17 *New World palaeoecology at the Last Glacial Maximum and the implications for New World prehistory*

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Introduction

The discovery and acceptance of Clovis (approximately 10 800–11 200 BP) in North America as cultural groups associated with hunting of mammoth and extinct forms of bison occurred with little fanfare or controversy and as something of an anticlimax to the earlier discovery and acceptance of Folsom (approximately 10 100–10 800 BP) (dates are from V. Haynes 1987, p. 84). This is because the evidence for Clovis was straightforward and all investigators properly trained in scientific procedures could find no valid grounds for refuting the evidence. The fact that Clovis did represent hunters of extinct fauna (mammoths) in both Old and New Worlds and the similarity between certain bone and ivory artefacts (see Haynes 1970) found in Clovis sites and Upper Palaeolithic sites in the Old World generated thinking that Clovis was a manifestation somehow related to the Old World Upper Palaeolithic, that had migrated across the Bering Strait and eventually spread throughout the New World. The question did arise, however, as to whether Clovis was derived from groups that had migrated earlier to the New World (e.g. Wormington 1962, Bryan 1965, Müller-Beck 1966) or whether Clovis represented a more recent migration in late glacial times (see Green 1963, Haynes 1964).

Clovis origins at this time appeared to be a problem that should have been easy to resolve by following standard processes of archaeological investigation. If Clovis developed out of earlier New World residents, the stratified evidence would soon appear. If recent migration was the answer, the trail could be traced back into northeast Asia. But, after more than two decades of intensive research by numerous investigators, the problem remains unresolved. As the needed answers continue to remain elusive, investigators have become continually more frustrated and have tended to collect and evaluate any kind of data, however vague, that might lead to a plausible solution. However, too much of the data have been equivocal enough that some investigators accept them while others do not, depending upon any given investigator's approach to scientific investigation. This varies from those who are easily convinced to those who are more conservative and feel that the data have to be subjected to intense scrutiny and the most rigid testing before acceptance.

It would be difficult to envision a situation more fertile than this to inspire searches for new data, to re-evaluate old data, and to offer solutions to the problem based on speculation. The results have been interesting to say the least. Many archaeological sites have held the promise of firmly establishing human presence in the New World well before Clovis times. Good examples include the Tule Springs site (Wormington & Ellis 1967) in Nevada (Fig. 17.1), where what was first thought to be cultural levels producing surprisingly early radiocarbon dates later proved to be the result of natural rather than cultural activity.

The Lewisville site (Crook & Harris 1957, 1958, 1962) in Texas was at first generally accepted, though with some reservations, as evidence of people in the New World as early as 37 000 years ago. The validity of this interpretation was questioned (Heizer & Brooks 1965). A reinvestigation of the Lewisville site in 1979 and 1980 has since demonstrated that the early radiocarbon dates resulted from the use of lignite for fuel in cultural fire hearths. Therefore, in this case, the radiocarbon results would be at or near the maximum limit (Banks & Burton 1988).

The Old Crow River area in the northern Yukon has been claimed as yielding evidence for human occupation in Beringia (Fig. 17.2) as early as 27 000 years ago. The real cornerstone of the claim for its antiquity was a bone date on the apatite fraction of an unquestionable human tool, a flesher made on a caribou tibia found in 1966 (Irving & Harington 1973). Recently, the tool in question, as well as three other caribou antler tools thought to be of the same age, were dated by the accelerator mass spectrometer (AMS) method. The results were all less than 3000 BP (Nelson *et al.* 1986). The original date on the flesher actually triggered a large-scale, long-term research project in the Old Crow Basin which is still yielding data strongly suggestive, but not accepted by all investigators, for pre-Clovis human occupation (see Irving *et al.* 1986).

A number of locations on Santa Rosa Island, Santa Cruz Island, San Miguel Island, and Point Conception on the coast of California near Santa Barbara contain features that have been interpreted as the result of cultural fires containing burned mammoth and bird bones (Orr 1968). Recent studies of these features claim that the red sediments, carbonized vegetation, and darkened bone resulted from non-cultural activity, and are actually the result of a process that did not involve heating, but rather involved a reaction with groundwater (Cushing *et al.* 1986).

