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The Later Pleistocene Cultures of Africa

It was during this time that cultures on the African continent first showed regional specialization.

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From the end of the Middle Pleistocene onward, the cultures of North Africa, in particular of the Mediterranean littoral, show significant differences from those of sub-Saharan Africa. The Sahara itself provided a meeting place for influences from both north and south at times when the climate was favorable to the spread of Mediterranean and savanna vegetation into country that is now desert. In North Africa the cultures often show closer relations with those of the Levant and Europe than they do with those of sub-Saharan Africa, and this is reflected in the terminologies that are used, that for North Africa being in large measure adapted from Europe, that for the sub-Saharan region deriving initially from the South African terminology set up in 1929. This serves to emphasize the isolation and independence of cultures in the Old World at the Paleolithic level (Fig. 1).

During this time the Khoisan, Negro, and Afro-Mediterranean populations became regionally and genetically differentiated. In North Africa the *Atlanthropus* stock was replaced after the end of the Acheulian by Neanderthalers, makers of the Levallois-Mousterian industries who were contemporary with the Rhodesioids in sub-Saharan Africa. Brothwell (*1*) has recently discussed early population change in sub-Saharan Africa, and his interpretation of the distribution of the human populations in the Gamblian Pluvial and the subsequent spread of *Homo sapiens* is shown in Fig. 2. The Kanjera fossil, with an Acheulian industry, is shown as representing a Proto-Khoisan-Negro stock from which both the large Bush type present throughout southern and eastern Africa during the Middle Stone Age and the robust ancestral negroid form became differentiated during the later half of the Gamblian. The Florisbad skull may thus represent an early example of this large Bush stock. By 30,000 to 35,000 years ago the spread of *H. sapiens* genes had brought about the extinction of the Neanderthaloid and Rhodesioid populations.

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The Final Acheulian Cultures

The distribution of the Earlier Stone Age/Lower Paleolithic hand-axe culture shows well which were the most favorable regions for human settlement, if one bears in mind the limitations imposed by man's technical ability, his competence at exploiting his environment, and the sparseness of the population. These regions include most of south and south-central Africa, the winter rainfall zone, the Karroo, and the High Veldt (but not the Low Veldt, which probably supported thicket and *Copaifera mopane*). The desert areas of the Kalahari and Namib, though not devoid of Acheulian industries, are clearly marginal to the main regions. The same aversion to low-lying thicket and wooded areas is found in the northern part of Mozambique and in the Horn, but the more arid areas of the west coast up to central Angola were settled by hand-axe man. The park savanna of the Rift Valley was particularly favorable country, but the lowland and montane forest of the Congo basin and the rain forest of West Africa were not significantly occupied until final Acheulian times. Most parts of the Sahara show that it constituted a very favorable environment for Acheulian occupation (for example, Hoggar, Mauretania, and Ténéré). The Atlantic and Mediterranean coasts, the Nile Valley, and the slopes of the Atlas massif in the Maghreb supported Acheulian hunting bands.

This, then, was the situation when, perhaps 60,000 to 70,000 years ago, a drying and cooling climate began to affect the availability of surface water, bringing about readjustment of the long-established vegetation patterns and, with it, of the food resources, both animal and vegetable, and causing significant alteration in the distribution of the Acheulian hunting populations, in their behavior, and in the long-established pattern of their technology. The temperature curves of Fig. 3 show the changes in climate deduced from pollen evidence at Kalambo Falls and the climatic and cultural correlation with Europe.

In North Africa at about or shortly before this time (or so we think, though as yet we lack dates to confirm this), Acheulian man was camped around water holes and springs (at Sidi Zin in Tunisia and mound springs in the Kharga Oasis) (Fig. 4, top). In the Sahara, communities of later Acheulian hunters had been sharing the resources of a lakeside life, an environment that represented a southern expansion of the Mediterranean flora, with elephant, hippo, and other large mammals of the

