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GEOLOGIC ANTIQUITY OF MAN IN AMERICA[1]

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THE PROBLEM

THE Europeans who first explored the Americas found in this "New World" numerous tribes of dark-skinned, black-haired people. They differed in dress, habits and social organization, but all of them lived by agriculture or by a combination of agriculture, food-gathering, hunting and fishing. Only a few tribes were solely dependent on hunting, and most of them were in touch by trade with agricultural groups. These cultural similarities and a common physiognomy led to the popular recognition of these newly found people as a separate race, the Red or American. More detailed scientific study has shown that these peoples are much more diverse in physical and cultural attributes than was at first supposed. It is clear that there has been an intimate blending of racial strains. One must suppose that these people, descended from whatever diverse stocks, have a long common history.

From the beginning of exploration also the question of the origin has been posed. As the people of the Americas are obviously not closely related to the peoples of western Europe their origin by migration across the Atlantic has been rejected except by advocates of the myth of Atlantis. The Mongolian strain clearly marked in many American tribes and the narrow seas of Bering Strait point to migration from Asia. Most of the immigrants must have crossed on foot either on the ice north of the strait[2] or on a land bridge produced by the lowered sea level of glacial

[1] Address of the retiring vice-president and chairman of the Section on Geology and Geography of the American Association for the Advancement of Science, Philadelphia, December 27, 1940.

[2] P. S. Smith, "Certain Relations between North-western America and North-eastern Asia: Early Man," pp. 85–92. Ed. by G. G. McCurdy. Philadelphia, 1937.

time. No one can deny the possibility of travel in boats. There are several possible routes: (1) across Bering Straits; (2) across the sea from Kamchatka to the Aleutian Islands; (3) across the northern Pacific on the Japanese Current; (4) across the southern Pacific from Oceanica. It is obvious, however, that the longer boat journeys and even the narrow waters of Bering Strait could have been available only to people of a sufficiently advanced culture to have the requisite boats. Large numbers of primitives could only have reached the Americas by the ice route or during periods when there was a land connection in the area of Bering Strait. During glacial times the level of the sea was lowered (85 m. in the last stage, and 105 m. at the maximum), and at such times Bering Strait would have been largely dry land. In fact Smith[3] believes on the basis of existing surveys that a course could be laid out that would be dry land with a lowering of sea level of only 40 m.

Further, the central part of Alaska and a large part of the Mackenzie Basin were free of ice during the whole of the Pleistocene. An entrance into Alaska and residence there was possible at any time by people adapted to life in an Arctic and near-Arctic environment.

The passage southward is more difficult. The coast route along the chain of fjords and islands of southern Alaska and British Columbia is narrow at best and requires both a specialized fishing culture for survival and the use of boats for movement. The plains route east of the Rocky Mountains must have been blocked by ice during periods of glaciation. It was always and is, even yet, a harsh environment requiring for survival a specialized hunting technique.

These geographic relations imply that the peopling of America occurred largely if not exclusively by migration from northeastern Siberia across ice or land in the Bering Strait region to Alaska and thence south. Entrance into Alaska would have been easier during glacial stages when sea level was low. Movement southward would have been easy only after the climax of each glacial stage when the Canadian plains were free of ice. One could imagine successive pulsations by which people entered in glacial intervals and were trapped for a considerable time in Alaska and in the Mackenzie basin by the rising sea level of interglacial time. Thereafter they were permitted to filter south as the ice dam in the Plains disappeared about 10,000 years after the glacial maximum. In the absence of archeological data such an idea is intriguing, but perhaps fanciful. The crossing of the straits and the passage southward may both have occurred in the relatively genial climate of interglacial and interstadial times. Even in such periods Alaska would have had a climate not much warmer than at present. Whatever the original culture, the migrants must have adapted themselves to specialized hunting and fishing as a livelihood. The longer the period of migration the less the memory of any postulated homeland or of any previous method of livelihood. Only those traits of the original culture which could be easily used or retained by a hunting-fishing people in a cold environment would survive. On this line of reasoning the present cultural characteristics of the peoples of North and South America must be regarded as largely a new development. Even hunting cultures must have been much modified by movement into the warmer south and the change in economy with change in fauna. The possibility that the survivors of shipwrecked Chinese junks or wide-ranging Polynesian canoes may have brought in cultural ideas must be recognized. There is, however, little tangible basis for postulating these recruits to America. At best they must have been late comers without possibility of influence on the earlier phases of New World cultural development.

In the foregoing, the difficulties of the route have been emphasized. To the relatively advanced and well-organized tribes developed in Asia in the past 2,000 to 4,000 years, many of the difficulties would be small. In proportion to their cohesion and adaptability, such tribes may have made much more rapid progress than the earlier people.

Not only does the preponderance of evidence imply a single migration route into the New World, but it was essentially a one-way road. Those who crossed to Alaska could easily cross back as environmental differences are small. Those who once went southward into the broad spaces of the American continent changed their habits, and thus built an environmental wall behind them. Whether in time, the expansion of population in the south might have set up a counter pressure and might thus have forced a retracing of the route is an interesting speculation. It is, however, beside the point. The early comers found empty the expanses of two great continents, and for them there was no inducement to backtrack.

