Colonising hunter-gatherer populations in North and Central America at the end of the Pleistocene utilised Clovis technology. Clovis technology is known for ‘fluted’ flaked stone points that were used to hunt prey and served as knives, but it also included the production, use and discard of a diversity of other implements made from stone, bone and other materials. Clovis technology lasted for several centuries, perhaps as long as a millennium and a half. Clovis technology shares some similarities with Siberian Paleolithic technology, which is consistent with current genetic evidence, indicating that ancestors of the people using Clovis technology originated in Asia. Clovis technology, as archaeologists generally recognise it, likely emerged piecemeal as people dispersed into the New World – some aspects of it can be tied to ancestry in Siberia, while other aspects are likely indigenous to North and Central America. Several studies have shown that Clovis technology was subjected to both micro- and macroevolutionary forces.

Introduction

A working definition of ‘technology’ is as follows: a kind of behaviour that involves the interaction between an agent and its physical tool(s) towards a task (Arthur, 2009; Dusek, 2006), including, but not necessarily limited to, tool production, tool use and tool discard. Like other biological and cultural phenomena, technologies can and do evolve as well as go extinct. Given that archaeologists are limited to the study of artefactual remains, archaeologists cannot, and do not, study technology directly, but instead must infer it from those tools that preserve in the archaeological record. In this article, we discuss aspects of what archaeologists refer to shorthand as Clovis technology, a fuzzy set of human–tool interactions found across North and Central America during the terminal Pleistocene. The people who used Clovis technology are generally considered to be among the first colonising populations of North and Central America.

The Clovis Toolkit

Clovis flaked stone technology

The overwhelming bulk of Clovis artefacts archaeologists find and study are those made from cryptocrystalline stone types that can be flaked, such as flint (chert), obsidian and quartzite. The process of flaking stone into tools is called ‘knapping’, and people who used Clovis technology likely used noncryptocrystalline stones, antler and possibly wood as percussion and pressure implements to flake stone. These people appear to have knapped stone via three principal strategies. First, they knapped stone bifacially, on two sides, to make weapon tips and knives as well as to create broad, flat flakes that could be used as tools themselves or modified into other tools (Figure 1). A widely held belief based on intuitive and authoritative reasoning is that knappers who made Clovis stone tools intentionally ‘overshot’ flakes during bifacial knapping such that the stone flake travelled the entire distance across a piece of stone and removed a part of the opposite margin. Recent modelling and experiments, however, indicate that overshot flakes were likely mistakes (Eren et al., 2013a). Moreover, it appears that these overshot mistakes are not limited to, and thus not necessarily diagnostic of, the Clovis period (Muñiz, 2014; Sellet, 2015). Second, people who used Clovis technology less often knapped stone prismatically, which created longer, narrower pieces called ‘blades’, which, like flakes, could be used immediately after being detached from a nodule or modified into other tools (Figure 1). The process of modifying flakes or blades into other tools was accomplished with the third strategy, which is by knapping stone unifacially, on one side (modifying flakes or blades occurred bifacially as well) (Figure 1). People who used Clovis technology on occasion used other knapping strategies, for example bipolar knapping, which involves smashing a piece of stone on an anvil (Morgan et al., 2015), or more opportunistic flake knapping from blocks of stone.

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Figure 1  Examples of Clovis flintknapping strategies. A person knapping Clovis technology would start off with a nodule of chert (centre top, Wyandotte variety, image by M. Eren). By knapping two sides of the nodule, referred to as bifacial knapping, they would produce a biface (left middle, DeGraffenreid cache, Texas, image permission courtesy of D. Kilby) as well as a number of flakes (centre middle, image by M. Eren). The biface could be used as is, or bifacially knapped into a different bifacial tool, such as a fluted point (left bottom, Paleo Crossing, Ohio, image by M. Eren). The flakes could be used as is, or knapped bifacially or unifacially (centre bottom, Welling, Ohio, image by M. Eren) into tools. A second Clovis strategy would be for a person to knap flakes more opportunistically from a stone nodule. A third strategy would be for a person to knap stone prismatically. This produces long, thin pieces called blades (right middle, image by M. Eren), as well as a prismatic blade core (right top, Debra Friedkin, Texas, image permission courtesy of M. Waters). These blades could be used as is, or be unifacially knapped into other tools. People making Clovis technology also utilised bipolar percussion (right bottom, Paleo Crossing, Ohio, image by M. Eren), which involved smashing artefacts on an anvil resulting in crushed, angular bits and small sharp pieces. Specimens shown here are not necessarily to scale.

