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The Earliest Americans

New developments increase the known antiquity of man in the New World but leave many problems unsolved.

C. Vance Haynes, Jr.

During the 19th century several discoveries were made in America suggesting the presence of man during the Ice Age, but the evidence was inconclusive. Two schools of thought developed. One held that evidence of the presence of man in the New World did not extend back much beyond the obvious evidence of the prehistoric Mound Builders, Pueblos, Aztecs, or Incas of no more than 2000 B.C. The other school held that man lived among, and hunted, the giant game animals that became extinct at the end of the Pleistocene (*1*).

It became apparent that, if the truth were to be known, the skeletons of late Pleistocene game animals would have to be scientifically excavated by trained observers, to see if any evidence of man could be found. If it could be, the undisturbed association of artifacts with bones of an extinct animal in geological deposits of Pleistocene age could be presented to witnesses from the scientific community for verification. Such was the case in 1926 when paleontologists from the Denver Museum of Natural History discovered fluted stone projectile points in association with skeletons of extinct bison near Folsom, New Mexico (*2*). The following year, as more bones and "Folsom points" were found *in situ*, scientists from various parts of the continent witnessed the discovery, and in subsequent years more than 100 sites have been described where artifacts of early man occur *in situ* with bones of either mammoth, camel, extinct horse, or bison (*3*).

In the United States today we have an excellent, but by no means complete, understanding of cultural development during the final phase of the Pleistocene glaciation, known as the Valderan Substage. As for the earlier substages, after 40 years of searching, little positive evidence for earlier occupation of the New World has been found. But, as discussed below, we may be on the threshold of a second breakthrough regarding knowledge of the antiquity of man in America.

Geochronology

At the time of the Folsom discovery it was not possible to estimate the age of the find any more precisely than to say that the association with *Bison antiquus* meant that man was present in America near the end of the Ice Age. Today our understanding of the time range for early man is much more precise because of the study of geological sequences to which archeological finds can be related. Radiocarbon dating has made possible both the precise dating and the accurate correlation of these sequences in widely separated areas (*4*).

The study of stratigraphic sequences of loess, till, and lake sediments in the mid-continental area has provided a record of geological time corresponding to the fluctuations of late Pleistocene glaciers, but occurrence of archeological sites within these strata are rare. Most of the stratigraphic record of early man is in the western United States, where erosion and sparse vegetation provide better exposures for the accident of discovery. For convenience of discussion I have subdivided the Paleo-Indian period, or the time of early man, into three hypothetical subperiods (Fig. 1) and have arbitrarily selected the boundaries to correspond to those of the time-stratigraphic subdivisions of the Wisconsinan stage as defined by Frye and others (*5*).

The late Paleo-Indian period corresponds to the Valderan substage of between 11,800 and 7000 years ago.

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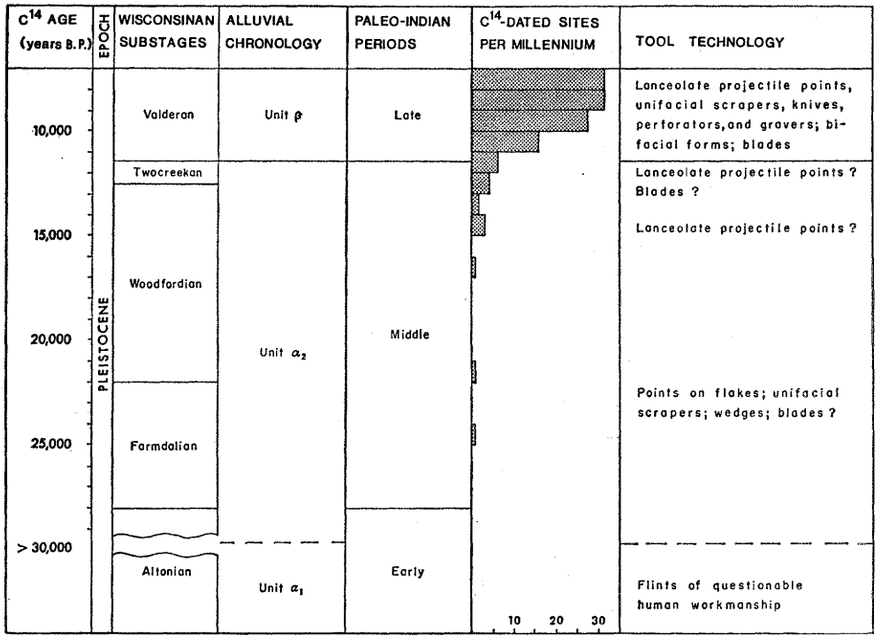

Fig. 1. Chart showing the correlation of geological and archeological events of the Wisconsinan stage in America south of Canada (see *4*, *5*, and *23*).