The route of entry and the type of culture necessary for the journey as outlined above have long been parts of the established doctrine of American anthropology. The date of entry has, however, been much disputed. The American Indian at the time of the Conquest was largely agricultural, acquainted with pottery and in some localities semi-civilized. Even the hunting and fishing tribes had a typical "Neolithic" stone industry.

As shown by many archeologic excavations, their immediate predecessors were like them in general aspect. Arguing from these facts most anthropologists have, up to a few years ago, held that the American Indian is a recent immigrant. From time to time finds were

[3] P. S. Smith, *op. cit.*, p. 89.

made to which a greater antiquity was attributed. Some were without merit; others in spite of merit were decried as merely the result of mistaken zeal.

The possibility of greater antiquity for the inhabitants of the New World was placed in a different light by the finding in 1927 near Folsom, New Mexico, of fluted points of a distinct type, indubitably associated with the bones of extinct bison. In the past thirteen years there has been much activity and many localities have been found at which artifacts and the bones of extinct animals are known.[4] Besides the fluted points other stone tools and various bone artifacts are now the recognized components of the Folsom culture.[5] Other stone cultures differing from the normal types of the American Indian have been described.[6] These obviously earlier cultures have been grouped under the name "Paleo-Indian" by Roberts.[7]

It is obvious that the question of the antiquity of man in the New World has been narrowed down. Whereas previous to 1927 the question rested on an almost entirely hypothetical basis, the accumulation of new data is now so great that there is a solid, if still meager, framework of fact. We are no longer asking the question: What is the antiquity of the American Indian, but What is the antiquity of the Paleo-Indian?

Furthermore, the advance of knowledge made in the Old World in the relation of human races and cultures to the chronology of the Pleistocene has provided a sound theoretical basis for the interpretation of our new-found facts. Many archeologists and geologists aided by a host of amateurs in both sciences are engaged in adding to our data and to our interpretations. The rate of progress is accelerating. All this material is valuable, but much of it is so newly acquired that it has not yet been evaluated. I shall, therefore, speak only of those localities and those cultures which seem at the moment to have the greatest value as guideposts on an inquiry into antiquity. Many of the data not mentioned may yet prove more important than they seem at present, as relative values change in a rapidly advancing subject.

LINES OF APPROACH

The question of antiquity may be attacked from several view-points, each in itself valuable. At the moment the several lines of approach, with the exception of the geological, are largely inconclusive. They are important on the negative but not on the positive. Each is here summarized briefly and all too inadequately.

Physical anthropology. The inhabitants of the New World are a blended mixture of races of *Homo sapiens* in which the Mongolian is prominent and in many tribes dominant. This blending implies either a long occupance of the New World by originally distinct races or a mixture in the Old World previous to migration or both.

All known skeletons are those of modern man or *Homo sapiens.* The lack of more primitive types such as the Neanderthal has often been used as an argument that man is a newcomer to these continents. However, new finds in England establish *Homo sapiens* as living in that country as early as the second interglacial.[8] Modern man has thus a very respectable antiquity. Neanderthaloid characters are unnecessary requirements for immigrants to North America if they are to arrive in the latter part of the Pleistocene.

The skeletal finds which have some claim to antiquity have a general likeness. All are long-headed and heavy-featured and thus resemble the Europeans of the time of the advance and recession[9] of the last ice. Similar physical types are not unknown among the modern Indians, but are most common in small tribes on the periphery of the two continents. These people may be the relatively unchanged descendants of the earliest migrants.

Thus the present data of physical anthropology can be interpreted to permit a Pleistocene antiquity of man in the New World, but these data lend no confirmatory proof.

Association with extinct animals. The earlier view that animals now extinct lived in the Pleistocene and that the presence of the modern fauna is proof of Recent or post-Pleistocene time was strongly supported by Hay[10] and others. These ideas have been largely abandoned. Most vertebrate paleontologists[11] concede that the now extinct vertebrates may have survived to within a very short time ago. Furthermore, it is at present impossible to assign any given extinct fauna to any one phase of the Late Pleistocene or Recent. The stratigraphic evidence is at the moment too imperfect, although hope burns bright for the future.

American cultivated plants and agriculture. The plants cultivated by the pre-Columbian inhabitants of the New World have a strictly new world origin.

[4] E. H. Sellards, *Geol. Soc. Amer. Bull.*, 51: 373–432, 1940.

[5] Frank H. H. Roberts, Jr., *Smithson. Misc. Coll.*, 94: 4, 1935, and 95: 10, 1936. Ann Rept. for 1938, Smithson. Inst., pp. 531–546.

[6] Helen Marie Wormington [Volk]. Colo. Mus. Nat. Hist., Popular Ser. No. 4, 1939 (discussion and references to original papers).

[7] Frank H. H. Roberts, Jr., *Smithson. Misc. Coll.*, 100 (Swanton vol.): 51–116, 1940.

[8] E. A. Hooton, "Why Men Behave Like Apes and Vice Versa," pp. 78–80, 1940. (Summary statement). Committee Report: *Jour. Roy. Arch. Inst.*, 67: 17–98, 1938. T. T. Paterson, *Proc. Prehist. Soc.*, pp. 166–169, 1940.

[9] E. A. Hooton, *op. cit.*, p. 134.

[10] O. P. Hay, Carnegie Inst. Wash. Publ. No. 322, 1923–27.

[11] A. S. Romer, 5th Pac. Sci. Congr. Canada, pp. 47–83, 1933.