(Lothrop, 1989). The widespread beliefs that Clovis stone tool production was conducted by select occupational craft specialists, required more skill and was inherently more sophisticated or complex to knap than other prehistoric technologies or held artistic or symbolic significance to its makers currently lack evidential support.

There are several broad categories of Clovis tools made by late Pleistocene knappers, the most iconic being the fluted point (Figure 2a,b), a bifacially flaked implement that has parallel to slightly convex sides, a concave base and flake-removal scars – termed ‘flutes’ – on one or both faces that extend on average from the base to about one-third of the way to the tip. Flutes are visually distinctive, and archaeological and experimental studies suggest that they are costly to knap, often resulting in the breakage of the point (Meltzer, 1993). Fluted points often exhibit impact scars, which is strong observational evidence that they were hafted and functioned as tips of thrusting or projectile weaponry. Current experimental and observational evidence of microfracture features on damaged fluted point tips suggests that Clovis hunters used spear-throwers (Hutchings, 2015). Successful experimental use of replica fluted points in penetrating the hide of deceased elephants is consistent with the idea that they could have similarly been used to inflict lethal wounds on mammoths (Frison, 1989), the latter on occasion being found with fluted points at archaeological sites. Analysis of microwear on fluted points indicates that these items also served as cutting and butchery implements (Miller, 2013; Smallwood, 2015), also consistent with experiments (Frison, 1989). Some fluted points
were likely long-life tools in that they were resharpened and used time and again (Haynes and Huckell, 2007), but recent analyses suggest that this is not always the case (Buchanan et al., 2015).

A second common Clovis tool category is the endscraper (Figure 2c,d), a predominately unifacially flaked specimen that is roughly triangular to rectangular in plan-view shape, possesses a broad distal bit and sometimes lateral notches. Microwear analysis suggests that endscrapers were hide- or plant-working tools and were often hafted onto a handle (Loebel, 2013; Miller, 2014), findings consistent with morphological studies (Eren, 2012). A recent study of endscraper allometry suggests that Clovis endscrapers (and other unifacially knapped tools) were produced on flakes and blades with high surface area to thickness ratios in order to enhance tool portability, longevity and functional flexibility (Eren, 2013).

A third Clovis tool category is the graver spur (Figure 2e,f), a sharp, at times needle-like, projection used for a variety of tasks, such as ripping, tearing or piercing hide, engraving materials like bone (Miller, 2013) or possibly tattooing. Spurs are sometimes added as accessories to other tool categories, such as endscrapers (Eren et al., 2013b) (Figure 2d). Beyond these three broad stone tool categories, there exist other less common forms, referred to by archaeologists as ‘sidescrapers’, adzes, chopping tools, knives, ‘spokeshaves’, drills as well as a variety of otherwise modified or expediently used flakes or blades (Meltzer, 1988; Smallwood, 2010).

Geochemical analyses of stone tools indicates that people who used Clovis technology acquired their stone raw material from widely varying distances; sometimes they camped directly on stone sources, while other times they acquired stone from sources over 500 km away (Boulanger et al., 2015). Stone was likely acquired by people directly, but trade via intermediaries perhaps occurred as well. Direct acquisition of stone from far distances is consistent with the hypothesis that people who used Clovis technology were highly mobile and as a colonising population had essentially unrestricted access to the landscape. Archaeologists often state that people who used Clovis technology favoured high-quality raw materials, but this hypothesis is currently unsupported given that ‘quality’ is not defined and thus not measured.