The middle Paleo-Indian includes the Twocreekan, Woodfordian, and Farmdalian substages, from 28,000 to 11,800 years ago, and any sites older than the Farmdalian-Altonian boundary (28,000 years ago) would fall into the early Paleo-Indian period. My discussion follows the reverse order of stratigraphic succession, proceeding from the best understood to the least understood period.

Late Paleo-Indian Period

During Valderan time, continental glacial ice expanded from Canada into the United States for the last time, and its retreat through the Cochrane District of Ontario brought the Valderan substage to a close. During this time early man was well established in the New World, where, since the Folsom discovery, his hunting sites and camps have been found from Tierra del Fuego to Nova Scotia. In the earliest part of this period, between 11,500 and 11,000 years ago, there existed throughout the United States a culture of highly skilled and technologically advanced hunters who used a distinctive fluted projectile point known as the Clovis point for killing mammoths as well as other big game animals. The transition from the use of Clovis points to Folsom points approximately 11,000 years ago coincides with the extinction of mammoths, horses, camels, and several other members of the Pleistocene megafauna (Fig. 2), but species of bison remained and were hunted between 11,000 and 7000 years ago by early man using a variety of projectile point types collectively called Plano points.

This sequence is understood because geologists and archeologists working together in the western United States have mapped sequences of alluvium, reflecting cycles of deposition and erosion, within which the temporal relationships of culture, fossils, and samples for radiocarbon dating could be accurately read and correlated with the glacial chronology (*6*).

At the Hell Gap site in eastern Wyoming, archeologists have uncovered an unusually complete sequence of superimposed cultural horizons in which the change in early man's artifact assemblages has been observed through a span of 4 millennia between 11,000 and 7000 years ago. Actual "living floors" for Folsom, Agate Basin, Alberta, Cody, and Frederick cultural horizons were uncovered, and thousands of artifacts were found lying where they had been abandoned or lost by early man. The occurrence of discontinuous carbonaceous layers throughout the sequence permitted multiple radiocarbon dating of the entire sequence (*7*).

In the eastern United States late Pleistocene alluvial sequences are rare and not so easily mapped, and most late Paleo-Indian sites have been found either on the surface or within the plowed zone where artifacts of all ages are mixed. Because of these factors the temporal relationship of fluted points to archaic eastern types, or of these to the western finds, was not understood. However, in recent years cultural-stratigraphic sequences have been demonstrated in North Carolina and in West Virginia, and a buried site producing fluted points was found in Nova Scotia. Whereas the earliest age for fluted points in the East is still not known, we now know that the Debert fluted points of Nova Scotia are 10,600 years old and are, therefore, an eastern contemporary of the Folsom type in the West (*8*). At the Saint Albans site in West Virginia and the Doerschuck site in North Carolina, archaic artifacts are 8000 to 10,000 years old and hence overlap in time late Paleo-Indian artifacts elsewhere (*9*).

The most important find to be made in South America since the discovery of the 10,000-year-old early-man site of Fells Caves in Tierra del Fuego is at Lake Tagua Tagua in central Chili, where an assemblage of stone and bone artifacts has been found in association with bones of extinct game animals in deposits for which an age of 11,380 ± 320 years [a radiocarbon date of 11,380 ± 320 B.P. (GX-1205)] has been obtained (*10*). What is significant about this discovery, other than that it dates from early Valderan time, is the fact that it is within a stratigraphic sequence containing overlying deposits with bones, shells, and artifacts which, taken all together, constitutes compelling evidence in support of the interpretation that the site was a late Pleistocene hunting camp where animals were butchered for food, skins, and other uses. So far, no projectile points have been found at the site, but it seems reasonable to expect that some will appear with further excavation.

