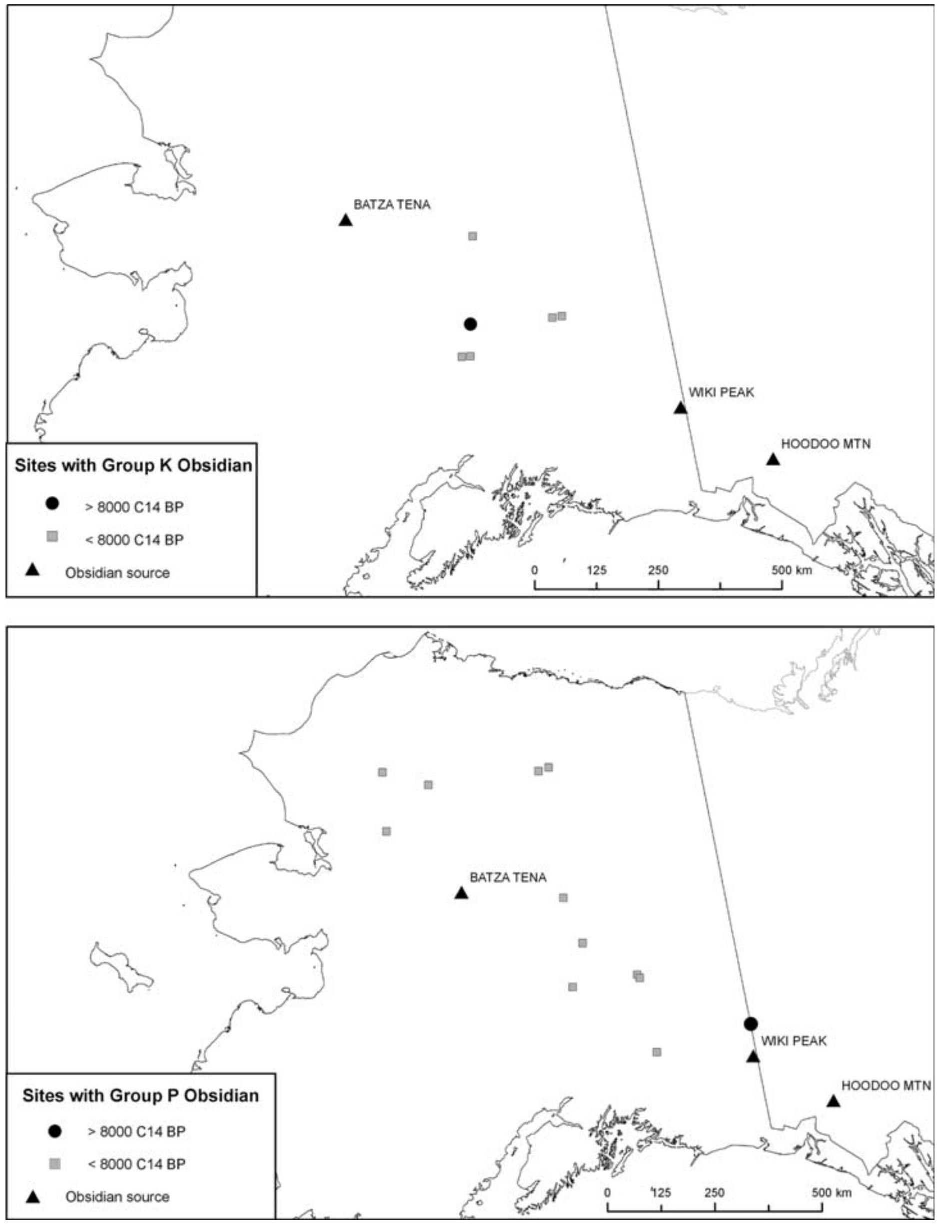


Figure 16.6. Distribution of Group K and Group P obsidians.

and Chindadn assemblages (Lively 1996). A Chindadn point from this component at Chugwater was made from Wiki Peak obsidian.

The Denali component at the Little John site dates to about 10,740–11,070 cal BP (Easton et al., this volume). The occupants of this period obtained Wiki Peak and Group P obsidians as well as obsidian from an unknown source that is geochemically similar to the Airdrop Lake/Hoodoo Mountain source materials; pending additional analyses, we are reluctant to assign this material to this obsidian source. If an assignment to the Airdrop Lake/Hoodoo Mountain source is confirmed in future analyses, the presence of this obsidian group in the Denali component at the Little John site would be its earliest documented usage in eastern Beringia. Group P is prevalent later in the Holocene, but at Little John it appears in the 10,900 cal BP Denali component (Easton et al., this volume). This sole appearance of Group P at the Little John site for archaeological assemblages dating earlier than 7000 cal BP age pushes the age of the earliest use of this group back by nearly 4,000 years and may reflect the low sample size for terminal Pleistocene and early Holocene sites with obsidian that has been analyzed at this early stage of research. Group P becomes one of the most widely distributed obsidians in the later Holocene (figure 16.6).

