The Colonization of Beringia and the Peopling of the New World

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The colonization of Beringia appears closely linked to the arrival of the oldest firmly documented archeological tradition in mid-latitude North America (Paleoindian). The discovery of a Paleoindian complex in central Alaska, combined with the recent redating of the Bering Land Bridge and key archeological sites, suggests that Beringia was settled during the final Pleistocene interstadial (12,000 to 11,000 years before present). Its population expanded rapidly into other parts of the New World. Beringia probably was colonized in response to changes in climate and vegetation that occurred during this interstadial. Access to the Americas was controlled by Beringian environments and not by changing sea levels or continental ice masses.

For over a century, controversy has surrounded the peopling of the New World (*1*). Although the presence of a population in North and South America at the close of the Pleistocene [roughly 11,000 years before present (yr B.P.) (*2*)] has been thoroughly documented in the archeological record, prehistorians continue to debate the question of earlier settlement. New claims of sites older than 11,500 yr B.P. are made regularly (*3–5*). Most claims are withdrawn or dismissed in the course of subsequent investigation, but at least a few sites [such as Meadowcroft Rockshelter in Pennsylvania (*6*)] have widely accepted ages of 20,000 to 12,000 yr B.P. or earlier. On the other hand, some archeologists have steadfastly maintained that compelling evidence for sites older than 11,500 yr B.P. has yet to be found (*7, 8*).

The oldest archeological sites in the New World are assumed to lie in Alaska and the Yukon. These regions represent the eastern remnant of Beringia, which provided the only land connection with the Old World and a plausible migration route for a Pleistocene population. However, archeologists were slow to discover early sites in this remote part of the hemisphere. When convincing evidence of Pleistocene settlement finally emerged in the 1960s and 1970s, the archeological remains bore close similarities to some late Pleistocene industries of northeast Asia but little resemblance to those from early sites in other parts of the New World. The archeological finds in Beringia did not shed much light on the problem of the initial peopling of the Americas (*9*).

In recent years, new discoveries in Alaska have yielded traces of an industry older than 11,000 yr B.P. that exhibits many similarities to early sites in mid-latitude North and South America. New research also has provided a more accurate picture of changing sea levels and environments in Beringia at the close of the Pleistocene and has revised the dating of some important archeological sites in Beringia and North America. In this article, we review the new evidence and present a synthesis for the colonization of Beringia. We also discuss the implications for the broader issue of the peopling of the New World.

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Beringia and the Land Bridge: A Revised Chronology

The term Beringia was originally proposed by Hultén to represent the land mass between the present shores of northeast Asia and Alaska created by the emergence of continental shelf areas during low sea-level stands of the Pleistocene (*10*). Most researchers now equate this definition with the Bering Land Bridge. Hopkins offered a broader definition of Beringia, incorporating existing land areas of northeast Siberia and western Alaska (*11*), whereas others have expanded the boundaries to the Lena River in the west and the Mackenzie River in the east (*12–14*).

We draw the boundaries of Beringia along the Verkhoyansk Range in the west and the margin of the maximum limit of the Laurentide Ice Sheet, west of the Mackenzie River, in the east (Fig. 1). The Verkhoyansk Range appears to mark a major barrier to human settlement. The area adjoining the western slope of the range (Lena Basin) was probably occupied 20,000 to 15,000 yr B.P. or earlier (*15*), whereas lands east of the range now seem to have been settled only at the close of the Pleistocene. The Verkhoyansk Mountains are unlikely to have blocked human colonization of Beringia [although they were glaciated from 25,000 to 14,000 yr B.P. (*16*)] but appear to have been a boundary of some environmental significance [they currently delineate differences in temperature and moisture (*17*)]. In the east, the margin of the Laurentide Ice Sheet was an impenetrable (but dynamic) ecological barrier.

Past episodes of cold climate, by generating growth in continental ice masses with corresponding reductions in global sea level, have periodically united the two halves of Beringia. A drop in sea level of ~50 m was necessary for creation of the land bridge (*18*). Although reconstruction of the land bridge's history has been complicated by isostatic uplift and postglacial marine-sediment deposition, a chronology for the Late Pleistocene (128,000 to 10,000 yr B.P.) has been developed on the basis of dated shorelines, marine-sediment cores, and other data sources (*19–21*). According to the chronology, at least portions of the Bering Land Bridge were exposed during most, if not all, of oxygen-isotope stage 3 (60,000 to 25,000 yr B.P.). During the succeeding stage 2 (or Last Glacial Maximum and Late Glacial), global sea level fell as much as 121 m below that of the present day and the land bridge probably reached its maximum extent between 20,000 and 18,000 yr B.P. Until recently, it was believed that a rapid rise in sea level after the Last Glacial Maximum cold peak reduced the land bridge to a "narrow isthmus" at Anadyr Strait as early as 15,500 yr B.P., which was flooded by 14,400 yr B.P. (*20, 21*). In short, it appeared that a land migration to the New World was not possible after ~14,000 yr B.P.

New studies of global sea level since 17,000 yr B.P. have underlined the need for significant revision of the previously accepted chronology. Analysis of coral cores (dated by ^{14}C) from Barbados indicates that sea level remained below −70 m as late as 12,000 yr B.P. and did not rise above −50 m until after 10,000 yr B.P. (*22*). Application of the Barbados chronology to Beringia is supported by terrestrial plant and animal remains dated (^{14}C) to 11,330 and 11,000 yr B.P., respectively, which were found in peat cores recovered at depths of −50 m off the coast of northwest Alaska (*23*). A land connection between northeast Siberia and Alaska thus appears to have survived as late as 11,000 or 10,000 yr B.P.