Recent discoveries in Alaska suggest that different core and blade industries, indicating cultural diversity, had become established there during early Valderan time (*11*), but the age of fluted points found on the surface in northern Alaska remains undetermined.

Although there is still much to learn about the temporal relations of various cultures of the late Paleo-Indian period, the trend of investigation today is toward learning more about early man's way of life. Where possible, the precise distribution of artifacts on an ancient surface of occupation is plotted to determine different activity areas. This was done at the Debert site in Nova Scotia, where over 4000 arti-

facts were discovered *in situ*, making this the largest single-component early-man site yet found east of the Great Plains. The data supported the interpretation that the site was probably a caribou hunting camp visited seasonally by a band of perhaps 40 individuals (*12*).

The Murray Springs site in southeastern Arizona, while smaller than Debert, probably has the least disturbed "living floor" of any Clovis site known. The removal by hand of an unusual layer of black organic material laid down very soon after occupation has revealed this floor, in which even the tiniest flake lies exactly where it has lain for 11,200 years. Hemmings and I have mapped the *in situ* position of stone and bone tools and of thousands of waste flakes relative to the positions of butchered carcasses of mammoths, bison, and a horse (*13*).

If a deposit does not lend itself to precise plotting, the artifact distribution by unit area can be treated statistically. In this manner, at the Holcomb site in Michigan, Fitting (*14*) was able to define a central area where flint was treated with heat to facilitate flaking, and several peripheral areas where prepared flint was flaked into tools. The number and distribution of activity areas suggested that the Paleo-Indian band numbered 30 to 60 individuals.

Another recent trend is to ascertain more precisely than has been done in the past the techniques of manufacture and the function of stone tools. The debitage (waste flakes) is examined statistically and compared to that of known techniques of flaking, and the pattern of wear on different types of tools is studied microscopically to learn how each was used (*15*).

For the late Paleo-Indian period, the increasing number of artifacts and artifact assemblage of known age has broadened our understanding of early man in America. For earlier periods the sample is at present inadequate.

Middle Paleo-Indian Period

The maximum extent of the late-Pleistocene glaciation occurred during the Woodfordian substage when practically all of Canada may have lain under a great thickness of ice which effectively blocked the passage of man or animals between Alaska and the coterminous United States. The preceding Farmdalian substage is believed to have been relatively less glacial, but it is not known how much of Canada was ice-free during this time. The end of the Woodfordian substage was the beginning of deglaciation which began 14,000 or 15,000 years ago and proceeded with an alternative series of retreats and diminishing advances through the Valderan substage. A major recession is believed to have occurred during the Twocreekan substage.

It is not known how far the ice borders retreated during Twocreekan time, but it has been suggested that the Cordilleran and Laurentide ice which merged along the eastern front of the Rocky Mountains may have separated during this time, thus making travel between Alaska and central North America possible for the first time in approximately 10,000 years. It has also been suggested that this happened either 13,000 years ago or in late Valderan time (*16*).

Twocreekan deposits are rare, because erosion was more prevalent than deposition, but at the type site near Two Creeks, Wisconsin, a deposit of sand contains trees that were killed by rising water of glacial Lake Chicago when advancing Valders ice blocked the outlet and subsequently submerged the trees 11,900 years ago (*17*). In the eastern part of the continent no arti-