10,200–8780 cal BP

Five components from four sites in interior and northern Alaska date between 10,200 and 8780 cal BP. In the middle Tanana Valley, these are Gerstle River component 3 (ca. 9910–10,150 cal BP) and component 5 (ca. 9030–9230 cal BP; Potter 2005) and the lowest component at the Delta River Overlook site (ca. 9500 cal BP; Bacon and Holmes 1980). These three components contained Wiki Peak obsidian from more than 250 km southeast of the sites.

The other two components are from northern Alaska: Onion Portage and Richard's Blade Site (RBS). The earliest assemblage containing obsidian at Onion Portage is the Kobuk component, suggested by Anderson (1988:48) to date between 9260 and 8780 cal BP. Three of the 111 artifacts recovered from the Kobuk levels were made of obsidian, representing 2.7% of the assemblage. Two of the three obsidian artifacts—a scraper and flake tool—were sourced to Batza Téna, approximately 230 km southeast. RBS is a single-component microblade production site dating to approximately 9000–8780 cal BP in the western Brooks Range (Esdale and Rasic 2003). At least 70 of the more than 6,000 artifacts recovered from RBS were composed of obsidian; the majority of the obsidian artifacts were microblades. Three obsidian artifacts, including a microblade and lanceolate projectile point, were sourced to Batza Téna, approximately 350 km southeast.

To summarize, as noted in earlier obsidian source studies, Batza Téna and Wiki Peak obsidians were widely utilized by the earliest populations of the northern and interior regions of eastern Beringia; both became increasingly used and more widely distributed throughout the Holocene (figure 16.4; Cook 1995; Glascock, Cook et al. 2004; Speakman 2007). Five minor groups (A′, H, K, and P) as well as at least two additional unknown sources were exploited early on, with the major uses of groups H and K apparently dating before 10,200 cal BP. Although no primary or secondary geological source deposits have been found for groups H and K, their distributions overlap, and obsidian assigned to these groups is confined to interior Alaska, with the majority of the sites located in the northern Alaska Range.

Other sources such as Mount Edziza and the Airdrop Lake/Hoodoo Mountain sources are not distributed as far north as interior Alaska after 8800 cal BP (possibly as late as 5600 cal BP). Although exploitation of the Mount Edziza source occurs as early as 11,600 cal BP, its presence in eastern Beringia appears to have been relegated to southeast Alaskan coastal sites, such as Hidden Falls, Ground Hog Bay Site 2, and On Your Knees Cave (Ackerman 1996; Davis 1989; Dixon 2001). Future analysis of obsidian artifacts form the Denali component at the Little John site may substantiate the use of the Airdrop Lake/Hoodoo Mountain site in interior eastern Beringia as early as 10,990 cal BP.

Sourcing Analyses and Lithic Technological Variability: The Case of Obsidian Procurement and Use at the Dry Creek and Laraine's Lookout Sites

We believe one of the next stages of eastern Beringian archaeological obsidian-sourcing analysis should focus on variables relating to lithic raw materials that may explain inter- and intrasite lithic assemblage variation in the region. Raw material characteristics such as abundance, quality, shape, and size of material available in a region limit how a given resource is used within technological systems that people choose to employ at any given time. Multiple types of obsidian of similar quality may have been used by occupants of a site in the employment of what some researchers have viewed as different weaponry strategies, such as bifacial projectiles points versus osseous bone spears or points inset with microblades (Dixon 1999; Hoffecker and Elias 2007). Such is the case for Batza Téna and Group K obsidians in component 2 of the Dry Creek site and at Laraine's Lookout. A total of 47 obsidian artifacts from this component have been analyzed. Thus far, ten samples from Batza Téna obsidian (335 km northwest) have been identified in Dry Creek component 2, including two biface fragments and debitage. A total of 37 artifacts from Group K were identified, including three microblade fragments, a microblade core tablet, a burin spall, and debitage. Group K obsidian was first identified at the site by Cook (1995), and the geological source has yet to be discovered for this group. The archaeological distribution is primarily concentrated around the Healy area in central interior Alaska. Group K obsidian has no distinct visual characteristics (relative to Batza Téna obsidian) and appears similar in structure and knapping quality.

Fourteen artifact clusters (A–N) were identified in component 2 that reflect multiple activity areas, involving microblade inset weaponry manufacture and maintenance, bifacial projectile point production, and hide working and butchering (Powers and Hoffecker 1989; Powers et al. 1983). Obsidian artifacts are associated with nearly half of the clusters (Powers et al. 1983). Batza Téna obsidian is associated with two adjacent clusters that are interpreted as a microblade manufacturing area (cluster C) and a bifacial tool production and maintenance and butchering area (cluster D). Group K obsidian is associated with activity areas that include microblade manufacturing and spear maintenance (clusters B and G) and bifacial tool production/maintenance and butchering (clusters D and I). Both obsidian groups are associated with clusters that represent multiple types of activities. However, analysis of a sample of formal artifact types (noted above) from component 2 suggests that Batza Téna obsidian was used more for biface tool manufacture, with Group K obsidian used more for microblade production. This pattern occurs regardless of the interpretations of activities at specific clusters (Powers et al. 1983) and may indicate that the microblade and bifacial tool production and maintenance activity areas overlap spatially.