The Calico Hills site (see Simpson 1978) in California is one that has laid claim to considerable antiquity but has been questioned on the basis of studies of site formation processes (see Haynes 1973). The endorsement of its age of between 50 000 and 80 000 years ago by L. S. B. Leakey (Leakey *et al.* 1968) ensured the site a solid foothold among those with claims for pre-Clovis age.

Figure 17.1 Sites and localities referred to in the text: 1, St Lawrence Island; 2, St Matthew Island; 3, Pribilof Islands; 4, Old Crow River area; 5, Boone Lake, Alberta; 6, California Channel islands; 7, Point Conception, California; 8, Calico Hills, California; 9, Black's Fork area, Wyoming; 10, San Diego area, California; 11, Dutton-Selby site, Colorado; 12, Meadowcroft site, Pennsylvania; 13, Lewisville site, Texas; 14, the Hueyatlaco area, Mexico.

However, even Mary Leakey felt that the determination of age was not made on valid grounds (M. Leakey 1984). Other evidence from the San Diego area in southern California has produced even earlier claims for the human occupation of the New World, dating to as much as 100 000 years ago (Carter 1978, Reeves 1983).

In other cases, anthropological and geological data have conflicted and prevented a satisfactory resolution. In the Valsequillo Reservoir Basin in Mexico at Hueyatlaco several successive stratigraphic levels produced faunal remains of extinct animals in good association with human artefacts (Irwin-Williams 1967). However, geologic studies of these deposits by recognized geologists have argued that the occupation of the Hueyatlaco site dates in the range of 200 000 years (Steen-McIntyre *et al.* 1981). Hueyatlaco artefacts, however, are considered to be entirely too modern in appearance and technology to have been produced by hominids who lived in the Old World at that time-period (see Szabo *et al.* 1969). Furthermore, the faunal assemblage at Hueyatlaco is indicative of an age near the Last Glacial Maximum (LGM).

South America has actually forged ahead of North America in claims for sites of pre-Clovis age. Included among these is Pikimachay Cave in highland Peru (MacNeish 1979). More recently, the open-air site of Monte Verde in southern Chile has produced numerous early radiocarbon dates (Dillehay 1984, 1986; Collins & Dillehay 1986). Other claimed early sites are in the Sao Raimundo Nonato region of east central Brazil. One rockshelter, Toca do Boqueirao da Pedra Furada, is stratified and has produced several radiocarbon dates on purportedly cultural remains ranging from 6000 to 31 000 BP. Two other stratified rockshelters, Toca do Sitio do Meio and Toca do Caldeirao dos Rodrigues I, have also yielded similar dates (Guidon 1986).

It is not possible for us to critically evaluate the validity of the South American sites without careful, first-hand study of the sites and recovered materials. Morlan (1988) has attempted such an evaluation based on published articles. He takes much the same position; the data have not yet been carefully studied and critically evaluated. However, he freely admits that he may have to accept the antiquity of the South American evidence if it survives the necessary testing.

The list of sites and localities that have either not withstood critical re-evaluation or for which the claims of antiquity are seriously questioned can be expanded (see Bryan 1978, 1986, Morlan 1988). This clearly demonstrates that critical and rigid evaluations of site data regularly reveal flaws in interpretation, and indicates that the sooner the scientific community is made aware of these flaws, the sooner other investigators will be deterred from following erroneous paths of inquiry.

One archaeological site which continues to withstand critical evaluation is Meadowcroft Rockshelter (Adovasio *et al.* 1978, Adovasio & Carlisle 1988) in Pennsylvania (Fig. 17.1). Based on an impressive sequence of radiocarbon dates, its investigators claim an almost certain human occupation as early as 16 000 BP and a likely human occupation at least 3000 years beyond that

(Adovasio *et al.* 1978, Adovasio & Carlisle 1988). Although caution has been urged in the acceptance of these radiocarbon dates because of possible contamination (C. V. Haynes 1980) and bioturbation (Kelly 1987), the veracity of the Meadowcroft data is difficult to assail on the basis of methodological procedures, and the site may presently be the best candidate for evidence of a pre-Clovis occupation in North America.