Many of these plants, of which maize is the prime example, have been so modified by man that the wild progenitor has been eliminated. They have become "cultogens" dependent on man for survival. Furthermore, American agriculture in "hills" is quite different from the "broadcasting" of Euro-Asiatic agriculture. All botanical authorities on the American "cultogens" agree that a long time is necessary to select and develop the plants, and, as Ames insists, to invent and perfect the agricultural practices of the New World.[12] How long this period may have been can not be closely estimated by botanical methods. If the period of migration over the tundra of Siberia and Alaska was a long one, the immigrants may be supposed to have entered North America without knowledge of any southern flora. On this line of reasoning, their intimate knowledge of the New World flora and their successful breeding of agricultural plants was a wholly new development. It is a fair inference that the time required was as long as the time required to develop Old World agriculture. In both areas also a very long preliminary stage in which food gathering and the hunting of medicinal plants yielded an intimate knowledge of the flora must be inferred.

Archeology. The principle that types of stone tools, however simple and primitive, are characteristic of certain cultures and therefore that they are criteria of the time interval when these cultures flourished has been widely accepted. In France and England long study and much correlation with geologic events has proved that hand axes and the Levallois, Clactonian and Mousterian flake types are characteristic of the Pleistocene at various intervals from the first interglacial to the first part of the fourth glacial. Recent work has shown that in the Middle Pleistocene there was in Asia over a great triangle from the Indies to Java and north to Peking in China a characteristic chopping-tool industry.[13] This technique, different from that of Europe, influenced the forms developed in Asia in the fourth glacial stage.

Thus the typology of stone tools successfully established as a chronologic sequence in Europe is not applicable to the world as a whole. Also the absence of typically European implements in the New World is to be expected. It appears much more likely that the immigrants from Asia would have imported the stone techniques of eastern Asia. Our knowledge of these stone cultures does not extend into the area of northeastern Asia from which migrations must have started. Consequently at the present time there can be no true comparison between New and Old World stone cultures except on the broadest basis.

Typology can be used on the negative. As the use of pressure flaking either along with or in combination with percussion flaking did not come into use in Europe or as far as known in Asia until the latter part of the last glacial stage, this technique should not be much earlier in the New World. The New World cultures having the greatest claims to antiquity are in part of the pressure flaking type. For them there is a limit of antiquity. They should not be older than the later part of the last ice age. Even this reservation is, however, not absolute as the area of northeastern Siberia from which migration is presumed to have occurred is unexplored archeologically.

Geology. The geological method of determining antiquity is full of pitfalls and blind alleys. It is, at the moment, the only available method. In the future the other methods, heretofore reviewed, will be more valuable than at present, and will become supporting and additional aids. For complete success of the geologic method a detailed and comprehensive knowledge of the chronology of the Pleistocene such as we do not yet possess, is required. The presence of the relics of man in "geologic" deposits is, however, an enormous stimulus to research. The Europeans by the close integration of archeological and geological work have of late years acquired a knowledge of the Pleistocene truly amazing in its relative perfection. This stimulus, long denied, we now have, and an eager search for new facts, new criteria and new data in glaciated and unglaciated areas is in progress.

THE GEOLOGIC METHOD

The geologic method of attack on the antiquity of man may be carried to successful completion only under a combination of circumstances not always available. An archeological site must meet four requirements: (1) the relics of man or his culture must be associated with a definite bed or beds; (2) these beds must be related to some definite and local geologic event; (3) this event must be related to other events over a large area or must itself have wide geographic extent; (4) these events or these sequences of events must also be related to some geologic chronology.

A single implement or even a skeleton found under the best of auspices has only moderate value. It is too easy to challenge its provenance. The publicity-seeking exploiters of such finds meet their match in a group of professional challengers of great skill and ingenuity. The "site" valuable for geologic dating is one that produces archeological objects repeatedly. The association with a given bed or "horizon" is thus indubitable because subject to repeated proof. The

[12] Oakes Ames, "Economic Annuals and Human Cultures," Harvard Univ. Bot. Museum, 153 pp., 1939. E. D. Merrill, "Domesticated Plants in Relation to the Diffusion of Culture: Early Man," pp. 277–284. Ed. by G. G. McCurdy. Philadelphia, 1937.

[13] H. L. Movius, Jr., *Peabody Mus. Bull.* (in preparation).

repeated production of relics implies that the site has been excavated by an archeologist or several archeologists of skill and devotion.

From this "site," which is a restricted locality, the bed or "horizon" must be traced and related to a local geologic event such as the building of a valley floor, now perhaps a terrace, the existence of a lake, now drained or dried up, the movement of a glacier, long since dissipated. The local event, however interesting in itself, may give little clue to the date of the deposit. It may, however, furnish the basis for a qualitative judgment that there is a material degree of antiquity. Unless this local event can be related to other events and these in turn can be related to still other events over a wide area it is unlikely that a more definite answer to the question of antiquity can be given. The limitations of a purely local incident are best shown by the deposits of caves. There may exist an easily demonstrated sequence of events within the cave, but there is ordinarily little chance of a direct physical connection between any one of the deposits in the cave and the deposits produced by geologic processes outside the cave. Thus the cave sequence may be unique. If it is to be related to events in the world outside there must be a cross-dating by means of the cultural or the paleontological contents of one or more of the cave deposits. By whatever means the local sequence of events is extended, it is obvious that the greater the area the greater the opportunity for critical contact with established geologic chronologies.