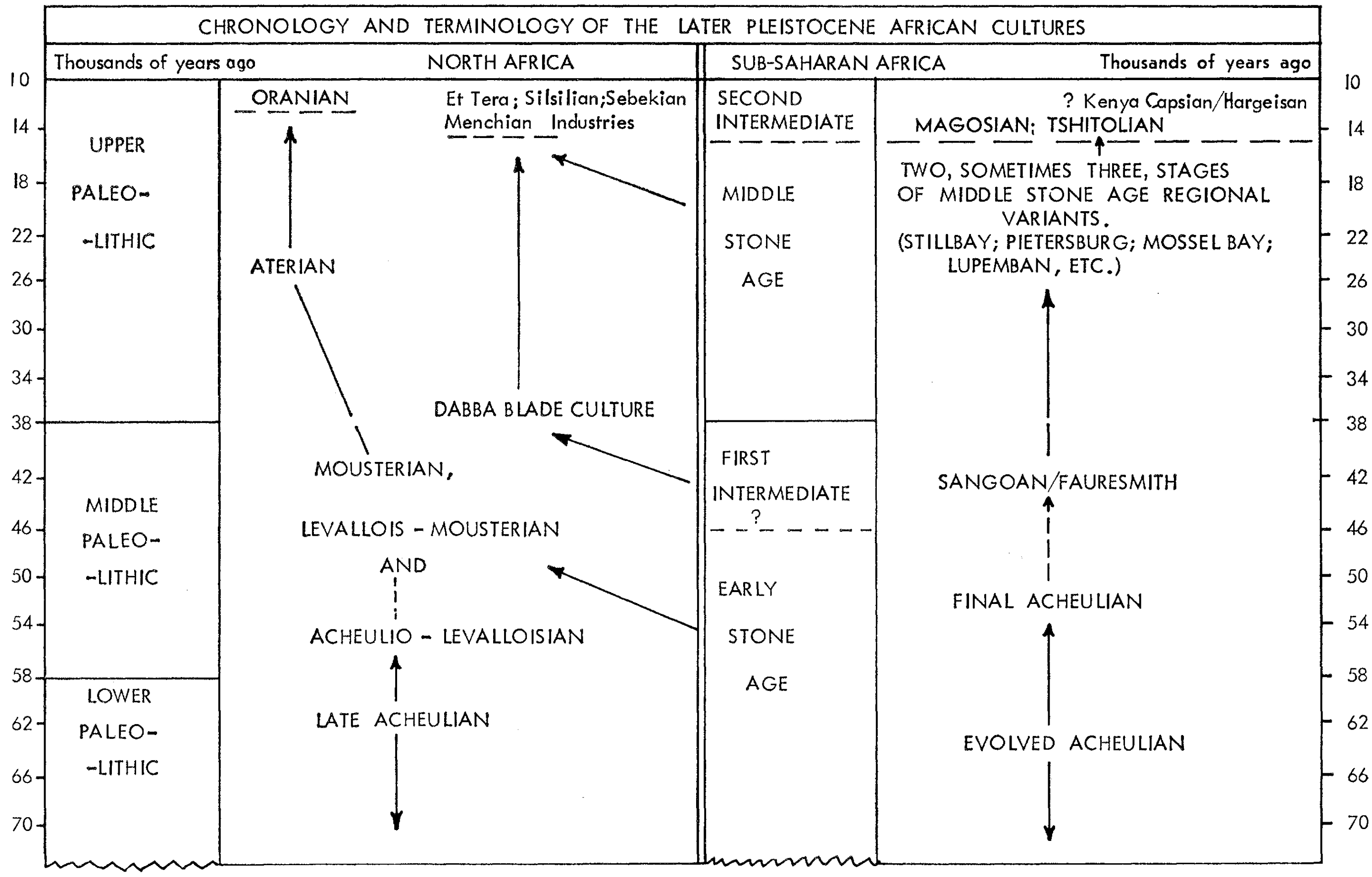


Fig. 1. Cultural terminology for the African Later Pleistocene.

Ethiopian fauna, together with some Eurasian mammals such as *Bos primigenius* and *Megaceros*, at such sites as Erg Tihodaine, northwest of the Hoggar (*2*), and Adrar Bous in Ténéré (*3*). This occupation is generally assumed to antedate such sub-Saharan late Acheulian sites as Kalambo, Isimila, and the Cave of Hearths. However, we are now by no means certain that it does, since the presence of the Eurasian faunal species indicates that these sites might, in fact, date to the time of one of the warmer interstadials of the early Würm glaciation, such as that which produced the warm, subhumid or humid climate evidenced by the earlier of the two stages of wadi filling in coastal Cyrenaica (*4*). The phase of increasing aridity which brought to an end the Acheulian occupation in the Sahara would then be the equivalent of the cooler, later phase of wadi filling in Cyrenaica.

A late stage of the Acheulian at Kalambo Falls has been dated at 57,600 ± 750 years ago—at about 55,650 B.C. (radiocarbon sample GrN 2644). The climate at Kalambo at the time (Fig. 3) is shown from the pollen spectra to be the same as, or rather warmer and drier than, the present climate, with a rainfall of 75 to 100 centimeters, some 25 to 35 centimeters lower than at present. This date would place the close of the Acheulian here as the equivalent of the Brörup interstadial of the early Würm glaciation in Europe. Of similar age is the occupation of the small lake basin at Isimila in central Tanganyika.

Bond (*5*, p. 317) has estimated that the rainfall in late Acheulian times at Lochard on the Zambezi-Limpopo watershed in Rhodesia was about 64 centimeters a year—a little over half what it was during the main Acheulian. In eastern Bechuanaland the rainfall is estimated to have been 25 to 30 centimeters immediately prior to the appearance of the Sangoan culture (*5*, p. 325). In Angola and the southern and western Congo generally, the deeply weathered and lateritized rock on the slopes of the valleys was denuded of the soil and thick vegetation cover under which this long weathering process developed; the area was occupied by small groups of Acheulian peoples. The same evidence is present also in southwestern Uganda, where the M/N horizon contains a very rich assemblage of final Acheulian (for example, at Nyabusora) and mixed Acheulian and Sangoan industries (for example, at Nsongezi) (*6*, *7*).

On the Jos plateau in northern Nigeria the late Acheulian is the earliest industry that occurs with any certainty in the former area of rain-forest distribution, the assemblages coming, as in most parts of southern and central Africa, from the basal sediments which fill the channeling that initiated the Last or Gamblian Pluvial. Acheulian culture now also spread to the formerly unoccupied parts of the Horn and is found at sites overlooking the coast of the Gulf of Aden.

On the whole the tool kit was fairly generalized, and the range of specialization was small. The tools were the hand axe, cleaver, and bifacial knife; a variety of small, informal, light-duty tools for scraping, boring, and grooving, made on flakes, flake fragments, and chunks; and a group of heavy-duty tools such as picks, choppers, and scrapers, polyhedral stones, and other crude bifacial and large flake tools. There is, however, some significant variation in the quantitative occurrence of the different forms which points to some specialization in the activities of the group (*8*). It is difficult at this time to see any regional significance, though it may be that when the results of systematic studies of edge-wear patterns are available they may reveal the existence of important functional differences between industries in what are today very different types of environment.