It has never been clear if the presence of the land bridge was critical to the occupation of the New World. During the Holocene, hunter-gatherer peoples moved freely across the Bering Strait by way of water or sea ice, and comparable bodies of water were crossed elsewhere during the Pleistocene [for example, the Timor Sea (*24*)]. However, the presence of the land bridge does hold major implications for the colonization process because the submergence of continental shelf areas would have converted a dry interior plain in central Beringia into a maritime coastal region. Once this event took place, only peoples adapted to coastal environments would have been likely to move from northeast Asia into Alaska. The evidence for a younger land bridge indicates that big-game hunters adapted to continental interior environments could have colonized Beringia as late as 12,000 to 10,000 yr B.P.

Retreating ice masses in western Canada yielded access from Beringia to the North American Plains by at least 14,000 yr B.P. An ice-free corridor between the Laurentide and Cordilleran ice sheets may have been present throughout much of the Last Glacial Maximum (25,000 to 14,000 yr B.P.) but might have sustained little in the way of plant and animal communities (*25, 26*). The evidence for viable access routes to mid-latitude regions of North America indicates that a Beringian population could have colonized other parts of the New World as early as 14,000 yr B.P.

The Beringian Environmental Debate

During the Last Glacial Maximum, Beringian environments were significantly colder and drier than those of the present (*27, 28*). However, there is still disagreement among researchers regarding the character of the landscape. Paleoenvironmental models of Beringia under full glacial conditions range from a relatively productive cold steppe, populated with a diverse community of large mammals (based primarily on faunal remains) (*29*), to a bleak polar desert, unable to support a substantial mammalian biomass (based on palynological data) (*30*).

The palynological data are derived from lacustrine sediment cores and from loess and buried peat deposits in various parts of Beringia. Most of the data have been collected from localities in Alaska and the Yukon, where calibrated sequences for the last 25,000 years consistently yield a succession of three major stages: (i) an herb zone dominated by grasses, sedges, willow, and sage (*Artemisia*) (25,000 to 14,000 yr B.P.); (ii) a zone that exhibits a significant increase in dwarf birch (beginning 14,000 to 12,000 yr B.P.); and (iii) a time-transgressive zone characterized by a sharp increase in alder and some spruce (beginning 10,000 to 7,000 yr B.P.) (*28, 31–33*). A similar (but not identical) sequence of stages is evident in northeast Asia (*34*).

There is widespread agreement that the herb zone, which corresponds to the Last Glacial Maximum, reflects an almost complete absence of trees from Beringian landscapes. This conclusion is supported by the scarcity of wood fragments in riverine deposits dated between 25,000 and 14,000 yr B.P. (*28, 35*). However, controversy surrounds the interpretation of the nonarboreal pollen record. Colinvaux, Ritchie, and Cwynar have used the low influx rates, limited ecological diversity, and arctic-alpine affiliations of the pollen spectra taken from several key lake cores to argue that the herb zone represents an arctic tundra or polar desert (*36*). They concluded that Beringian environments of the Last Glacial Maximum could not have sustained a large and diverse community of ungulates, and Colinvaux and West further suggested that the poverty of large mammalian prey inhibited human colonization of Beringia until the spread of mesic shrub tundra vegetation recorded in the birch zone (after 14,000 yr B.P.) (*30*).