A similar pattern of differential obsidian group usage appears at the undated Laraine's Lookout site (Derry 1977). Five obsidian artifacts from this site were analyzed, with three sourced to Batza Téna and two assigned to Group K. Artifact types made from Batza Téna obsidian include two projectile points and one modified flake, whereas microblade fragments are the sole artifact type made on Group K obsidian at this site. The fact that two varieties of obsidian of similar quality are exploited for different technological strategies by the occupations at these two sites leads us to ask questions about these choices.

Artifact size and weight may help to shed light on factors that lead to such decisions. The average maximum size dimension for artifacts made of Batza Téna obsidian at Dry Creek is 18.9 mm with a range of 36.9–4.8 mm, whereas average maximum dimension of Group K obsidian artifacts is 15.7 mm with a range of 45.3–10.6 mm. At Laraine's Lookout the average maximum dimension for Batza Téna artifacts is 28.4 mm with a range of 30.0–26.5 mm, whereas the two Group K artifact maximum dimensions are 12.2 mm and 13.0 mm. The average weights of artifacts made of Batza Téna obsidian at the Dry Creek site and Laraine's Lookout are 3.38 g and 4.10 g, respectively. The average weight of artifacts made of Group K obsidian for the two sites is 1.03 g at the Dry creek site and 0.23 g at Laraine's Lookout. In sum, artifacts made from Group K obsidian are smaller than artifacts made from Batza Téna obsidian at these two sites.

At Dry Creek, cortex is not present on any of the artifacts made from Batza Téna obsidian. Cortex is present on five Dry Creek Group K artifacts that fall into the upper range of this group's maximum size dimensions, supporting the idea that Group K obsidian was derived from a more local raw material source from the Healy area, likely originating in the central Alaska Range and incorporated into glaciofluvial terrace gravels throughout the Nenana River region. Average size dimensions and weights derived from the entire dataset of the AAOD are 24.0 mm and 8.41 g for Batza Téna and 15.92 mm and 0.65 g for Group K.

The average size dimensions and weights generally show smaller measurements from the two sites and within the overall AAOD dataset for Group K obsidian artifacts as compared to those made of Batza Téna obsidian and suggest that the package size of available raw materials may have been an important factor in the decision to utilize two similar-quality obsidians differentially. However, the more important factor may be the shape of the available raw materials.

Currently, we do not know the exact characteristics of Group K obsidian raw material packages available to prehistoric lithic toolmakers, but the smaller average size dimensions and weights indicate smaller package sizes. If Group K package sizes were smaller and more locally available, the choice to utilize this material in a weaponry system that emphasizes smaller artifacts used in combination with other materials, such as bone or antler, in an inset technology would make sense from the perspective of material conservation. The efficiency of microblade technologies as maximizing the utility of raw material is up for debate; its efficient use of raw material may be situational. In some instances it may be viewed as conserving raw materials (Dixon 1999:161), whereas others argue that it can be a relatively wasteful process (Esdale and Rasic 2003). Within a technological system that employed two types of armatures, curation and conservation of raw materials that allowed for the manufacture and maintenance of potentially larger single-component weaponry, such as bifacial chipped stone projectile points, while using smaller nodules for the production of standardized microliths for insetting in composite armatures would be advantageous for efficient use of raw materials of differing package sizes and shapes and abundances, both local and nonlocal.

Summary and Discussion

Although the number of archaeological components in this study sample is relatively small, and chronological control is not always precise, there are provocative patterns that shed light on not only the procurement and use of obsidian by the late Pleistocene and early Holocene inhabitants of eastern Beringia but also the use of other lithic raw materials, the process of landscape learning, and the development of exchange networks.

One pattern that stands out among the assemblages examined in this study is the early use of multiple varieties of obsidian. The earliest dated archaeological component known in eastern Beringia, Swan Point CZ 4, contains obsidian, and within the earliest millennium of demonstrated occupation (14,000–13,000 cal BP) there are at least five archaeological components that contain five obsidian groups. It is no surprise that among these early obsidian groups are the two sources that dominate archaeological obsidian through the entire prehistoric period in eastern Beringia, Batza Téna (Group B) and Wiki Peak (Group A). The Wiki Peak source area is not well known, but Batza Téna is an extensive source area with abundant outcrops and secondary sources of obsidian. It is likely that Batza Téna was highly visible to prehistoric foragers. In contrast, the three remaining early sources (A′, H, and an unknown source) were used only rarely and sporadically through the Holocene—at least in our study area—and have yet to be discovered by archaeologists or geologists. Thus, the earliest known occupants of eastern Beringia appear to have developed a relatively extensive knowledge of local and distant lithic resources, contrary to assertions that the earliest colonizers had little knowledge of high-quality, exotic lithic resources (Yesner and Pearson 2002:151).

It is clear that the early inhabitants of eastern Beringia quickly identified most of the more visible (and larger) sources of obsidian in the region, as well as a considerable portion of those less visible. It can be assumed that they were rediscovering other varieties of flakeable stone raw materials and other fixed-location resources at the same rate. It seems that prehistoric stone tool users "mapped" on to lithic raw materials at least as fast as populations and settlement densities made these foragers visible in the archaeological record.