The lack of conclusive data has led over the years to a number of speculative models on the first human migration to the New World. Some were based on similarities between Old and New World artefact assemblages. Renaud (1938), lacking stratigraphic evidence, compared surface collections taken from the Black's Fork river area in southwest Wyoming to Old World materials, and attributed an erroneously old age to them on morphological similarities. Some materials were naturally flaked pebbles which Renaud mistakenly identified as pebble tools. Others were quarry blanks which he thought were choppers and handaxes (Sharrock 1966). The resulting 'Black's Fork Culture' was subsequently suggested by Kreiger (1964) as a candidate for his 'pre-projectile point' stage. Müller-Beck (1966) conducted a typological study of what he identified as 'Mousteroid' and 'Aurignacoid' elements in New World lithic assemblages. He then attempted to correlate movements of these elements (which reflected human populations), with changes in the sea-level and with movements of continental glaciers in northern North America, in order to formulate a model to explain and date the peopling of the New World.

Migration routes for early man from the Beringia area into the area south of the continental icecaps have also been proposed. Fladmark (1979) suggested that a route may have existed along the northwest coast of North America. The concept that has intrigued archaeologists for several decades, however, is the dating of the existence of ice-free corridors between the Cordilleran and Laurentide ice sheets. The corridors presumably opened and closed as the glaciers advanced and receded, thereby restricting movements of both human and animal populations to the open periods.

The archaeological evidence needed to confirm the time of human arrival into the New World has not been forthcoming and the event, or events, in question are generally believed to have involved movements across the Bering Strait during the late Wisconsin glacial periods. Consequently, archaeologists studying a problem have turned to palaeoecological studies in order to formulate alternative models of human subsistence strategies and adaptation to different environments, in order to explain what has not been forthcoming through the use of standard archaeological methodologies. Since some evidence for early man in the New World suggests a human presence well before the LGM at about 18 000 BP, palaeoecological studies of considerable time-depth into the late Pleistocene are eagerly sought.

North America at the LGM

Somewhere around 18 000 to 20 000 BP, the last major glacial maximum occurred in North America. During this time, essentially all of present-day Canada was covered by two major ice sheets, the Cordilleran to the west and the Laurentide to the east. The Laurentide was the larger and consisted of three separate ice masses:

(a) the Labrador ice mass which extended out over the Canadian maritime provinces, the New England states, and the Great Lakes in the east;
(b) the Keewatin ice mass which extended from the base of the Rocky Mountains eastward to the Labrador ice mass; and
(c) the smallest of the three, the Foxe Basin ice mass, which fronted on the ocean to the east.

The Cordilleran ice sheet was centred over the north–south lying mountain system of western Canada. In the west it extended either to the continental shelf (exposed due to the lowering of sea-levels) or else it calved into the Pacific Ocean. In the east it coalesced at various times and for varying distances with the Keewatin section of the Laurentide ice mass (Fig. 17.2).

Both of these ice masses extended well south of the Canadian border. The Laurentide ice sheet extended to well south of the Great Lakes in the eastern United States. All of this is well documented by extensive end-moraine systems (Dyke & Prest 1987). On the Pacific side, the Cordilleran ice sheet spread south into the northern part of the state of Washington. Northward, the Cordilleran ice sheet covered all of the mountains of southern Alaska to the Aleutians, while the Laurentide sheet spread to within about 100–200 km from the Alaska border. Finally, there was a corridor between the two ice sheets from about 25 km to 100 km wide that extended nearly to the present northern border of British Columbia.