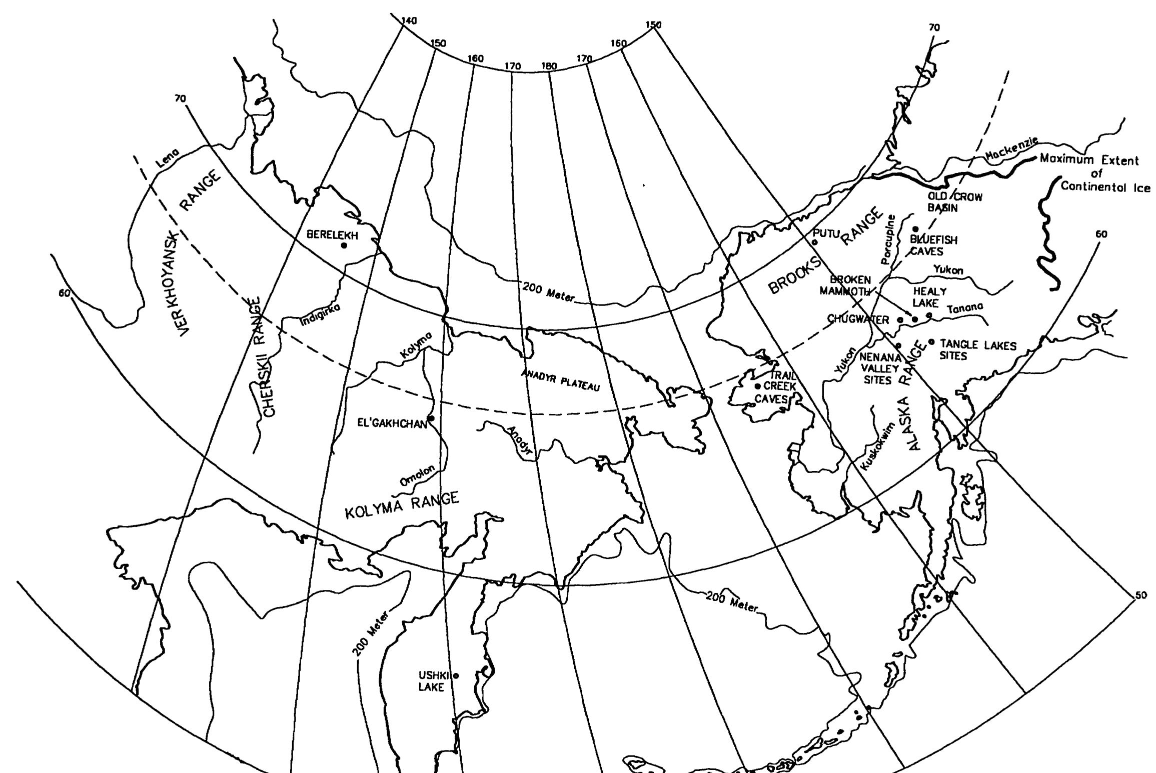

Fig. 1. Map of Beringia illustrating major geographic features, including approximate position of coastal margins during the Last Glacial Maximum (corresponding to the 200-m depth contour) and principal archeological localities discussed in the text.

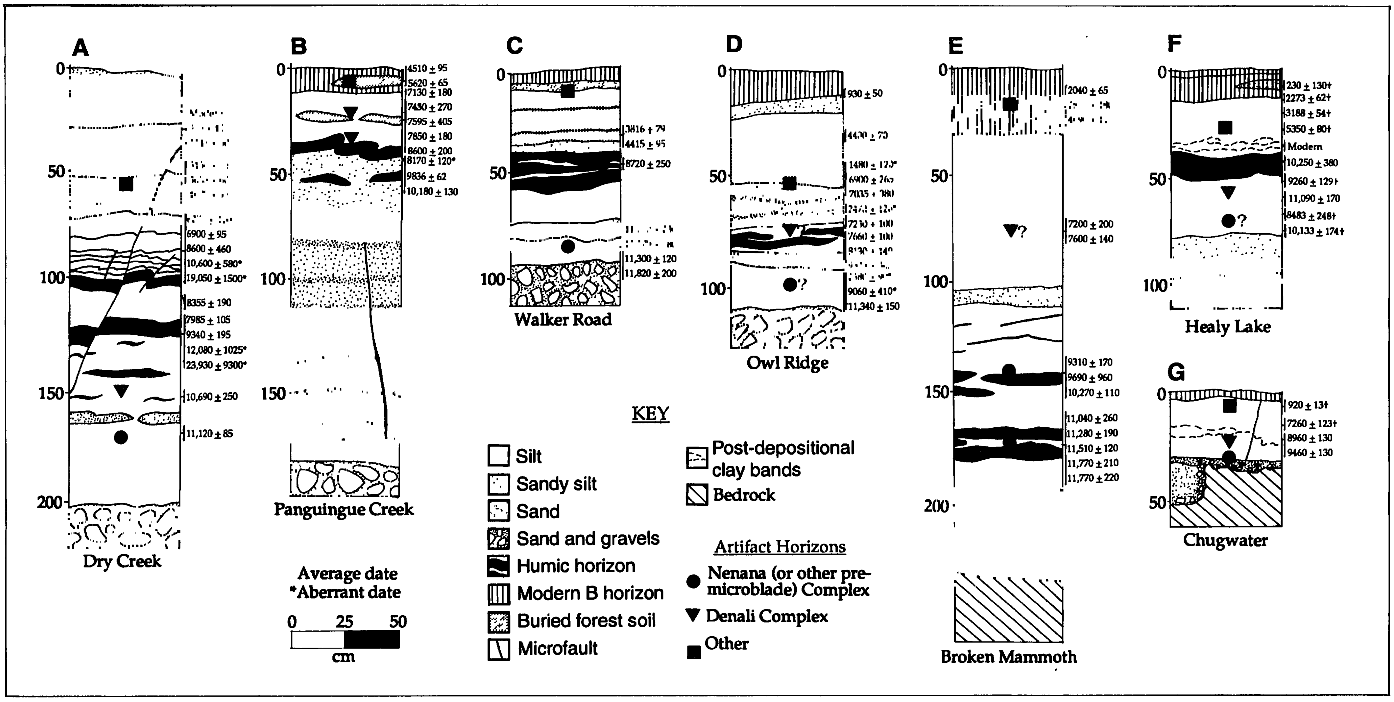

Fig. 2. Stratigraphic profiles from archeological sites in central Alaska: (**A**) Dry Creek (Nenana Valley), (**B**) Panguingue Creek (Nenana Valley), (**C**) Walker Road (Nenana Valley), (**D**) Owl Ridge (Teklanika Valley), (**E**) Broken Mammoth (Tanana Valley), (**F**) Healy Lake (Tanana Valley), and (**G**) Chugwater (Tanana Valley) (*39, 43–47*). "Other complex" includes, for example, Northern Archaic and Late Microblade. Numbers to the right of each profile in years before present.

Alternatively, Guthrie and others argued that Beringian environments were more steppic in character and supported a diverse community of large mammals (*29, 37*). Many of the species in this community, which include woolly mammoth, steppe bison, horse, reindeer, camel, saiga, and others, could not have subsisted on tundra vegetation. Contrary to earlier assertions (*32*), a growing number of radiocarbon dates indicate that most, if not all, members of this community were present during the Last Glacial Maximum (herb zone) and Late Glacial (birch zone) (*37*). Guthrie concluded that large mammalian prey populations were abundant in Beringia before 14,000 to 12,000 yr B.P. and that another factor—probably lack of adequate wood for fuel—prevented human colonization of the region until the Late Glacial (*29*). The eastern Beringian pollen record reflects significant increases in aspen, followed by successive peaks of willow and juniper, after 12,000 yr B.P. (*33*).

