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Paleohunters in America: Origins and Diffusion

The Paleo-Indian culture, whose technology stems from Pleistocene Eurasia, resulted from topographic isolation.

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The existence of the Paleo-Indian "lithic complex" has been an accepted fact in American archeology (*1*) for a little more than three decades. But this complex still lacks a well-established definition. Here I shall consider any archeological inventory dated into the Pleistocene and connected with hunting evidence as belonging to this Paleo-Indian complex, although I shall also use the term "Paleo-Indian" to refer to similar industries from the Holocene. Nowhere are there strict typological boundaries corresponding to successive archeological stages. If we keep to this general usage we may put any Pleistocene archeological site in America and even a good part of those from the Lower Holocene into the Paleo-Indian complex. "Paleo-Indian" thus becomes a synonym for the Old World "Paleolithic" and could be used instead of it, although in the Old World, too, the upper boundaries are generally obscure.

The Paleo-Indian complex—or American Paleolithic, as it could also be called—divides into two distinct technical traditions: one in which stone projectile points were used and one in which they were not. The tools of this second tradition consist largely of crude stone implements, with only a few better-worked tools. The origins of the two traditions are very different, and I shall discuss only the first here. The makers of the projectile points were probably already highly specialized hunters of the plains and possessors of a very uniform culture. With their atlatls (thrown javelins) they speared not only huge game such as prairie elephants (Stepenelefanten) or "mammoths," probably mastodons (*2*), bison, and the big ground sloths, but also smaller animals such as camels, tapirs, horses, and hares. Also, like all hunters, they collected many kinds of plants and fruits.

The origins of the American Paleo-Indian projectile-point complexes have remained an unsolved problem. The main reason for this has been the lack of any reliable documentation of the presence of similar industries in America before some 13,000 years ago (*3*). Again and again some kind of connection with the archeological sequence of the Old World has been postulated (*4*), but attempts to establish such a connection have proved to be insufficient. The materials—mainly from Siberia—considered as possible bases of a connection either were typologically too different or were only slightly older, contemporary with, or sometimes even younger than the American complexes. How far this question still is from being solved is shown by the suggestion of some authors that there may have been a connection between the Paleo-Indian stages and the Solutrean of Western Europe as a result of ice drift and the passage of small boats over the Atlantic (*5*). The only possible conclusive solution to this problem would entail a complete revision of the relevant archeological facts from the Old World. Technical and typological aspects would be as important in such a revision as ecological and chronological ones. It will be best to begin such a task by determining the stratigraphic sequence as comprehensively as possible.

The Geological Background

Pleistocene archeology is no longer restricted to typology and technology but is deeply involved in all fields of paleobiology. Geological stratigraphic evidence and ecological facts help in the interpretation of the archeological remains and sequences, for older cultural events are understandable only against and as part of their natural surroundings. So we first must have a general impression of the part of the geological past to which our materials belong; that is, of the Upper Pleistocene, which for easier and clearer use in all languages could be called "Neopleistocene." Here we may restrict our interest to the Northern Hemisphere (Fig. 1). At the beginning of the Neopleistocene there occurred a warm stage which is usually called an interglacial but could as well be named a thermal to give to it its own definitive and "positive" meaning. This thermal is known in Europe as Eemian (*6*), which in general terms is equivalent to the American Sangamon (*7*). Paleobotanical evidence shows its climatic evolution very well. The average temperature in the warmest phase was somewhat higher than in the Holocene hypsithermal, during which the postglacial optimum occurred. The age of this thermal,

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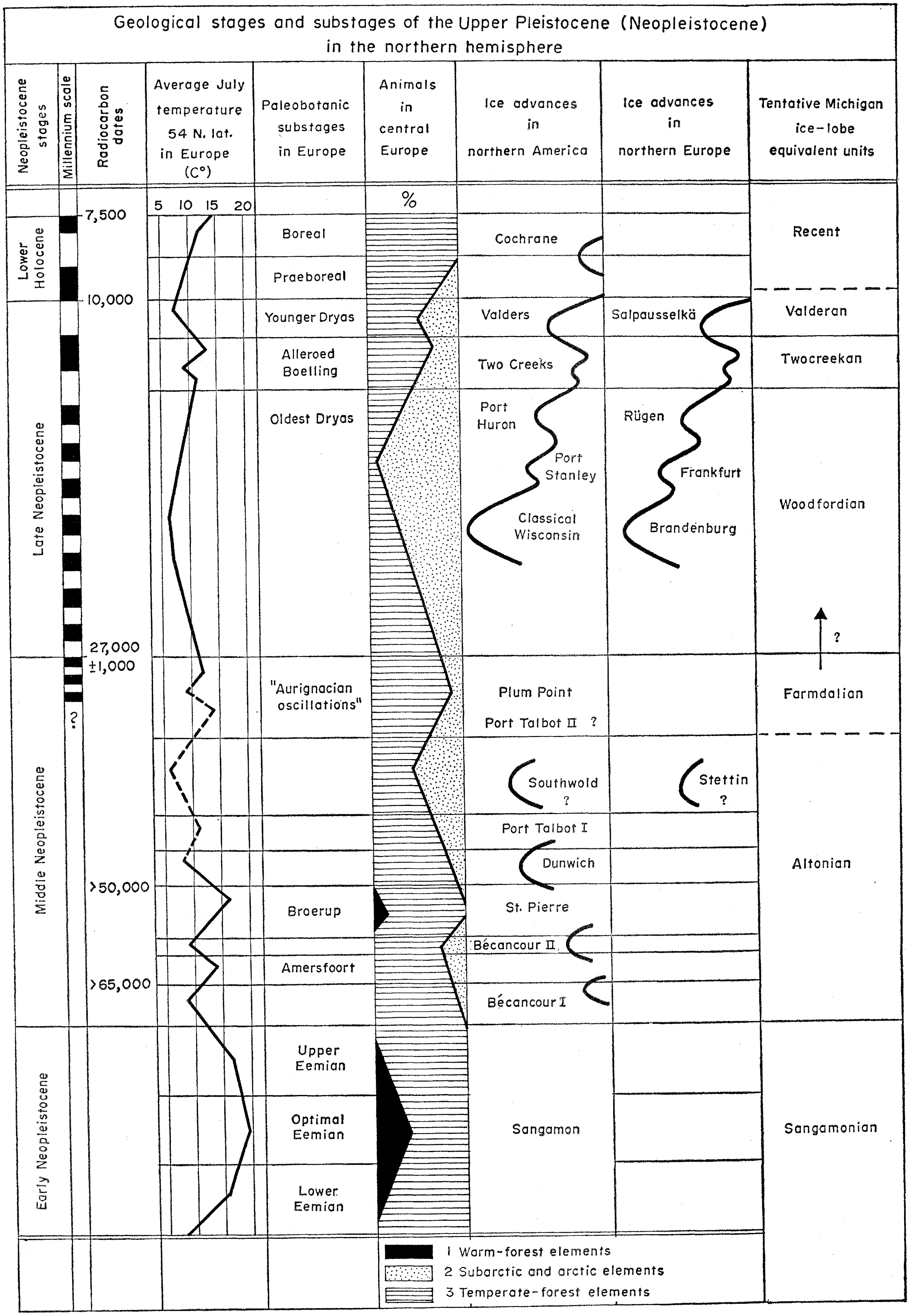

Geological stages and substages of the Upper Pleistocene (Neopleistocene) in the northern hemisphere
Neopleistocene stages
Millennium scale
Radiocarbon dates
Average July temperature 54 N. lat. in Europe (C°)
Paleobotanic substages in Europe
Animals in central Europe
Ice advances in northern America
Ice advances in northern Europe
Tentative Michigan ice-lobe equivalent units
5 10 15 20
%
Lower Holocene
Late Neopleistocene
Middle Neopleistocene
Early Neopleistocene
7,500
10,000
27,000 ±1,000
>50,000
>65,000
Boreal
Praeboreal
Younger Dryas
Alleroed Boelling
Oldest Dryas
"Aurignacian oscillations"
Broerup
Amersfoort
Upper Eemian
Optimal Eemian
Lower Eemian
Cochrane
Valders
Two Creeks
Port Huron
Port Stanley
Classical Wisconsin
Plum Point
Port Talbot II ?
Southwold ?
Port Talbot I
Dunwich
St. Pierre
Bécancour II
Bécancour I
Sangamon
Salpausselkä
Rügen
Frankfurt
Brandenburg
Stettin ?
Recent
Valderan
Twocreekan
Woodfordian
?
Farmdalian
Altonian
Sangamonian
1 Warm-forest elements
2 Subarctic and arctic elements
3 Temperate-forest elements

Fig. 1 (left). Geological stages and substages of the Upper Pleistocene (Neopleistocene) in the Northern Hemisphere. The time scale is reconstructed in proportional segments, one for every millennium, until 33,000 years ago. Earlier fixed dates are not yet available (*8, 9*). The average July temperature, based on different sources (*8, 10, 11*), is given as a histogram because not enough fixed points are known to make possible the construction of a real curve. The plotted ice advances (*8, 12*) show relative sizes only.

which geologically would be identical with the Early Upper Pleistocene (*8*), is unknown. It had definitely ended about 65,000 years ago and possibly earlier (*9*), and may have lasted 30,000 or 50,000 years.

The Middle Neopleistocene began with a cold but probably rather short substage, which was interrupted by a short warm interval known in Europe as Amersfoort (*10*). After this twofold cold substage the average temperature increased for some time during the Broerup oscillations (*11*), which seem to have been identical with the St. Pierre interval in North America (*12*). The Amersfoort oscillation started some time before 65,000 years ago (*9*); the Broerup, before 50,000 years ago (*11*).

After the relatively long-lasting Broerup oscillations, which could be regarded as an independent minor thermal, the temperature decreased again and, after a minor interruption known as the "main" Port Talbot interval, which must have occurred more than 45,000 years ago (*8, 12*), it reached a minimum. This decrease may correspond to the Southwold ice advance in North America (*12*) and very probably to the Stettin ice drift in northern Europe (*8*).

The end of the Middle Neopleistocene is formed by a group of warmer oscillations, which are identical with the "Aurignac interval" of J. Bayer (*13*) and which were closed by the Paudorf substage (*8*). The sequence of these oscillations, which were more or less contemporary with the Plumpoint and Farmdale intervals in North America (*12*), is not yet certain. This warmer period ended, according to the evidence of a great number of radiocarbon dates from Europe as well as from America, about 27,000 ± 1000 years ago (*8*).

After the opening of the Late Upper Pleistocene a new cold substage followed in which the temperature again reached a minimum, about 20,000 years ago (*12*). This minimum is contemporary with the ice advances of the classical Wisconsin in America (*12*), the outermost ice lobes of the Weichselian in northern Europe (Fig. 1), and the Würmian in the Alps (*8*). Shortly afterward the temperature increased again until the smaller Boelling and larger Alleroed intervals, between 12,500 and 11,000 years ago (*8, 14*). These two intervals were, in general, contemporary with the Two Creeks substage in North America (*12*). Colder conditions returned in the Valders-Salpausselkä period which lasted until 10,000 years ago (Fig. 1) and closed the last stage of the Pleistocene (*15*). But in the beginning of the Holocene the climate remained relatively cool, as the European Praeboreal (*16*) and the Cochrane readvances in America (*12*) show. Thus the temperature during the Upper Pleistocene went from one main maximum through a number of oscillations toward a main minimum and then started to rise again. Between the thermal maxi-