If Alaskan coastal sites such as Hidden Falls, On Your Knees Cave, and Anangula are included in our discussion, then at least twelve different geochemical varieties of obsidian were exploited by the terminal Pleistocene and early Holocene inhabitants of eastern Beringia. The high diversity of obsidian group usage indicates that these early populations had an intimate knowledge of the landscape and geological resources. In fact, the variety of obsidian groups utilized increased later into the Holocene, and, if we assume that knowledge of resources across the landscape increased through time, this could account for this pattern. Interestingly, similar patterns of use of multiple, distant, high-quality obsidian resources are found in the terminal Pleistocene and early Holocene components at the Ushki Lake sites, Kamchatka (Kuzmin et al. 2008). However, obsidian from Chukotka and Kamchatka has yet to be identified in terminal Pleistocene and early Holocene Alaskan assemblages (Cook 1995; Glascock et al. 2006; Speakman et al. 2005).

The distributions of Batza Téna and Wiki Peak obsidians, nearly 460 km and 500 km from their sources, respectively, indicate procurement or trading of obsidian over long distances in the terminal Pleistocene and early Holocene. Population densities in both western and eastern Beringia were relatively low and are characterized as having high degrees of logistical and residential mobility (Goebel 1999; Potter 2005). These distances from sources may be close to mobility range estimates for early Paleoamerican hunter-gatherer populations in other parts of North America (Amick 1996; Kelly and Todd 1988). It is likely that, in the interior and northern regions of eastern Beringia, exchange networks developed during this period and long-distance direct procurement was shortened by trade. Previous obsidian sourcing research has provided suggestions that mainland and coastal trade networks were established by 11,600 cal BP in southeast Alaska and British Columbia (Dixon 2001). Coastal sites such as On Your Knees Cave, Ground Hog Bay 2, and Hidden Falls contain obsidian obtained from Mount Edziza, located nearly 300 km from the Pacific coast (Ackerman 1996; Davis 1989; Dixon 2001; Lee 2001; Moss and Erlandson 2001). The development of trade networks indicates that a sufficiently large population base was established to maintain long-distance relationships in eastern Beringia.

The distance from source to archaeological deposition increased later in the Holocene (table 16.1). After 8800 cal BP, Batza Téna obsidian was recovered from sites over 900 km south of the source. Mount Edziza obsidian was recovered from sites more than 1,000 km to the west, and Okmok obsidian was found over 970 km from the caldera. Interestingly, Wiki Peak distribution remained at a similar distance from the source (480 km). The increased distribution of many of the obsidian groups may imply that exchange networks in Alaska and western Canada became increasingly sophisticated. Perhaps one group of people (or a relatively few groups of people) directly procured materials from the Batza Téna, Wiki Peak, and Mount Edziza sources and then distributed them throughout the region. The question of whether terminal Pleistocene and early Holocene populations directly procured materials—as we typically assume with people who were highly mobile—or if exchange was the means to acquire materials from faraway sources remains open for future research. We expect that both direct procurement and exchange were working interchangeably to acquire materials, but we still do not know how much contact and trade between groups occurred (Meltzer 1989).

For the purposes of this volume, we have asked how obsidian-sourcing studies can help us understand terminal Pleistocene and early Holocene lithic technology in eastern Beringia. As we increasingly systematize our observations and pool research efforts, emerging patterns such as the differential use of Group K and Batza Téna at Dry Creek and other sites can help explain variability in lithic technology. Raw material package size and shape certainly were important in decisions about whether to employ one technology over another (Andrefksy 1994a; Kuhn

1995; Wilson 2007). In addition, several factors that may influence the way a technological strategy is organized—such as raw material and artifact portability (Kuhn 1994), raw material accessibility and conservation (Andrefsky 1994b; Kuhn 1991), and differential curation or roles of artifact types within a system (Binford 1979; Kelly 1988)—may be analyzed as the dataset in the AAOD increases. If archaeologists are to move beyond obsidian studies that seek only to identify the rarest groups or document evidence of long-distance trade to explore fundamental conditioning factors of lithic assemblage variability, we must go beyond site-specific case studies and test the ideas and models presented within the chapters of this volume.

Acknowledgments

We acknowledge several people and institutions that have contributed to this research: Ted Goebel and Ian Buvit for organizing the SAA annual meeting symposium that led to the development of this volume; Pete Bowers, E. James Dixon, and Ben Potter for reading earlier drafts of this chapter; the Smithsonian Institution and National Park Service for funding and technical support to develop the AAOD; Michael Glascock and the University of Missouri Research Reactor for providing important sourcing contributions to this work; Nicole Little and Javier Iñañez for providing technical assistance during the Smithsonian's XRF and LA-ICP-MS analyses; and Jim Whitney of the University of Alaska Museum of the North for invaluable time and effort finding obsidian artifacts in the Museum's archaeology collections. We also thank those who provided samples to the AAOD project that were included in this research: Douglas Anderson, Norm Easton, Julie Esdale, Ted Goebel, Chuck Holmes, Mike Kunz, Ben Potter, Aaron Robertson, Brian Wygal, David Yesner, and numerous other archaeologists.