Although the debate continues, consensus has emerged that Last Glacial environments probably contained a complex mosaic of vegetation that included some steppic communities. There seems to have been a diverse large-mammal community between 25,000 and 12,000 yr B.P. The apparent discrepancy between the faunal and palynological data is probably due, at least in part, to the variability in plant communities among different regions and topographic settings in Beringia. More steppic vegetation may have been concentrated in the river valleys, broad outwash plains, and south-facing slopes (*27, 33, 38*). In any case, we agree with Guthrie that lack of adequate mammalian prey is unlikely to have been the barrier to human settlement before 14,000 to 12,000 yr B.P.

The Late Glacial Archeology of Beringia: Central Alaska

The early prehistory of Beringia remains poorly understood. A substantial portion of the original landscape is under water and inaccessible to archeologists. More important, the remnants of Beringia (northeastern Yakutia, Chukotka, Alaska, and the Yukon) have been subjected to limited modern settlement. Activities that typically produce archeological discoveries (such as road and dam construction) are relatively rare in these regions. Most of the early prehistoric sites discovered to date in Alaska have been found along major highway corridors.

Central Alaska contains the most important early sites in Beringia, in no small part because of the stratigraphic and chronologic context provided by the loess deposits that occur in this region. The two principal concentrations of sites are in the north-central Alaska Range and the Tanana Valley. Remains at these sites are buried in aeolian sand and silt that typically contain buried soil horizons. At many sites, the deposits are sufficiently deep (1 to 2 m) that mixture of materials from different time periods has been minimal. Although most are poor in paleobotanical and faunal remains, information derived from the sediments and buried soils facilitates both their integration with the regional paleoclimatic sequence and cross correlation among sites (*39, 40*) (Fig. 2).

Sites in the Alaska Range are found in both the range itself and the northern foothills. In the range, sites are located in the upper reaches of three major rivers that flow north into the Tanana Basin: Teklanika River (Teklanika East and West sites), Nenana River (Carlo Creek site), and Delta River (Tangle Lakes sites) (*12, 41, 42*). With the exception of Carlo Creek, where artifacts and faunal debris are buried in fluvial sediment, remains at these sites are contained in shallow aeolian deposits (0.2 to 0.5 m). Occupation of the Tangle Lakes and Carlo Creek sites is dated (^{14}C) between 10,150 and 8,400 yr B.P., whereas a dated buried soil of Middle Holocene age overlies the occupation level at Teklanika West.

The Tangle Lakes and Teklanika River sites contain artifacts (including wedge-shaped microcores, microblades, burins, and lanceolate points) characteristic of the Denali Complex, which was defined by West (*41*). This complex represents a regional and temporal variant of a microblade

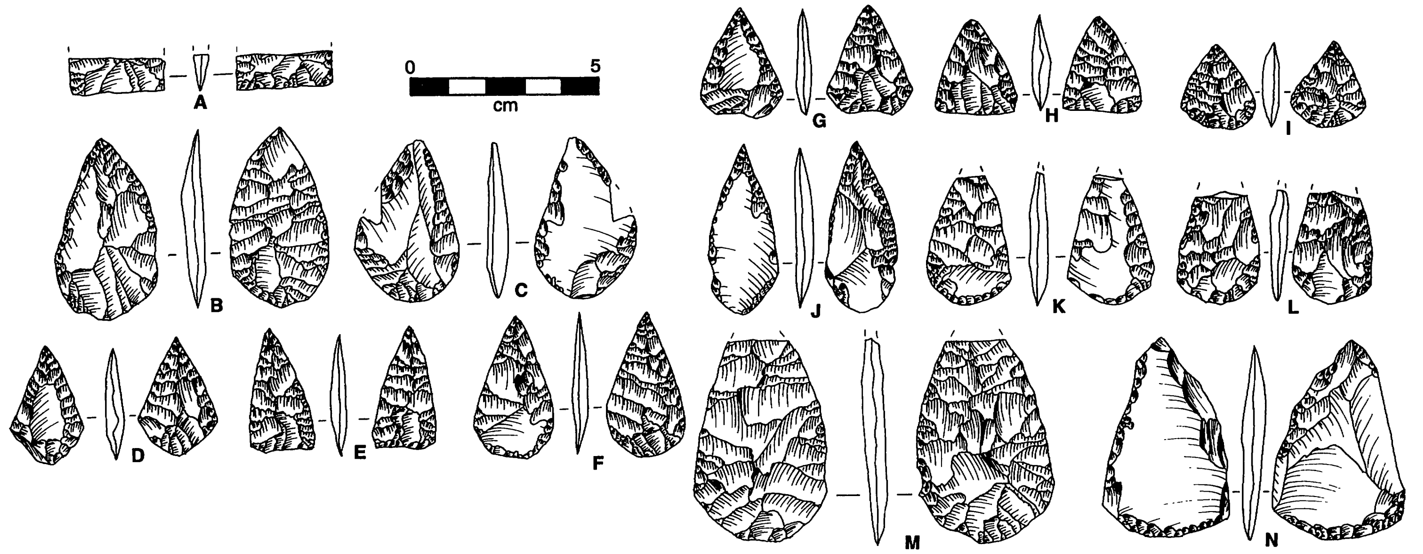

Fig. 3. Bifacially retouched artifacts assigned to the Nenana Complex from (**A** and **E**) Dry Creek (Nenana Valley), (**B, C,** and **F**) Walker Road (Nenana Valley), (**D, G, H, J, K,** and **M**) Healy Lake (Tanana Valley), and (**I, L,** and **N**) Chugwater (Tanana Valley).

industry that was widespread across northeast Asia and northwestern North America in the Late Pleistocene and Early Holocene (*9, 12, 15*). The Carlo Creek assemblage is small and contains few diagnostic items but is assigned to the Denali Complex on the basis of dating and presence of some generic Denali types (lanceolate bifaces and large blades) (*42*).