**Figure 2** Examples of some Clovis tool classes: fluted points from Blackwater Draw, New Mexico, and Vail, Maine (a,b, images by M. Eren); endscrapers from Paleo Crossing, Ohio (c,d, images by M. Eren); spurs from Paleo Crossing, Ohio (e,f, images by M. Eren); bone rod from East Wenatchee, Washington (g, image permission courtesy of P. Bostrom); bone point from Sheridan Cave, Ohio (h, image permission courtesy of B. Redmond); bone wrench from Murray Springs, Arizona (i, image permission courtesy of P. Bostrom). Arrows in (a) and (b) indicate flute scars. Arrows in (d) are pointing to an accessory spur (top) and to lateral notches (bottom). Arrows in (e) and (f) are pointing to prominent spurs. Specimens shown here are not necessarily to scale.
not operational, nor have any systematic, quantitative or experimental studies on this topic been conducted.

**Clovis bone and ivory technology**

Tools made of bone and ivory (referred to hereafter as bone tools) represent a relatively small proportion of the Clovis toolkit. However, it is clear from the distribution of bone tools across North America that preservation is a significant biasing factor in the recovery of these organic artefacts, and thus the bone tool component of Clovis technology likely may have been more substantial than archaeologists currently recognise. Well-documented and well-dated Clovis bone artefacts have been recovered from sites in only nine states (Alaska, Arizona, California, Florida, Montana, New Mexico, Ohio, Oregon and Washington) and one Canadian Province (Saskatchewan).

The majority of the well-documented bone tools are bevelled bone rods (O’Brien et al., in press) (Figure 2g). These worked bones are cylindrical in shape and have beveling on one or both ends; when both ends are bevelled they are usually angled in opposite directions. There has been much speculation concerning the function of Clovis bone rods. The majority opinion seems to indicate that the bone rods were probably used as foreshafts or handles on which Clovis flaked stone points were hafted (O’Brien et al., in press). Replica Clovis points and bone rods have been used to demonstrate possible hafting methods for bone rods as parts of composite weapons (Pearson, 1999) and as handles for hand-held saws (Lyman et al., 1998). Comparison of the range and average widths of bone rods (n = 44, mean = 17.2 mm, 95% CI 15.2–19.2 mm, range = 4.9–30 mm) and a large sample of Clovis points (n = 313, mean = 27.7 mm, 95% CI 26.7–28.6 mm, range = 5.5–66 mm) indicates that Clovis points are on average wider than bone rods, suggesting that, if hafted, bone rods may have pinned or been set within a notch of the fluted basal sections of Clovis points.

Other bone tool types are less common and include probable bone projectile points (Waters et al., 2009) (Figure 2h) and a possible shaft straightener (Figure 2i). The single bone tool inferred to be a shaft straightener was recovered from the Murray Springs site in Arizona (Haynes and Huckell, 2007). This artefact is cylindrical with one circular end. The hole is believed to have been used to straighten wooden spear shafts; however, there is no evidence beyond the form of the specimen to support this hypothesis. It may alternatively be some sort of wrench-like implement.

In addition to the bone tools mentioned above, there is a single carved segment of mammoth ivory from the Clovis type site (Blackwater Draw Locality #1) that has been interpreted to be a ‘semifabricate’, or an ivory piece in the early stages of production (Saunders et al., 1990). There are also bone specimens that have been found in several locations across North America with questionable status as to whether they were modified by people who used Clovis technology or by some other taphonomic or noncultural process (Laub, 2000).

**Other aspects of Clovis technology**

Beyond flaked stone and bone tools, there are only a few other preserved aspects of Clovis technology. Rare stones incised with geometric lines or patterns and the presence of ochre on artefacts have been asserted to be expressions of Clovis portable art and personal adornment, although more utilitarian functions are also possible, and not mutually exclusive (Lemke et al., 2015).

Subsurface features (sediments discoloured relative to surrounding sediments) of various sizes at archaeological sites may possibly be Clovis trash pits or postmolds, the latter indicative of posts stuck in the ground to serve as part of some sort of structure. One type of prominent Clovis subsurface feature is the ‘cache’, a collection of artefacts, often many of the same type (e.g. flaked stone points), found closely together and interpreted to be buried intentionally by people who used Clovis technology (Huckell and Kilby, 2014; Waters and Jennings, 2015) (Figure 3). Meltzer (2002) interprets Clovis caches as precautionary resupply depots for a colonising population. Travelling far across the foreign Ice Age North American landscape, by caching artefacts, Clovis colonisers would not have had to travel the entire way back to a known stone source for resource resupply in the event that they could not find stone sources in unfamiliar territories.

