However, a hiatus or highly condensed sequence, representing the latest Eocene and Oligocene, reflects a prolonged interval of bottom erosion over the shallow-water South Tasman Rise. This hiatus is equivalent to that in the Tasman Sea, Coral Sea (*13*), and other oceanic sequences throughout the world (*14*), and appears to reflect intensified oceanic circulation resulting from Antarctic glacial development.

During the middle to late Oligocene, about 25 to 30 million years ago (Fig. 2C), a drastic change in regional sediment patterns occurred throughout the southwest Pacific region and in the Southern Ocean. At this time the opening developed between the southern part of the South Tasman Rise and Antarctica, creating an active Circum-Antarctic deep-sea circulation. As a result, the deep basins adjacent to Tasmania and the South Tasman Rise have virtually no sedimentary record for the entire Neogene and Oligocene (the last 30 million years). On the Campbell Plateau (Site 277), continuous Paleogene calcareous oozes underlie a major hiatus spanning the latest Oligocene to Pleistocene (*1*). This change from deposition to erosion near the Neogene-Paleogene boundary almost certainly resulted from highly active bottom currents over the plateau related to Antarctic current development and the establishment of a highly eroding western boundary current system to the east of New Zealand (Fig. 2C). The absence of extensive bottom-current erosion in the northern Tasman-Coral Sea regions since the Oligocene is due to the diversion of important northward-flowing bottom currents from the Tasman Sea to the east of New Zealand. This diversion resulted from either the development of topographic barriers in the northern Tasman Sea or the deflection of potentially northward-flowing bottom currents by the active Circum-Antarctic Current. The Lord Howe Rise had already developed by the Late Cretaceous in the northern Tasman Sea (*13*), and hence the development of the Circum-Antarctic Current appears to have created the paleocirculation changes rather than deep-sea topographic changes in the northern Tasman Sea. Sediment distribution in the region suggests that no major changes have occurred in deep-sea circulation patterns since the late Oligocene (Fig. 2D), although further major changes have occurred in the intensity of bottom-water flow (*15*) and in the development of the Antarctic Convergence. The separation of Australia from Antarctica led to a fundamental change in the world's oceanic circulation and its climate that marks the onset of the modern climatic regime.

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Bone Foreshafts from a Clovis Burial in Southwestern Montana

Abstract. *Formal and functional analyses of bone artifacts from a Clovis burial in southwestern Montana suggest that they were constructed to serve as (detachable or nondetachable) foreshafts for attaching fluted projectile points to lance shafts.*

The late Pleistocene technological system accepted by most scholars as being representative of the first groups of hunters has been consistently radiocarbon-dated between 10,960 and 11,500 years before present (*1*, pp. 77–92). The primary evidence for the existence of these peoples was found first at Dent, Colorado, in 1932 and later in the Llano Estacado area near Clovis, New Mexico. Hence, the name "Clovis" has been used specifically for the temporal, spatial, and technologically distinctive type of fluted stone projectile point utilized by them, and as a general index for an entire cultural system (*2*).

At present, the source data in the western United States for the Clovis

Table 1. Description of foreshafts from a Clovis burial. The letters in parentheses after specimen numbers are B, broken; F, fragment; and C, complete. Other abbreviations are Wt, weight; L, length; W, width; T, thickness; DW, distal width; PW, proximal width; LC, length of constriction; X, cross-hatching; R, resin; O, ochre; and P, polish.

Specimen	Wt (g)	Maximum measure (mm)			Measure of bevel (mm)			LC	X	R	O	P
		L	W	T	L	DW	PW					
37 (B)			17	12	49	2.5	10		+	+	+	+
38 (F)			19	13			10			+	+	+
39 (B)					48	4	13		+	+	+	+
67 (C)	48.5	220	15	12	58	5	12	45	+	+	+	+
94 (B)			18	13	44	4	12		+	+	+	+
95 (B)			18	13	44	3	11		+	+	+	+
117 (F)			15	10							+	+
118/119 (C)	75.0	281	18	14	46	2	11					
					51	2	12		+		+	+
120 (F)			19	11							+	+
122 (F)			20	13							+	+
123 (F)			20	14							+	+

system come from a number of mammoth (*Mammuthus* sp.) kills and a few campsites. These sites are located near Dent, Colorado; Miami, Texas; Domebo, Oklahoma; Leikem, Murry Springs, Lehner, Naco, and Escapule, Arizona; and Mockingbird Gap and Clovis, New Mexico. As a result, the data categories reflecting Clovis adaptive patterns are heavily skewed toward task-specific activities of mammoth killing and processing (*1*, p. 79).