Sites in the north-central foothills of the Alaska Range are found in major valleys along the margins of terraces adjacent to tributary streams and comprise those in the Nenana Valley (Dry Creek, Walker Road, Panguingue Creek, and Moose Creek) and Teklanika Valley (Owl Ridge) (*39, 40, 43*). Remains at these localities are buried in loess and aeolian sand deposits (typically 1 m or more in depth) that began to accumulate ~12,000 yr B.P. The oldest occupation levels in the foothills occur near the base of these aeolian deposits and are dated [conventional and accelerator mass spectrometry (AMS) ^{14}C] between 11,820 and 11,010 yr B.P. A small quantity of faunal remains (sheep and wapiti) was recovered from Dry Creek.

Lithic assemblages from the lowest occupation levels at Dry Creek and Walker Road reflect flake and blade core technology, but wedge-shaped microcores and microblades are completely absent. Retouched items include small bifacial points (teardrop-shaped and triangular), bifaces, end scrapers, side scrapers, wedges (*pièces esquillées*), and planes. These assemblages are assigned to the recently defined Nenana Complex (39) (Figs. 3 and 4). The dating and character of the lowest assemblages at Moose Creek and Owl Ridge are uncertain. These assemblages are dated to >11,000 yr B.P. and lack microblade technology, but preliminary test excavations have not yielded diagnostic elements of the Nenana Complex.

Sites in the foothill zone also contain assemblages assigned to the Denali Complex. These assemblages, which are found at Dry Creek, Panguingue Creek, and possibly Owl Ridge, have been dated (conventional and AMS ^{14}C) between 10,690 and 7,230 yr B.P. The artifacts from Dry Creek and Panguingue Creek are highly diagnostic and include wedge-shaped microcores, microblades, burins, lanceolate points, and bifacial knives (Fig. 5); some faunal remains (bison and sheep) were recovered from Dry Creek. The assemblage from Owl Ridge that falls in this time range lacks diagnostic artifact forms. The Donnelly Ridge site, located on a Late Pleistocene terminal moraine in the Delta Valley, contains a typical Denali Complex assemblage but remains undated (*41*).

Sites in the Tanana Valley are situated on bedrock ridges and knobs overlooking the north side of the river. These sites, which include Healy Lake, Chugwater, and Broken Mammoth, also contain remains buried in aeolian sand and loess that vary from 0.3 to 2.5 m in depth (*44–47*). At Healy Lake, where the deposits are relatively shallow (~0.5 m), artifacts diagnostic of both the Nenana and Denali Complexes (such as teardrop-shaped and triangular points and wedge-shaped microcores) were recovered from the lower levels. These levels, which appear to have been mixed, yielded ^{14}C dates between 11,090 and 6,650 yr B.P. (*45*). Although the deposits at Chugwater are equally shallow (0.3 to 0.5 m), excavators identified a Denali component (dated at 9460 to 6260 yr B.P.) overlying a Nenana component (undated) (*45*).

The recently discovered Broken Mammoth site, which is located at the mouth of Shaw Creek, is likely to become the most important early prehistoric site in the Tanana Basin (*47*). Artifacts and a large quantity of faunal remains (including bison, elk, caribou, and various small vertebrates) are buried in deposits of loess and aeolian sand that average 2.3 to 2.5 m in depth. The lowest occupation level has yet to produce diagnostic artifacts but has been dated (^{14}C) at 11,770 to 11,040 yr B.P. The overlying occupation horizon has yielded a small bifacial point and point

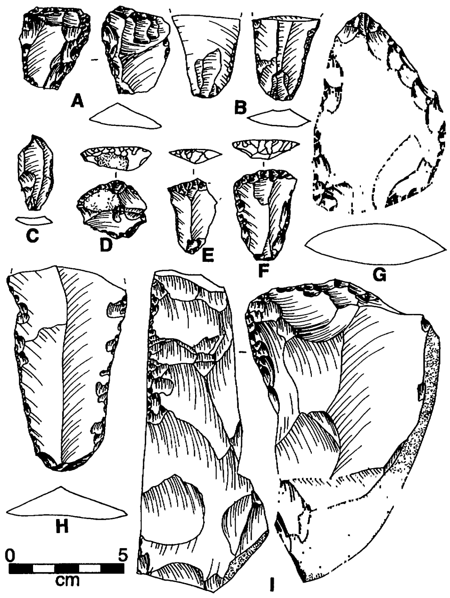

Fig. 4. Other characteristic artifact types assigned to the Nenana Complex, including (**A**) *pièce esquillée*, (**B** and **H**) retouched blades, (**C**) graver, (**D** to **F**) end scrapers, (**G**) side scraper, and (**I**) plane. All specimens are from the Walker Road site (Nenana Valley).