There were also several smaller, less significant areas of glacial ice in North America. These included the Brooks Range in northern Alaska along with other smaller isolated areas. South of the two ice sheets, there were local valley glaciers in the Rocky Mountains, Sierra Nevada, and Cascade Range. The maximum extent of the ice sheets was not simultaneous: it is claimed that the maximal ice advance in the Great Lakes area was around 20 000 BP, while in Iowa and the Pacific Northwest it occurred several thousand years later. The maximal Laurentide expansion in northern Canada occurred still later (Mickelson *et al.* 1983). The reasons for this asynchrony are not yet fully known or understood.

Periglacial conditions existed in the non-glaciated areas of Canada and Alaska, and well to the south of the maximum extent of the ice sheets. Similar periglacial conditions were found beyond the margins of valley glaciers as well. The presence of ice-wedge casts across the northern United States from Montana to New Jersey and well south of the terminal moraines indicate the

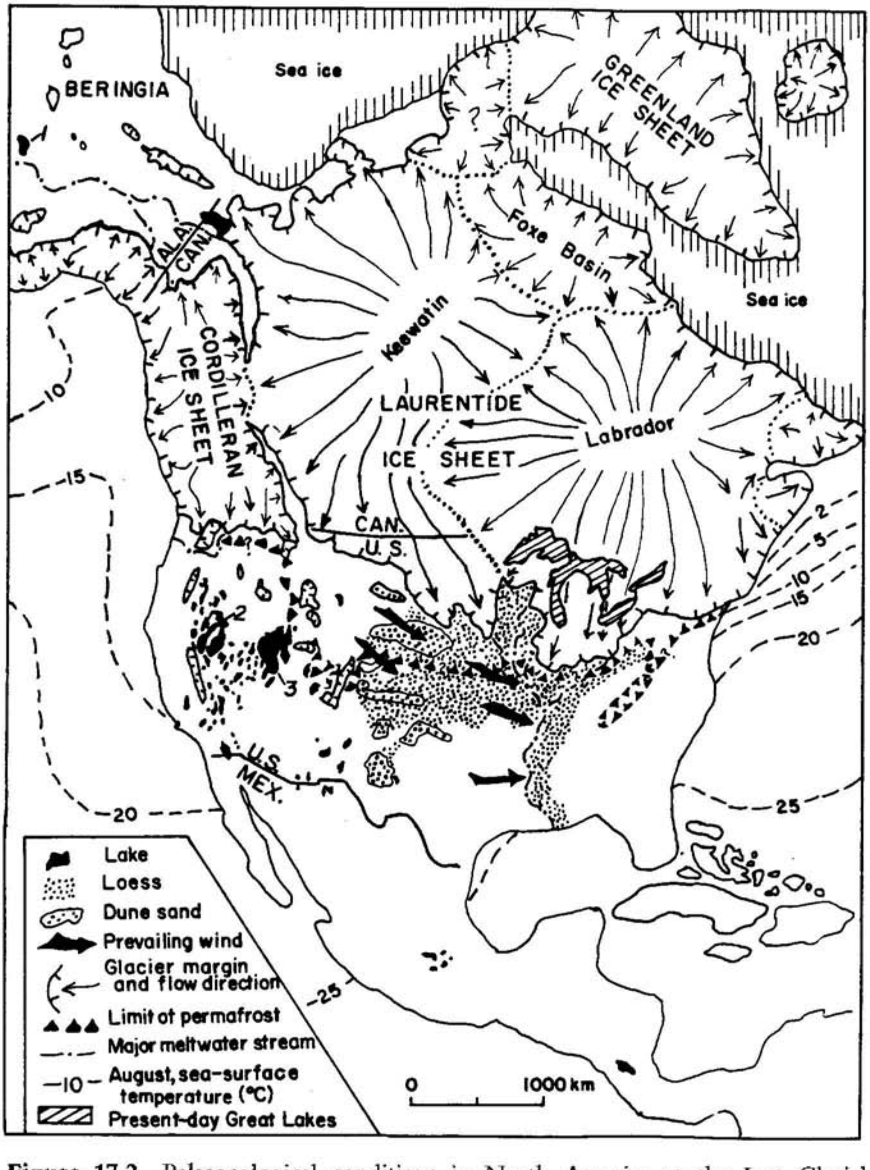

Figure 17.2 Palaeocological conditions in North America at the Last Glacial Maximum approximately 20 000 years ago. Locations of St Lawrence Island (1), Lake Lahontan (2), Lake Bonneville (3), the present-day Great Lakes, and international boundaries are shown for reference. Coastlines assume a lowering of sea-level of 150 m. (From Porter 1988.)