References Cited

Ackerman, Robert E. 1996. Ground Hog Bay, Site 2. In *American Beginnings: The Prehistory and Palaeoecology of Beringia,* edited by Frederick H. West, pp. 424–430. University of Chicago Press, Chicago.

Amick, Daniel S. 1996. Regional Patterns of Folsom Mobility and Land Use in the American Southwest. *World Archaeology* 27(3):411–426.

Anderson, Douglas D. 1988. Onion Portage: The Archaeology of a Stratified Site from the Kobuk River, Northwest Alaska. *Anthropological Papers of the University of Alaska* 22(1–2).

Andrefsky, William, Jr. 1994a. The Geological Occurrence of Lithic Materials and Stone Tool Production Strategies. *Geoarchaeology* 9(5):345–362.

———. 1994b. Raw Material Availability and the Organization of Technology. *American Antiquity* 59(1):21–34.

Bacon, Glen H., and Charles E. Holmes. 1980. Archaeological Survey and Inventory of Cultural Resources at Fort Greely, Alaska, 1979. Unpublished final report to U.S. Corp of Engineers Alaska District, by Alaskarctic, Fairbanks.

Bamforth, Douglas B. 1990. Settlement, Raw Material, and Lithic Procurement in the Central Mojave Desert. *Journal of Anthropological Archaeology* 9(1):70–104.

Bever, Michael R. 2001. An Overview of Alaskan Late Pleistocene Archaeology: Historical Themes and Current Perspectives. *Journal of World Prehistory* 15(2):125–191.

Bigelow, Nancy H., and W. Roger Powers. 1994. New AMS Dates from the Dry Creek Paleoindian Site, Central Alaska. *Current Research in the Pleistocene* 11:114–116.

Binford, Lewis R. 1979. Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research* 35(3):255–273.

Carlson, Roy L. 1994. Trade and Exchange in Prehistoric British Columbia. In *Prehistoric Exchange Systems in North America,* edited by Timothy G. Baugh and Jonathon E. Ericson, pp. 307–361. Plenum Press, New York.

Cecil, Leslie G., Matthew D. Moriarty, Robert J. Speakman, and Michael D. Glascock. 2007. Feasibility of Field-Portable XRF to Identify Obsidian Sources in Central Petén, Guatemala. In *Archaeological Chemistry: Analytical Methods and Archaeological Interpretation,* edited by Michael D. Glascock, Robert J. Speakman, and Rachel S. Popelka-Filcoff, pp. 506–521. ACS Publication Series 968. American Chemical Society, Washington, D.C.

Clark, Donald W. 1972. Archaeology of the Batza Tena Obsidian Source, West-Central Alaska. *Anthropological Papers of the University of Alaska* 15(2):1–21.

Clark, Donald W., and Annette McFadyen Clark. 1993. *Batza Téna: Trail to Obsidian.* Archaeological Survey of Canada Mercury Series Paper 147. Canadian Museum of Civilization, Ottawa.

Close, Angela E. 1999. Distance and Decay: An Uneasy Relationship. *Antiquity* 73(279):24–32.

Cook, John P. 1969. The Early Prehistory of Healy Lake, Alaska. Unpublished Ph.D. dissertation, Department of Anthropology, University of Wisconsin, Madison.

———. 1995. Characterization and Distribution of Obsidian in Alaska. *Arctic Anthropology* 32(1):92–100.

———. 1996. Healy Lake. In *American Beginnings: The Prehistory and Palaeoecology of Beringia,* edited by Frederick H. West, pp. 323–327. University of Chicago Press, Chicago.

Davis, Stanley D., ed. 1989. *The Hidden Falls Site, Baranof Island, Alaska.* Aurora Alaska Anthropological Association Monograph Series 5, Anchorage.

Derry, David E. 1977. Archaeological Research in the Livengood (Alaska) Area. In *Pipeline Archaeology,* edited by John P. Cook, pp. 257–299. Institute of Arctic Biology, University of Alaska, Fairbanks.

Dixon, E. James. 1999. *Bones, Boats and Bison: Archaeology of the First Colonization of Western North America.* University of New Mexico Press, Albuquerque.

———. 2001. Human Colonization of the Americas: Timing, Technology, and Process. *Quaternary Science Reviews* 20: 277–299.

Eerkens, Jelmer W., Jeffrey R. Ferguson, Michael D. Glascock, Craig E. Skinner, and Sharon A. Waechter. 2007. Reduction Strategies and Geochemical Characterization of Lithic Assemblages: A Comparison of Three Case Studies from Western North America. *American Antiquity* 72(3):585–597.

Eerkens, Jelmer W., Amy M. Spurling, and Michelle A. Gras. 2008. Measuring Prehistoric Mobility Strategies Based on Obsidian Geochemical and Technological Signatures in the Owens Valley, California. *Journal of Archaeological Science* 35:668–680.