Unfortunately also the history of the Pleistocene must be built up from many diverse lines of evidence and by unlike methods of work. In some localities there are marine and fresh-water beds so that the study is primarily stratigraphic and paleontological. In other localities the deposits of glaciers afford the evidence. The study of such deposits is by a combination of methods. In still other places all the events of the period are erosional and the study is exclusively geomorphic. To bring these several chronologies into order and into agreement with each other requires some unifying principle. Fortunately this principle exists in the climatic rhythm characteristic of the Pleistocene.

THE CLIMATIC RHYTHM OF THE PLEISTOCENE

One of the great triumphs of the science of geology is the detection and analysis of the relics of ancient glaciation. Furthermore, these ancient glaciers advanced more than once, and wherever adequate work has been done four glacial stages separated by time intervals marked by warm climate have been found. This four-fold subdivision of the glacial period is quite generally accepted for Europe and North America. Very active work in Europe in recent years has brought into prominence the view that the glacial stages are multiple and that each consists of at least two ice advances separated by intervals of ameliorated climate warmer than the present.[14]

This idea is best supported for the last or Wisconsin glacial period. It appears both in Europe and America to have been divided into at least three main substages of ice advance separated by two interstadial periods of climate warmer than the present but not so warm as the interglacial stages.

Unfortunately, there is no absolute proof that glaciation was synchronous over the earth. The synchroneity is at best a doctrine supported by: (1) the similarity in the number and apparent length of the glacial stages and the interglacial stages between them; (2) the general similarity in the amount of weathering and erosion suffered by glacial deposits of corresponding age; (3) the similarity throughout the interval of the changes in the animals and in man. These arguments when set down seem weak indeed. On the other hand, there is no valid argument to the contrary. Furthermore, for the last or Wisconsin period the parallelism of events appears to be so close that a common cause operating simultaneously appears to be the only reasonable explanation.

Many of these objections to synchroneity would seem less formidable if the cause of the glacial periods were known. On this question there is no agreement, and it may well be that the glacial period is polygenetic in origin. But even if origin by the cooperation of diverse causes is granted, it is also true that the mere existence of great ice sheets would induce world-wide changes in climate.[15] It is therefore possible to assume that, at the time of ice advance, there were general changes in climate, even if we are ignorant of the fundamental causes behind the initial formation of the ice sheets.

There have been many studies of the phenomena of the glacial period in areas outside of those directly affected by the ice. The concurrent eustatic fluctuations of the sea, the phenomena of intensive frost action, sand dunes and loess deposition in periglacial areas, the rise of lake levels, the terraces on rivers and the changes in flora and fauna—all phenomena connected with the inferred general changes in climate of the ice age have received attention. In these phenomena and in the possibility of building a chain of argument from an artifact-bearing horizon through them to the climatic rhythm rests the hope of a geologic date.

If these phenomena had been more intensively studied, if local chronologies had already been built up, the task would be easier. Unfortunately it is

[14] F. E. Zeuner, *Geol. Mag.*, 72: 350–376, 1935. Wolfgang Soergel, *Fortschr. Geol. und Pal.*, Vol. 13, 251 pp. 1925. Die Vereisungskurve, Gebrüder Borntraeger, Berlin.

[15] C. E. P. Brooks, "Climate through the Ages," 436 pp. 1926.

necessary to discover and to test each of these types of evidence. Each must be placed in the climatic rhythm, before it is valuable for the purpose. Here the stimulus of archeologic importance blows as a fresh breeze impelling workers to an intensity of effort heretofore lacking.

THE DATING OF ANCIENT CULTURES

In the foregoing the requisite anthropological and geological theory has been reviewed. The practical task of reaching a conclusion as to the date of an ancient culture rests on the assumption that these theories are sound. Recapitulated they are: (1) Man entered the New World by way of Bering Strait and had the cultural characteristics thereby engendered. (2) During times of glacial advance, sea level was lowered and entrance into Alaska easier, but the route southward was blocked by ice. (3) During interglacial or interstadial times it was harder to reach Alaska but easier to advance into the more genial heart of the Continent. (4) Glaciation was synchronous over the world. (5) The rhythmic fluctuations of the glacial ice are related to or themselves produced concurrent climatic changes which affected the level of enclosed lakes, the régime of streams and left other identifiable traces. (6) There were also concurrent changes in vegetation and in animal life which affected the distribution and economy of mankind and thereby his culture.

Consciously or unconsciously, investigation of and, more particularly, the dating of early man rests on the assumption that these theories or doctrines are true. The investigations test and retest these theories. There is thus a constant and accelerating advance by which hypothesis becomes theory, and theory becomes doctrine.

THE ANTIQUITY OF THE FOLSOM CULTURE[16]

The long-continued excavation of the Lindenmeier site in Colorado has afforded a suite of artifacts from which the Folsom culture can be defined.[17] Here the characteristic fluted points and many other types of implements are found in a dark bed overlying eroded white tuff. The bed forms the floor of an old and almost abandoned valley preserved by reason of a remarkable series of stream captures. From time to time it has formed part of one or another tributary of Cache le Poudre River some 30 miles away. Local details demonstrate that the artifact-bearing old valley floor is the equivalent of the 30-foot or Kersey terrace on the main river.