former extent of continuous or discontinuous permafrost. Active ice-wedges are believed to be restricted to areas of mean annual temperatures of -6°C or colder (Péwé 1983), so that the evidence of former ice-wedges provides some indication of temperature conditions during the LGM.

Numerous inland lakes, mainly in the Great Basin area, existed during the LGM (Smith & Street-Perrott 1983). The largest was Lake Bonneville, which covered over 50 000 km^2 and was an expansion of the present-day Great Salt Lake. Further west lay Lake Lahontan which covered an area of nearly 23 000 km^2. The maximum rise of these lakes correlated closely with maximum expansion of the ice caps and mountain glaciers. The cause of the rise in lake levels is not well understood and varies from claims of increased precipitation to an alternative of less precipitation but decreased evaporation because of cooler temperatures.

Estimates of the lowering of sea-levels at the LGM vary from 100 to 150 m (Bloom 1983). At the time of maximum lowering of sea-levels, more land was exposed along the coasts. In many areas, the ice sheets extended beyond the present shorelines and probably calved well into the oceans. In other localities, they extended onto the newly exposed coastal areas but did not reach the water. It is significant to note that a 46 m lowering of the sea-level exposed a continuous land surface across the Bering Strait. Further sea-level lowering continually exposed more of the Bering–Chukchi Shelf, bringing into existence a broad land mass commonly referred to as Beringia. Under these conditions, the St Lawrence, St Matthew, and the Pribilof Islands would have appeared as low hills on a flat plain. This condition was maintained for as long as 10 000 years both before and after the time of the LGM. The land connection was probably maintained for a much longer time-period before that. Beringia was, at that time, a large, unglaciated land mass with low topographic relief, which would have provided an attractive spot for human occupation. There seems little doubt that great numbers of large animals inhabited Beringia at this time so that human hunting groups, such as those known from the northeast Asian Upper Palaeolithic, would have been able to survive in the area. Archaeological evidence in western Beringia to date, however, has not produced evidence that can be regarded as pre-Clovis (West 1983). Controversial evidence of earlier human occupation, as noted before, has been found in the Old Crow River Basin area of eastern Beringia (Irving *et al.* 1986).

Lacustrine sediment cores document the vegetational history of western Alaska from 24 000 to 16 000 BP. These show an herbaceous tundra vegetation community with Gramineae, Cyperaceae, *Salix*, and *Artemisia* along with a variety of forbs as the major components. The LGM vegetation pattern would have been made up of predominantly dry tundra communities with some mesic and wet tundra communities (Ager 1982). Overall, it was probably a treeless region with large tracts best described as steppe-like (Matthews 1982). Data on hand suggest that the large mammal species living together in East Beringia were many times more diverse than the extant tundra fauna, and included mammoth (*Mammuthus*), bison (*Bison*), horse (*Equus*), caribou (*Rangifer*), and musk ox (*Ovibos*) (Matthews 1982). This clearly implies that the vegetation of the late Wisconsin was able to support more herbivores than it does today. According to Schweger (1982), pollen records indicate a variety of floodplain communities that would compare favourably to present-day floodplain samples from Banks Island further to the north.

At the southern margin of the ice sheets a narrow strip of tundra occupied the periglacial zone. Tundra existed further to the south along the crest of the Appalachian Mountains as well. South of the tundra were large areas dominated by conifers. The treeline was about 1000 m lower than at present. Further discussion of vegetation is too complex to present here but was largely controlled by topography, altitude, and latitude (see Porter 1988).