The concentration of artifacts and associated occupation waste on the living floors shows that the groups that lived on some of these sites may have numbered as many as 20 individuals. Other sites are known which cover only a square meter or so (Broken Hill; Elsworth's Brickyard at Gwelo) and represent only a temporary flaking floor or stopping place for a single group.

The camping places were always close to permanent water, and it would seem that it was not until the time of the Final Acheulian that man was in a position to occupy caves and rock shelters. A feature of these open sites where fauna is preserved is often the quantity of broken animal bones, mostly from medium- to large-sized antelopes or bovids. It is by no means uncommon, however, to find butchery places where animals such as elephants, hippos, giraffids, and other large creatures had been dismembered. While the human inhabitants must have taken advantage of deaths from natural causes, it is probable that they had become sufficiently expert at group hunting to drive, corner, and dispatch the sick or young of these large species (*9*).

The Acheulian populations were, thus, unspecialized hunters and gatherers who made unselective use of a variety of animals and, it may be inferred from the habits of the present-day Bushmen, of vegetable foods also. Some of the Acheulian occupation floors at Kalambo Falls preserved fruits, nuts, and seeds from local trees that fruit in the dry winter months of May to October. Such fruits, nuts, and seeds are still collected by the existing Bantu peoples; there can be no doubt that they were also eaten and used by Acheulian man, and such finds show also that these waterside sites were probably occupied during the latter part of the dry season.

If climatic factors were responsible for the readjustment of the distribution of the human populations at this time, it was the technical advances, which now make their first appearance, which permitted man to exploit more fully the resources of his environment, especially where occupation of different eco-

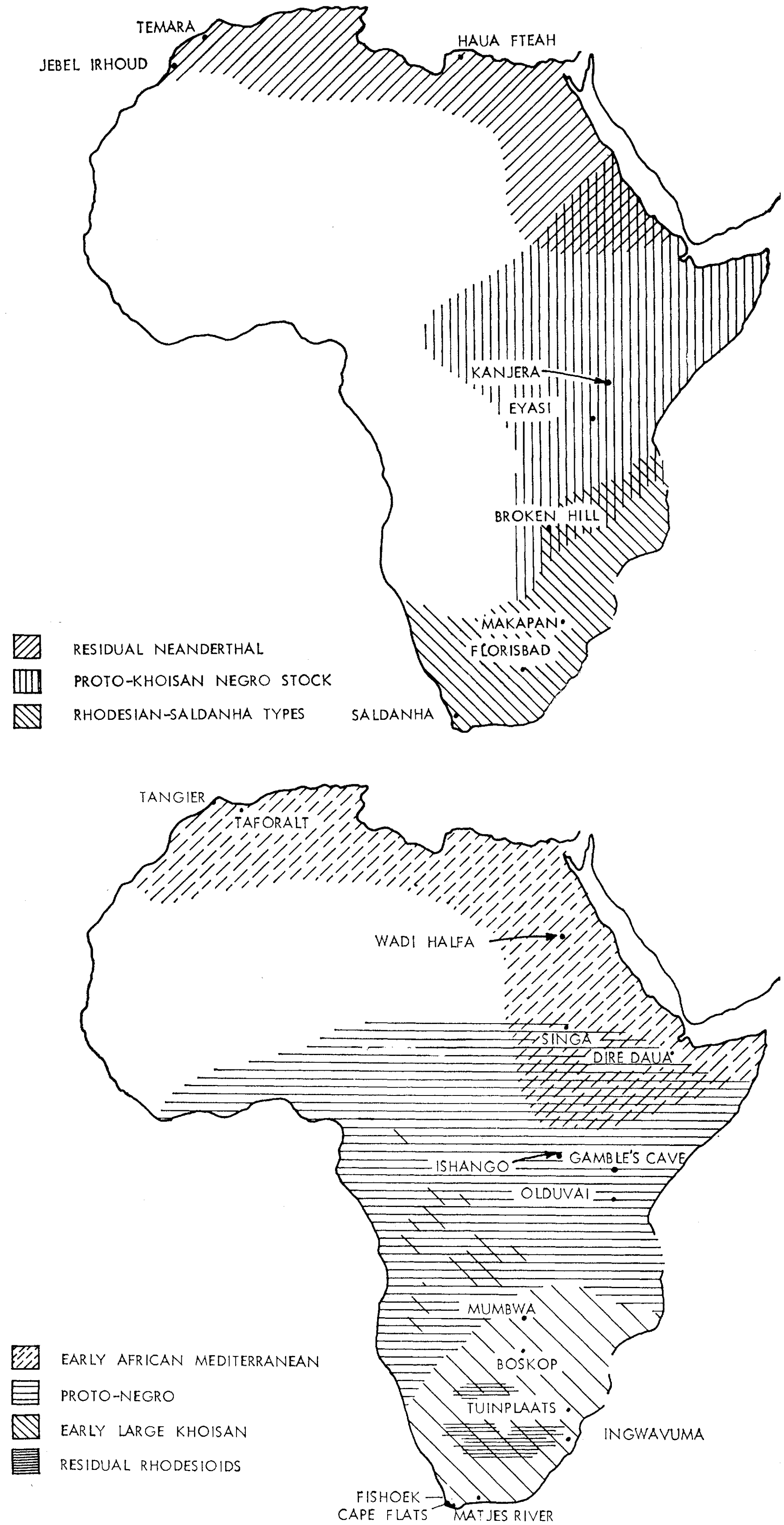


Fig. 2. The human population in Africa during the Later Pleistocene: (top) before 25,000 years ago; (bottom) between 25,000 and 10,000 years ago. [After Brothwell, 1963]