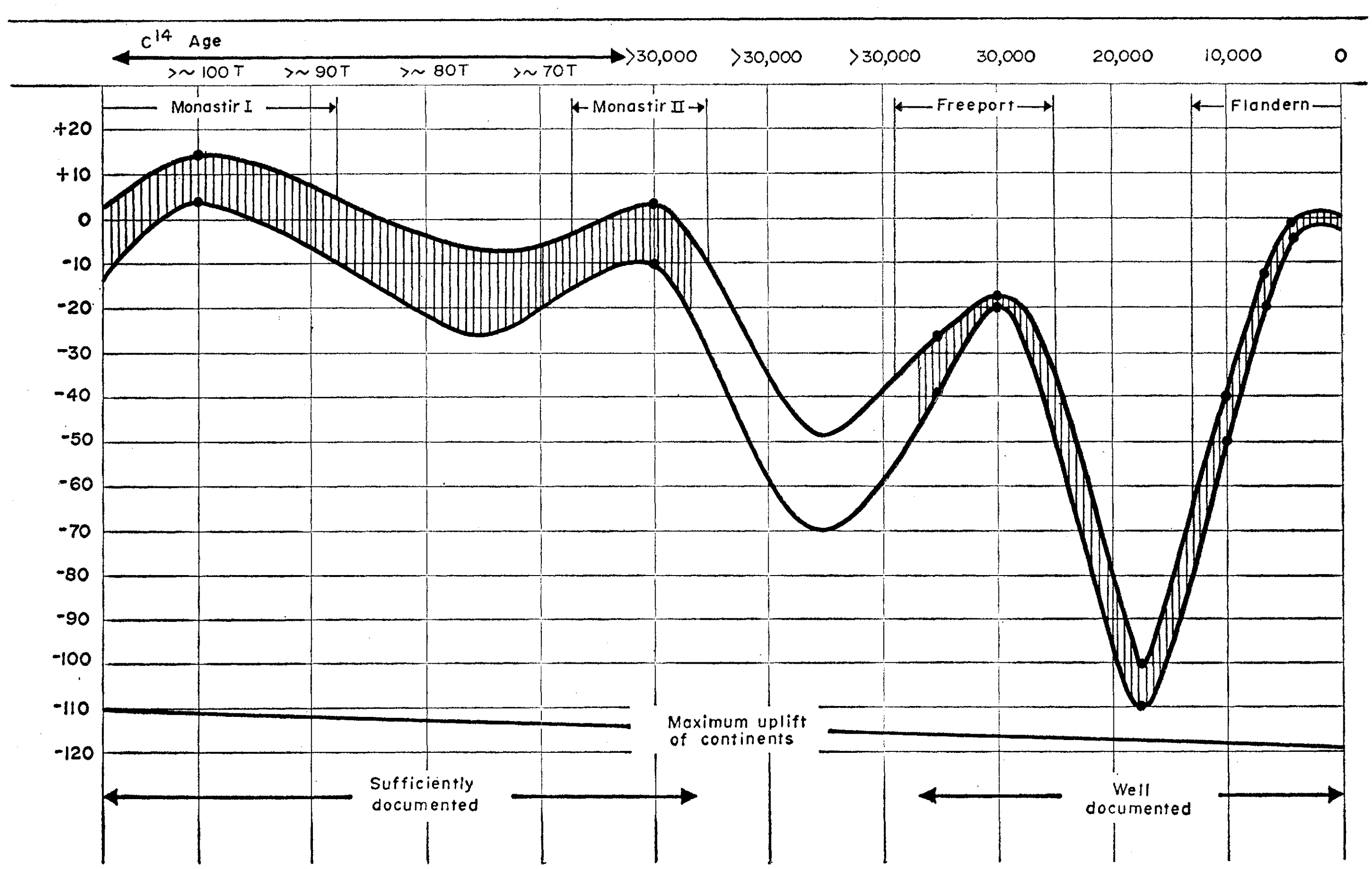


Fig. 2. Changes of sea level in the Neopleistocene, given in the form of a curve-range including any possible error (*8, 20–22*). The true curve would lie in this range.

mum in the Early Upper Pleistocene and the glacial minimum in the Late Neopleistocene a long period of time passed. But only the brief minimum was contemporary with moraine-based geomorphological proofs of the classical Wisconsin, the Weichselian and the Würmian advances (Fig. 1).

Mammalian Fauna

The paleobotanical changes and the glacier movements during the Neopleistocene directly reflect the temperature oscillations. But they differ somewhat from the relatively well-known central European faunal sequence, which changed more gradually and forms a balanced reflection of the climatic events. In the Early Neopleistocene the central European fauna consisted of temperate- and warm-forest elements (*17*), among which the forest elephant (*Palaeoloxodon antiquus*) and two forms of rhinoceros (*Dicerorhinus kirchbergensis* and *D. hemitoechus*) were most typical.

At the beginning of the Middle Neopleistocene the warmer elements were replaced by some subarctic forms (Fig. 1) such as the woolly mammoth (*Mammonteus primigenius*) and the reindeer (*8, 17*). In the time of the Broerup interval at least, *D. hemitoechus* invaded central Europe again (*17*), but the forest elephant never came back. In the coldest part of the Middle Upper Pleistocene a high percentage of subarctic and arctic elements—among them even the musk-ox (*Ovibos moschatus*) (*18*)—was reached. But a good number of temperate forms still existed also.

Their numbers increased significantly during the following "Aurignac oscillations" (see *8*) but fell back to an absolute minimum in the Late Upper Pleistocene, when even the larger subarctic species such as mammoth and woolly rhinoceros became rare, evidently because of the lack of food (*19*) and space. With the rise in temperature, at the end of the Late Upper Pleistocene the proportion of temperate forest dwellers increased. The last subarctic species disappeared from central Europe in the Lower Holocene (*8*; Fig. 1).

Fig. 4 (right). Stone implements of the Weimar complex from Ehringsdorf, Germany. 1, Projectile point; 2, endscraper; 3, point with burin strokes; 4 to 8, double- and single-ended thick points, some bifacially worked; 9 and 10, small, backed knives; 11, bifacially retouched knife.

Movements of Sea Level

Changes in sea level have a special importance for the problem of the origin of the Paleo-Indian culture. The sea level depended directly on the size of glaciers and the amount of water bound as ice. The different levels in the Upper Pleistocene are well or sufficiently documented for only parts of the stages (Fig. 2). The available data do not allow the reconstruction of an exact curve in the form of a thin line, but at least an average range can be constructed within which the real curve, with its minor oscillations, should run.

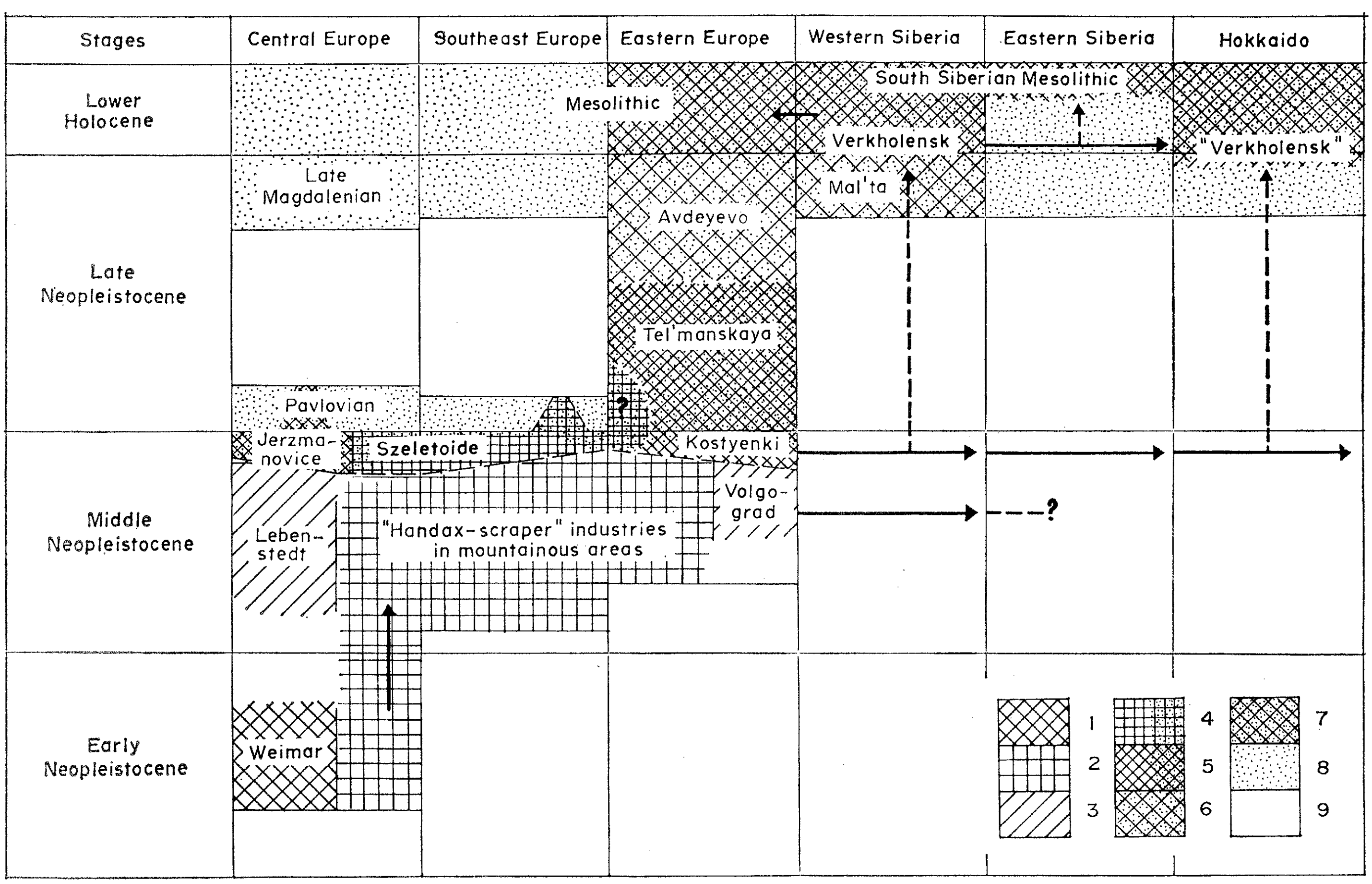
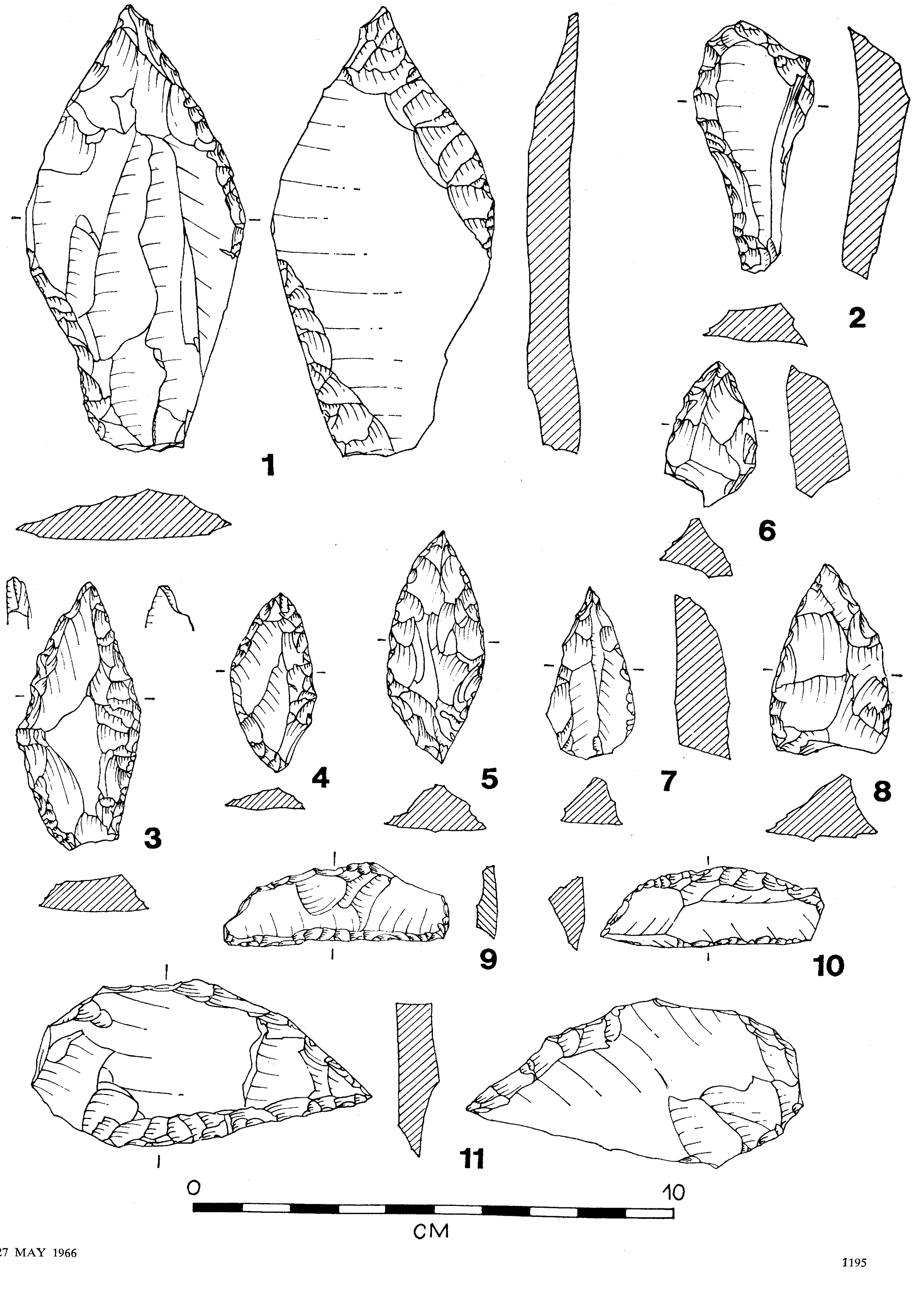