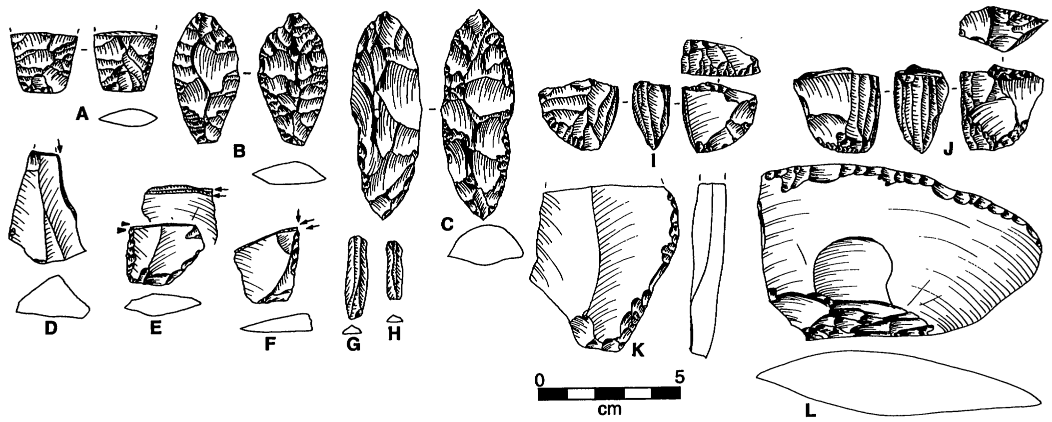

Fig. 5. Artifacts assigned to the Denali Complex, including (**A**) lanceolate point fragment, (**B** and **C**) bifaces, (**D** to **F**) burins, (**G** and **H**) microblades, (**I** and **J**) wedge-shaped microcores, (**K**) retouched flake, and (**L**) side scraper. All specimens are from the Dry Creek site (Nenana Valley).

fragment similar to those from Nenana Complex assemblages. However, ^{14}C ages on this layer (10,270 to 9,310 yr B.P.) are slightly younger than the dates on the Nenana Complex from the northern foothills of the Alaska Range. The uppermost occupation level contains a microblade assemblage dated at 4690 to 2040 yr B.P.

The central Alaskan record indicates that the earliest documented occupants (represented in the Nenana Complex) entered the region during the 12,000 to 11,000 yr B.P. interstadial (*48*). They hunted large mammals such as bison and elk in the Tanana Valley and sheep in the northern foothills of the Alaska Range; they also may have exploited smaller mammals, birds, and fish. The earliest inhabitants of central Alaska manufactured a stone tool kit that included small bifacial points, end scrapers, and a variety of less diagnostic items but no wedge-shaped cores or microblades. A microblade industry did not appear until ~10,700 yr B.P., which coincided with the onset of the final cold oscillation of the Late Pleistocene (*48*). The people who manufactured this microblade industry not only occupied the Tanana Basin and foothill zone but infiltrated alpine valleys in the Alaska Range. Although they sometimes camped at the same locations (where their remains occur stratigraphically above those of the Nenana Complex) and exploited the same resources, their technology and tools differed sharply from those of the earlier occupants of the region. Nevertheless, there is evidence of some temporal overlap between the two complexes from the Tanana Basin (at Broken Mammoth).

The Late Glacial Archeology of Beringia: Other Regions

Archeological sites of Pleistocene age are found in other parts of the former Beringian land mass but fail to provide a coherent picture outside the context of the central Alaskan record. Until recently, these sites were widely believed to demonstrate that humans settled Beringia at least 15,000 yr B.P. and that a Beringian microblade industry existed before 11,000 yr B.P. (*12, 14*). However, research conducted during the past decade has undermined both propositions.

Sites in other parts of Alaska yield little information on events before 11,000 yr B.P. On the Seward Peninsula, Trail Creek Cave 9 contained a bison bone that appeared to have been broken by humans 13,070 yr B.P. (*49*). However, no other traces of human occupation are documented and the breakage is generally assumed to be of nonhuman origin (probably carnivore) (*50*). In the northern Brooks Range, artifacts were recovered from shallow loess deposits (<0.5 m) at the Putu site that contained a hearth dated to 11,470 yr B.P. Dates of 8454 to 5700 yr B.P. were also obtained from charcoal and soil organics in the loess. The assemblage includes fluted points, lanceolate points, burins, and microblades, but it is not clear which artifacts are associated with the dated hearth (*51, 52*). By contrast, sites in many parts of Alaska reflect the spread of microblade technology after 10,700 yr B.P. [for example, at Trail Creek Caves, Onion Portage, Ugashik lakes, and Ground Hog Bay (*49, 53*)].

Several researchers formerly postulated a human presence in the Old Crow Basin of the northern Yukon as early as 80,000 to 30,000 yr B.P. on the basis of flaked and fragmented mammal bones dating to this time interval (*54*). However, the specimens now appear to represent naturally fractured bone and artifacts of Holocene age (*55*). Late Pleistocene occupation of the northern Yukon also has been suggested at the Bluefish Caves, where stone artifacts (including wedge-shaped microcore, microblades, and burins) and faunal remains (mammoth, bison, horse, and others) were recovered from shallow loess deposits (*14, 50*). Although ^{14}C ages between 25,000 and 12,000 yr B.P. were obtained from the bones, the relation between the bones and artifacts remains unclear and the age of the latter has yet to be established.

To date, only two stratified Pleistocene sites have been reported from western Beringia: Berelekh (near the mouth of the Indigirka River) and Ushki I (central Kamchatka). At Berelekh, artifacts were originally reported in association with a large concentration of faunal debris (chiefly mammoth) that yielded dates from 13,420 to 12,240 yr B.P. (*15*). However, subsequent investigation revealed that, although most of the mammoth remains are buried 3.5 to 4 m below the surface, the artifacts are found at depths of 1.5 and 2.5 m (*56*). With the exception of several mammoth and horse bone fragments, faunal remains associated with the artifacts are confined to modern species. Investigators suggested that the mammoth fragments (which are more weathered than other faunal remains recovered with the artifacts) were scavenged from the older bone bed and that the site was not occupied by humans until after 12,000 yr B.P. The character of the artifact assemblage is ambiguous. Neither the isolated small blade fragments (found in stratigraphic context) nor single microcore (found on the riverbank) conforms to diagnostic types of the Siberian and Beringian microblade industries. One teardrop-shaped bifacial point also was recovered on the riverbank.