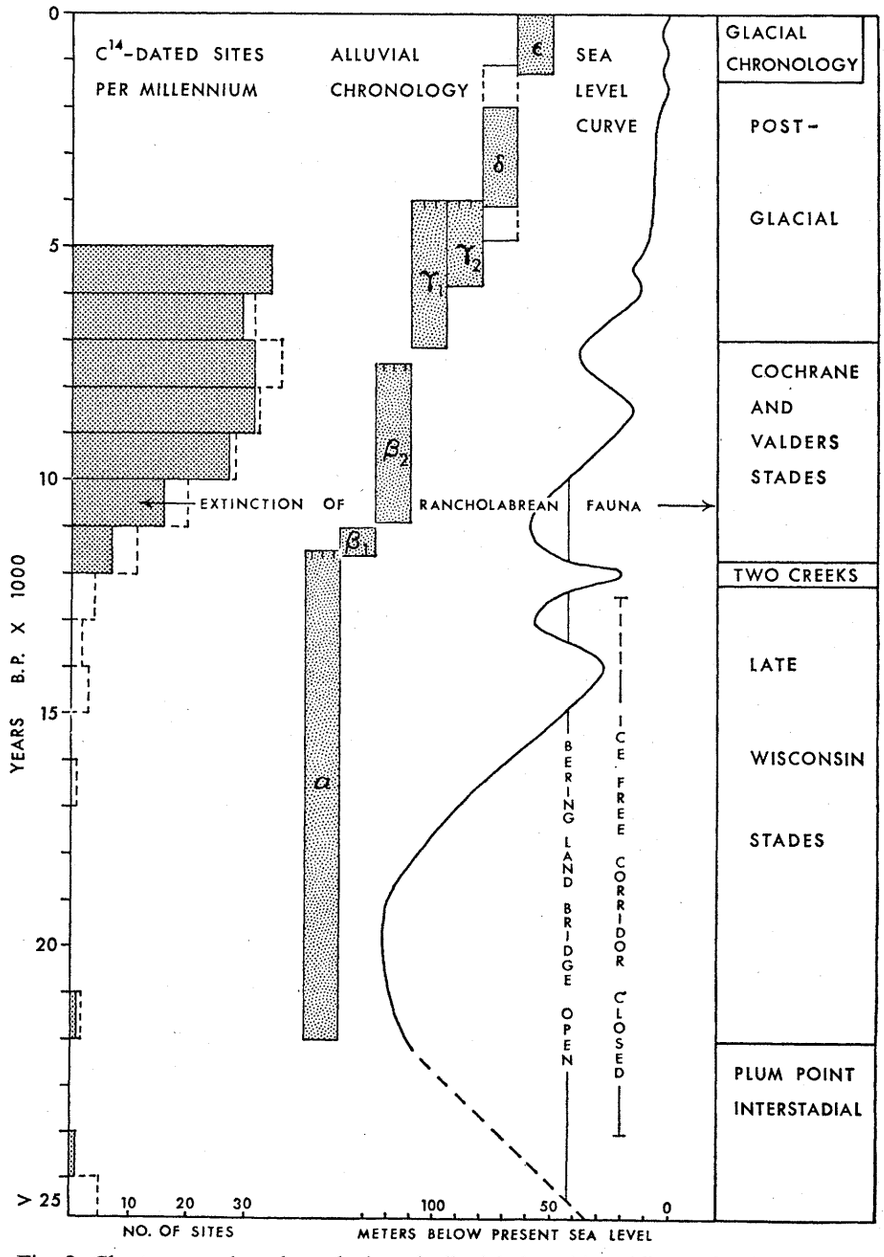

Fig. 2. Chart comparing chronologies of alluvial deposition (*6*), sea-level fluctuations [after Hopkins (*32*)], and glaciation to the increase in the number of Paleo-Indian sites with time, as measured by the radiocarbon method (*23*).

facts have been found in Twocreekan deposits.

In the western United States pluvial lakes were at their highest stands during Woodfordian time and earlier, as evidenced by shore features and lacustrine beds dated by the radiocarbon method. In both halves of the continent there have been surface finds of artifacts thought to be temporally related to shore features of lakes of Woodfordian or Twocreekan age, but none have been recovered enclosed in lacustrine deposits where contemporaneity could be clearly demonstrated. The situation is similar for the surface distribution of fluted points in the glaciated mid-continent. Whereas no artifacts have been recovered from within glacial deposits, the surface distribution of fluted points in Michigan and Wisconsin appears to be related to Port Huron and Valders moraines, suggesting that man entered the area between late Woodfordian and early Valderan time (*18*).

Until recently the very existence of a middle Paleo-Indian period was subject to challenge on grounds of insufficient evidence, but recent finds in the northwestern United States are more convincing than any others yet made in this country. In a cave beneath a lava butte in south-central Idaho, stone artifacts and cut bone were found in deposits that were subsequently assigned ages of 14,500 to 15,000 years, and a leaf-shaped projectile point found in the deposits is of a type thought by some to have been a developmental predecessor of fluted points (*19*); however, I have offered an alternative interpretation of the dating in my comments to Bryan (*16*). At Fort Rock Cave in Oregon, a radiocarbon date of 13,200 ± 170 B.P. (GAK-173) was recently obtained for charcoal reportedly associated with a lanceolate projectile point, although the documentation has not yet been published. Again the material was found in a cave or rock shelter in which there was an overlying sequence of archeological strata for which consistent dates had been obtained (*20*).