Thus the Lindenmeier site fulfils the requirements of datability. There is a large artifact-bearing horizon which is related to a local event, the existence of this old valley floor. The old valley is of the same age as the Kersey terrace, an abandoned grade not only of the Cache le Poudre but of the South Platte drainage. Associated with the Kersey terrace on the South Platte near Kersey and at Dent are Folsom sites. These sites in themselves are not important and the facts concerning them not completely recorded. Their existence, however, confirms the geomorphic correlation between the valley floor at Lindenmeier and the Kersey terrace.

The Cache le Poudre and South Platte Rivers rise in the Southern Rocky mountains where even yet small glaciers exist. These mountains had much larger glaciers in the past. The Kersey terrace has been traced up the Cache le Poudre to the Corral Creek moraine. It is the outwash plain of this glacial substage. Thus by a geologic linkage the Folsom culture is of glacial age, but to which substage in the general chronology does it belong?

The Wisconsin ice advanced three times in the Southern Rocky Mountains.[18] Each advance left a moraine in the canyon floors and each was followed by a complete withdrawal of the ice before a new advance ensued. Three sets of moraines were built, the Twin Lakes, Home and Corral Creek. There was also a fourth readvance or slight pause in retreat, the Long Draw, and a later period of refrigeration, the Sprague. These newly won data on glaciation in these mountains can be correlated with Wisconsin events in continental United States and in Europe as shown in Table I:

[16] Based on Kirk Bryan and Louis L. Ray, *Smithson. Misc. Coll.*, 99: 2, 76 pp., 1940.

[17] Frank H. H. Roberts, Jr., *Smithson. Misc. Coll.*, 94: 4, 1935; 95: 10, 1936. Ann. Rpt. for 1938, Smithson. Inst., pp. 531–546, 1939.

[18] Louis L. Ray, *Geol. Soc. Amer. Bull.*, 51: 1851–1918, 1940.

TABLE I

CORRELATION AND DATING OF THE FOLSOM CULTURE

Short Designation	Terraces	Southern Rocky Mountains	North American Continental Substages	European Continental Substages	Date in Years
	Absent	Sprague (Protalus Rampart)	?	?	
W4	Kuner	Long Draw	Cochrane?	Fennoscandian	10,000 ±
W3	Kersey	Corral Creek	Mankato	Pomeranian	25,000 ±
W2	Pleasant Valley	Home	Tazewell-Cary	Weichsel	?
W1	Pleasant Valley	Twin Lakes	Iowan	Wärthe	?

There is no physical connection between the glacial deposits of the Southern Rockies and the deposits of the continental glaciers of the Middle West. It would be possible to trace the glacial deposits of the Northern Rockies directly into the deposits of the continental glaciers, but this task is as yet incompletely done. Even if it were accomplished there would still be a gap across the Wyoming basin between the Southern and Northern Rockies. A correlation must therefore be made by a mental leap of more than a thousand miles. It rests on a general argument that the number of stages is the same and that the general state of weathering of the deposits of each of the stages is comparable. Weak as such an argument may be, it is the best that we can do in the absence of confirmation by paleontological or archeological cross-dating.

With this correlation it is possible to make a similar leap over 3,000 miles of ocean to Europe and correlate with the European chronology. The correlation of the Mankato with the Pomeranian stage has long been made, and detailed consideration has been given by Antevs[19] to the accordance in geochronological dating. Armed with his data we can say with some assurance that the Pomeranian ice advance and therefore that of the Mankato and the Corral Creek stages occurred about 25,000 years before our time.

The culture layer at Lindenmeier presumably represents the time just after the maximum, as it corresponds to the top of the Kersey terrace. Thus the date of the Folsom culture is just after 25,000 ± years ago. The data present no limitation as to time of the beginning or the end of this culture, except that Roberts[20] reports the finding of two Yuma or Yuma-like points in the rubble above the main Folsom horizon at Lindenmeier. As this rubble appears to have been deposited after the floor of the Lindenmeier Valley became dry, it is later than the climax of the Corral Creek stage. How much later there is no means of determining.

Antiquity of the Sandia Culture

To the enterprise and skill of Dr. Frank C. Hibben we owe the discovery of the Sandia Cave.[21] Here there is complete and incontrovertible evidence of a pre-Folsom culture.

The cave consists of a tunnel-like opening on the east wall of Las Huertas Canyon in the Sandia Mountains about 35 miles northeast of Albuquerque. The cave is 2 to 3 meters in diameter and extends 135 meters into the mountain where it closes in. The cave is now dry and dusty for the first 100 meters; further in it is still dry, but the dust is damp enough to lie on the floor; at the end it is damp. The upper deposits consist of a layer of dust and guano containing Pueblo refuse, including potsherds dating from the period 1400 to 1600 A.D. Below this dusty layer is a stalagmite floor ½ to 6 inches thick overlying and sealing in, without possibility of contamination, the lower beds. These consist of (1) an Upper Breccia, containing Folsom artifacts; (2) a sterile layer of yellow ochre; (3) a Lower Breccia, containing the new Sandia culture; (4) a sterile gray clay. The breccias consist of fragments of limestone, chert, yellow ochre, fossil bone and artifacts cemented by calcium carbonate. The larger part of the material is camp refuse which has moved down the sloping floor. That there was once an outer chamber which has now disappeared seems obvious, as in the Upper Breccia there are no hearths and only a few in the Lower Breccia. There is so much refuse that a long occupation must be inferred and many hearths should occur unless their absence by reason of a disappearance of the entrance chamber be inferred.