Fig. 3. The evolution of the bifacial traditions of northeastern Eurasia during the Neopleistocene. 1, Hand-ax-scrapers and early projectile points, contemporary with flake-tool industries; 2, unspecialized hand-ax-scraper industries; 3, late hand-ax-scraper industries of the open plains, contemporary with flake-tool Mousterians; 4, Szeletoid conservative groups with partial Mousteroid traditions and Aurignacoid influences; 5, projectile-point industries of the open plains, partially contemporary with the oldest Aurignacoid complexes; 6, Aurignacoid groups with restricted bifacial traditions; 7, late bifacial traditions with strong Aurignacoid influences; 8, Aurignacoid industries; 9, no archeological traces of any kind known so far.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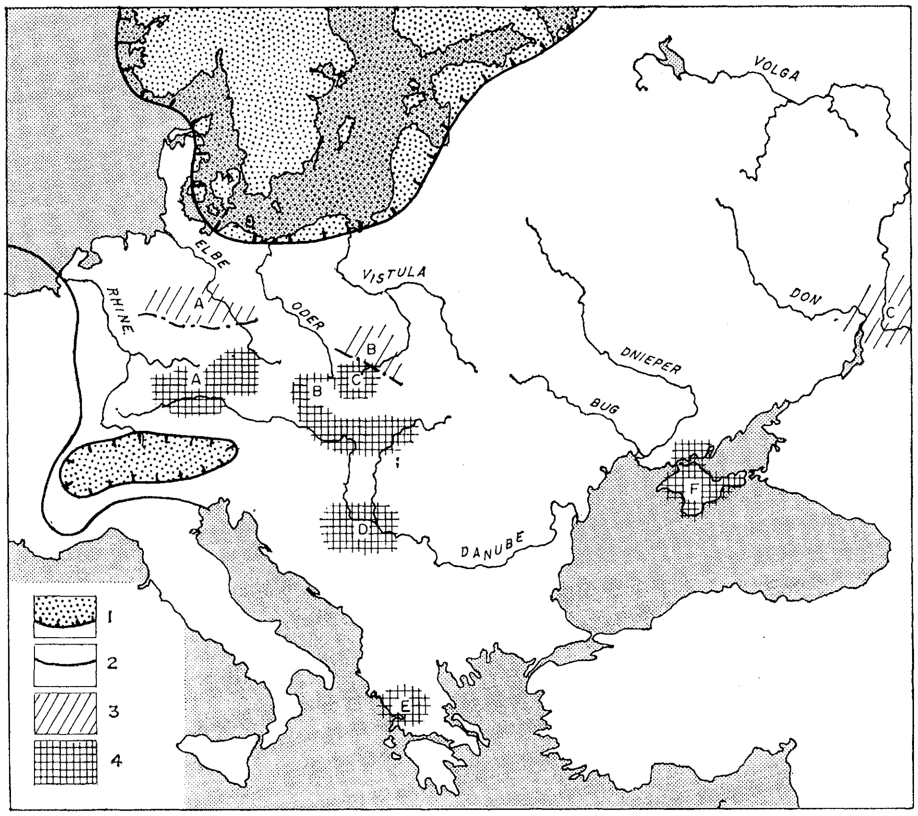


Fig. 5. Locations of hand-ax-scraper complexes in Europe in the Middle Upper Pleistocene. 1, Probable greatest ice extension in the Middle Upper Pleistocene; 2, range of the Micoqoid industries and the Mousterian with Acheulian traditions in western Europe; 3, complexes of the open plains; 4, complexes of the mountainous regions.

For earlier sea levels a general uplift of the continents with respect to the oceans could be important (*8*). Nevertheless, a greater transgression, the Monastir I, in the Early Neopleistocene is a well-established fact (*20*). This was followed by a minor regression and a new transgression, the Monastir II (*20*). This second transgression in the Neopleistocene must lie outside the Eemian in view of the paleobotanical evidence (*6*) mentioned before, which does not show any colder substage in the Early Neopleistocene itself. It is much more likely that the sea level during the twofold cooler substage, including the small Amersfoort interval, would stand beween the levels of Monastir I and II. This would mean that the Monastir II should be related to the Broerup (*11*) at the beginning of the Middle Neopleistocene. After Monastir II there occurred another regression of which the details are so far unknown.

The Middle Upper Pleistocene closed with a minor transgression, apparent in some detail near Freeport, Texas (*21*), which brought the shoreline back within about 18 to 20 meters below the present sea level. This transgression seems to have been contemporary with the "Aurignac oscillations" and was succeeded by the largest regression in the Neopleistocene, to more than 100 meters below the present sea level (*22*), equivalent to that of the main ice advances about 20,000 years ago (Figs. 1 and 2). A new, sometimes relatively rapid transgression, with a number of minor oscillations which are not visible in the scale used in Fig. 2, led into the Holocene and up to the present sea level (*23*).

Eurasian Paleohunters

Archeological sites from the Early Neopleistocene are rare, depending on sedimentation conditions (*8*). There are only a few which are reliably connected with the Eemian in central Europe. These few can be separated into two groups. The industries of one group produced simple, more or less well-worked flake tools (*24*). Tools from the other group exhibit bifacial stonechipping, as found in the Middle Pleistocene hand-ax complexes in Europe, southwestern Asia, and Africa (*25*). This second group of industries may be divided into two different facies (in themselves uniform subgroups, topographically and chronologically restricted) (Fig. 3): a technically simpler one restricted to the rather mountainous regions (*8, 26*), and a more refined one found in the open plains (*8, 27*).

The more refined industry, to be called "Weimar stage," from the most typical site known, has a large number of bifacially retouched tools, such as knives (usually called "scrapers"), small hand axes, and thick points (Fig. 4), but also typical end scrapers, primitive burins, and small, backed knives, altogether very advanced forms more characteristic of the much later Upper Paleolithic. Especially important are the projectile points with partially retouched surfaces (Fig. 4), the oldest known in such a distinct form.

In the Middle Upper Pleistocene, again, the industries with bifacial stone working, also contemporary with "Mousteroid" flake-tool complexes, show two different aspects (Fig. 3) which may be considered as facies (Fig. 5). In the open northern plains of Europe, which were then part of the subarctic climatic region, industries adapted to cool or even subarctic conditions can be traced for the first time (*8, 28*). Among the tools from this region are some large stone tools such as "late" hand axes, bifacial scrapers, and smaller burins and blades (Fig. 6), but also some bone implements such as hoe-shaped (*29*) or ax-like clubs, dagger-like instruments up to 70 centimeters long, and even a well-made bone point (Fig. 7) which, like the Weimar point, must have been hafted on a separate shaft and which represents without doubt an early "combined" effective throwing weapon.

A somewhat different aspect is represented by another group of industries found in the mountainous regions of central and eastern Europe (Fig. 5). These industries were more conservative and produced a higher proportion of slightly cruder bifacially retouched tools (*30*). The "hand-ax-scrapers" (*8*), combining hand axes and scrapers with a definite cutting function, are especially characteristic. The rest of the tools in the group are more uniform "Mousteroid" (*31*), and the animal bones found in context with these industries (*6, 27*) show that adaptation to cold conditions was not as far devel-

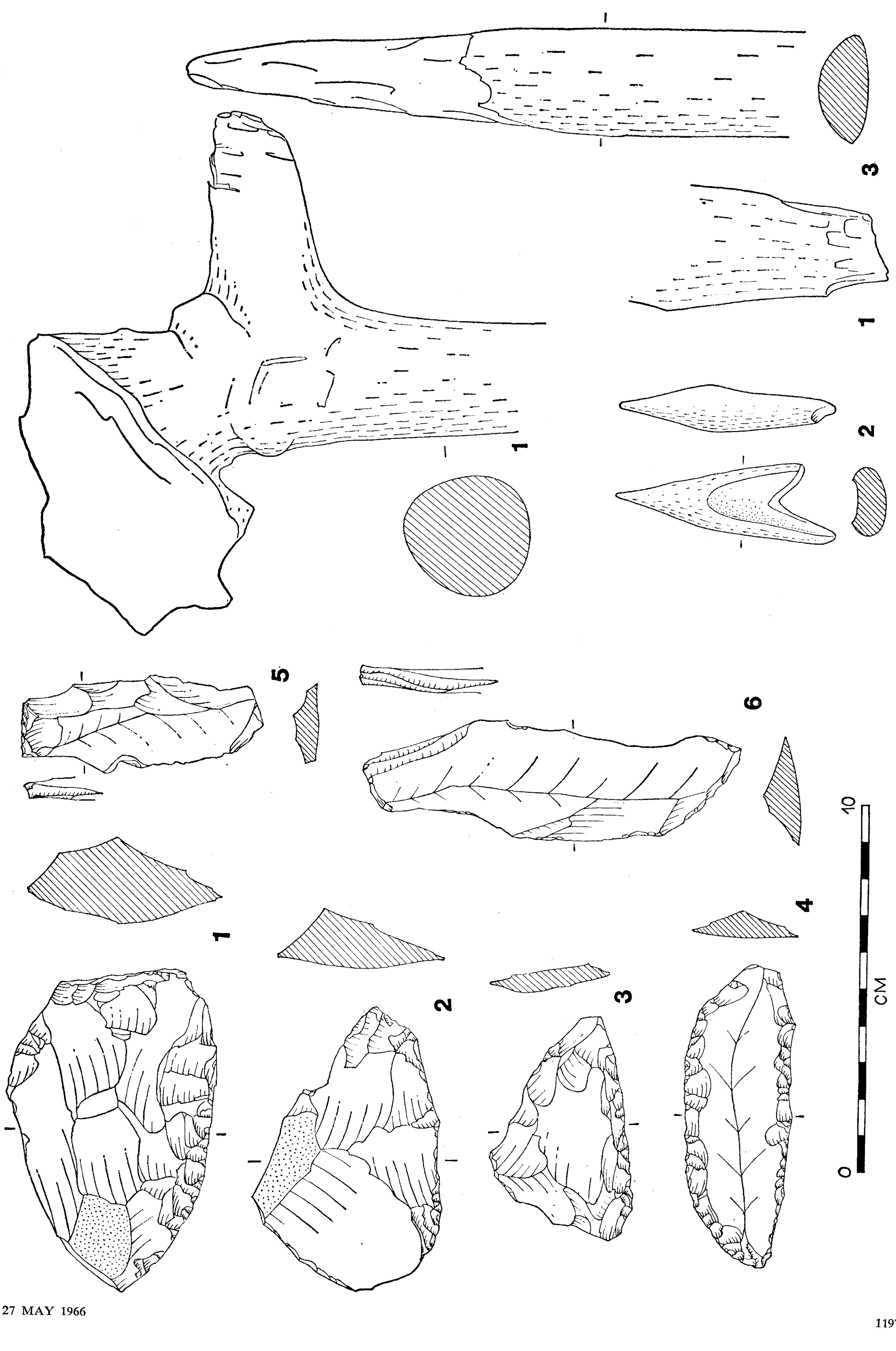


Fig. 6 (left). Stone implements from Lebenstedt, Germany. 1 to 3, Bifacial and unifacial knives (1, typical hand-ax-scraper); 4, large, backed prismatic blade; 5 and 6, burins. Fig. 7 (right). Bone implements from Lebenstedt, Germany. 1, Hoe-shaped club made of reindeer antler; 2, projectile point; 3, tip of a dagger-like weapon, a type of tool up to 70 cm long.

oped as in the northern complexes of the same age.

At the end of the Middle Upper Pleistocene, more or less at the same time as the warmer "Aurignac oscillations," those older, generally "Micoquoid" (*32*) industries were replaced by groups which possessed as a characteristic feature totally or partially bifacially retouched leaf-shaped projectile points (*33*). Here again there were two different groups (Fig. 3), one connected with the open plains in the north and the other with the mountainous regions (Fig. 8). The northern group contains well-worked tools and also some slender projectile points closely resembling the older Weimar point (Fig. 9). This "Jerzmanovice" (*34*) could be considered in some respects a close forerunner of the central European Aurignacian (*35*).

The other complex is composed of numerous regional industries (Fig. 8) scattered all over the mountainous landscapes of central and eastern Europe (*8, 36*). This 'Szeletoid" complex is uniform only in that the regional industries all produced leaf-shaped points; together with these points are found different but more or less strong local Mousteroid traditions (*36*). The roughly contemporary older Perigordian of France possesses a similar general feature but without fully bifacially retouched types (*37*). Ecologically close to the northern complex belongs the Kostyenki facies of central Russia (Fig. 8). There again well-worked triangular projectile points with concave bases and slight fluting (Fig. 10; *38*), a type unknown in the west at this time, exist, together with a specialized end scraper with cornered edges (Fig. 10). From the same period date the first large specialized bone points, the Lautscher points (*39*), of which the best worked and probably oldest examples (*8*) have so far been concentrated in southern Poland (Fig. 8). Some time later, but still during the warmer oscillations at the end of the Middle Upper Pleistocene, came the first true Upper Paleolithic group, the Aurignacian (*35, 40*). Its inventory is characterized by a high percentage of blade-tools and smaller bone points, especially with split bases (Fig. 11).