Direct evidence of hearths is surprisingly rare in the Clovis archaeological record, although Clovis flaked stone tools often show signs of damage from burning in the form of crazing and pot-lidding. This fire damage could have come from controlled or uncontrolled (natural) fires.

**Geography and Chronology of Clovis Technology**

Evidence for Clovis technology can be found across the lower 48 states of the United States, throughout southern Canada, and Central America (Figure 4). It is important to note, however, that most aspects of Clovis technology are rarely, if ever, found at a single site, or even within a broad geographical region. There are many factors likely influencing the distribution of different aspects of Clovis technology, such as cultural transmission processes, demography, functional necessities, environmental factors, discard rates, drift, selection and post depositional processes such as preservation and survey and excavation biases.

There are two models for the timing and duration of Clovis technology. The ‘short chronology’ model suggests that Clovis technology lasted as little as 200–450 years, between 13 125 and 12 925 calBP or between 13 250 and 12 800 calBP (Waters and Stafford, 2007). This result was derived from a small, highly selective sample of radiocarbon ages from only 11 Clovis sites across the United States, and thus is not likely correct (Haynes et al., 2007). The short chronology model, however, does provide a valuable minimum benchmark for the duration of Clovis technology. The second model is the ‘long chronology’ model, which suggests that the duration of Clovis technology could have been as long as 1500 years (Prasciunas and Surovell, 2015). This result was derived from Clovis radiocarbon ages, computer simulation and mathematical modelling and provides compelling evidence that Clovis technology spread across North America via the expansion of colonising populations, as opposed to the spread of technology across already established populations.
The Emergence of Clovis Technology

Studies of modern and ancient DNA (deoxyribonucleic acid) indicate that the first Late Pleistocene colonists of the New World came from Asia (Rasmussen et al., 2014; Raff and Bolnick, 2015). Where Clovis technology originated, however, is currently unknown, and indeed the notion that there should necessarily be a holistic, obvious ‘proto-Clovis’ technology located somewhere in Asia is a mistaken one. It is likely that there was no single origin point for the entire Clovis technology ‘package’, but instead particular aspects of Clovis technology may have emerged piece-meal at different times and places during the dispersal of Homo sapiens ‘Out of Asia’ into North America. Indeed, consistent with this scenario, Hamilton and Buchanan (2007, 2010) found that
spatial gradients of radiocarbon-dated occupations across Eurasia and North America support a post-Last Glacial Maximum diffusion that stalled in Beringia and then followed a northwest to east dispersion across the contiguous United States (Tackney et al., 2015). Clovis bone technology, for example, may have ancestry in Siberia (Pitulko et al., 2004) based on similarities in the form and inferred function between Siberian and Clovis specimens. The same can be suggested for stone tool production practices such as bifacial knapping. It is also possible that certain size and shape attributes of Clovis prismatic blades is autochthonous to North America, but the strategy of producing blades is ultimately derived from the Siberian practice of producing microblades (Buchanan and Collard, 2008). Other aspects of Clovis technology, however, may be completely indigenous to North America, such as the practice of fluting points.

### Microevolution of Clovis Technology

Microevolutionary studies of Clovis technology are relatively recent, and thus far have predominately focused on fluted points. These types of studies test for, and model the impact of, evolutionary forces such as drift and selection on the form of artefacts. Studies of drift and selection at the continental scale suggest that both processes may have modified Clovis points. A progressive reduction in Clovis point size from the northwestern United States to the east fits the predictions of a drift model that accounted for the accumulation of copying errors made during the learning process (Hamilton and Buchanan, 2009). Hamilton and Buchanan’s (2009) model also accounted for biases in the learning process that reflected a reduction in variance consistent with there being only a small number of knapping teachers. Other studies have shown that the shape of Clovis points across the continent is regionally patterned (Buchanan et al., 2014; Smith et al., 2015), perhaps suggesting that shape was adapted to the environmental differences between these regions. However, it is possible that drift alone could also explain the shape difference. To help differentiate between these two possibilities, experiments are needed to test the performance characteristics of the particular shapes of Clovis points.