The sterile gray clay at the base is an ordinary cave earth reflecting faintly moist conditions.

The Lower Breccia containing the Sandia culture shows increasing cementation from bottom to top. Thus an increasing drip of water from the roof must be inferred. Not only was calcium carbonate deposited, but also limonite (yellow ochre) which, however, was largely broken up and incorporated in the breccia as fragments. The layer of ochre is sterile, and it must be assumed that the entrance was closed or that the cave was so wet that not even animals could use it. Increased wetness seems a necessary postulate, as in no other way may the nearly complete absence of calcium carbonate be explained. There must have been so much water that the lime was carried to areas below the level of the cave. The Upper Breccia containing the Folsom culture is cemented by crystalline calcium carbonate demonstrating a strong drip from the roof which continued into the period of the stalagmite layer. At the time of the formation of the stalagmite layer the entrance must have been closed, as this layer is sterile. It may be that at this time the entrance chamber was sheared off by a rock fall. The drip from the roof gradually ceased, never to be renewed.

The pre-Pueblo deposits of this cave may thus be attributed to a single episode by which the cave became wetter to a climax at the time of the yellow ochre and the wetness ended with the stalagmite layer. In order that the cave should be wet, one must suppose a greater precipitation on the ridge in which the cave lies. Also there must have been a vegetative change from the present pinyon-juniper woodland to a forest of pine or spruce. The lower pine boundary is now about

[19] E. Antevs, Canada Geol. Survey, Mem. 18, 1931.
[20] Frank H. H. Roberts, Jr., personal communication.
[21] Frank C. Hibben, *Amer. Antiquity*, 2: 4, 260–263, 1937. And *Smithson. Misc. Coll.* (in press).

8,300 feet or 1,000 feet above the ridge. Such a lowering of the forest zones may be compared with the Wisconsin lowering of the snow-line estimated for the Southern Rockies at 2,000 feet by Klute.[22]

The Sandia cave deposits thus belong to a wet and presumably also a cold episode comparable in its intensity to the climatic fluctuations of the Wisconsin. To which of these fluctuations toward the wet and cold does it belong? If we accept the results of the Lindenmeier investigation, the Folsom culture flourished just after the climax of the Corral Creek or Wisconsin 3 glaciation. As Folsom points occur in the Upper Breccia and the Upper Breccia follows the climax of wetness in the cave, this climax should also be Wisconsin 3. The Lower Breccia and its contained Sandia culture would therefore be assigned to this period of glaciation also, but in a position earlier than the climax or more than 25,000 years ago.

As occupation of the cave by the people of the Sandia culture and the deposition of the Lower Breccia began together, it appears that the cave had been previously uninhabited. Thus there is no available geologic information on the date of arrival of the people who carried the Sandia culture into New Mexico or into the continent, except that the date must have been earlier than the cold-wet episode of W3. Also there is no information as to when the Sandia people ceased to occupy the area. So far as the evidence of the cave permits, at some time about the climax of Wisconsin 3, the Sandia culture was succeeded by the Folsom culture. Whether this change was induced by the incoming of new people or by cultural evolution remains in the realm of anthropological speculation. Furthermore, the cave deposits give no data as to time when the Folsom culture died out, and was succeeded by later cultures.

Times of Migration into the Continent

The proved existence of a pre-Folsom culture and the inference here set forth that this culture flourished before the climax of the last ice (Wisconsin 3) raises anew the question of the time of entrance of man into the continent. The antiquity of many finds has been challenged on the ground that entrance into the continent must have occurred after a partial withdrawal of the last ice. This theory has been elaborated by Antevs[23] from its earlier form set forth by Johnston.[24] As the Canadian great plains were covered by ice in part derived from the Cordillera on the west and in part from the Kewatin region to the east, passage down the plains was barred until the time when the ice withdrew, forming a corridor. This time is estimated by Antevs as about 10,000 years after the climax of the last ice (W3) or 15,000 years ago. It is contended that entrance by man must be later than 15,000 years ago or else it was "pre-Wisconsin." However, this theory ignores the three-fold character of the Wisconsin. The three substages were separated by interstadial periods as mild in climate as the present. The corridor should therefore have been open twice within the Wisconsin.

The existence of the pre-Mankato, W2/W3, interstadial is attested by the Two Creeks Forest bed[25] of the State of Wisconsin which underlies the Mankato till and overlies the till of the next older stage. This bed contains the remains of a forest like that of the present in Manitoba. With such a mild climate in Wisconsin one must assume that little or no ice remained in Labrador.

The idea that a long interval intervened between the Iowan, W1, and the next younger stage, the Tazewell-Cary, W2, has long been held. The evidence of a mild climate in this interval is not so definite. Near Lisbon, Iowa, where the "Peorian" loess is thick its basal portion is unleached and calcareous and rests on calcareous Iowan till. There is no weathering of the till.[26] On these facts and on evidence that the "Peorian loess" in Illinois contains larch twigs and moss, it is obvious that the loess is essentially glacial and was mostly deposited in the early stages of retreat. In the famous Farm Creek section near Peoria, Illinois, the unweathered "Peorian" loess underlies the Tazewell (Shelbyville) till.[27] Near the west end of the section, however, there is preserved a humus-bearing soil of very infantile development, elsewhere cut off by the overriding Tazewell ice.[28] West of Mackinaw, Illinois, the loess also has an infant soil development and is overlain by the Tazewell till.