Everywhere in Europe the "Aurignacoid" (*41*) industries predominated during the Late Upper Pleistocene after about 27,000 years ago. But in some areas with a favorable climate bifacial traditions survived, for instance in France and Spain (*42*), central and southern Russia (*6, 43*), large areas of Africa (*44*), and very probably in central Siberia (*8*), although no direct evidence from any archeological site of this age is available there at present (Fig. 3).

All these complexes, with the exception of those from northern Africa (Fig. 19), are heavily influenced by Aurignacoid techniques. In this they differ markedly from the older levels, which contain bifacially retouched projectile points and must be dated in the Middle Upper Pleistocene. At the end of the Late Neopleistocene the bifacial traditions had vanished in western Europe (*45*), and had almost disappeared in central and southern Russia (*8*). However, bifacially retouched tools have been well preserved in southern and central Siberia (Fig. 3), where they appear with conservative types in the oldest archeological levels known there (*8, 46*), just at the transition to the Holocene (Fig. 3). This Siberian group, though it shows the influence of Aurignacoid traditions, must have had a local forerunner, as noted earlier. This opinion is supported by the fact that, during the still relatively cold Late Neopleistocene, a forest region with park-like features, the typical ecological area for this kind of industry, prevailed in central Siberia (*47*).

The pure Aurignacoid complexes were also represented at the same time in Siberia by industries adapted, as they were everywhere else, to colder conditions and containing a large proportion of bone tools as the result of a lack of workable hard wood. Very typical of these complexes are the Mal'ta facies in central Siberia (*48*), which must date from between 16,000 and 12,000 years ago (*8*), or slightly earlier, and similar industries from Hokkaido within the same time range (*49*), when Hokkaido, as a result of lower sea level, formed a part of eastern Siberia. So here also the Aurignacoid groups form the outer rim of the human living space (Fig. 19). With the temperature increase at the end of the Neopleistocene the makers of the Aurignacoid inventories moved more to the north. The Siberian bifacial industries also

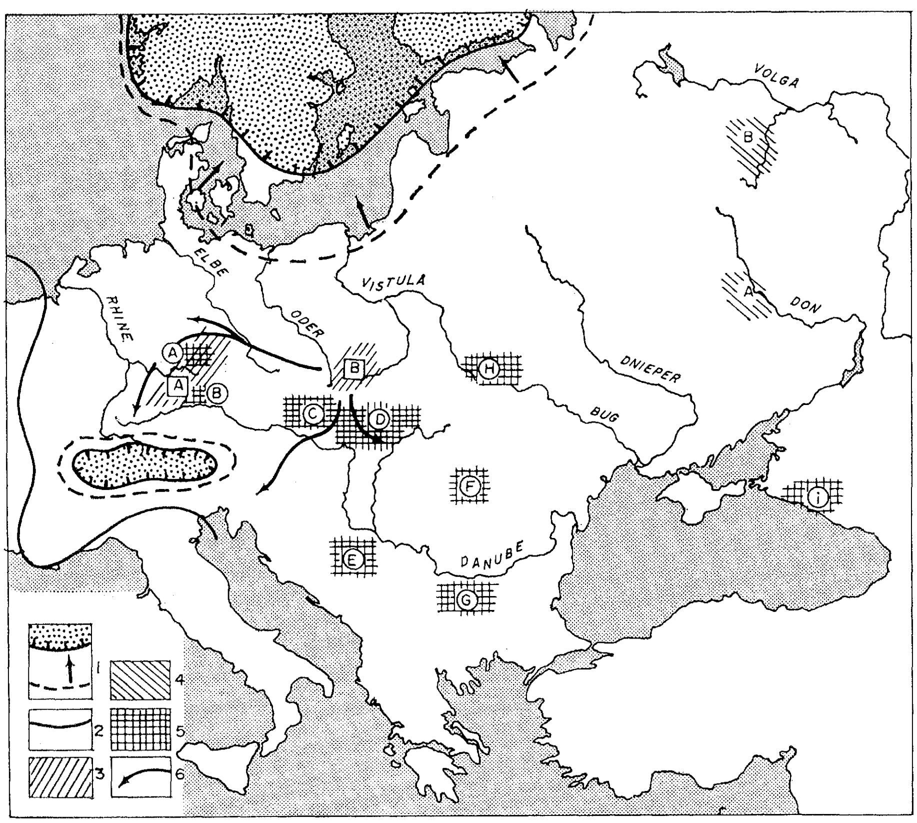
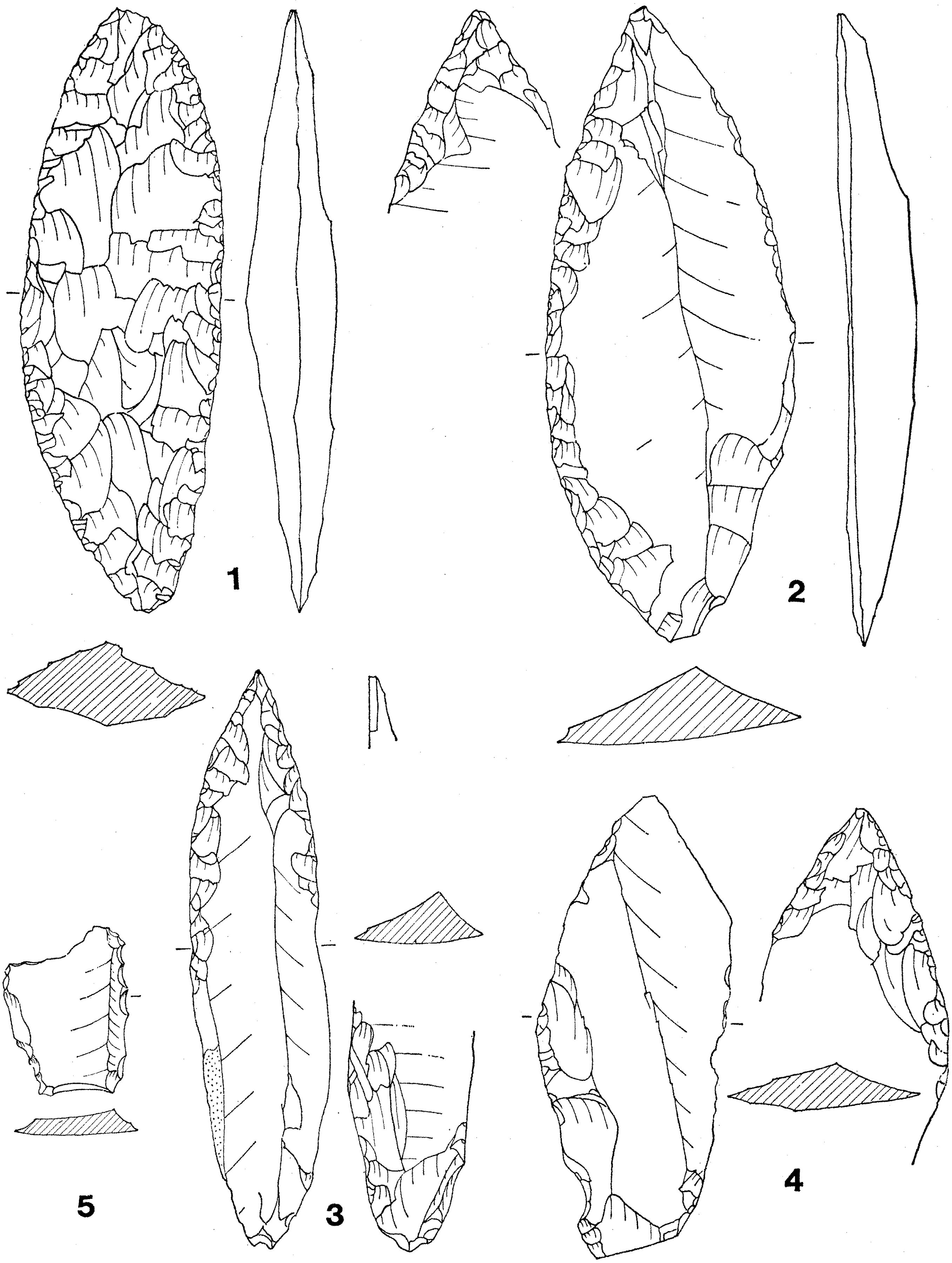


Fig. 8. Locations of archeological groups in central and eastern Europe at the end of the Middle Upper Pleistocene. 1, Probable ice retreat; 2, range of the late Mousterians and the Perigordian of western Europe; 3, Jerzmanovice and similar industries in the northern plains; 4, Kostyenki and related industries of the Russian plains; 5, Szeletoid groups of the mountainous areas; 6, extension of the bone points, type Lautsch.

Fig. 9 (right). Stone implements of the Jerzmanovice from Nietoperzowa Cave, Poland. 1, Bifacial knife; 2 to 4, projectile points (3, with burin stroke); 5, multiedged side scraper.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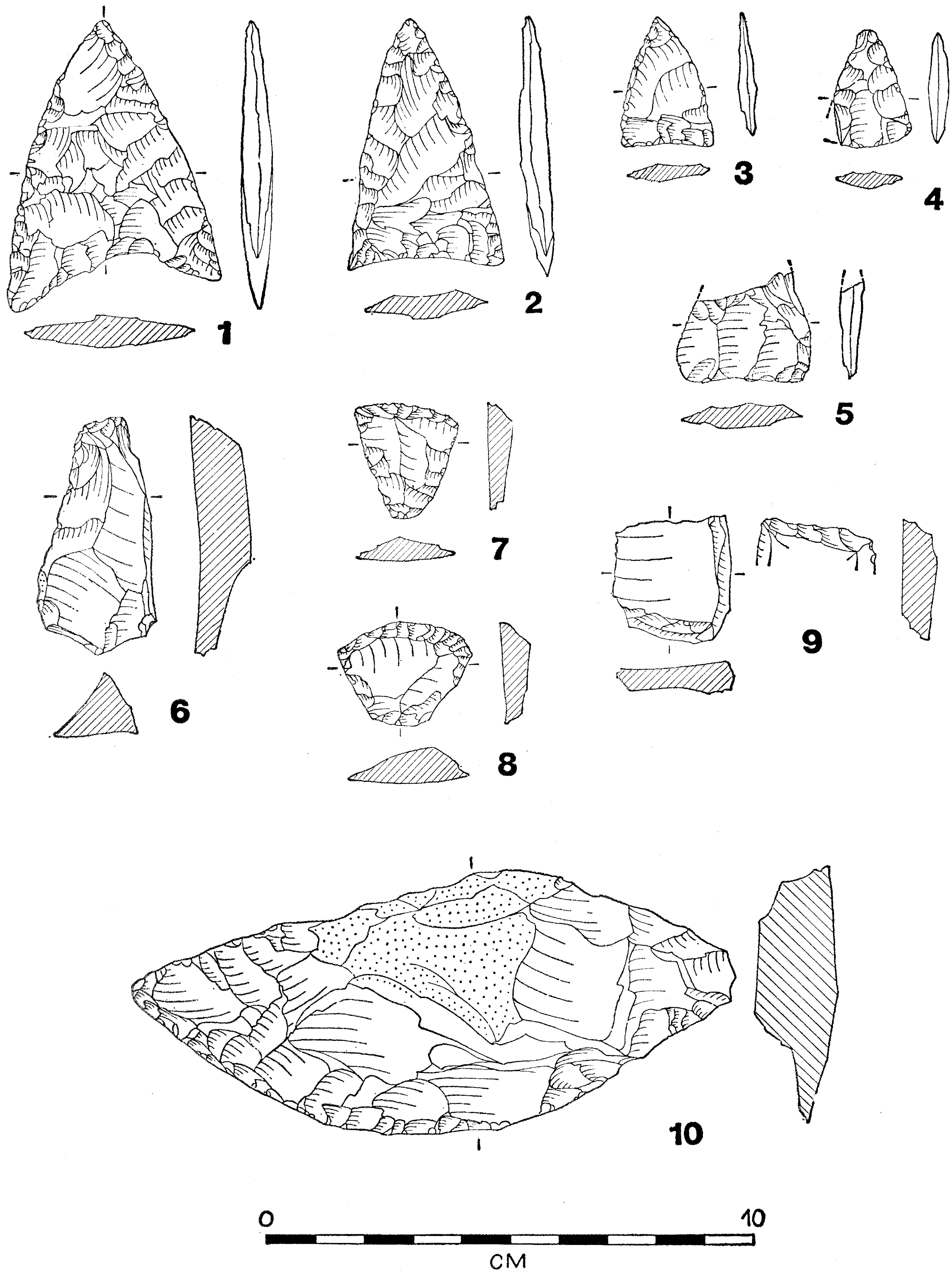


Fig. 10. Stone implements from Kostyenki, site 5, level 1. 1 to 3, triangular projectile points; 4 and 5, fluted triangular projectile points; 6, atypical end scraper; 7 and 8, cornered scrapers; 9, burin; 10, bifacial knife.