Erlandson, Jon M., Madonna L. Moss, and Richard E. Hughes. 1992. Archaeological Distribution and Trace Element Geochemistry of Volcanic Glass from Obsidian Cove, Suemez Island, Southeast Alaska. *Canadian Journal of Archaeology* 16:89–95.

Erlandson, Jon, Rudy Walser, Howard Maxwell, Nancy Bigelow, John Cook, Ralph Lively, Charles Adkins, Dave Dodson, Andrew Higgs, and Janette Wilber. 199.1 Two Early Sites of Eastern Beringia: Context and Chronology in Alaskan Interior Archaeology. *Radiocarbon* 33(1):35–50.

Esdale, Julie, and Jeffrey T. Rasic. 2003. The RBS Site: Analysis of an 8,000 Year Old Microblade Production Site in Northwest Alaska. Paper presented at the 30th Annual Meeting of the Alaska Anthropology Association, Fairbanks.

Fladmark, Knut R. 1985. *Glass and Ice: A Report on the Archaeology of Mt. Edziza and Spectrum Ranges, Northwest British Columbia.* Publication 14. Department of Archaeology, Simon Fraser University, Burnaby, British Columbia.

Giddings, J. Louis, Jr. 1962. Onion Portage and Other Flint Sites of the Kobuk River. *Arctic Anthropology* 1(1):6–27.

Glascock, Michael D. 1992. Characterization of Archaeological Ceramics at MURR by Neutron Activation Analysis and Multivariate Statistics. In *Chemical Characterization of Ceramic Pastes in Archaeology,* edited by Hector Neff, pp. 11–26. Prehistory Press, Madison, Wisc.

———, ed. 2002. *Geochemical Evidence for Long-Distance Exchange.* Bergin and Garvey, Westport, Conn.

Glascock, Michael D., Geoffrey E. Braswell, and Robert H. Cobean. 1998. A Systematic Approach to Obsidian Source Characteristics. In *Archaeological Obsidian Studies: Method and Theory,* edited by M. S. Shackley, pp. 15–66. Plenum Press, New York.

Glascock, Michael D., John P. Cook, Randy L. Korotev, and Larry Haskin. 2004. Characterization of Sources and Distribution of Obsidian Artifacts in Alaska. Paper presented at the 69th Annual Meeting of the Society of American Archaeology, Montreal.

Glascock, Michael D., and Hector Neff. 2003. Neutron Activation Analysis and Provenance Research in Archaeology. *Measurement Science and Technology* 14:1516–1526.

Glascock, Michael D., Hector Neff, and Kevin J. Vaughn. 2004. Instrumental Neutron Activation Analysis and Multivariate Statistics for Pottery Provenance. *Hyperfine Interactions* 154(1–4):95–105.

Glascock, Michael D., Vladimir K. Popov, Yaroslov V. Kuzmin, Robert J. Speakman, Andrei V. Ptashinsky, and Andrei V. Grebennikov. 2006. Obsidian Sources and Prehistoric Obsidian Use on the Kamchatka Peninsula. In *Archaeology in Northeast Asia: On the Pathway to Bering Strait,* edited by Don E. Dumond and Richard L. Bland, pp. 73–88. University of Oregon Anthropological Papers 65, Eugene.

Glascock, Michael D., Robert J. Speakman, and Hector Neff. 2007. Archaeometry at the University of Missouri Research Reactor and the Provenance of Obsidian Artifacts in Eastern North America. *Archaeometry* 49(2):343–357.

Goebel, Ted. 1999. Pleistocene Human Colonization of Siberia and Peopling of the Americas: An Ecological Approach. *Evolutionary Anthropology* 8(6):208–227.

Goebel, Ted, W. Roger Powers, Nancy H. Bigelow, and Andrew S. Higgs. 1996. Walker Road. In *American Beginnings: The Prehistory and Palaeoecology of Beringia,* edited by F. H. West, pp. 356–363. University of Chicago Press, Chicago.

Goebel, T., Robert J. Speakman, and Joshua D. Reuther. 2008. Results of Geochemical Analysis of Obsidian Artifacts from the Walker Road Site, Alaska. *Current Research in the Pleistocene* 25:88–90.

Griffin, James B., Gary A. Wright, and Adon A. Gordus. 1969. Obsidian Samples from Archaeological Sites in Northwestern Alaska: A Preliminary Report. *Arctic* 22(2):152–156.

Hoffecker, John F., and Scott A. Elias. 2007. *Human Ecology of Beringia.* Columbia University Press, New York.

Hoffecker, John F., William R. Powers, and Nancy H. Bigelow. 1996. Dry Creek. In *American Beginnings: The Prehistory and Palaeoecology of Beringia,* edited by F. H. West, pp. 343–352. University of Chicago Press, Chicago.

Holmes, Charles E. 1996. Broken Mammoth. In *American Beginnings: The Prehistory and Palaeoecology of Beringia,* edited by F. H. West, pp. 312–317. University of Chicago Press, Chicago.

———. 2001. Tanana River Valley Archaeology circa 14,000 to 9000 B.P. *Arctic Anthropology* 38(2):154–170.