These data indicate that some amelioration of climate occurred in the Iowan-Tazewell interval, but it is as yet necessary to rely on Europe for evidence that a complete retreat of the ice and a mild climate characterized the interstadial interval W1/W2.

If, then, we accept the threefold division of the Wisconsin and the existence of two interstadial periods of mild climate, there are two opportunities for the formation of the corridor on the Canadian Plains within the Wisconsin period. In order to explain the pres-

[22] F. Klute, *Zeitschr. f. Gletscherkde,* 16: 70–93, 1928.
[23] E. Antevs, *Geog. Rev.,* 25: 302–309, 1935.
[24] W. H. Johnston, "Quaternary Geology of North America in Relation to the Migration of Man: The American Aborigines." Ed. by D. Jenness, pp. 9–45, 1933.
[25] L. R. Wilson, *Wisc. Acad. Sci. Trans.,* 27: 31–46, 1932.
[26] W. C. Alden and M. M. Leighton, *Iowa Geol. Survey,* 26: 156–157, 1915.
[27] M. M. Leighton, *Jour. Geol.,* 34: 167–174, 1926.
[28] M. M. Leighton, "The Peorian Loess and the Classification of the Glacial Drift Sheets of the Mississippi Valley," *Jour. Geol.,* 39: 48–50.

ence of Sandia man before the climax of W3, it is only necessary to assume that he entered the continent in the interstadial W2/W3 or at the time of the Two Creeks forest bed.

The implication that man entered the interval in W2/W3 or previous to the Mankato ice has an immediate bearing on the much disputed Minnesota "Girl."[29] This skeleton found in the varved silts of Glacial Lake Pelican was accompanied by a bone knife and two shell ornaments, one of which is a Gulf Coast species. Thus the cultural objects imply trade relations with the Gulf of Mexico and therefore a considerable time of cultural development previous to the date of the skeleton. On this account there has been much anthropological objection to the date assigned the skeleton on geologic grounds. Lake Pelican existed when the ice was forming the Big Stone moraine or after the climax of the Mankato, W1, at a time estimated at 5,000 years after the climax or 20,000 years ago.[30] It is obvious that if man entered the continent in pre-Mankato time there was opportunity for a very considerable cultural development before the date of the Minnesota skeleton. The anthropological objections to this find are thus no real barriers. Only the questions raised by the absence of trained observers at the time of the discovery remain.

The Berclair Terrace of Bee County, Texas

One of the most important new finds lies in the Coastal Plain of Texas in terrace deposits on tributaries of Mission River in Bee County, Texas, as reported by Sellards.[31] Twenty-five species of fossil vertebrates have been collected at fourteen localities. One site in the Buckner ranch has been excavated. Here deposits of the Berclair terrace rest disconformably in fossiliferous Pliocene beds. The terrace consists of a basal part (sand and gravel) with fossil vertebrates and artifacts, a middle horizon (silt) which is sterile, and an upper part containing a different type of artifact. The artifacts of the basal part are a strange assemblance of Folsomoid, Yuma, and side-notched triangular points. The upper horizon contains more familiar types like those in the base of the Morkiss mound or the lower archeological horizons of Central Texas. These artifacts are scattered in the upper horizon, which was presumably flood-disturbed, and they are thus younger than the main body of the terrace.

Both the base and top of the Berclair terrace have a lower slope than the present stream grade, and about ten miles from the sea join with and merge with the Beaumont plain, which has an elevation of seventy or eighty feet above sea level. This plain is underlain by the Lower Beaumont clays. The vertebrate fauna also indicates that the Berclair terrace is the age equivalent of the Lower Beaumont or at least its upper portion. The vertebrate fauna is also similar to the bone-bearing layer or No. 2 horizon of the famous Vero and Melbourne localities of Florida. The human culture of the lower horizon is thus definitely tied to the stratigraphic sequence of the Gulf Coastal Plain. Unfortunately it is as yet impossible to relate the Pleistocene beds of this region to the climatic rhythm of the Pleistocene with any assurance. In the Texas portion of the Coastal Plain there have been diastrophic movements, so that the Beaumont is known to be deformed. In Florida, however, there has been little diastrophic movement, and it seems likely that the Melbourne formation is related to a sea level higher than the present. Thus it might be related to either the higher sea level of the interstadial W2/W3 or more probably to that of the period of greatest melting or post-Glacial optimum about 5,000 years ago.

It is distressing that no more definite correlation can be attempted at present. If however, the latest form found is considered as setting the date of a deposit, the side-notched forms of the basal bed would fit best into a late post-Glacial horizon. More complete geologic and archeological knowledge is obviously necessary.

The Alluvial Chronology

In the Southwest the floodplains of the minor streams are underlain by alluvium of several ages. Repeatedly these streams have incised their channels and thereafter built up their floodplains as summarized in Table II. These alternations of régime appear to be climatic and presumably synchronous over the region. Synchroneity has, however, been established only for the period of alluviation which falls in the interval 1400 to 1885 A.D. or later. The next previous period of erosion is more or less well dated in the interval 1100 or better 1250 to 1400 A.D. The problems both geologic and anthropological involved in this chronology have been recently described.[32] It is pertinent here to consider some of the difficulties of correlation.