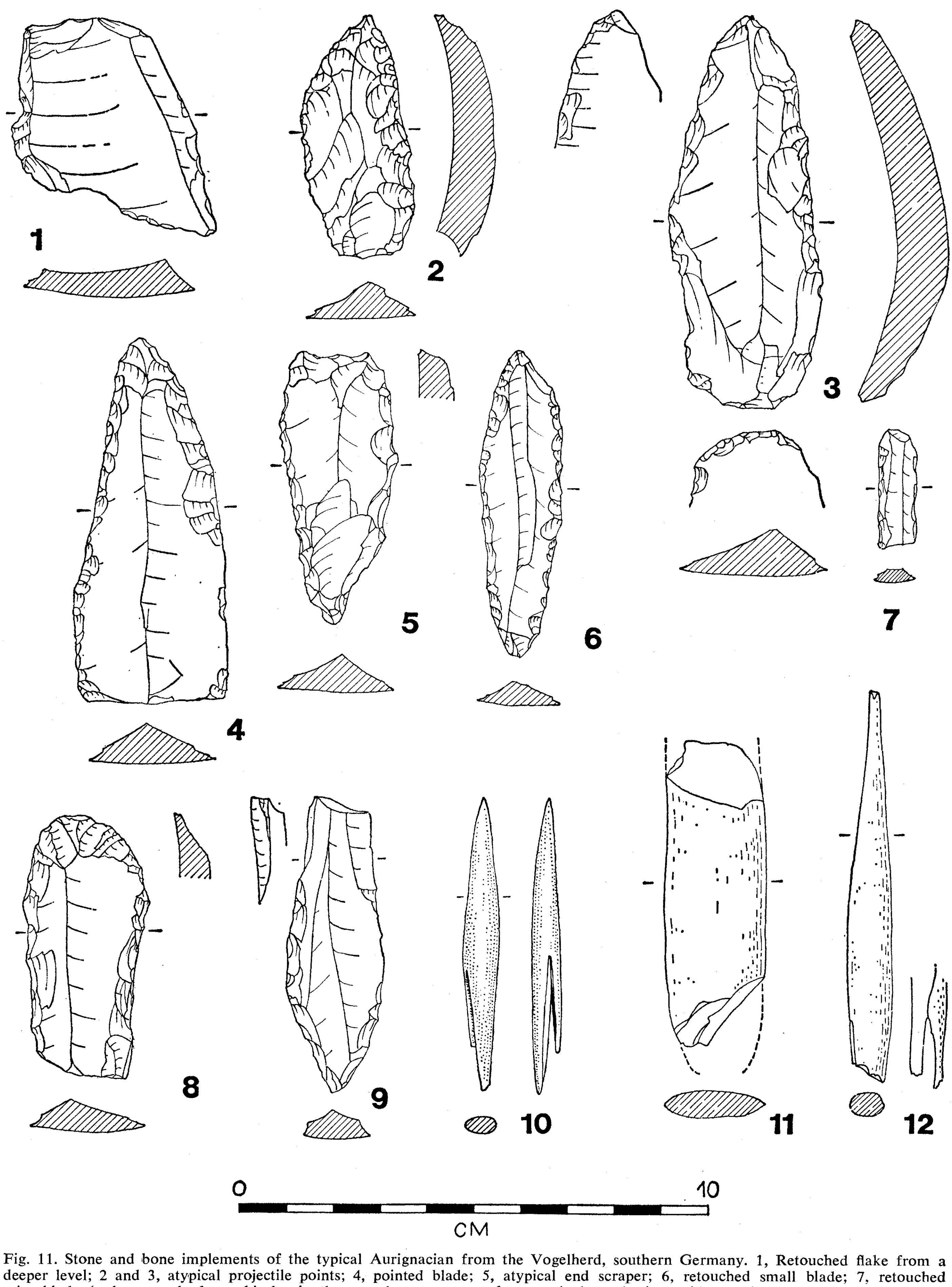


Fig. 11. Stone and bone implements of the typical Aurignacian from the Vogelherd, southern Germany. 1, Retouched flake from a deeper level; 2 and 3, atypical projectile points; 4, pointed blade; 5, atypical end scraper; 6, retouched small blade; 7, retouched microblade (only example from this level—the type becomes more frequent in later Aurignacoid stages); 8, end scraper; 9, burin; 10 and 12, bone projectile points with split bases; 11, fragment of a Lautsch point.

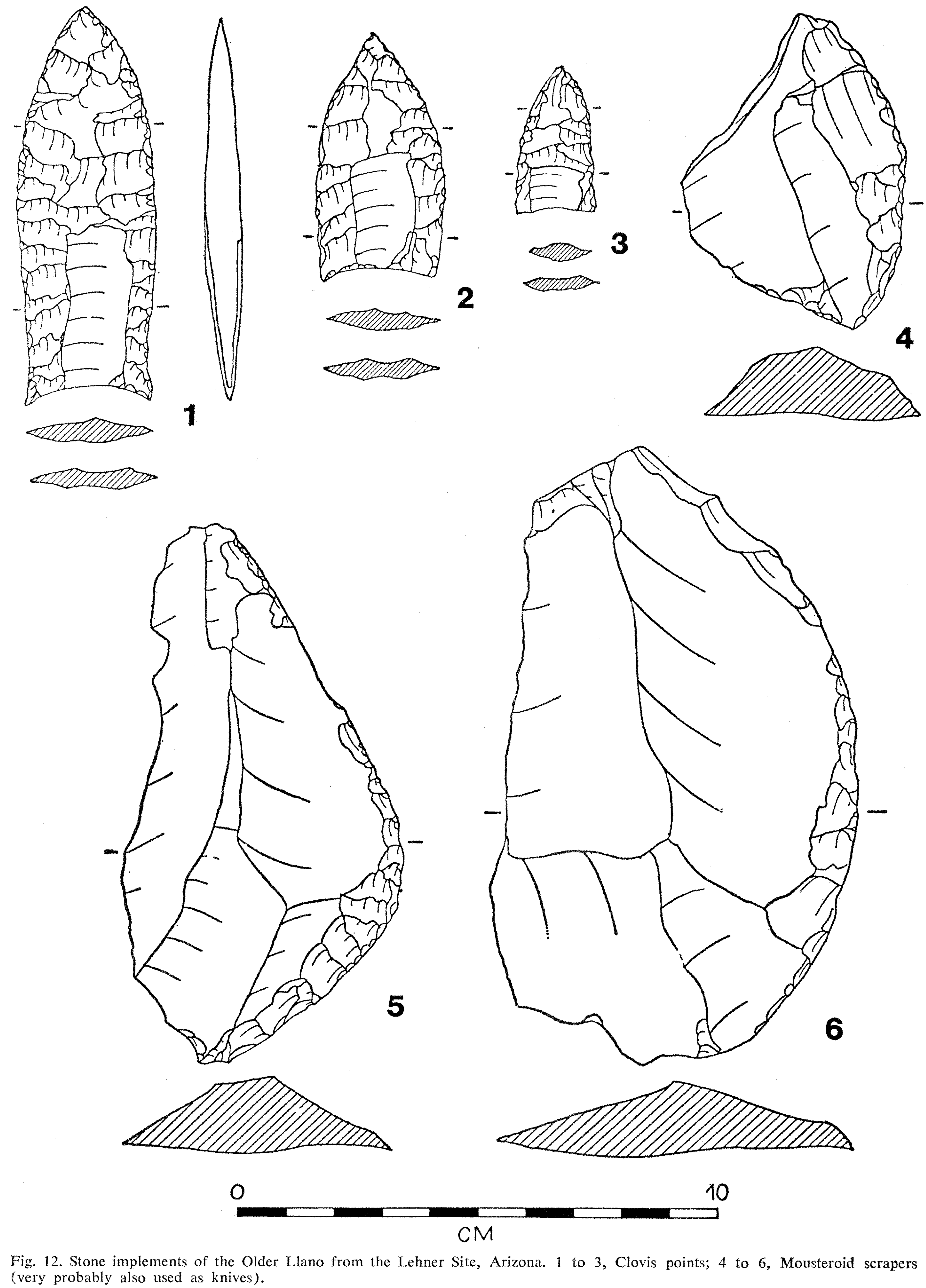


Fig. 12. Stone implements of the Older Llano from the Lehner Site, Arizona. 1 to 3, Clovis points; 4 to 6, Mousteroid scrapers (very probably also used as knives).

spread out of the core zone they had occupied before. These movements went on during the Lower Holocene, when the size of some stone artifacts of the Aurignacoid traditions (*50*) was greatly reduced in most areas of the Northern Hemisphere and even in some parts of Africa, where they are known now.

History of the Bering Region

The geological history of the Bering region is an important key to the understanding of archeological and paleontological contacts between the Old and the New World. The highest part of the now-submerged platform between Siberia and Alaska is about 35 to 40 meters below the present sea level (*51*). Even a small channel eroded during the Holocene by the ocean currents off the coast of Siberia (*8*) is in some places no deeper than this. This means that there was a dry land bridge between Asia and America whenever the sea level fell about 40 meters below the present level. A land bridge would have existed again (*52*) between about 50,000 and 40,000 years ago and once more between 28,000 and 10,000 years ago (Fig. 2) (*53*). The more recent land bridge was a bit wider than in its first Neopleistocene period and reached its maximum width about 20,000 years ago (Fig. 2). During the existence of this bridge it would have been easy for animal and man, adapted to the climatic conditions (*8, 51*) in the region, to cross over from the Old to the New World. All evidence points to the fact that during the first Neopleistocene connection average climatic conditions were much better than during the second one (*8*). The fact that at least

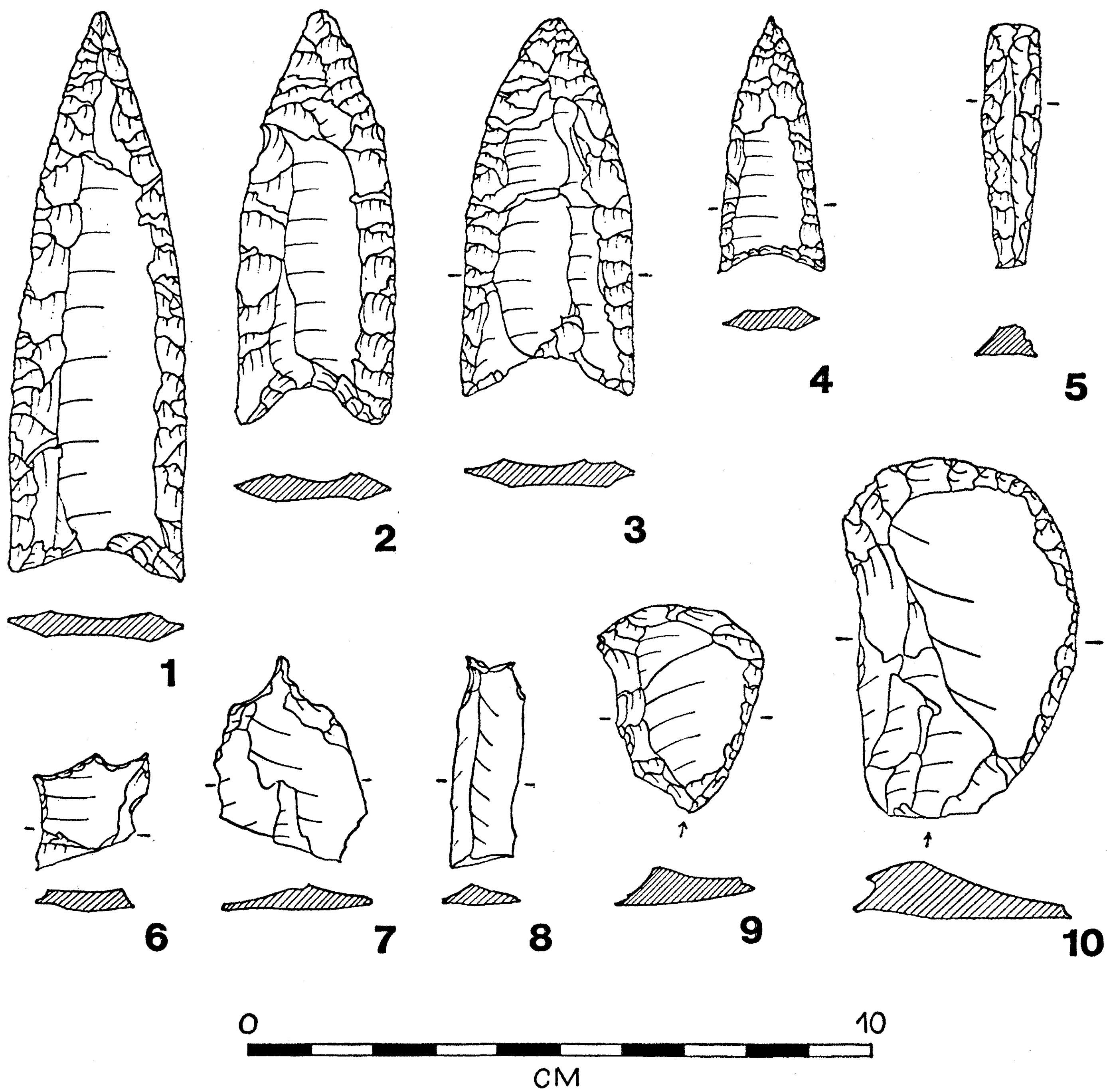


Fig. 13. Stone implements of the Younger Llano from Bull Brook, Massachusetts. 1 to 4, Late Clovis points; 5, "rasp"; 6 to 8, gravers; 9 and 10, end scrapers.