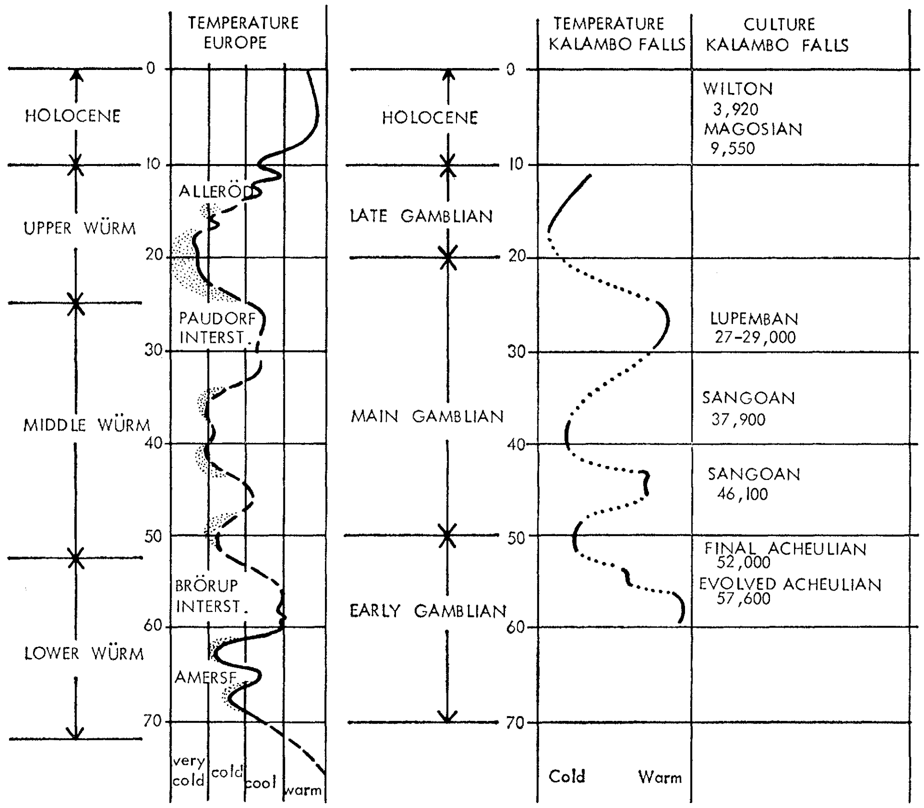


Fig. 3. Comparison of the Last Glacial climatic changes in western Europe and at the Kalambo Falls. [After Clark and van Zinderen Bakker, 1964]

systems encouraged him to experiment. The most important of these innovations was the regular use of fire, for which there is no record in Africa prior to this time. By the protection it gave, firemaking enabled man to occupy caves and rock shelters, and some of the most important cultural successions are found at such sites (Figs. 5 and 6). By enabling man to work wood and its byproducts more efficiently, the use of fire permitted the manufacture of containers and utensils for food and, particularly, water, thus releasing man from his reliance on a waterside habitat. The use of fire also enabled him to improve his hunting techniques and equipment and, by ensuring warmth and hot food, encouraged the formation of larger and more closely knit social groupings.

At Kalambo Falls are preserved several sticks with one end obliquely truncated by charring. These are believed to have been digging sticks. Also found here were a short, knobbed implement, probably a throwing club; several short single- and double-pointed tools; and an object which is perhaps a fragment of a spear point (Fig. 7*b*). The wooden spear is known from at least two earlier sites in Europe [Clacton-on-Sea (England) and Lehringen], so there is no reason to doubt its use in Africa also at this time.

A rough semicircle of stones on one of the Kalambo floors (*B*/59 floor 5) may possibly have formed the base of a structure of some kind, perhaps a windbreak. Further evidence for dwelling structures now comes from Arkin, near Wadi Halfa in the Sudan (see *10*).

The final or transitional Acheulian occupation at Kalambo Falls is contemporary with the very beginning of the main Gamblian Pluvial and has now been assigned an age of greater than 52,000 years. Somewhere, therefore, between 70,000 and 50,000 years ago the old Acheulian hand-axe culture underwent considerable metamorphosis and was replaced by new cultural traditions of a very different kind, based upon the use of the prepared-core technique.

Africa North of the Sahara

In North Africa the final Acheulian was replaced by industries of Levallois-Mousterian type based on the production of light, thin-sectioned flakes and flake-blades made both from discoid cores and from small prepared cores showing Levallois technique. In Cyrenaica, industries of this kind made their first appearance in the earlier period of wadi filling. Near the base of these deposits at Hajj Creiem in the Wadi Derna, McBurney (*4*, p. 142) found a hunting camp that contained the remains of between 11 and 18 individual animals which had provided food for the hunters. Of this meat, 97 percent came from four species—Barbary sheep (49 percent), zebra (20 percent), buffalo (14 percent), and land tortoise (14 percent)—indicating a selectiveness not shown at the earlier Acheulian sites. The tools comprised scrapers of various kinds (single- and double-sided and convergent) as well as some points and were made from flint that had been carried inland a distance of 6 to 8 kilometers from the seashore.