The faunal evidence

Provided that the Bering Strait and the ice-free corridor or some other avenue to the lower latitudes was the route of human entry into the New World, faunal resources must have been a major part of human subsistence, similar to human groups living in northern latitudes today. The strategies for survival of these animals could be a key to that of the humans. The full glacial (pre-13 000 BP) mammalian fauna of North America, because of its more recent age, may be the best-known fossil fauna we have. The fauna has been extensively reviewed by Kurtén & Anderson (1980), with more recent regional reviews by Lundelius *et al.* (1983) and Graham *et al.* (1987). While some members of this fauna are extant, the make-up of much of the fauna is dominated by now extinct species, as well as by many which no longer inhabit the areas they did during the late Pleistocene. This indicates that there is no modern-day analogue for the North American full glacial mammalian fauna. Most of these local faunas exhibit a higher species diversity, especially among small mammals, than exists today.

Palaeontological studies have attempted to use this higher species diversity to reconstruct Late Pleistocene environments, with varying degrees of success. During the 1950s, prior to the attainment of our present knowledge of the fauna, paleaoenvironmental models suggested a direct shift southward or northward of all communities, as the ice sheets developed or waned (Graham 1979). We now know this to be a simplistic model, because extant data indicate such communities did not respond to environmental and climatic changes, but rather each individual species in those communities responded in its own physiologic and ecologic manner (Graham 1979, 1985a, 1985b, 1986, Walker 1986).

Looking strictly at climatic interpretations of these diverse faunas, most researchers feel that the overall climate of the Late Pleistocene was more equable; that is, there was less seasonal variability in temperature and precipitation from year to year. This means that the summers were cooler and the winters warmer than recorded today. Similarly, this diversity also suggests (a) greater heterogeneity in habitats than found today (Graham 1986); and (b) a more continental environment (Hibbard 1970, Graham 1979, 1986).

For comprehensive palaeoenvironmental reconstructions, however, we cannot just look at climatic and habitat factors, but should also consider how these factors interacted and affected each taxon. One of us (DNW) has suggested elsewhere (Walker 1986) that environmental seasonality is a blanket term, with 'climatic seasonality' (as used above) and 'resource seasonality' (see Boyce 1978, 1979) as its specific subsets.

Wisconsin faunas from the central and northern Rocky Mountains and Beringia contain some now allopatric species, but only those found today at higher latitudes or altitudes, areas which are more resource seasonal (Walker 1987). While the faunal data suggest that 'climatic seasonality' was more equable, the winter snow accumulation was greater and summer melt less extensive than today. This resulted in 'resource seasonality' being greater due to a winter seasonal bottleneck of non-availability of these resources (Guthrie 1980, 1982, 1984a, 1984b). Most northern and montane Wisconsin faunas do not exhibit the mixture of southern and northern extant taxa seen in other North American Wisconsin faunas (Lundelius *et al.* 1983, Walker 1987). Instead, a suite of taxa is present that can be considered diagnostic of a resource seasonal environment (Boyce 1978, 1979, Guthrie 1982).

Except for small mammals (under 1 kg), most members of the Late Pleistocene mammalian fauna were larger than their present-day counterparts. Kurtén (1959, 1968), among others, has shown that most glacial period taxa were larger than related interglacial forms. This is a consequence of the greater resource seasonality extant during the Pleistocene (Guthrie 1982, 1984a, 1984b, Walker 1986). Guthrie (1984a, 1984b) has demonstrated that as resource seasonality decreased at the end of the Pleistocene and the winter seasonal bottleneck lessened, most large ungulates decreased in body size. The winter seasonal bottleneck was, thus, the most critical period of the yearly cycle for all large mammals. Those with a large body size are better able to survive a period of food shortage (Lindstedt & Boyce 1985). This period would have also seen the highest mortality, a fact that tends to reduce competition the following spring during the peak in resource availability.