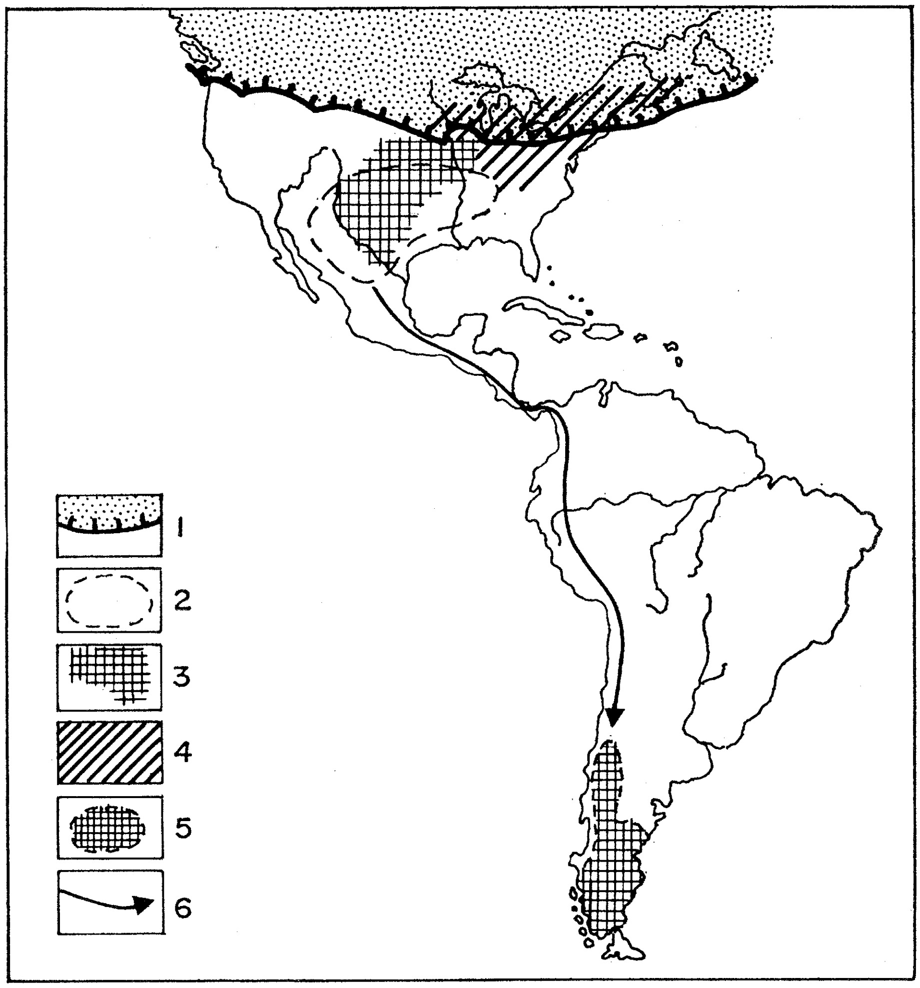


Fig. 14. Locations of projectile-point complexes in America at the end of the Neopleistocene. 1, Maximum extension of the Wisconsin ice; 2, known core area of the Older Llano; 3, Folsom-Llano; 4, Younger Llano; 5, Toldense; 6, route of invasion into South America.

Fig. 15 (right). Stone implements of the Folsom-Llano from the Lindenmeier Site, Colorado. 1, Late Clovis point; 2 to 10, Folsom points; 11 to 16, fluting flakes (12 to 16, with graver tips); 17, bifacially retouched knife.

an animal migration took place during the land-bridge periods is shown by the first appearance of the wooly mammoth, reindeer, and other species (*54*) in America during the Neopleistocene. However, in the second period, the contact between the interiors of Asia and America was restricted because during the climatic minimum of the Upper Neopleistocene the land bridge became a part of the most extreme tundra, which supported just a few animals adapted to coldest arctic conditions (*8, 51*). Still more important was the formation of a large ice barrier south of Alaska, which then was morphologically part of Asia, by the contact between the Cordilleran and Laurentide ice sheets (*12*). This barrier lasted with varying limits and few if any discontinuities at least from about 23,000 to 13,000 years ago (*8, 12, 55*) and made migration from Asia into the interior of America practically impossible, even if one does not consider the large, cold, hostile tundra-belt mentioned above. At the end of the Pleistocene, after the new division of the ice, contact would have been possible again, but for some millennia only for those groups which had already become adapted in Asia to the cold conditions still prevalent in the Bering region (*51*).

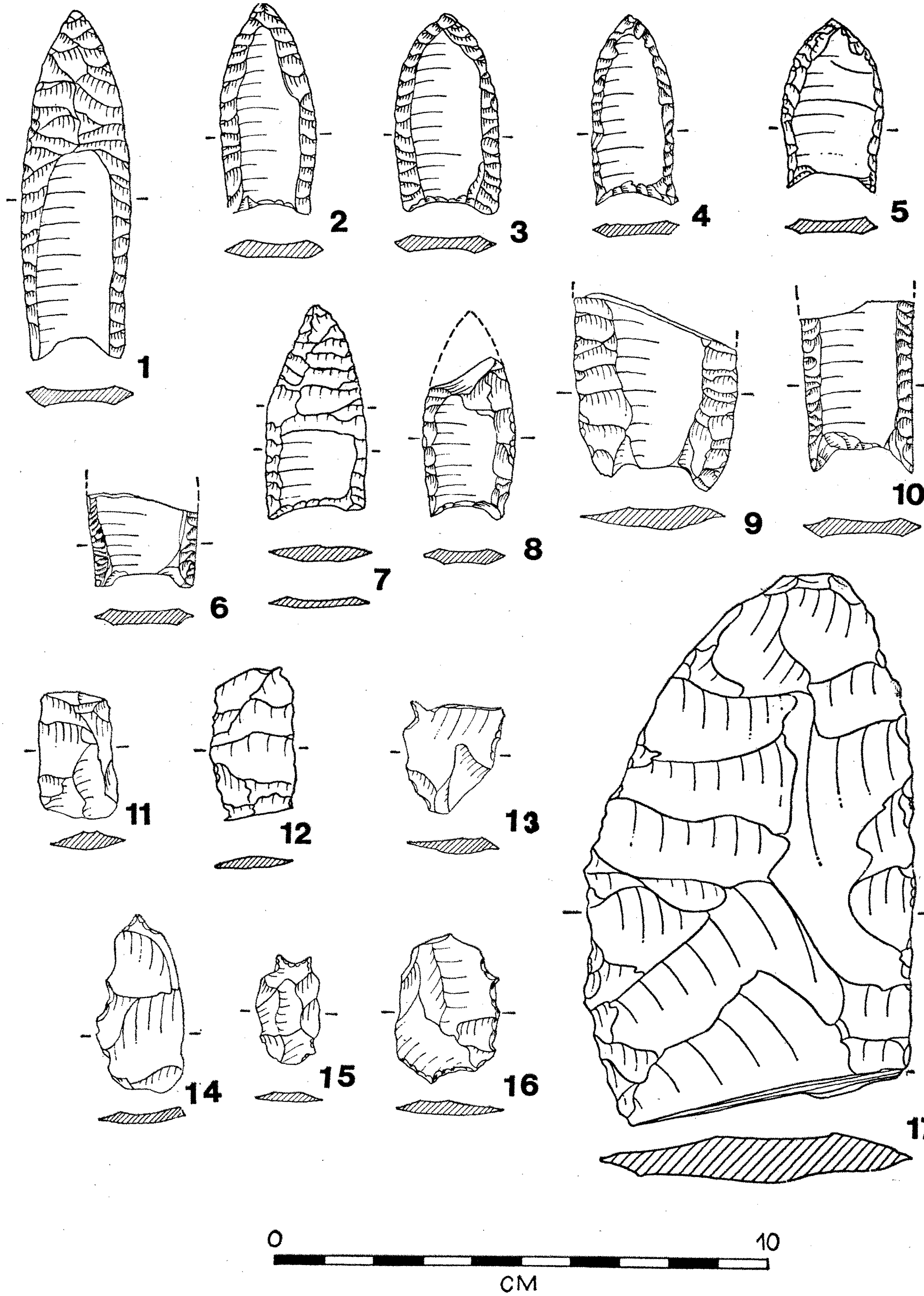
American Paleohunters

The earliest American sites with bifacially worked and leaf-shaped projectile points may be dated definitely back to about 12,000 years ago or even slightly earlier (*56*). These dates should be considered as minimum values and relatively late ones for the presence of man in this continent (*8*). They are connected with an industry known chiefly as "Llano" (*57, 58*), of which the Clovis points (Figs. 12 and 13) are especially typical. Though not yet accurately dated, the Sandia points (*59*) probably belong to a specialized phase (or "facies") within this "Llano."

The oldest known and really dated traces of the Llano industries are restricted to the southwestern part of the United States and northern Mexico (Fig. 14) (*60*). In this area, which seems to be at least an important primary core zone of technological improvement, the "Older Llano" (*61*) developed into a complex generally characterized by the famous Folsom points (Fig. 15). In its overall features this younger complex is so similar to the "Older Llano" that we could call it "Folsom-Llano" (*62*) (Fig. 16). The complex extended a little farther north than the known area of the "Older Llano" and was more or less restricted to the plains (Fig. 14), its beginnings dating from the very end of the Upper Pleistocene (*8, 58*).

In the northeast followed another (Fig. 14) but still less changed facies, the younger Llano (*8, 63*), which was split into a number of different local groups. Altogether these groups contain late types of Clovis points and related forms, as well as artifacts akin to the Folsom-Llano (Fig. 13). The existence of numerous sites of this complex in the area covered earlier by the Wisconsin ice (*64*) shows that there was an expansion northward after the extension of the more favorable climatic regions.

Another direct or indirect successor to the Older Llano, with fluted fishtail points, can even be traced over Central America and western South America (Figs. 14 and 16). Such points have been found even in Patagonia, where they have been dated at more than 10,000 years ago (*8, 65*). This rather impressive uniform "Toldense" (*66*) is the oldest reliably dated industry with specialized projectile points in South America. It represents the first invasion of this part of America which can be considered as proven (*67*) and seems to be related to the passability of the hostile forest area in Central America during the sea-level movements at the end of the Upper Pleistocene (*68*). The relatively old Ventana complex (*69*), which in its general aspects is different from the industries mentioned so far and thus may represent a totally distinct tradition (not discussed here), includes some projectile points. These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points are relatively crude but could be explained as result of a contact with the Folsom-Llano, which was really contemporary (Fig. 16). A relatively early contact between the Ventana-complex tradition and the projectile-point industries may also be represented in Gypsum Cave, Nevada (*70*). Both the Ventana complex and the Gypsum complex seem to be early representatives or forerunners of the "Desert Culture" (*58*), which in itself seems not to be too uniform and is better called "Desert Cultures" (Figs. 16 and 17).

About 9000 years ago, in the Lower Holocene, the fluted points so typical of all the Llano complexes were nearly everywhere replaced by unfluted or only very slightly fluted forms. Only in the southeastern United States some late fluted types seem to have persisted—inasmuch as typological criteria can be considered valid for such a statement; direct dates of geologically independent value are lacking from this area (*8, 71*). The number of specialized projectile points, very often with extremely restricted regional range, increases enormously. There are the Plainview, with a more simple base thinning, the stemmed Scottsbluff and Eden, and many others (*58, 72*). But except for this replacement the overall aspect of the inventories with knives, end and side scrapers, gravers, and so on remains so unchanged that all these tools can be referred to under the single term "Plano" (*73*). The Plano would branch into three large areal complexes (Fig. 16) of which the northern and eastern ones would at least partially be more closely related to the Younger Llano and the southern would be partially related to the Folsom-Llano (Fig. 17).