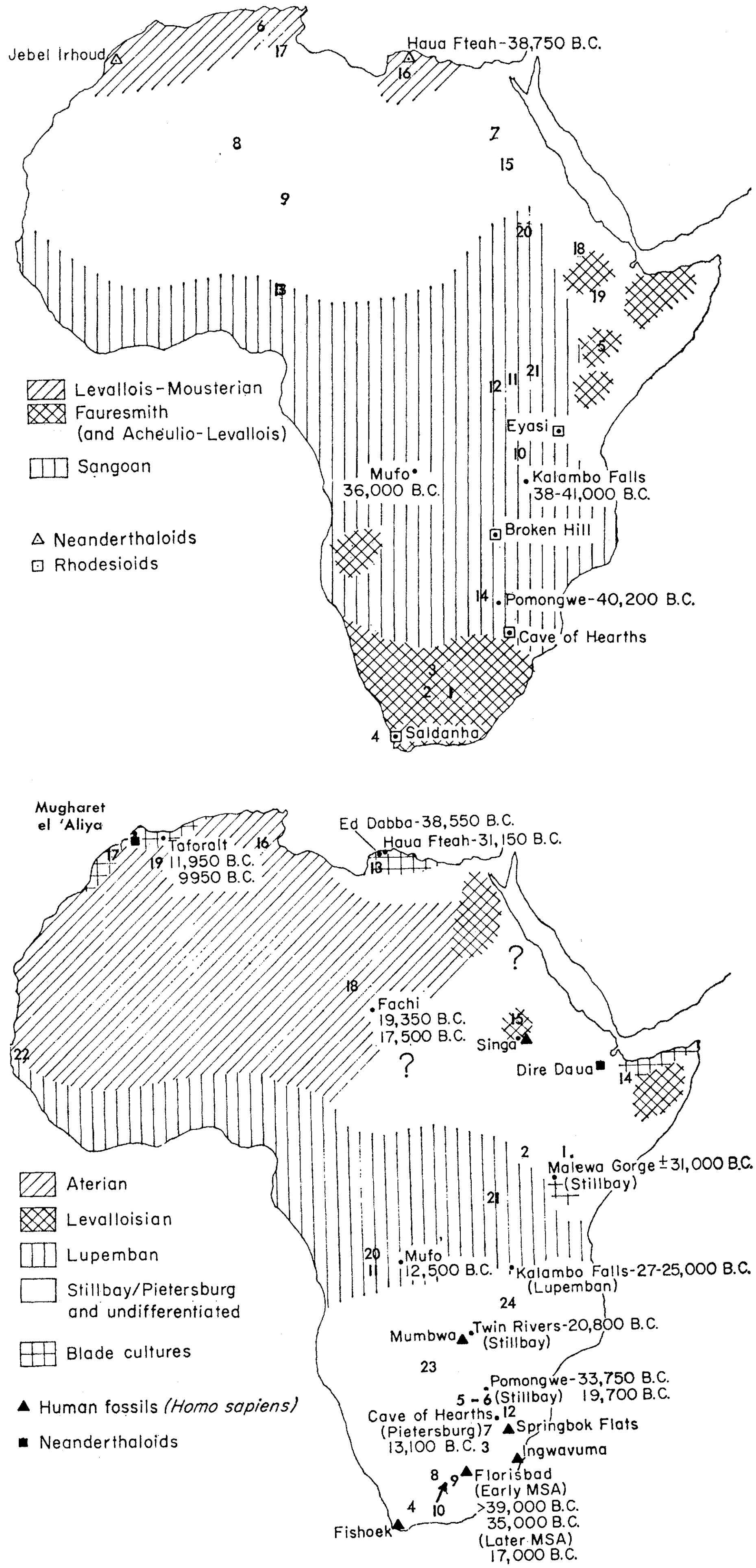
The cave of Haua Fteah in the Gebel Akdar (*11*) also contains thick accumulations of red, sandy loam with a Levallois-Mousterian industry, and from one of the upper layers comes a fragmentary jaw of a juvenile Neanderthaler which is dated at 38,750 B.C. ± 500 years.

A preponderance of cutting and scraping tools is characteristic of the Mousterian cultures of Eurasia, and there is a particularly close similarity between these Cyrenaican industries and industries in Palestine and Jordan. The faunal exchanges indicate that the desert was no barrier to animal migration at this time, and neither, it would seem, was it a barrier to the human populations; the movement was probably in both directions.

The sudden replacement of the Acheulian by the Levallois-Mousterian is seen by McBurney as indicative of a stage of rapid technical advance in North Africa, whence the new technology spread to southwest Asia, where the Acheulian was replaced by local industries (Jabrudian and others) which resemble the European "Mousterian of Acheulian tradition" and which were replaced, in turn, by the Levallois-Mousterian. Since the Neanderthal stock appears to be intrusive into North Africa, I consider it more probable, however, that the main stream of movement was in the other direction from southwest Asia into north and northeast Africa—but additional age determinations are needed before we can be certain on this point.

In the Maghreb, the industry of this time more closely resembles the European "Typical Mousterian." It is best seen from the newly discovered site at Jebel Irhoud in Morocco, where it is associated with hearths, charred animal bones, and two Neanderthal