No bones of early man from the middle Paleo-Indian period have as yet been found by the archeologist, but in eastern Washington human bones, stemmed lanceolate projectile points, bone points, and a delicate bone needle were found *in situ* in a stratigraphic sequence for which the geochronology had already been worked out. The estimated age of between 10,800 and 13,000 years makes this find at the Marmes shelter the oldest firmly established date for human skeletal remains in the New World. Current investigations of the site, which include radiocarbon dating, may reveal more precisely whether this occupation was Valderan or earlier (*21*). The Midland skull from western Texas is probably at least as old as the Marmes find, but the geochronology of the Scharbauer site is less precisely known (*22*).

The existence of sites of pre-Valderan age in South America has been indicated by dates, obtained by the radiocarbon method, between 12,000 and 16,000 years ago, but so far their association with artifacts has been questionable (*23*). In Mexico, the discoveries near Puebla and Tlapacoya constitute the strongest evidence yet offered of a middle Paleo-Indian occupation of the New World. At several sites in and around the Valsequillo reservoir near Puebla the occurrence of a developmental sequence of artifacts in association with bones of extinct game animals, all within a thick stratigraphic sequence, lends support to the interpretation that at least the lower parts of the sequence are Woodfordian or older. A radiocarbon date of 21,850 ± 850 B.P. (W-1895) on shell, which commonly yields erroneous dates, suggests a Woodfordian age for part of the sequence. At the Hueyatlaco site a marked unconformity within the Valsequillo gravels separates upper deposits with bifacially flaked artifacts from lower deposits in which only flake- and blade-type artifacts have been found.

Fossil mammal bones indicating a late Pleistocene fauna occur in association with artifacts in both deposits, but the terminal date for these fauna in Mexico is not known. It is likely that extinction occurred later there than it did farther north. The Valsequillo sequence would be an excellent one on which to test this hypothesis, but material suitable for radiocarbon dating has been lacking at the critical sites, and the volcanic-alluvial strata do not contain buried soils that would be helpful in making correlations with nearby volcanic deposits for which dates have been obtained. Several modern techniques for correlation and dating are being tried in the hope of resolving the problem of the age of the Valsequillo deposits (*24*), but other aspects of the site are not without controversy (*25*).

At the Tlapacoya site between Mexico City and Puebla, shore deposits of ancient Lake Chalco surround a volcanic hill around which two sites of early man have been found. Both are in volcanic ash that is interfingered with littoral peat deposits; an age of approximately 24,000 years has been obtained for wood from these deposits. It is believed that at least some obsidian flakes and artifacts were introduced into the deposits by rodents, but a shallow depression containing powdered charcoal which yielded a date of 24,000 ± 4000 B.P. (A-794B) is believed to be an ancient hearth. Bones of late Pleistocene animals occurred in beach gravels around the hearth, and at another site on the opposite side of the hill an obsidian blade was found beneath a large log which yielded a date of 23,150 ± 950 (GX-959), indicating that the site is of Farmdalian age (*26*)—the only site of that age yet known.

As yet no site from the middle Paleo-Indian period has yielded anywhere near the quantity of artifacts and debitage known for many of the late Paleo-Indian sites, and, with the possible exception of Valsequillo, no cultural stratigraphic sequence has been demonstrated. Although none of the sites are as convincing as the Folsom site was for the late period, it appears to be only a matter of time before a convincing find is made, but, until it is, the existence of a middle Paleo-Indian period must not be considered proven.

Early Paleo-Indian Period

If evidence from the middle period seems scarce, that from the early Paleo-Indian period is practically nonexistent. Sites that may be of this age, such as Tule Springs in Nevada, Lewisville in Texas, and several sites in California, simply have not provided the evidence considered minimal to prove the presence of early man before Farmdalian time (*27*). In most cases the geological age is reasonably well understood, but either the association or the nature of the possible artifacts is questionable.