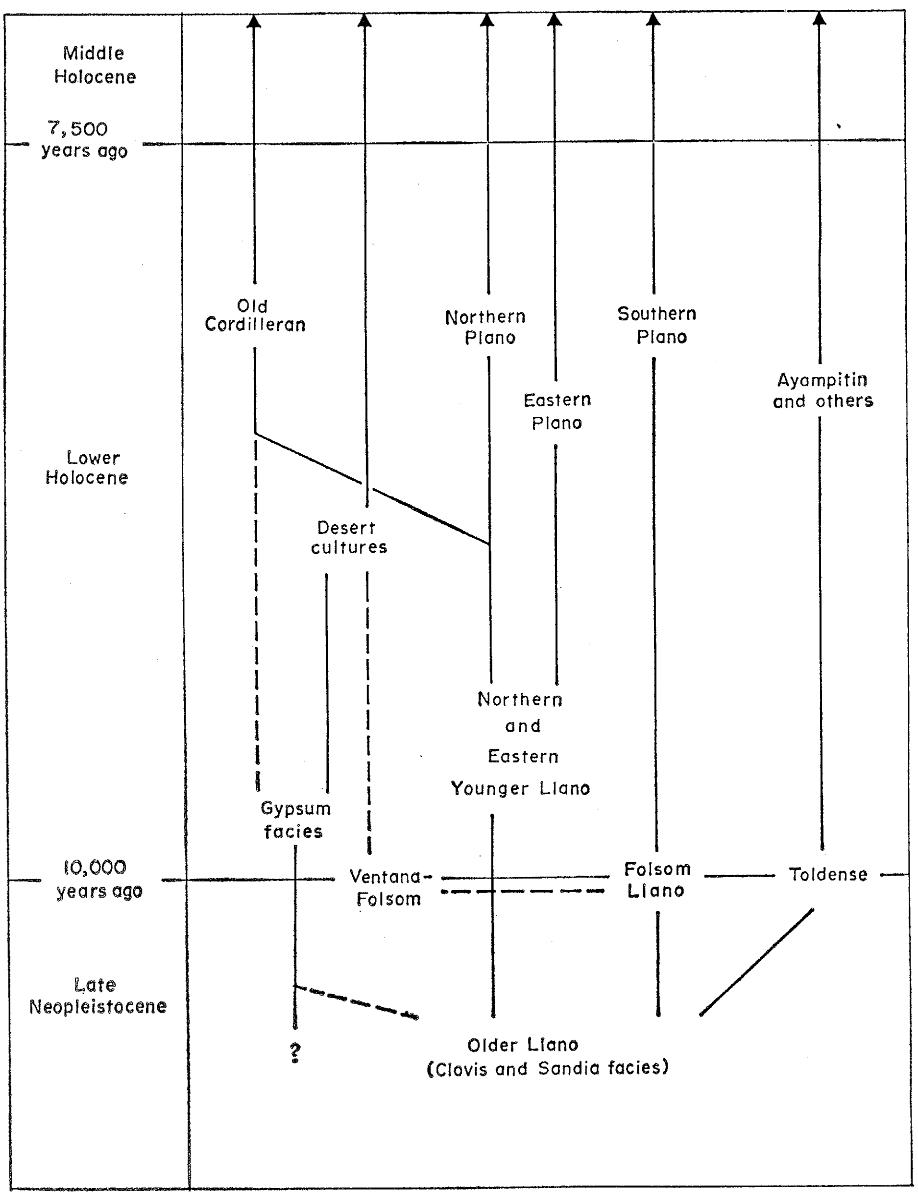


Fig. 16. Sequence of bifacial projectile-point traditions in America. Solid lines give direct connections; broken ones, indirect influences.

The Northern Llano seems the most important and also, because of its extension to the north (Fig. 17), the most "active" complex. In the more northern part of the Rocky Mountains the "Old Cordilleran" (*74*) existed at the same time (Figs. 16 and 17). Even this complex could be considered as at least partially an offspring of the Plano as defined here. But it is not impossible that even influences from the Desert Cultures are present (Fig. 16) (*8*). In South America the Toldense industries were largely replaced during the Lower Holocene by complexes containing points that are simplified with respect to the form of the bases. One of these complexes is the "Ayampitin" (*8, 58*), known from the central and southern Andean highlands as well as from Patagonia (Fig. 17). Others, again distinct from each other only in their different types and traditions of projectile points, have been reported from Uruguay, the northern Andes, and Venezuela (*58*) (Fig. 17).

Of special importance is the appearance of true burins in the Southern Plano (*75*). These burins are so typical of the more "northern" Aurignacoid stages in Asia, and so different from the well stratified and dated (from 8000 to 10,000 years ago) inventories from levels which are certainly Southern Plano, that they must be considered to be intrusive (*8*). The only possible explanation for such an intrusion would lie in some contact between Aurignacoid industries and the Plano in general. Such contact is very probable, for Aurignacoid groups, in extending the area they occupied at the end of the Upper Pleistocene, would either cross the Bering land bridge again just before it was submerged, or, if they were already present in Alaska (*76*), would expand into the formerly ice-covered and barren areas. The oldest inventories of this kind, forming a subgroup of the Aurignacoid industries without any significant bifacial features such as have been found in Alaska, are more than 8000 years old (*77*).

So the contact with the Plano, which was moving definitely to the north (*8*; Fig. 17), occurred on American soil. The progressive burin—an implement mainly associated with bone working—was taken to the south as a new feature but never became as widely used there as it was in the north. But it is very likely that this contact also was of "spiritual" importance (*78*) and in this respect had a lasting influence on the makers of the stone projectile point—the ancestors of hunters of the American plains who were found there by the first Europeans millennia later.

The Archeological Invasions

From the facts discussed so far there is sufficient evidence for the evolution of a specialized hunting technology, documented by well-made projectile points and combined weapons, in the open plains of central Europe during the Early Upper Pleistocene. This technology was mainly a continuation of the hand-ax traditions and was contemporary with simpler bifacial industries and flake-tool inventories. This three-lined evolution went on at least in large parts of Europe during the slowly cooling Middle Upper Pleistocene. Again, the making of the refined points in bone and stone was confined to the open plains. The most advanced points in central Europe existed in the "Jerzmanovice" and some time later in the early Aurignacian in bone, and in eastern Europe in the Kostyenki complex still in stone.

It is not yet known how far into the east and into Siberia the Kostyenki complex reached. But it is quite certain that no other stone-age industry anywhere at any time was typologically as close to the Older Llano. This is stressed not only by the correspondence of the point forms but also by the cornered end scraper, then unknown farther west, the Mousteroid typological features, the lack of any special Aurignacoid trait, and the ecology of the complex. A complex similar to the Kostyenki would probably be the root of the bifacial traditions in central Siberia, which are so far known only at the end of the Upper Pleistocene, when they moved to the north. This "Kostyenki" did not exist at the time of the first land-bridge period in the Neopleistocene. But in all probability during the Aurignac oscillations the area of such complexes, of which "Jerzmanovice" and "Kostyenki" are western facies only, had reached the Asiatic coast of the Pacific (Fig. 18). In western Eurasia it bordered on the region of the Mousterians (*25*), mostly in hilly and mountainous areas, and also included some bifacial tools and others with true leaf-shaped points. In eastern Asia "Kostyenki" complexes were found in the neighborhood of late pebble-tool industries (*79*). With the same momentum in which it was possible to cross the emerging land bridge, this huge province of specialized projectile-point industries and hunters of the open plains automatically stretched outward into the American continent (Fig. 20). The first invasion of man in the New World for which a reliable archeological reconstruction seems possible—there could have been earlier invasions—took place about 28,000 to 26,000 years ago. At the same time, in western Eurasia, the complex of the Aurignacian industries (*80*) started to expand with increasing speed. But in some areas the bifacial traditions, as well as some Mousterian complexes, persisted. The same was the case with the pebble-tool industries of eastern Asia (Fig. 20).

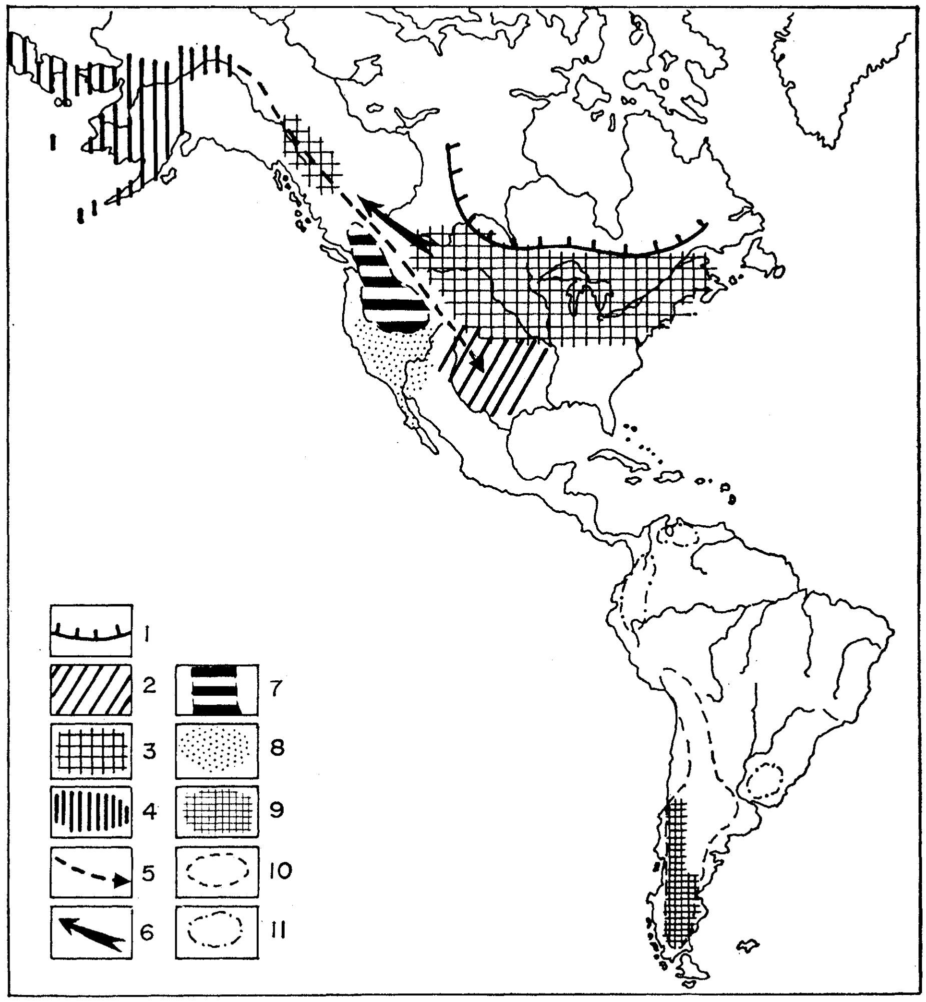
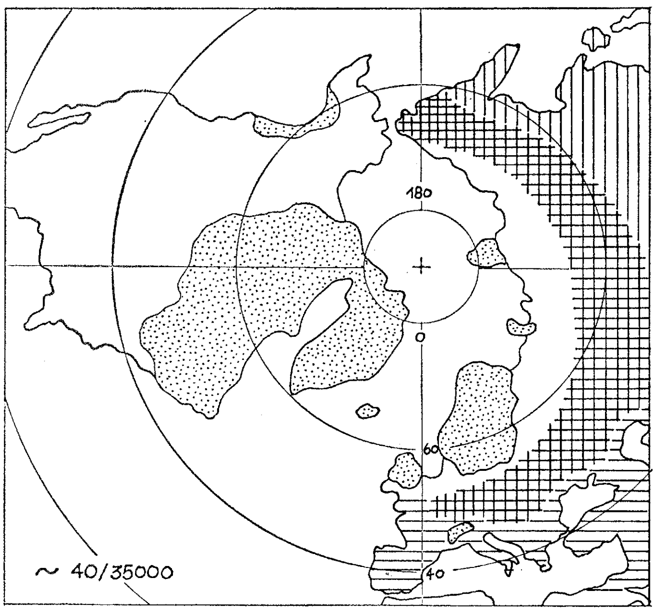


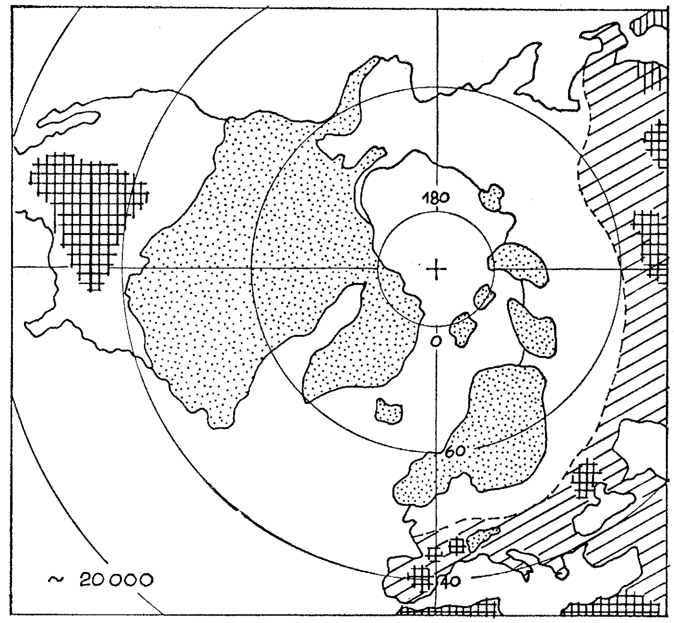
Fig. 17. Locations of projectile-point industries in America in the Lower Holocene. 1, Ice boundary averaged; 2, Southern Plano (main area); 3, Northern Plano (generalized); and 4, Aurignacoid groups from Asia; 5, route of the burin influence; 6, extension of the Northern Plano; 7, Old Cordilleran; 8, Desert Cultures; 9, Toldense; 10, Ayampitin region; 11, other known projectile-point complexes in South America. The Eastern Plano is not shown because of the difficulty of distinguishing it from the Younger Llano (Fig. 14) and the Northern Plano.