In 1968 construction activities at a small, collapsed rock-shelter near Wilsal, Montana, resulted in the discovery of the first known Clovis burial, since named the Anzick site. When fully analyzed it promises to expand existing knowledge about various aspects of Clovis origins, technology, and lifeways.

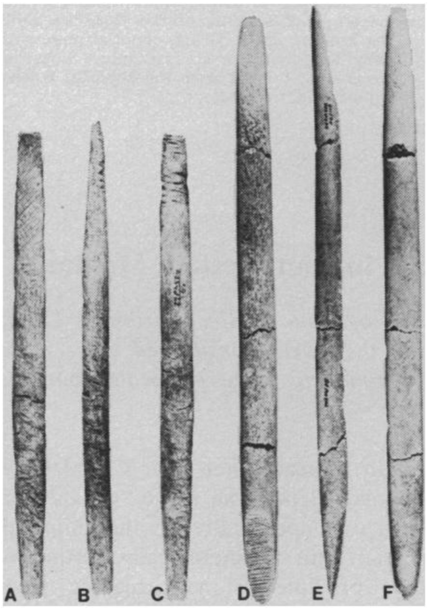

Fig. 1. Bone foreshafts from Clovis burial near Wilsal, Montana. (A to C) Specimen 67; (D to F) specimen 118/119 (× 0.3).

The burial assemblage contained the red ochre–covered remains of two subadults and over 100 stone and bone artifacts. The general artifact categories represented include fluted stone projectile points, ovoid and lanceolate bifaces, a blade, an endscraper, utilized flakes, and what we have termed bone foreshafts (Figs. 1 and 2). This report is specifically concerned with a discussion of the bone foreshafts (*3*).

Bone artifacts similar to those from the Anzick site have been found in early contexts in the Tanana Valley, Alaska (*4*); the Grenfel site, southeastern Saskatchewan (*5*); the Lind Coulee site in Washington (*6*); the Klamath Lake area of Oregon (*7*); Goose Lake, California (*8*); Blackwater Draw, New Mexico (*9*); the Itchucknee River, northcentral Florida (*10*); and the Aucilla River in northern Florida (*11*). In previous publications artifacts of this type have been referred to as bone rods (*12*), bone points (*10*), and fleshers (*13*), as well as bone foreshafts (*7*). Although there are general resemblances among the known bone specimens, they vary considerably in size, structure, and other characteristics. We do not assume that all these bone artifacts served the same function. However, we do suggest that those contained in the burial assemblage were utilized for hafting fluted, stone projectile points to lance shafts. Our purpose in this report is to provide an information base which can be used for comparison with other finds of similar bone artifacts.

Two complete foreshafts, four beveled ends, and five midsections were associated in the burial assemblage with seven fluted points. The contextual relations of the fluted points to the foreshafts were destroyed, as they were exposed by a front-end loader removing fill from under a collapsed rock shelter. There can be little question that the fluted points, foreshafts, other artifacts, and skeletal remains were associated, as all are covered with red ochre and related manufacturing techniques crosscut the bifaces and projectile points.

The bone foreshafts are made from large mammal bone diaphyses, but it has not been possible to identify the genus or genera to which they belong. Mammoth bone could have been used for the construction of the foreshafts, judging from the large maximum cross-sectional thickness of the specimens, which ranges between 10 and 14 mm (Table 1).

The foreshafts illustrated in Fig. 1 were reconstructed by mending broken pieces. The fragmented state of these specimens, in conjunction with the fact that the other midsection and beveled end fragments exhibit old fracture surfaces, suggests that they were broken before interment. Indentations on the polished surfaces adjacent to the fracture area (Fig. 1F) suggest that the foreshafts were purposefully struck and broken by percussion. Ceremonial breakage of this nature is known to have occurred in ethnographic times and is commonly interpreted as representing ceremonial killing of the spirit of the object broken. The combination of ceremonial breaking patterns and red ochre covering is probably the earliest evidence for New World religion.