The influence of drift on Clovis points has also been documented at the regional scale. Eren et al. (2015) documented small but significant changes in point shape among three samples of Clovis points from a relatively small region within the midcontinental United States. The three samples were each made from a distinct chert type that outcropped within the study region. Because the samples were from a small region where environment was relatively homogenous, the point shape differences could not be tied to environmental adaptation (selection), but instead only to drift processes. Specifically, knappers who made Clovis tools preferentially used each of the outcrops and became increasingly isolated from one another (a form of sampling bias), and a subsequent infusion of innovation and copy error caused differences in Clovis point shape.

Potential selection processes at the regional scale have been documented by Buchanan et al. (2011) in the Southern Plains and Southwest. In this area, Clovis hunters appear to have modified the size and shape of their points to hunt different-sized prey. Clovis points used to hunt mammoth and bison in this region were found to have significantly different forms.

### The Macroevolutionary Transition from Clovis to Post-Clovis Technologies

In recent years macroevolutionary studies examining the transition from Clovis to post-Clovis technologies have become quite common. General observational studies suggest that Clovis fluted points appear to have evolved into several regional forms (Meltzer, 2002) (Figure 5). Furthermore, in recent years, several formal, quantitative studies have examined how and why Clovis points differ from post-Clovis ones. One example is that by White (2013), who examined several morphometric traits from Clovis, Late Paleoindian, and Early Archaic flaked stone points from the North American Lower Great Lakes region. Among several interesting findings, White (2013) showed that variation in point morphometric traits related to hafting remained relatively steady across the Clovis–post-Clovis transition, while variation in morphometric traits related to style progressively increased or decreased over time. However, while variation in hafting attributes remained steady, mean hafting width gradually declined from Clovis to post-Clovis times. White (2013) suggested that a general shift to lighter projectiles may have been tied to reductions in the sizes of available game animals during the transition from the Pleistocene to the Holocene.

Beyond fluted points, many other aspects of technology evolved between Clovis and post-Clovis technology. For instance, Andrews et al. (2015) showed that Clovis and post-Clovis samples of unifacially knapped tools possess inverse allometric patterns. Large Clovis unifacial tools are flat relative to plan-view surface area, while small Clovis unifacial tools are round. This pattern is consistent with steady resharpening and reuse of stone flakes possessing geometric shapes engineered for a long-use life, which would be useful for mobile Clovis colonising populations who would be unfamiliar with the location of stone sources in new territories. Alternately, large post-Clovis unifacially knapped tools are round, while small ones are flat. Because it is impossible to unifacially knock a round tool into a flat tool, the post-Clovis tool pattern suggests that post-Clovis foragers were not as concerned with possessing tools with resharpening potential and long-use life. This is because with their increased knowledge of the landscape, noncolonising post-Clovis populations would have more likely known where they could have resupplied their stone, making unnecessary the need for tools with long-use lives. In another example, Jennings et al. (2010) conducted an experimental assessment of stone-nodule knapping efficiency using a modern knapper to replicate different Paleoindian knapping strategies. Their experiments showed that the knapping strategies employed by people who used Clovis technology (bifacial and prismatic) were less efficient in terms of transport costs than were those employed by post-Clovis people (discoid and amorphous).
Clovis points across North America evolved into several distinct regional post-Clovis styles. (a) Dent, Colorado (image by M. Eren); (b) Kimmswick, Missouri (image by M. Eren); (c) Carson-Conn-Short, Tennessee (image permission courtesy of A. Smallwood); (d) Welling, Ohio (image by M. Eren); (e) Bull Brook, Massachusetts (image by B. Buchanan); (f) Hell Gap, Wyoming (image by B. Buchanan); (g) Sloan, Arkansas (image permission courtesy of D. Morse, photo credit Jane Kellett, Arkansas Archaeological Survey); (h) 40HR370, Tennessee (image permission courtesy of J. Tune); (i) Thedford II, Ontario (image permission courtesy of C. Ellis); (j) Michaud, Maine (image by B. Buchanan). Specimens shown here are not necessarily to scale.

These differences were explained by the hypothesis that people who used Clovis technology were less residentially mobile, but more logistically mobile, than the post-Clovis people in question.

References


Further Reading