Fig. 4 (right). (Top) Distribution of Levallois-Mousterian, Sangoan, and Fauresmith cultures (Upper Pleistocene). 1, Fauresmith; 2, Barkly West; 3, Kuruman; 4, Montagu; 5, Mega; 6, Sidi Zin; 7, Kharga; 8, Tihodaine; 9, Adrar Bous; 10, Isimila; 11, Nyabusora; 12, Nsongezi; 13, Jos; 14, Gwelo; 15, Arkin; 16, Hajj Creiem; 17, El Guettor; 18, Gondar; 19, Melka Kontoure; 20, Khor Abu Anga; 21, Sango Bay. (Bottom) Distribution of Upper Paleolithic and Middle Stone Age (MSA) cultures (Upper Pleistocene). 1, Gamble's Cave; 2, Magosi; 3, Primrose Ridge; 4, Stillbay; 5, Tshangula; 6, Bambata; 7, Pietersburg; 8, Kimberley; 9, Mazelspoort; 10, Mossel Bay; 11, Chambuage; 12, Kalkbank; 13, Et Tera; 14, Hargeisa; 15, Abu Hugar; 16, Bir-el-Ater; 17, Dar-es-Soltan; 18, Wanyanga; 19, Ain Meterchem; 20, Lupemba; 21, Ruwindi; 22, Dakar; 23, Sambio; 24, Luangwa. [After Clark (22)]



crania. Similar industries are known from coastal and plateau sites in Algeria (12), and from the spring site of El Guettor in southern Tunisia comes a very rich industry associated with a pile of large, carefully rounded stone balls (13). Such artifacts have been variously described as the heads of throwing clubs (the stone being enclosed in, and attached to the shaft by, a greenhide sleeve) or as the stones of a bolas on the South American pattern. They are characteristic tools of the populations south of the Sahara during Gamblian times. That man was experimenting with hafting tools by this time is also indicated by the presence of one tanged flake at the El Guettor site.

In the Nile Valley and the Horn the Acheulian hand-axe tradition did not die as quickly as it did in the Mediterranean basin, and in those regions the earliest industries combine features and techniques of both the old and the new traditions, suggesting that the one derives more gradually from the other. These are known as Acheulio-Levalloisian industries, and from the Ethiopian high plateau, near Gondar, comes a similar industry in lava (14). These Somaliland industries represent the earliest evidence of occupation of the Horn, though a presumably older Acheulian industry has recently been found at Melka Kontoure in the Ethiopian Rift east of Addis Ababa (15).

These Acheulio-Levalloisian industries were replaced in northeast Africa by a Levalloisian or Levallois-Mousterian industry consisting mostly of ovoid, long, quadrilateral and subtriangular flakes with multifaceted striking platforms struck from Levallois cores and showing minimal retouch of the edges.

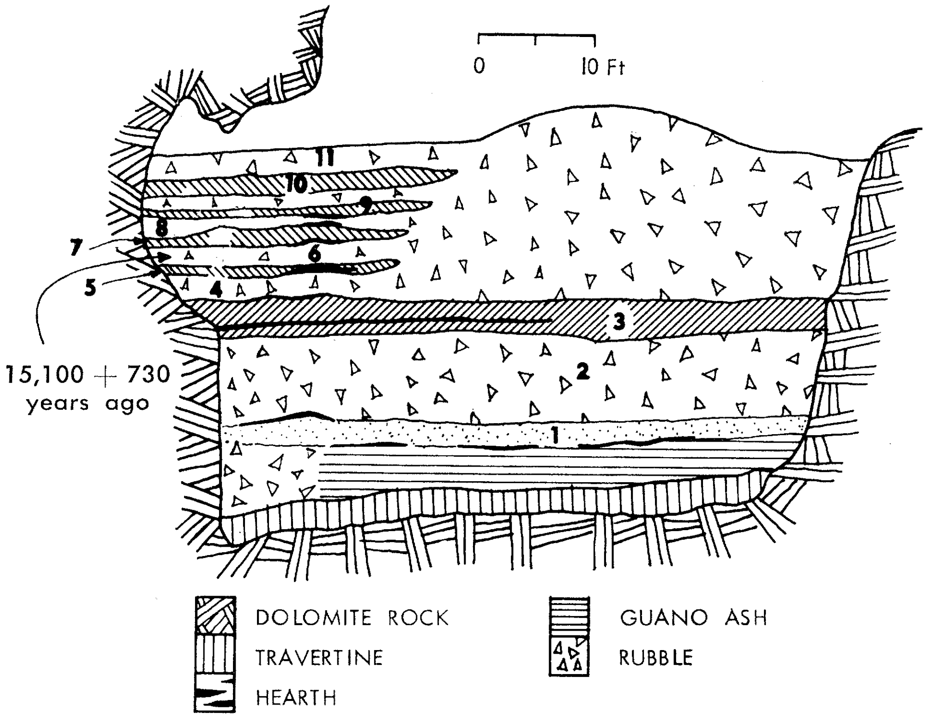


Fig. 5. Stratigraphic and cultural succession at the Cave of Hearths, northern Transvaal: 1–3, Earlier Stone Age (Acheulian Fauresmith); 4–9, Middle Stone Age (Pietersburg); 10, Later Stone Age (Smithfield); 11, Iron Age. [After Mason (*23*)]

Two main stages have been recognized, the chief characteristics being the "informal" nature of the flake cutting-tools and the apparent absence of any heavier equipment. However, some of the Levallois-type cores show retouch, which suggests that they may also possibly have served a secondary purpose, as did the discoid cores in sub-Saharan Africa, as adzes or bifacial scrapers.