This higher resource seasonality had a direct effect on Late Pleistocene human populations as well as on other mammals. First, people would have had a shorter peak period for collection and preservation of plant resources. Similar problems were also experienced by the large ungulates. Secondly, while the overall mammalian fauna was more diverse, competition for the reduced resources resulted in lower numbers of animals (Guthrie 1982, 1984a, 1984b), and human groups would have had to spend more time hunting to find enough meat to carry over the winter. It is only after the lessening of this seasonal bottleneck in resource availability that we begin to see large numbers of mass kill sites of bison. Thirdly, the same bottleneck would have also produced low human population size. If sufficient food could not be collected to provide for overwintering of large numbers of humans, smaller group sizes would have been the norm.

The ice-free corridor

Few things have captured the attention of archaeologists concerned with the peopling of the New World more than the interrelated complex of features and events that led to the existence of the Bering Landbridge, Beringia, and the ice-free corridor. Considerations that the buildup of the glacial ice sheets opened the landbridge and vice versa have provided a basis for almost endless model building and speculation. Unfortunately the timing of the two events is not well known or agreed upon, nor is the length, the time-period, or the nature of the contact between the Cordilleran and Laurentide ice sheets.

Reeves, some years ago, wrote that the coalescence of the Cordilleran and Laurentide ice sheets within about the last 100 000 years consisted of contact 'during a few thousand years of a few mountain piedmont lobes with the Laurentide ice sheet for relatively short distances' (Reeves 1973, p. 13). The implication was that, except for a short, local blockage between about 20 000 and 18 000 years BP, there would have been no physiographic barrier to prevent movement of human groups between the two ice sheets. Reeves (1973) mentioned also that he did not claim that the ice-free corridor contained the necessary biotic communities to support these same human groups.

Subsequent studies of the two ice sheets have revealed new data. Dyke & Prest (1987) in their latest map series show the coalescence of the two ice sheets at 18 000 BP from nearly 50° to 60°N. By 14 000 BP they depict the corridor opening for nearly half the distance from the southern end. By 13 000 BP they show a narrow corridor free of ice with lakes extending across it, and by 12 000 BP the corridor is shown quite wide but still with large meltwater lakes. Analysis of sediment cores from Boone Lake in the upper Peace River district in Alberta (Fig. 17.1) at about 56°N tend to support these conclusions. Radiocarbon dates on two cores support a coalescence of the Laurentide and Cordilleran ice at about 12 000 BP, although there was a continually fluctuating, ice-free zone between the two ice sheets to the south. This zone was characterized both at the glacial maximum and at deglaciation by periglacial conditions with meltwater lakes and a sparse tundra cover of upland shrubs and herbs (White *et al.* 1985). In sum, these two examples clearly indicate that palaeoenvironmental reconstructions of conditions in the ice-free corridor both before and after the glacial maximum are still in the data-gathering stage.

Taphonomic studies

Many of the uncertainties in sites of pre-Clovis age arise from the difficulty of identifying evidence of human activity as being distinct from the activities of other mammals and natural causes. Site assemblages containing faunal materials, but lacking lithics that are unequivocally of human origin, have enriched the controversial subject of pre-Clovis human occupations in the New World. In fact, few areas of enquiry that were earlier pursued with considerable confidence have witnessed the retrenchment and re-evaluation of earlier data than that dealing with bone technology.

New World use of taphonomy as an archaeological tool was initially inspired largely by the studies of Voorhies (1969) on an Early Pliocene vertebrate fauna. Voorhies noted that although information from taphonomic studies may be useful in palaeoecological reconstructions, there is a distinction to be made between taphonomy and palaeoecology. He stated also that 'Taphonomy overlaps palaeoecology only insofar as the mode of life of an organism influences its chances of burial and preservation' (Voorhies 1969, p. 2).

Archaeologists quickly perceived that certain principles of taphonomy dealing with age structure of faunal assemblages found at kill sites could reveal something about the human activities involved (see, for example, Frison 1978, Todd 1987). It was primarily the interest in distinguishing between human, animal, and natural modification of bone, however, that has led the New World archaeologists to studies involving site assemblages dating to the LGM and older.