Central Kamchatka is situated at a more southerly latitude (57°N), in a more maritime climatic setting, and may reflect a somewhat different history of settlement than the regions discussed above. At Ushki I, the lowest occupation horizon (layer 7) yielded an artifact assemblage with numerous bifacial points (chiefly stemmed), end scrapers, side scrapers, burins, and other items dated at 14,300 to 13,600 yr B.P. (*57*). Subsequently, a younger ^{14}C date of 9750 yr B.P. was reported for this level (*58*). Although the assemblage lacks microblades and may antedate 11,000 yr B.P., its relation to other Beringian sites is unclear. The overlying layer 6 contains an assemblage of wedge-shaped microcores, microblades, bifacial knives, and burins dating from 10,860 to 10,360 yr B.P.

The recently discovered El'gakhchan site, on the Omolon River in western Chukotka, may represent another Pleistocene occupation in western Beringia (59). The site currently is under excavation, and only preliminary data are available. A lithic assemblage containing small bifacial points (stemmed and teardrop-shaped), bifacial knives, side scrapers, end scrapers, and burins is reportedly buried in loess deposits (~1 m in depth).

The Search for Older Sites

It is impossible to prove the negative in the historical sciences. The lack of evidence for settlement in Beringia and the New World before 12,000 yr B.P. can always be attributed to insufficient preservation or sampling. Therefore, the appropriate question is: What is the significance of the negative evidence?

There is a considerable body of negative evidence regarding human settlement south of the Laurentide Ice Sheet before 12,000 yr B.P. (60, 61). The issue is pertinent to the problem of Beringian colonization because the firmly documented presence of humans in other regions of the New World before this time implies that there must have been equally old or older sites in Beringia. However, despite years of intensive archeological investigation in many areas of North and South America, only a handful of sites have been discovered that may antedate 12,000 yr B.P. Even the most impressive examples, such as Meadowcroft Rockshelter (6) and Monte Verde (62), remain problematic (61, 63). The consistent failure to find indisputable evidence of human occupation in promising sedimentary and topographic contexts (64) lends much weight to the argument that humans were not present before 12,000 yr B.P.

Beringia must be evaluated separately because much of it remains inaccessible, untested, and thinly settled. However, there is a small but growing body of negative evidence against Beringian colonization before 12,000 yr B.P. Several major reconnaissance and survey projects have specifically sampled Quaternary deposits in Alaska and the Yukon that might contain archeological remains from this time. These include alluvial deposits in the Old Crow Basin (54), cave deposits along the Porcupine River (65), and loess deposits in the Middle Kuskokwim region (66). A variety of settings (loessic colluvium, glaciofluvial outwash, and fan alluvium) have been tested in the northern foothills of the Alaska Range (67). The most significant evidence against earlier Beringian settlement may be the lack of firmly dated occupations older than ~11,000 yr B.P. in mid-latitude North America and further south, despite apparent access to these regions from Beringia by at least 14,000 yr B.P.

The Nenana Complex and the Paleoindian Tradition

The Clovis Complex of the Paleoindian Tradition remains the oldest firmly documented archeological entity in mid-latitude North America (68–70). The industry is characterized by flake and blade core technology and production of bifacial projectile points (typically lanceolate fluted points), end scrapers, side scrapers, *pièces esquillées*, and gravers. Wedge-shaped microcores and microblades are absent, and burins are generally rare. Clovis assemblages are commonly associated with the remains of large mammals, especially mammoth and bison.

New AMS ^{14}C ages and reanalyses of old dates from key sites indicate that Clovis occupations tend to cluster between 11,200 and 10,900 yr B.P. and not, as previously thought, between 11,500 and 11,000 yr B.P. (71). The revised chronology reveals significant temporal overlap among Clovis, the slightly younger Folsom, and possibly other Paleoindian complexes (72). There now appears to have been considerable variability among Paleoindian assemblages in mid-latitude North America ~11,000 yr B.P., especially with respect to point typology. Such variability is also evident among the South American industries in this time range (73).

The absence of incontrovertible evidence of occupation before Clovis has encouraged researchers to seek its origins in the archeological record of Beringia and the adjoining areas of northeast Asia. However, there are striking differences between the technology and typology of the Clovis Complex and the microblade industry that dominated the early record of those regions for many decades (especially the absence of wedge-shaped microcores and microblades from the former). Some researchers emphasized that similarities do exist between the two industries (such as bifacial points and large blades) and suggested that the contrasts reflected rapid adaptive shifts in technology and tool kits as Beringian populations expanded southward into new environments (12, 29). Others postulated that a yet undiscovered or undated pre-microblade horizon was present in Beringia (9). Advocates of this hypothesis were encouraged by the repeated discovery from the late 1940s onward of fluted points in northern Alaska and the Yukon (52, 74). However, these points were recovered from surficial or undated contexts and could not be definitively assigned to an early time period (75).

New developments in central Alaskan archeology during the past decade have dramatically altered this situation. The discovery of a non-microblade industry in a Late Pleistocene stratigraphic and geochronologic context provided a link between the Clovis Complex and the colonization of Beringia (39, 70). A quantitative comparison of selected Nenana and Clovis assemblages indicates that the two complexes are highly similar and share most diagnostic elements (including bifacial projectile points, end scrapers, *pièces esquillées*, convex side scrapers, and gravers) (76). The major difference lies in the apparent absence of lanceolate fluted points in the Nenana Complex. However, the early Paleoindian sites contain a variety of bifacial point forms, and some Clovis assemblages include small non-fluted forms (77).