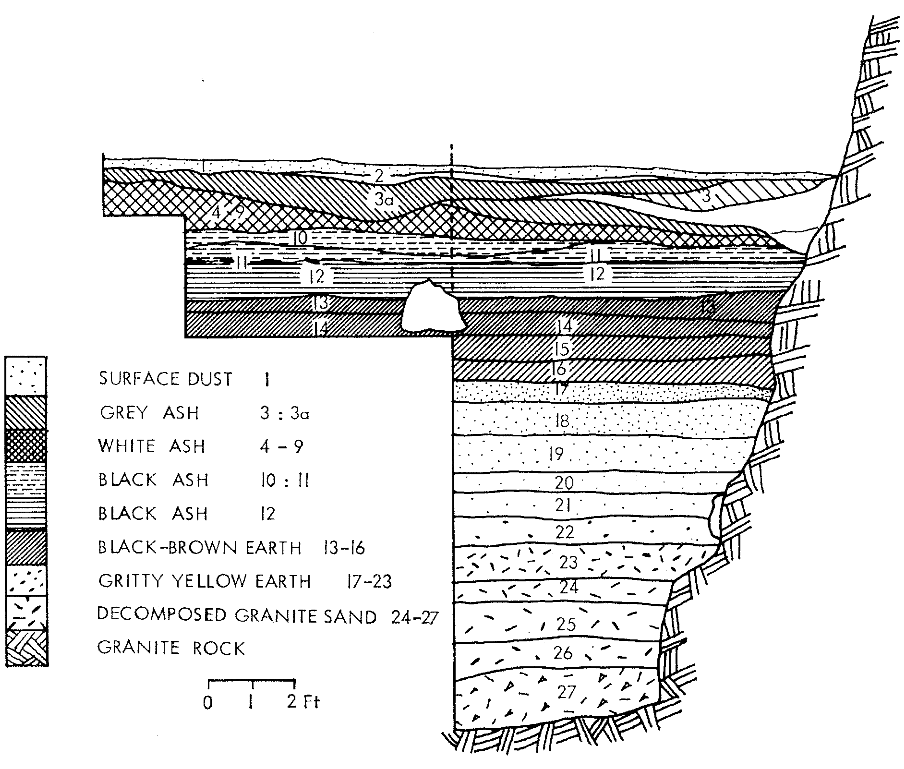


Fig. 6. Stratigraphic and cultural succession at Pomongwe Cave, Matopos Hills, Rhodesia. Culture layers: 10–12, Magosian (15,800 ± 100); 13–21, Stillbay (21,700 ± 400 to 35,750); 22–27, Proto-Stillbay (35,750 to > 42,000). [After C. K. Cooke (*27*)]

The Levalloisian light flake-tool element is widely diffused in the northeast and continues into post-Paleolithic times, the size of the tools gradually decreasing until they reach microlithic proportions in the later Sebilian and other "epi-Paleolithic" cultures.

One unusual Levalloisian-type industry is that from Abu Hugar (Fig. 4, bottom) from a deposit contemporary with that in which the Singa skull was found. The contemporary fauna includes the giant buffalo *Homoioceras* (Fig. 8) and a giraffid and may date back to between 20,000 and 30,000 years ago.

In some parts of Nubia, however, the bifacial tool does not completely die out, and the hand axe was replaced by foliate and lanceolate forms recalling the Lupemban tradition of Equatoria. An industry of this type has been described from Khor Abu Anga (*16*), and recent work by expeditions in the area scheduled for flooding by the Aswan High Dam indicates that these bifacial elements are more common there than had previously been realized (*17*) and could thus have provided the ancestral tradition for the bifacial elements in the Egyptian Neolithic cultures.

In the Sahara there is also evidence of the Levallois technique in association with late or transitional Acheulian industries, but thereafter there appears to be a gap in the cultural record until the makers of the Aterian industries spread over most of this region during the main Gamblian stage.

In northwest Africa the Mousterian culture is ancestral to the Aterian complex (Fig. 9). This is a tradition that is now known to have spread throughout the Maghreb into Tripolitania and most of the Sahara southward to its boundary with the West African savanna, and eastward to the western oases of Egypt, such as Kharga, and even to the Nile. The type site is at Bir-el-Ater in southern Tunisia, and it is usually supposed that the Aterian evolved in the Atlas massif and spread later from this homeland into the Sahara. The available radiocarbon dates and analytical studies suggest that this may, indeed, be the case. These industries are based upon the Levallois or prepared-core technique; the flakes often show faceted striking platforms, and most of them have been retouched into side scrapers, end scrapers, and points. The most characteristic feature of the Aterian is the manufacture of a shank or tang formed by retouch from one or both faces at the butt, though the tool itself is more commonly unifacial. The tang was to facilitate hafting, probably in a bone handle or collar, since it was impossible for Paleolithic man, without the aid of a metal boring tool, to make a sufficiently deep socket or sleeve in wood. Many of the tanged tools were scrapers or knives of various kinds, not projectile points as has usually been inferred, though the latter represent an important class of tool and become especially significant in the closing stages of the Pleistocene. In this most evolved phase the points are bifacially retouched, perhaps by pressure ("*pointe marocaine*"), and closely resemble those associated with the Solutrean levels underlying a Magdalenian at the cave of Parpallo in southern Spain, dating back to about 15,000 B.C. (*18*). Bifacial foliate, and lanceolate points and small, hand-axe-like tools are also present in some Aterian industries and are similar to those found with the Middle Stone Age artifacts from south of the Sahara and from Nubia, referred to above.

The Aterian is found at open sites on the seacoasts, and the later Aterian layer at the site of Mugharet el 'Aliya yielded fragmentary human remains (an immature maxilla and a mature canine) which, it is claimed, show a blending of Neanderthaloid and Atlanthropoid characteristics. As yet these are the only human remains definitely associated with the Aterian. Their exact classification is impossible on such incomplete evidence, but they do suggest that the Aterian populations of the Atlas massif still retained some physiological characteristics of the old Paleoanthropoid populations of North Africa.