Since bone working is an extractive process in which early steps of manufacture are altered by later modifica-

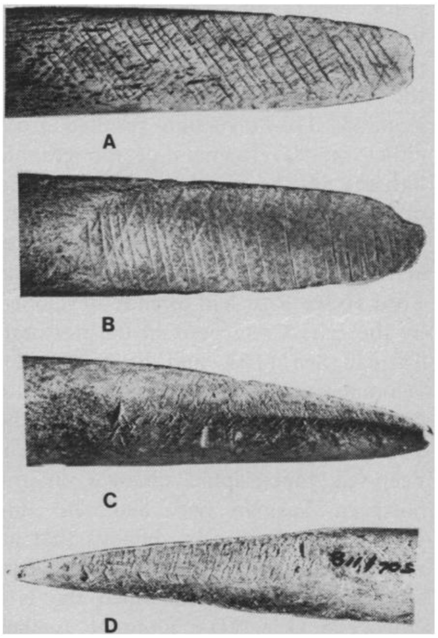

Fig. 2. View of beveled ends on bibeveled specimen 118/119 (× 1).

tions, it is impossible to totally reconstruct all the steps involved in the production of the bone foreshafts. For example, there is no indication how the bone segments or blanks from which the foreshafts were made were initially removed from the diaphyses. However, a number of technological attributes crosscut the entire sample of complete and broken foreshafts and suggest some of the manufacturing processes used to produce them. The foreshaft cross sections resemble squashed cylinders with slight longitudinal facets. From replication experiments in manufacturing bone implements with stone tools, R.B. has demonstrated that an identical morphological pattern can be created by drawing a steep angled edge of a stone tool parallel to the longitudinal axis of a long bone which has been softened by boiling in water. This softening procedure has been recorded in ethnographic accounts (*14*). A planning procedure such as this was probably used to shape the bone blanks.

When the foreshafts are viewed in plan view they appear straight. Frequently, bone sections or blanks extracted from long bone diaphyses are not straight because of the natural curvature of the bone. Although it is speculative, it seems plausible that the bone foreshafts may have been straightened. In a number of bone-working experiments it has been demonstrated that green bone boiled for an hour or more will acquire a semiplastic state and can be bent or molded into a preconceived shape (*15*). The foreshafts could fit inside the bone shaft wrench reported by Haynes and Hemmings (*16*), and a tool of this type could have been used in straightening them. A shaft wrench would be particularly useful if tied in tension to counteract the slight elastic rebound of bone, which attempts to resume its former shape as it gradually dries.

There is no morphological indication of the method used to cut the beveled ends of the foreshafts. The lengths of the seven bevels range from 44 to 51 mm (Table 1). The cross-hatching on the beveled ends was apparently accomplished by sawing back and forth with a sharp flake on the flat surfaces. If covered with resin, the cross-hatches would increase the coefficient of friction between the flat fluted surface of the projectile point and the foreshaft. A black material, probably resin, is still apparent on the beveled ends of six of the seven specimens. On specimen 67 incised lines occur at a right angle to the longitudinal axis on the back of the beveled surface (Fig. 1C). The placement suggests that these incisions were made to prevent a lashing such as sinew from slipping. The short, linear diagonal cuts on the side of the bevel on specimen 118/119 may have functioned as crevices in which sinew saturated in glue could bind (Fig. 2, C and D).