The Old Crow River area produced not only the celebrated caribou flesher but secondary deposits there have also yielded large numbers of broken bone of extinct mammals. Marks on bones, bone breakage, evidence of wear on the broken surfaces and resulting edges, and actual flaking of bone claimed for the assemblages have all been controversial because of disagreements about being able or unable to distinguish between human and other kinds of bone modification (e.g. Bonnichsen 1978, Irving 1978, Morlan 1978).

The possibility of a pre-Llano site on the Colorado high plains was proposed on the basis of broken extinct animal bones with the appearance of having been used as tools also. The Selby and Dutton sites (Stanford 1979) were found as the result of dredging out old playa lakes on the plains of eastern Colorado (Fig. 17.1). The bones in question were recovered in Peorian loess deposits with ages possibly as old as 30 000 BP. In the case of the Dutton site, there were unquestionable flaked stone artefacts of the Llano complex well above the Peoria loess. The mammal bones in the latter deposits, however, are lacking any associated lithic materials.

It is easy to envision the bone assemblage in the loess deposits at the Selby and Dutton sites as a result of human activity. The breakage is similar to that at proven human animal kills. The evidence of wear on certain exposed edges and surfaces are difficult to assign to non-human causes. As experiments with bone breakage continue and observations on bone modification by different scavengers and carnivores are made, however, the certainty between distinguishing the results of each in all cases diminishes (G. Haynes 1980, 1982). Natural causes, such as movements of sediments in water for long periods of time, have been found to cause bone edges to acquire a polish (Behrensmeyer 1984).

Cut marks at strategic locations for dismembering animals have been proposed as evidence of human activity. Not all marks thought to be of human origin, however, appear in the locations best explained by butchering and meat processing. Furthermore, trampling by animals, particularly in sediments containing sharp sand grains, can produce marks strongly resembling true cut marks (Behrensmeyer 1984). Microscopic techniques show promise in helping to determine the difference between actual cut marks and cut mark mimicry (see Shipman & Rose 1983, 1984) and can be especially valuable where the lithic part of an assemblage is lacking.

Much of the claim for pre-Clovis evidence in the New World comes from caves and rockshelters where there are successive levels that are sometimes actual occupation floors but in some cases are accumulated deposits of roof fall and materials carried into the shelters by different agencies, both human and animal. In many cases where the stratigraphy appears undisturbed, however, vertical displacement has, in fact, occurred. This has been well demonstrated through the analysis of conjoined pieces at Old World sites (Villa 1982) and should be anticipated in the New World. In brief, we still do not fully understand site formation processes, particularly in caves and rockshelters where the evidence for disturbance is not always clear.

Conclusions

The New World, and North America in particular, has witnessed an increased interest in palaeoecological studies of the late Wisconsin glacial period. Concomitant with this has been an increased emphasis on the problem of the peopling of the New World: a subject for which unequivocal evidence of actual fact has not been forthcoming. Consequently, old data have been restudied and new data have been gathered and presented. Claims for evidence of human presence in the New World have been extended as far back as 100 000 BP. Most, however, are in the time period of a few thousand years or so on both sides of the LGM. Unfortunately, the frustrations of not being able to recover undisputed evidence that will resolve this problem has led to the establishment of two camps in American archaeology: those who staunchly argue for human presence during the LGM and those who argue against it. Each investigator is expected to take one side or the other instead of letting the data eventually solve the problem. On the positive side, site data are being subjected to rigid scrutiny and testing, innovative and better methodologies are being tried, and the interpretive potential of different disciplines is being applied to the problem. There is also the chance that at any time unequivocal site data will come to light and some of the controversy can be laid to rest.

Of immediate importance to resolving the problem of early man in the Americas is to be able to evaluate properly the evidence coming from south America. Since only the southern end of the continent witnessed extensive ice-sheet coverage (see Flint 1971), the LGM would, very likely, have had little effect on human population movements coming from the north. Should the early dates for human occupation prove correct here, palaeoecological studies will be of utmost importance to establish the nature of the human subsistence strategies involved.

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High latitudes

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