Recently, at the Calico Hills site, near Yermo, California, very crude flints, reported to be artifacts, have been found in alluvial-fan gravels of Pleistocene age (*28*). Because this site exemplifies most of the problems encountered with possible archeological

sites thought to be of early Paleo-Indian age, I consider it here in some detail. The ancient alluvial-fan gravels, containing up to 10 percent of chert derived from bedrock which crops out in the Calico Hills 3 miles (3.8 kilometers) to the west, have been intensely weathered to a depth of over 6 meters. This ancient soil has superimposed upon it a calcareous red B-horizon and a vessicular A-horizon in the upper half meter, which indicates a second episode of weathering. The strength of soil-profile development shown by the upper red soil is as great as, or greater than, that of mid-Wisconsinan soils elsewhere in the southwestern United States, and many geologists, including myself, believe that the deposit is no younger than Altonian. The additional factor of 6 meters of rotten gravel below the red soil is convincing evidence that the deposit is of pre-Wisconsinan age (more than 70,000 years old), because such a depth of weathering is not known in Wisconsinan deposits. Some geologic age estimates of between 30,000 and 120,000 years have been made, but an age of 500,000 cannot be precluded (*29*).

The origin of what have been called artifacts within the deposits is even less certain, but some authorities, including those conducting the excavations, appear to be absolutely convinced that some of the fragments of chert show flaking that could only have been done by man. Others contend that even the best specimens could have been chipped and flaked naturally, especially in view of the fact that each "artifact" has been selected from literally hundreds or thousands of individual pieces of chert, excavated from gravels which, when fresh, experienced intergranular percussion and pressure at various times during their transportation from outcrops in the Calico Hills. Natural flaking would have been further aided by the igneous-rock cobbles which make up a significant percentage of the rocks and which, when fresh, would have served as natural hammerstones.

Another line of evidence that has been offered in support of the hypothesis that man was present during deposition of the alluvial fan is the occurrence of "artifacts" in anomalous concentrations, one of which is associated with fragments of bone and tusk, but the degree of concentration is dependent upon both the subjective selection of "artifacts" and the relative proportion of these to natural pieces of chert. The variability of this ratio for a representative sample of the fan has not been determined. The occurrence of dispersed fragments of bone and tusk is not unexpected in any Pleistocene gravel; therefore their presence has no bearing on the question of whether or not the flints are artifacts. The main difficulty in the Calico Hills case is that the situation there does not lend itself to definitive solution. The question is whether the flints are of archeological or of geological origin, but, as with "eoliths," the two could be indistinguishable at very early levels and under geological conditions where natural flints are a significant component of the deposit (*30*).

Geological Factors in Site Discovery

The scarcity of known archeological sites dating back to the middle Paleo-Indian period and earlier may be due not only to the fact that there were fewer people, and thus fewer sites, during the earlier times but also to geological factors. During glaciation, in many unglaciated areas there was greater alluvial and lacustrine deposition of sediments than there has been during all of postglacial time. Erosion, which exposes sites, eventually causes their destruction, so, from the standpoint of site discovery, depositional and erosional effects would to some degree counterbalance each other were it not for the fact that erosional surfaces are commonly buried again after being exposed. The important geologic factors, then, are the number of sites per unit volume and the relative amount of exposure of the stratigraphic units.

These factors are best evaluated in the southwestern part of the United States, where most of the stratified sites have been found in erosional exposures.

I estimate that at Blackwater Draw, New Mexico, where the type Clovis site is located, the Wisconsinan valley fill comprises 80 percent or more of the deposits of Twocreekan age or older (unit α of Fig. 2) and that less than 20 percent of the deposits are of Valderan age (unit β); the latter value includes 100 percent of the known sites of early man in that area. Despite excellent exposures of late Woodfordian deposits containing many remains of extinct game animals, no artifacts of this age have been found after 30 years of search by both amateur and professional archeologists. This is in marked contrast to the immediately overlying deposits, where there are more game-animal remains associated with artifacts than not (*31*). A similar situation exists in southeastern Arizona, where three mammoth skeletons in unit α of the alluvial chronology (Fig. 2) yielded no artifacts upon scientific excavation, whereas five of six mammoth skeletons at the bottom of unit β yielded Clovis points. The situations are qualitatively similar in other areas.