———. 2004 Pre-Clovis Traces at Swan Point, Alaska: Early Americans in Eastern Beringia. *Mammoth Trumpet* 20(1): 4–7.

Holmes, Charles H., Richard Vanderhoek, and Thomas E. Dilley. 1996. Swan Point. In *American Beginnings: The Prehistory and Palaeoecology of Beringia,* edited by F. H. West, pp. 319–323. University of Chicago Press, Chicago.

Kelly, Robert L. 1988. The Three Sides of a Biface. *American Antiquity* 53(4):717–734.

Kelly, Robert L., and Lawrence C. Todd. 1988. Coming into the Country: Early Paleoindian Hunting and Mobility. *American Antiquity* 53(2):231–244.

Kuhn, Steven L. 1991. "Unpacking" Reduction: Lithic Raw Material Economy in the Mousterian of West-Central Italy. *Journal of Anthropological Archaeology* 10:76–106.

———. 1994. A Formal Approach to the Design and Assembly of Mobile Tool-Kits. *American Antiquity* 59(3):426–442.

———. 1995. *Mousterian Lithic Technology: An Ecological Perspective.* Princeton University Press, Princeton, New Jersey.

Kunz, Michael L., Constance M. Adkins, and Richard E. Reanier. 2001. The Batza Tena Obsidian Source: Physical Description and Resource Availability. Paper presented at the 28th Annual Meeting of the Alaska Anthropological Association, Fairbanks.

Kunz, Michael L., Michael R. Bever, and Constance M. Adkins. 2003. *The Mesa Site: Paleoindians above the Arctic Circle.* BLM-Alaska Open File Report 86. Alaska State Office,