There appear to be three episodes of alluviation and three episodes of erosion. The dates of the second and third period of erosion and of the third period of alluviation are well established in some localities. Further data are needed, but the methods are known and these data will be easily acquired with the progress of archeological work in the area.

[29] A. E. Jenks, "Pleistocene Man in Minnesota, a Fossil *Homosapiens*," 197 pp. Qto. Univ. Minn. Press, 1936.

[30] Antevs and Leverett in Jenks, *op. cit.*

[31] E. H. Sellards, *Geol. Soc. Amer. Bull.*, 51: 1627–1658, 1940.

[32] Kirk Bryan, "Pre-Columbian Agriculture as Conditioned by Periods of Alluviation in the Southwest," 8th Amer. Sci. Congr. Proc. (in press).

TABLE II

ALTERNATE EROSION AND ALLUVIATION IN SOUTHWESTERN VALLEYS

	Erosion	Various dates after 1885 A.D. Established on historical evidence.
3.	Alluviation	Contains artifacts and potsherds indicating deposition from about 1400 to 1885 A.D.
	Erosion	In places dated by archeological means in the interval 1100–1400 A.D., probably 1250 A.D. and later.
2.	Alluviation	In places contains human cultures, may eventually be divisible into two or more periods of alluviation.
	Erosion	Large gullies formed with evidence of strong wind action.
1.	Alluviation	Usually contains extinct animals; artifacts generally absent, except the Abilene-Gibson culture of the Durst silt.

The second period of alluviation presents many problems. In places in New Mexico and Arizona it appears to be of early Puebloan date. In Texas it corresponds in time to part of the Clear Fork culture. These and related archeological stages are not yet harmonized, and it is possible that this second period of alluviation is actually a complex that will prove to be divisible into two or more stages.

The first period of alluviation is even more synthetic. The older beds which usually are slightly cemented and contain extinct animals have been put in this category. The fossils are so meager in number that they afford no critical evidence as to age. Only near Abilene is this older body of alluvium artifact-bearing. Here the Durst silt contains *Elephas,* Abilene and Gibson points.[33] These cultural objects are generally thought to have considerable antiquity, but until a definite tie with the Folsom culture can be made, the alluvial sequence hangs in the air. Even if a tie were made in Texas, the other alluvial beds which have been correlated with the Durst, but have so far proved sterile, may not be the exact equivalent.

The alluvial chronology even in its imperfect present state is an advance in knowledge. It seems likely that it may eventually be integrated with the sequence of dune deposits. Hack[34] has correlated the main body of dunes in the Hopi Country with the first period of erosion. Huffington and Albritton[35] have suggested that the three periods of dune formation in the southern High Plains correspond to the three periods of erosion of this sequence. When and if the alluvial and dune sequences can be tied to the general climatic rhythm, a powerful tool in chronology will have been forged.

CONCLUSION

The problem of the antiquity of man in America has lost its heretofore hypothetical character. It has become a series of detailed problems involving the antiquity of several Paleo-Indian cultures. These cultures, when better known, can be tied to each other archeologically. Also each site studied by geologic methods contributes to a general geologic chronology in step with the rhythm of climatic fluctuations.

OBITUARY

WILLIAM WEBBER FORD

1871–1941

WILLIAM WEBBER FORD, professor emeritus of bacteriology in the Johns Hopkins University, died of cancer at the Johns Hopkins Hospital on February 10, 1941, following a short illness. He was born December 15, 1871, in Norwalk, Ohio, the son of Dr. James Ford and Cornelia Cook Ford. Upon completion of his preparatory education he entered Western Reserve University, from which he received the A.B. degree in 1893. Possessed of an inquiring mind and influenced by his close association with his father it was quite natural that he should then take the obvious next step and enter upon the study of medicine. This he did by matriculation in the Johns Hopkins Medical School, from which he received the M.D. degree in 1898. The next year, 1898–1899, he served as resident house officer in the Johns Hopkins Hospital.

During his medical course Ford came directly under the influence of Dr. William H. Welch, who at that time was teaching pathology and bacteriology in the Medical School. As a consequence of this contact, though also influenced by his association with Kelly, Halstead and Osler—the Big Four of the early days of Hopkins—Ford's natural interest in scientific medicine and research received an impetus which resulted in his election of a career in teaching and investigation rather than in the clinical field. During the years 1899–1901 Ford served as a fellow in pathology at McGill University, and from that institution he received the D.P.H. in 1900. Subsequently, he was appointed a fellow in the Rockefeller Institute for Medical Research, 1901–1903, studying at the Institute for Infectious Diseases in Berlin, 1901–1902, and at the Johns Hopkins University, 1902–1903. In the years immediately following he successively served as instructor in bacteriology, 1903–5; associate, 1905–6; and associate professor, 1906–10, in Welch's depart-

[33] Cyrus N. Ray, *Tex. Arch. Pal. Soc. Bull.,* 12: 223–237, 1940, and papers referred to.

[34] John T. Hack, *Mus. of North. Ariz. Museum Notes,* Vol. II, pp. 67–73, 1939. *Geogr. Rev.,* Vol. 31, pp. 240–263, 1941.

[35] Roy Huffington and C. C. Albritton, *Am. Jour. Sci.* (in press).