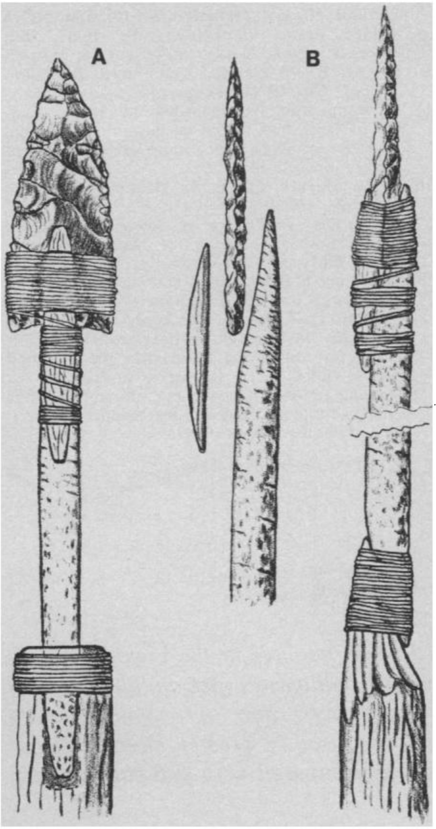

Fig. 3. Reconstructed foreshaft and projectile point composites. (A) Single beveled specimen, lance and projectile point; (B) bibeveled specimen, lance and projectile point (× 0.2).

The feasibility of these two postulated hafting procedures was partially tested through replication experiments. Scale models of shafts, carved wooden foreshafts, splints, and plastic casts of fluted points were assembled and articulated by L.L., demonstrating the practicality of the postulated reconstruction. Several major steps were entailed in producing the reconstructions. As can be seen in Fig. 3A, the structure of the replica dictated that a socketed lance handle be used to receive the end of the foreshaft. Likewise, the bibeveled foreshaft in Fig. 3B required a lance handle with a beveled end.

The same hafting procedure was used on both specimens for attaching the projectile points. A wooden splint was carved to fit onto the fluted surface of the projectile point and at the same time extend a short distance up the foreshaft. Both fluted surfaces of the points were covered with glue. Next the beveled ends of the foreshafts were set on one fluted surface of the points and the splint was placed into the opposite flute. Those three elements were then tighly bound together with string impregnated with glue, as sinew was not available.

Although there is no archeological evidence that splints such as the ones used in the reconstruction were employed, it does seem possible, as the reconstruction demonstrates that the splints serve to stabilize and prevent lateral movement of the point.

The composite shaft-foreshaft-point reconstruction postulated here would have been a more utilitarian type of hunting equipment than an alternative wood lance–fluted point combination. The bone foreshafts would undoubtedly be more resilient to stress than wood in the actual stabbing operation and would allow for deeper penetration of the point into the animal.

The reconstruction of this tackle suggests several things about mammoth hunting techniques. The composite, detachable lance head would have been a sophisticated piece of hunting equipment ideal for killing at close proximity. When ambushing, persistence hunting, or holding quarry at bay, hunters could make numerous accurate shots at vital nerve centers [18 of which are known in contemporary elephants (*17*)]. Retrieving the lance and inserting another foreshaft and point composite could have been done in seconds. This method would be far more efficient than carrying a number of lances into a dangerous situation. However, the second type of hafting procedure may have been more advantageous in some situations, for example, for repeated stabbing of weakened animals held at bay. Our postulated reconstruction of the hunting tackle used by Clovis hunters may help to explain how early hunters were able to slay giant mammoths that stood more than 3.5 m (12 feet) high at the shoulder and weighed several tons.

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Insulin Secretion by Anomers of D-Glucose

Abstract. *Isolated rat islets were incubated for 5 minutes in the media containing either the α or β anomer of* D*-glucose (2 milligrams per milliliter). The amounts of secreted insulin and changes of anomers ratio were concomitantly determined. In spite of rapid mutarotation, significantly greater stimulation of insulin secretion was observed by α-*D*-glucose as compared with β-*D*-glucose.*

D-Glucose, but not L-glucose, is known to be the most important stimulus for insulin secretion (*1*). However whether the pancreatic beta cells distinguish the α and β anomers of D-glucose as insulin secretagogue has not been studied. We have observed that the α anomer of D-glucose was more effective than the β anomer in triggering insulin secretion from isolated rat islets of Langerhans.