Bureau of Land Management, U.S. Department of the Interior, Anchorage.
Kuzmin, Yaroslav V., Robert J. Speakman, Michael D. Glascock, Vladimir K. Popov, Andrei V. Grebennikov, Margarita A. Dikova, and Andrei V. Ptashinsky. 2008. Obsidian Use at the Ushki Lake Complex, Kamchatka Peninsula (Northeastern Siberia): Implications for Terminal Pleistocene and Early Holocene Human Migrations in Beringia. *Journal of Archaeological Science* 35(8):2179–2187.
Lee, Craig M. 2001. Microblade Morphology and Trace Element Analysis: An Examination of Obsidian Artifacts from Archaeological Site 49PET1408, Prince of Wales Island, Alaska. Unpublished M.A. thesis, Department of Anthropology, University of Wyoming, Laramie.
Lively, Ralph A. 1996. Chugwater. In *American Beginnings: The Prehistory and Palaeoecology of Beringia,* edited by F. H. West, pp. 308–311. University of Chicago Press, Chicago.
Meltzer, David J. 1989. Was Stone Exchanged among Eastern North American Paleoindians? In *Eastern Paleo-Indian Lithic Resource Procurement and Processing,* edited by Christopher J. Ellis and Jonathon C. Lothrop, pp. 11–39. Westview Press, Boulder, Colo.
Moss, Madonna L., and Jon M. Erlandson. 2001. The Archaeology of Obsidian Cove, Suemez Island, Southeast Alaska. *Arctic Anthropology* 38(1):27–47.
Neff, Hector. 1994. RQ-mode Principal Components Analysis of Ceramic Compositional Data. *Archaeometry* 36:115–130
———. 2001. Synthesizing Analytic Data—Spatial Results from Pottery Provenance. In *Handbook of Archaeological Sciences,* edited by D. R. Brothwell and A. M. Pollard, pp. 733–747. John Wiley and Sons, Chichester, England.
Nelson, D. Erle, John M. D'Auria, and Roy B. Bennett. 1975. Characterization of Pacific Northwest Coast Obsidian by X-ray Fluorescence Analysis. *Archaeometry* 17(1):85–97.
Nelson, Margaret C. 1991. Study of Technological Organization. In *Archaeological Method and Theory,* vol. 3, edited by M. B. Schiffer, pp. 57–101. University of Arizona Press, Tucson.
Odess, Daniel, and Jeffery T. Rasic. 2007. Toolkit Composition and Assemblage Variability: The Implications of Nogahabara I, Northern Alaska. *American Antiquity* 72(4):691–717.
Patton, William W., Jr., and Thomas P. Miller. 1970. A Possible Bedrock Source for Obsidian Found in Archaeological Sites in Northwestern Alaska. *Science* 169:760–761.
Pearson, Georges A. 1999. Early Occupations and Cultural Sequence at Moose Creek: A Late Pleistocene Site in Central Alaska. *Arctic* 52:332–345.
Potter, Ben A. 2005. Site Structure and Organization in Central Alaska: Archaeological Investigations at Gerstle River. Unpublished Ph.D. dissertation, Department of Anthropology, University of Alaska, Fairbanks.
———. 2008 Radiocarbon Chronology of Central Alaska: Technological Continuity and Economic Change. *Radiocarbon* 50:181–204.
Powers, W. Roger, R. Dale Guthrie, and John F. Hoffecker. 1983. Dry Creek: Archaeology and Paleoecology of a Late Pleistocene Alaskan Hunting Camp. Report submitted to U.S. National Park Service, Anchorage.
Powers, William R., and John F. Hoffecker. 1989. Late Pleistocene Settlement in the Nenana Valley, Central Alaska. *American Antiquity* 54(2):263–287.
Rasic, Jeffrey T., and Robert Gal. 2000. An Early Lithic Assemblage from the Tuluaq Site, Northwest Alaska. *Current Research in the Pleistocene* 17:66–68.
Reimer, P. J., M. G. L. Baillie, E. Bard, A. Bayliss, J. W. Beck, C. J. H. Bertrand, P. G. Blackwell, C. E. Buck, G. S. Burr, K. B. Cutler, P. E. Damon, R. L. Edwards, R. G. Fairbanks, M. Friedrich, T. P. Guilderson, A. G. Hogg, K. A. Hughen, B. Kromer, G. McCormac, S. Manning, C. Bronk Ramsey, R. W. Reimer, S. Remmele, J. R. Southon, M. Stuiver, S. Talamo, F. W. Taylor, J. van der Plicht, and C. E. Weyhenmeyer. 2004. IntCa104 Terrestrial Radiocarbon Age Calibration, 0–26 cal kyr BP. *Radiocarbon* 46 (3):1029–1058.
Renfrew, Colin. 1969. Trade and Culture Process in European Prehistory. *Current Anthropology* 10(2/3):151–169.
Shackley, M. Steven. 2005. *Obsidian: Geology and Archaeology in the North American Southwest.* University of Arizona Press, Tucson.
Slobodina, Natalia, John Cook, Joshua Reuther, Robert J. Speakman, and Jeff Rasic. 2008. New Data from Old Collections: Alaskan Archaeological Obsidian Database. Paper presented at the 35th Annual Meeting of the Alaska Anthropological Association, Anchorage.
Speakman, Robert J. 2007. An Overview of Obsidian Provenance Studies in Alaska and Northwest Asia. Paper presented at the 34th Annual Meeting of the Alaska Anthropological Association, Fairbanks.
Speakman, Robert J., Michael D. Glascock, Vladimir K. Popov, Yaroslov V. Kuzmin, Andrei V. Ptashinsky, and Andrei V.Grebennikov. 2005. Geochemistry of Volcanic Glasses and Sources of Archaeological Obsidian on the Kamchatka Peninsula (Russian Far East): First Results. *Current Research in the Pleistocene* 22:11–13.
Speakman, Robert J., Charles E. Holmes, and Michael D. Glascock. 2007. Source Determination of Obsidian Artifacts from Swan Point (XBD-156), Alaska. *Current Research in the Pleistocene* 24:143–145.
Speakman, Robert J., and Hector Neff. 2005. *Laser Ablation-ICP-MS in Archaeological Research.* University of New Mexico Press, Albuquerque.
Stuiver, Minze, and Paula J. Reimer. 1993. Extended 14C database and revised CALIB radiocarbon calibration program. *Radiocarbon* 35:215–230.
West, Frederick H. 1996. The Archaeological Evidence. In *American Beginnings: The Prehistory and Palaeoecology of Beringia,* edited by Frederick H. West, pp. 537–560. University of Chicago Press, Chicago.
Wheeler, M. E., and Donald W. Clark. 1977. Elemental Characterization of Obsidian from the Koyukuk River, Alaska, by Atomic Absorption Spectophotometry. *Archaeometry* 19(1): 15–31.
Wilson, Lucy. 2007. Understanding Prehistoric Lithic Raw Material Selection: Application of a Gravity Model. *Journal of Archaeological Method and Theory* 14(4):388–411.
Yesner, D. R., and G. Pearson. 2002. Microblades and Migrations: Ethnic and Economic Models in the Peopling of the Americas. In *Thinking Small: Global Perspectives on*

Microlithization, edited by R. G. Elston and S. L. Kuhn, pp. 133–162. Archeological Papers of the American Anthropological Association 12, Arlington, Va.

Notes

1. Multiple obsidian sources exist in British Columbia, but Mount Edziza is the only British Columbian source currently known to have archaeological distributions extending into Alaska. For our purposes, only Mount Edziza is of relevance, given our focus on terminal Pleistocene and early Holocene distributions.

2. Important obsidian sourcing studies have been conducted on early Holocene assemblages from the coastal regions of Alaska and British Columbia (Ackerman 1996; Davis 1989; Lee 2001); however, many of these have yet to be incorporated into the AAOD. The contributions of these studies are briefly discussed throughout this chapter.

3. Letter designations presented in earlier studies do not correspond to letter designations presented here.

4. In the case of Cook (1995), the irradiation of samples took place at MURR. After irradiation, the samples were shipped to Washington University, St. Louis, for analysis.

5. Dates were calibrated using the Calib v5.0 software (Stuiver and Reimer 1993) using the IntCa104 terrestrial calibration model (Reimer et al. 2004). Dates are reported as 2-sigma age ranges.

6. All distances cited in this chapter are straight-line calculations from one point to another (i.e., from geological source to archaeological site).