At the moment the apparently abrupt and marked increase in the evidence for early man in unit β of the alluvial sequence as compared to unit α appears not to be due to strictly geological factors. A significant population increase is indicated, but, until more numerical data on the relative proportions of game-animal skeletons with and without early-man associations for various time-stratigraphic units are available, quantitative evaluation of New World population changes with time will not be very accurate.

Theoretical Considerations

Theories of the initial peopling of the New World are intimately related to sea level and glaciation during the late Pleistocene, because it is generally agreed that man passed from the Old to the New World by way of an emerged Bering platform and thence through central Canada. The vast continental glaciers grew at the expense of water from the oceans, so sea level was lowest when glaciation was greatest. During glaciation the emergence of the Bering platform made Alaska as much a part of the Asian continent as of the North American, and people living in northeastern Asia would naturally have migrated throughout Beringia into Alaska, and eventually through central Canada, once the glaciers there had retreated enough to open an ice-free corridor (Fig. 2).

Because of our lack of precise knowledge of the timing of these events, we do not know whether man could have crossed the Bering land bridge when it first emerged 28,000 to 25,000 years ago and still have had time to pass through Canada before the Laurentide ice merged with Cordilleran ice and blocked the passage (*32*, *33*). The passage would not have again become open until sometime after deglaciation began—between 14,000 and 8500 years ago. It is possible that the passage may have opened and closed several times in conjunction with the

retreats and advances of the ice during deglaciation, and it has been proposed that the first late Wisconsinan migration was a migration of the predecessors of the Clovis hunters during either the Two Creeks retreat or the Bowmanville (*34*).

If early man was on the North American continent during the early Paleo-Indian period, he would have had to cross the land bridge during Altonian time or earlier. One current hypothesis is that all early-man developments derived from an early migration and that passage through Canada was not again possible until late Valderan time, when early man may have migrated in the other direction, northward (*16*). On the other hand, the very existence of an ice barrier is questioned by some.

The detailed history of an early ice-free corridor through Canada may be very difficult to learn by means of geological investigation because later advances of the ice may have obliterated much of the evidence. On the other hand, the archeological record of early man in central North America may shed light on the history of ice-free corridors. Compelling evidence of man's presence in central North America before deglaciation began would indicate that man must have traversed Canada in pre-Woodfordian time. The relatively abrupt appearance of a new or different industry may correlate with the opening of an ice-free corridor during deglaciation, as has been suggested for the Clovis-point industry (*35*), but this appearance will be recognizable only from a horizon in the geochronological record beyond which positive evidence for the industry will be lacking. Therefore, in order for negative evidence to be significant, it is essential that the presence of industries at an early date be established by only the most compelling evidence.

No better example of the objective approach can be cited than that of W. J. McGee, who, as a member of the I. C. Russell field party that explored ancient Lake Lahontan in 1882, discovered a large obsidian projectile point protruding from Pleistocene fossil beds in Walker River Canyon, Nevada. Being alone and at least a day's ride from the nearest knowledgeable witness, yet realizing the importance of the discovery, McGee, after pondering all of the possible ways the point could have become imbedded, proceeded to test each hypothesis by carefully exhuming the object with his pocketknife. He concluded that (i) it was not embraced in a veneer of mud, (ii) it was not imbedded in a pseudostratum filling a horizontal crevice, (iii) it had not worked down a burrow, (iv) it had not worked down a fissure, and (v) it apparently had not been propelled to its position, because the tip projected outward.

After a delightful philosophical digression on inductive science, McGee, in 1889, concluded (*36*):

> Now the Nevada obsidian is an isolated and incongruous phenomenon, and any judgment concerning it must be of relatively little weight and subject to modification with new discoveries, and it is perfectly logical to accept the verity of the association and record the fact of its finding, yet to withhold immediate judgment as to its significance and allow the interpretation placed upon it to vary with the progress of discovery, either in the same deposit or in other parts of the country.

In spite of the progress that has been made, we still do not have enough data to make a definitive interpretation of the McGee find, but the data from Wilson Butte Cave (*19*), which produced a similar projectile point, and the Quaternary geology of Lake Lahontan (*37*) suggest a Woodfordian age.