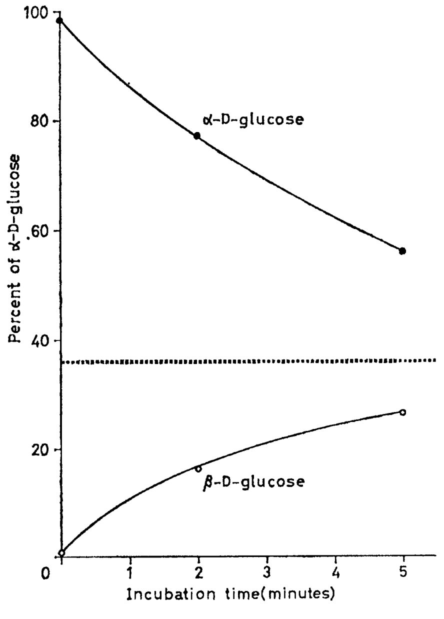

Fig. 1. Mutarotation of α- and β-D-glucose in incubation medium. The percentage of α anomer in total D-glucose was determined in the incubation medium supplemented with α- or β-D-glucose, with each 20 μl of the incubation medium taken out at the indicated times. Dotted line represents the percentage value of α anomer at equilibrium.

Islets of Langerhans from the pancreases of fed male Wistar rats weighing 250 to 300 g were isolated by the collagenase digestion method (*2*). All incubations were performed at 37°C in gassed (95 percent O_2 and 5 percent CO_2) Krebs-Ringer bicarbonate solution containing 0.2 percent bovine plasma albumin as the basic medium. After a preliminary incubation period of 30 minutes, batches of 10 to 20 islets of comparable size were incubated for 5 minutes in 300 μl of the media supplemented with either the pure α or β anomer, or with the mixture of both anomers at the equilibrated ratio (α : β, 36 : 64) of D-glucose (*3*) in solution; α and β-D-glucose were prepared as described (*4*). These anomers were rapidly dissolved in the basic medium, which had been warmed to 37°C, by vigorous shaking just before use. The final concentration of D-glucose was 2 mg/ml. Ratios of D-glucose anomers in the incubation medium before and during the incubation were determined by our method with the use of β-D-glucose oxidase, mutarotase, and oxygen elec- riod of 5 minutes was measured by media at the end of the incubation period of 5 minutes was measured by double antibody radioimmunossay with reagents obtained from Dainabot Radioisotope Laboratory, Ltd. (Tokyo, Japan), against porcine insulin standard. Assay of mutarotase, which catalyzes the interconversion of D-glucose anomers, in isolated islets of Langerhans was performed by our method (*6*).

Changes of the ratio of anomers in the incubation media under our experimental conditions are shown in Fig. 1. The major portion of each anomer just before the incubation was more than 98 percent, and during the 5-minute incubation the α and β anomers were converted to the other anomers by 42.4 percent and 26.8 percent, respectively. Mutarotation is not considered enzymatic, since no mutarotase activity was found in the homogenate containing some 250 islets [0.375 mg as protein by the modified Lowry method (*7*)].

The amounts of insulin secreted during 5 minutes of incubation were measured under these experimental conditions (Fig. 2). Statistical analysis was performed by means of the paired *t*-test (one-tail). The amount of insulin (microunits per ten islets per 5 minutes) in the incubation medium without D-glucose was 10.5 ± 1.1, and those with α- and β-D-glucose were 25.5 ± 2.3 and 18.5 ± 1.9, respectively. Thus insulin secretion stimulated by the α anomer

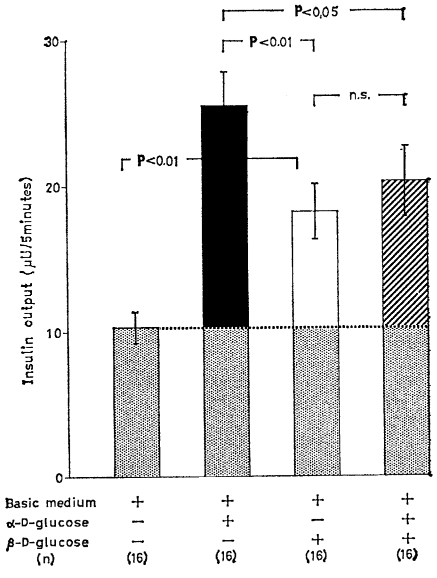

Fig. 2. Effects of either the α or β anomer of D-glucose, or the mixture of both anomers (α : β, 36 : 64) on insulin secretion from isolated islets of rat pancreas. Islets were incubated for 5 minutes with the anomers at the concentration of 2 mg/ml. Each column represents the mean of 16 observations with the standard error shown by the vertical line. The insulin output was measured in microunits pei 5 minutes per ten islets.