There is a solid technological and typological basis for the inclusion of the Nenana Complex into the Paleoindian Tradition (76, 78). Furthermore, the revised dating of key Clovis sites suggests that the Nenana Complex antedates Clovis by a hundred years or more, and so it emerges as a logical source for the latter. By contrast, the Beringian microblade industry (assigned to the Paleoarctic Tradition) cannot be reliably dated to earlier than 10,900 yr B.P. in western Beringia (Kamchatka) and 10,700 yr B.P. in eastern Beringia (Alaska).

The Colonization of Beringia: Timing and Causes

Recent discoveries and new research have undermined some past assumptions and interpretations of the colonization of Beringia. On the basis of these results, we propose a revised model for this major event in human prehistory and its relation to the peopling of the New World.

1) The settlement of Beringia began ~12,000 yr B.P. (although marginal areas of southwestern Beringia may have been occupied as early as 14,000 yr B.P.). The continued presence of a land bridge permitted rapid colonization of western and eastern Beringia. The lack of occupations in other regions of the New World that are firmly dated to before 11,200 yr B.P., despite apparent access to these regions from Alaska and the Yukon by at least 14,000 yr B.P., suggests the absence of a Beringian population before 12,000 yr B.P.

2) Beringia was colonized at the beginning of a major interstadial (12,000 to 11,000 yr B.P.) and probably in response to environmental changes that occurred at this time. The critical environmental variable may have been the reappearance of trees in river valleys and other areas, which provided adequate fuel sources for the first time since 25,000 yr B.P. or earlier (79). Palynological data from eastern Beringia indicate an invasion of trees (initially aspen

and balsam poplar) after 12,000 yr B.P.

3) No obvious source for the early Beringian Complex can now be identified in northeast Asia. The lithic technology and typology of the Nenana Complex bear limited resemblance to the microblade industries that were widespread in northeast Asia (including the Lena Basin, northern China, and Japan) between 15,000 and 10,000 yr B.P., although elements (such as bifacial points and end scrapers) are present in some sites. Non-microblade industries in these regions, which typically reflect flake and blade core technology and contain side scrapers, end scrapers, retouched blades, and other generic tool forms, are generally dated to before 15,000 yr B.P. (*15, 80*).

4) The people who occupied Beringia after 12,000 yr B.P. expanded rapidly into other parts of the New World. The lithic assemblages in mid-latitude North America (including those assigned to the Clovis Complex) that date to ~11,000 yr B.P. bear many similarities to those of the Nenana Complex and probably represent the same population. Movement from Beringia to mid-latitude North America was not constrained by continental ice masses, which apparently were not a barrier to migration as early as 14,000 yr B.P.

5) After the onset of the final Pleistocene cold oscillation at 11,000 to 10,500 yr B.P. (Younger Dryas), early Beringian industries were replaced by a distinctive microblade technology (*81*). This abrupt transition probably reflects the spread of a new population, which is consistent with the hypothesis (based on linguistic, dental, and genetic studies) that two or more migrations occurred at the close of the Pleistocene (*82*). The microblade technology never spread beyond the northern regions of North America.

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Mathematics Achievement of Chinese, Japanese, and American Children: Ten Years Later

Harold W. Stevenson, Chuansheng Chen, Shin-Ying Lee

A decade of heightened emphasis in the United States on mathematics and science education has had little influence on academic achievement or parental attitudes. American elementary school children in 1990 lagged behind their Chinese and Japanese peers to as great a degree as they did in 1980. Comparison of the performance of elementary and secondary school students between 1980 and 1990 reveals a decline from first to eleventh grade in the relative position of American students in mathematics. Parental satisfaction with American students' achievement and education remains high and standards remain low. Innate ability continues to be emphasized by Americans as a basis for achievement. American eleventh graders report more indications of stress than do their Chinese and Japanese counterparts.

The American educational system received greater attention and scrutiny in the 1980s than in any decade since the 1950s. President Bush and governors proposed an educational agenda for the nation, commissions were appointed, and boards of education and school systems throughout the country attempted to initiate reforms aimed at improving the academic achievement of American students. We are now at a point, 10 years after the reform movement began, where it is useful to ask whether these activities have resulted in any improvement in the performance of the students.

In 1980, we initiated a comparative study of American, Japanese, and Chinese elementary school students in Minneapolis, Sendai (Japan), and Taipei (Taiwan). The results showed that Chinese and Japanese first and fifth graders greatly surpassed their American counterparts in mathematics and that Chinese children were more capable readers than the Americans (*1*).

The low levels of achievement found in Minneapolis are especially worrisome because Minnesota students rank high among the states in mathematics achievement, and Minnesota has the highest percentage in the nation of students graduating from high school (*2, 3*). When problems are found in Minnesota, more severe ones might be expected to occur in many other states.

Four years after our original study, we returned to the same schools and followed up the first graders who were now fifth graders. No significant improvement occurred in the mathematics achievement of Minneapolis fifth graders during the 4 years, and cross-cultural differences were as great in 1984 as they had been in 1980 (*4*).

We began a new study in 1990. Once again we visited the schools included in the original study and tested a third sample of fifth graders. We also attempted to locate the first graders we had tested in 1980 (who were now eleventh graders) to trace their subsequent levels of academic achievement. To supplement the longitudinal sample, we tested over 1000 eleventh graders in each city. Data from the samples of students tested in 1980, 1984, and 1990 and 1991 form the basis of this article. These data allow us to assess possible changes in the performance of elementary school students

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