Summary and Conclusions

The presence of early man south of Canada during Valderan time has been demonstrated repeatedly by discoveries of sites where artifacts, including lanceolate projectile points, have been found in association with bones of extinct animals in geological deposits dated by the radiocarbon technique. During the first millennium of Valderan time, fluted projectile points predominate in archeological horizons throughout much of North America. Evidence for horizons characterized by earlier projectile points is limited to two cave deposits and possibly the Hueyatlaco site in Mexico. The seemingly abrupt appearance of the relatively sophisticated fluted point tradition throughout much of North America during late glacial time has led to the hypothesis that it may have stemmed from a separate migration through central Canada during one of the intraglacial retreats of the ice near the end of deglaciation. According to another hypothesis, all early-man industries derive from a common non-projectile-point industry that had its origin in the Old World but made its way to the New World in early or even pre-Wisconsinan time. It remains to be determined whether either or both of these hypotheses, or parts of them, are valid.

For establishing man's presence, the minimum requirements met for the Folsom site still apply for future excavations. The primary requirement is a human skeleton, or an assemblage of artifacts that are clearly the work of man. Next, this evidence must lie *in situ* within undisturbed geological deposits in order to clearly demonstrate the primary association of artifacts with stratigraphy. Lastly, the minimum age of the site must be demonstrable by primary association with fossils of known age or with material suitable for reliable isotopic age dating. These requirements have now been met repeatedly for the late Paleo-Indian period, but they have not yet been satisfactorily met for the middle Paleo-Indian period, and our knowledge of the early Paleo-Indian period is still hypothetical. In the future, and because of the importance of such data, the evidence must be witnessed and verified *in situ* by several authorities, just as it was at Folsom. This is particularly important in archeology, where, as in no other science, the evidence is partly destroyed in the recovery of data and can be duplicated only by the chance discovery of a similar situation.

Note added in proof: Pebble tools are known to occur in artifact assemblages of the late Paleo-Indian stage, and Borden (*38*) suggests that a distinct pot industry may have existed in British Columbia during the middle Paleo-Indian period. However, some geologists working in the area believe that the deposits postdate the last glaciation in that area.

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NEWS AND COMMENT

Nobel Laureates in Economics, Chemistry, and Physics

1. Economics

That Ragnar Frisch and Jan Tinbergen were both on the short list of candidates for the first Nobel prize in economics was well known and fully anticipated. The only surprise element in the final announcement of the prize was that the award was joint. This choice was by no means illogical, but the two men had not worked together on their greatest contributions although they were of the same generation and pioneered together in establishing the subjects of econometrics and mathematical economics. Their professional reputations are worldwide, and they have long stood as giants in their home countries, in leading academic centers, and in world gatherings of scholars.

During the 1920's, and especially in the 1930's, the quantitative approach to economics through the use of mathematics and statistical method began to flower. Acceptance of this approach was resisted in England and America, but Norway and Holland were renowned for researches along these lines because of the dominating influence of Frisch and Tinbergen and their students, many of whom are leaders in the present generation.

Econometrics grew in the United States. Before World War II, several of the leading figures were European immigrants. The Econometric Society was founded in 1930 by a mixed group of Europeans and Americans, some of the people being drawn from outside economics. Ragnar Frisch was instrumental in organizing the founding group.

It was not until the middle of the 1950's that econometrics was able to flourish in American universities. By then, textbooks had become available; several leading centers offered advanced courses in the subject and provided professorships in econometrics.

There is some confusion over the meaning of "econometrics" as a discipline, and it is worth while considering a careful definition, for this brings out more clearly the separate contributions of the two prizewinners and the relationships between their work. Econometrics is measurement in economics, where that measurement is applied to the mathematical formulation of economic theory and carried out according to the principles of mathematical statistics.

Mathematical economics exists apart from econometrics. It is simply the analysis of economic theory through the medium of mathematics. It is often deterministic theory and is not always put in measurable terms. Econometrics, on the other hand, requires a stochastic formulation of economic life and deals with measurable (or potentially measurable) magnitudes. Mathematical economics generates the hypotheses about the structure of an economy or its subsectors, while econometrics undertakes to test these hypotheses and estimate the implied interrelationships. Much of econometric theory is concerned with optimum methods of making statistical inferences within the framework of a mathematical statement of economic relationships.

The Econometric Society was founded jointly by people interested in mathe-