In the Late Neopleistocene the icesheet south of Alaska and the adjacent extreme arctic tundra isolated the American branch of the province and pushed the Siberian one back to the south (*81*) (Fig. 19). Everywhere in Eurasia at this time Aurignacoid industries predominated at the northernmost margin of the area occupied by man. Bifacial techniques persisted also in some smaller areas of western Eurasia but were influenced heavily by Aurignacoid technologies, as in central Siberia. A large area with persisting bifacial traditions, but lacking any significant influence from Aurignacoid complexes, still existed in Africa at this time (Fig. 19). The same would be expected in the topographically isolated America, and that this really was so is shown by the typology of the Older Llano, which lacks any Aurignacoid feature, but which on the other hand is still much closer to the older Kostyenki than any other industry anywhere at this time (*82*).

The next invasion of America from Asia probably did not take place before the improvement of the climate at the end of the Upper Pleistocene. Then again the Aurignacoid complexes of northeastern Asia, moving to the north, crossed over the still-existing land bridge (Fig. 21) (*83*). After the reopening of a passage between the Cordilleran and the Laurentide ice sheets, contact between them and the American Plano, which moved to the north as did its central Siberian counterpart, became possible (Fig. 21).

The technical exchange between the two traditions remained rather restricted, but this seems much less the case in spiritual respects (*78*). Although the





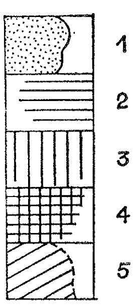
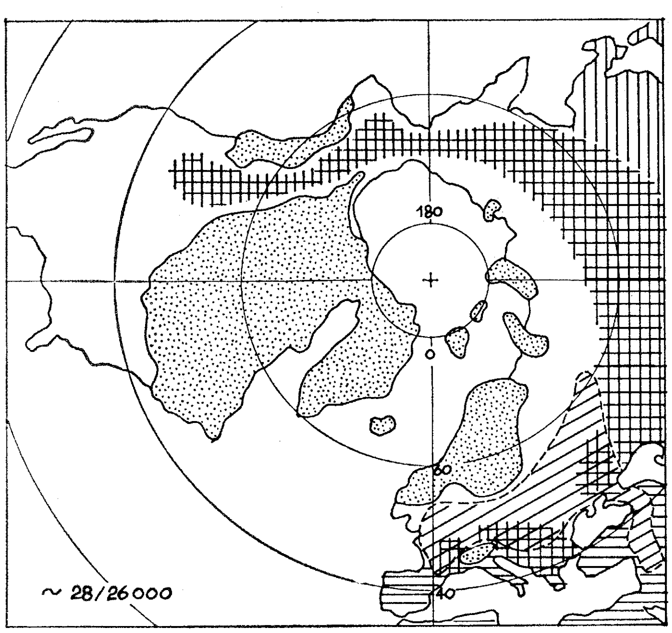


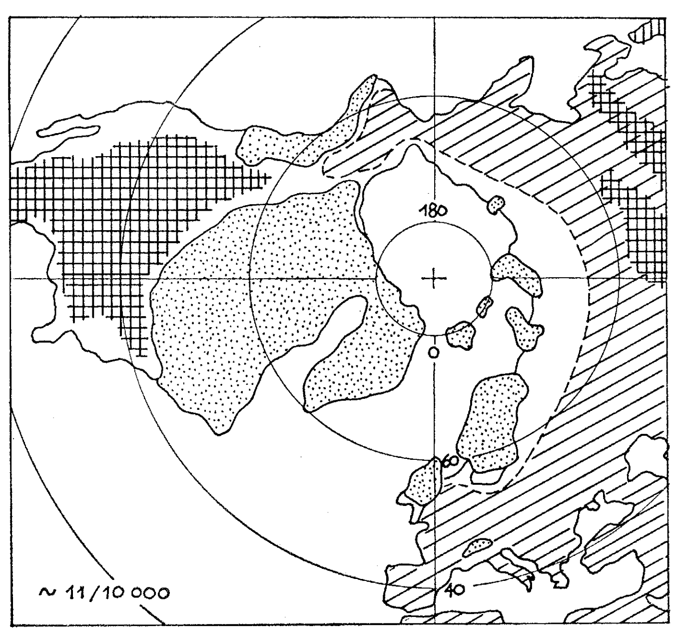
Fig. 18 (left above). Archeological-complex areas at the end of the Middle Upper Pleistocene. 1, Ice extension; 2, Mousteroid industries; 3, pebble-tool industries; 4, complexes with bifacial traditions and projectile points; 5, Aurignacoid industries.

Fig. 19 (right above). Archeological-complex areas at the time of the maximum ice extension in the late Neopleistocene; key as in Fig. 18.

Fig. 20 (left below). Archeological-complex areas at the time of the transition between Middle and Late Neopleistocene; key as in Fig. 18.

Fig. 21 (right below). Archeological-complex areas at the end of the Late Upper Pleistocene; key as in Fig. 18.





newly arriving makers of the Aurignacoid complexes were unable to change the original technology of the American Paleo-Indian hunters to a great extent, the invaders kept the Paleo-Indians from conquering the once more ice-free northern part of the continent. This region was slowly occupied by the Aurignacoid industries which formed the basis of the later Eskimo and Aleut cultures—the first of the most extreme adaptations of hunting man to hostile surroundings.

Summary

Against the background of the natural history of the most recent past, the specialization of the Paleohunters in the open plains of Eurasia since more than 65,000 years ago and their adaptation to a changing climate, up to subarctic conditions, can be documented. The expansion of these hunters over northern Eurasia and their crossing of the Bering land bridge, as the first known invaders of America, about 28,000 to 26,000 years ago, are reconstructed. Afterward the invaders were isolated by the ice advances of the Wisconsin maximum in the southern part of North America and separated from the continuing technological evolution of the Old World. The contact between Asia and interior America was not feasible again until the melting of the inland ice barrier, when Aurignacoid groups invaded or expanded over North America for the first time (*84*). The technical influence of those industries remained more restricted than their probable spiritual one. The first invaders must be considered as the ancestors of the Plains Indians; the second, as those of the Eskimos and Aleuts.

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all during the climatic minimum of the Late Upper Pleistocene, would have to have had an "Aurignacoid" technology (*41*) in order to survive. They would have represented one of the outermost advanced "subarctic" hunter-cultures in the Northern Hemisphere at this time.
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61. There is of course no sharp boundary for the end of the Older Llano, but it could be placed about where the Folsom-Llano becomes distinguishable.
62. There is really no distinct difference between the Llano phases *sensu strictu* and the "Folsom," except for a slight specialization of the points, which may be considered as subtypes of the classical Clovis point rather than as separate types (Figs. 13 and 16 give an impression of this typological "transition"). This is probably a good example of the overemphasis on the point typology, which is the main issue in discussions about Paleo-Indian problems, although the rest of the assemblages, which by far outnumber the points, have been very little discussed.
63. The younger Llano is practically contemporary with the Folsom-Llano and even shares with it stone-tool subtypes of lower order also. Only the projectile points are at all distinguishable. Southeastern "Llano" industries and related complexes are so far not sufficiently dated.
64. G. I. Quimby, *Amer. Antiquity* **23**, 247–254 (1958); R. J. Mason, *Late Pleistocene Geochronology and the Paleo-Indian Penetration into the Lower Michigan Peninsula* (Univ. of Michigan, Ann Arbor, 1958).
65. J. Bird, *Geogr. Rev.* **28**, 250–275 (1938); M. Rubin and S. M. Berthold, *Radiocarbon* **3**, 86–98 (1961).
66. O. F. A. Menghin, *Runa* **5**, 23–43 (1952); ——, in *Abriss der Vorgeschichte*, K. J. Narr, Ed. (Oldenbourg, München, 1957), pp. 162–218.
67. This does not exclude, of course, the possibility of a distinct older, or also contemporary, human immigration.
68. The rather quick regression at the time of the Valders readvance (Fig. 1) would probably make a shore area over larger distances in Central America available; such an area would for a time at least be less densely wooded and would permit easier migrations by animals and hunters than would the interior.
69. E. W. Haury, *The Stratigraphy and Archaeology of Ventana Cave, Arizona* (Univ. of Arizona, Tucson, and Univ. of New Mexico, Albuquerque, 1950).
70. M. R. Harrington, *Gypsum Cave, Nevada* (Southwest Museum, Los Angeles, 1933).
71. In reality the geological situation of those finds could rather speak against a greater age, just as the typology of the points found there seems to.
72. H. M. Wormington, *Ancient Man in North America* (Denver Museum of Natural History, Denver, Colo., ed. 4, 1957).
73. In this very generally undertsood term different local traditions would be included here, such as the Scottsbluff-Cody complex or the Plainview aspect, which will not be discussed here.
74. B. R. Butler, *The Old Cordilleran Culture in the Pacific Northwest* (Idaho State College, Pocatello, 1961).
75. H. L. Alexander, *Amer. Antiquity* **28**, 510–528 (1963).
76. Which must also be considered topographically a part of Siberia in this time.
77. W. S. Laughlin, *Science* **142**, 633–645 (1963).
78. It is not possible to discuss details here. However, such an influence would mean that at least some features of shamanism, numerous religious ideas as well as ornaments and artistic conceptions, were transferred from the Aurignacoid units to the Paleo-Indians and from them to the Indians of later times.
79. H. Müller-Beck, in *Handbuch für Urgeschichtes*, K. J. Narr, Ed. (Francke, Bern, in press); K. C. Chang, *Asian Perspectives* **2**, No. 2, 41–62 (1958); *Science* **136**, 749–760 (1962).
80. Even the Aurignacian is not a uniform "culture" but consists of locally restricted industrial subgroups (facies) and must be considered henceforth as a part of the "Aurignacoid complex" (*41*).
81. At least for some time. The groups that made leaf-shaped projectile-points, especially, were pushed to the south. After the introduction of the Aurignacoid technology some groups may have recovered some ground relatively early, even reaching Alaska again in time of still-severe climatic conditions there.
82. It could even be said that from the available evidence, ecological developments included, it would be difficult to explain this similarity in any other way.
83. This of course could have been the case before the ice belt in the south was reopened (*82*).
84. It may be mentioned here that in the Late Upper Pleistocene of Siberia two main traditions are present, from which only one—as represented in Mal'ta—may be considered as in the full sense Aurignacoid and adapted to colder subarctic conditions. The other one, with more bifacial stone-working but a definite strong influence from Aurignacoid technologies—as represented in Vercholensk—is known in slightly better ecological settings (*8*).
85. I thank the many colleagues who allowed me to study their collections in America, the Soviet Union, and Europe for their cooperation, as well as the Deutsche Forschungsgemeinschaft for the support of the studies and journeys from 1960 to 1965 connected with this research. The drawings were done by Mrs. B. Stucky-Böhrs, Bern (artifacts after my pencil originals) and Mr. H. R. Rohrer, Bern (maps and tables).

Current Problems in Particle Physics

Edwin M. McMillan

The title of my talk today is really a little misleading, with its implication that I will speak about some details of particular problems that now concern particle physicists. Actually, I intend to discuss the basic nature and philosophy of particle physics, and to show how particle physicists think and what they are trying to do, with a few current problems outlined as illustrations.

The real revolution in our thinking about particles occurred about 40 years ago, with the coming of quantum mechanics and its offspring, the quantum field theory. It took many years for the implications of these theories to sink into the consciousness of physicists, but now they are part of the essential philosophical background of those who work with particles. Previous to these theories, there was a clear separation between our description of particles (or of material bodies in general) and of the forces that act on them. The motion of a particle, or body, was described by giving its position at every instant of time; the particle was said to be at a given place at a given time, with this place changing as time went on. In contrast to this, forces were described by fields, like the well-known gravitational, electric, and magnetic fields. A field is distributed throughout space, rather than being located at a definite point, and requires a different type of mathematical description.

The quantum mechanics tells us that the position and momentum of a particle can no longer be specified exactly; this fact is familiar in the form of the "uncertainty principle." The position of a particle at a given time must be described by a distribution in space; thus the description of the particle ac-

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