The cave of Dar-es-Soltan is the only site where the Aterian has been directly dated by the radiocarbon technique. Two Aterian layers are present in this cave, the earlier dating back more than 30,000 years; the later and upper one is less than 30,000, and more than 27,000, years old (*19*).

Aterian groups spread, under favorable conditions, through most parts of the Sahara, and those at Fachi in Tibesti have been indirectly dated at about 20,000 years ago (*20*). At Wanyanga, also in southern Tibesti, Aterian tanged tools are found associated with bifacial foliates and small hand-axe-like forms. A late Aterian is also found in a mound spring at Kharga Oasis with finely made tanged and long, lanceolate forms, and it is probable that it was in fact Aterian influence that gave rise to the tanged element in the Equatorial Lupemban industries referred to above.

The earliest evidence for tangs occurs with Mousterian industries at Ain Meterchem and El Guettor in the Atlas massif, where they are exceptionally rare, and it is possible to see in the prepared flakes with converging side edges at the butt from Jebel Irhoud the original prototype form (*21*). The spread across the Sahara appears to have been a later development which took place only after the establishment of the tradition in the Maghreb—a hypothesis that is suggested also by the radiocarbon dates.

One of the significant technical elements in the Aterian is the bifacial foliate, and lanceolate element. This makes its initial appearance with the cultures of the First Intermediate period in Equatorial Africa and is considered to have been diffused to the Aterian populations in the same way that tanged forms were diffused to Equatoria from the Aterian zone.

Africa South of the Sahara

South of the Sahara the habitats in the Later Pleistocene may be broadly divided into two groups: (i) the forested, forest-mosaic, and more heavily wooded closed-thicket regions—that is the rain forest and "wet" savanna zones—usually, but not always, having today a rainfall of 100 centimeters and over, and (ii) the more open deciduous woodland, park savanna, and grassland, with rainfall usually less than 100 centimeters.

Figure 10 shows the main vegetation and rainfall zones of the continent.

Equatoria and the West African rain forest and "wet" savanna zones. Here the Acheulian is succeeded by a culture tradition known as Sangoan (Fig. 11), and this, in turn, by various industries of the Middle Stone Age which often reflect their Sangoan ancestry. The distribution of these forms covers much of the West African rain forest, the Congo basin, and central Africa west of the Rift Valley. It stretches southward into northern Bechuanaland

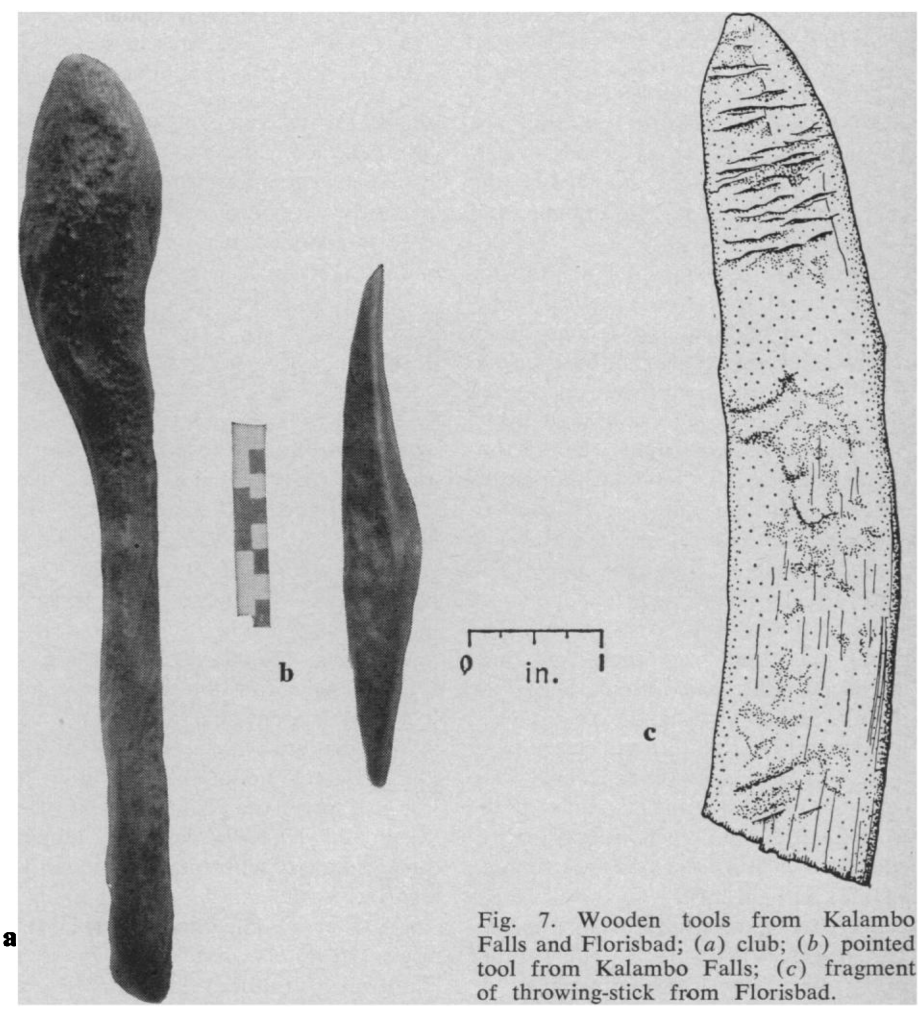


Fig. 7. Wooden tools from Kalambo Falls and Florisbad; (*a*) club; (*b*) pointed tool from Kalambo Falls; (*c*) fragment of throwing-stick from Florisbad.

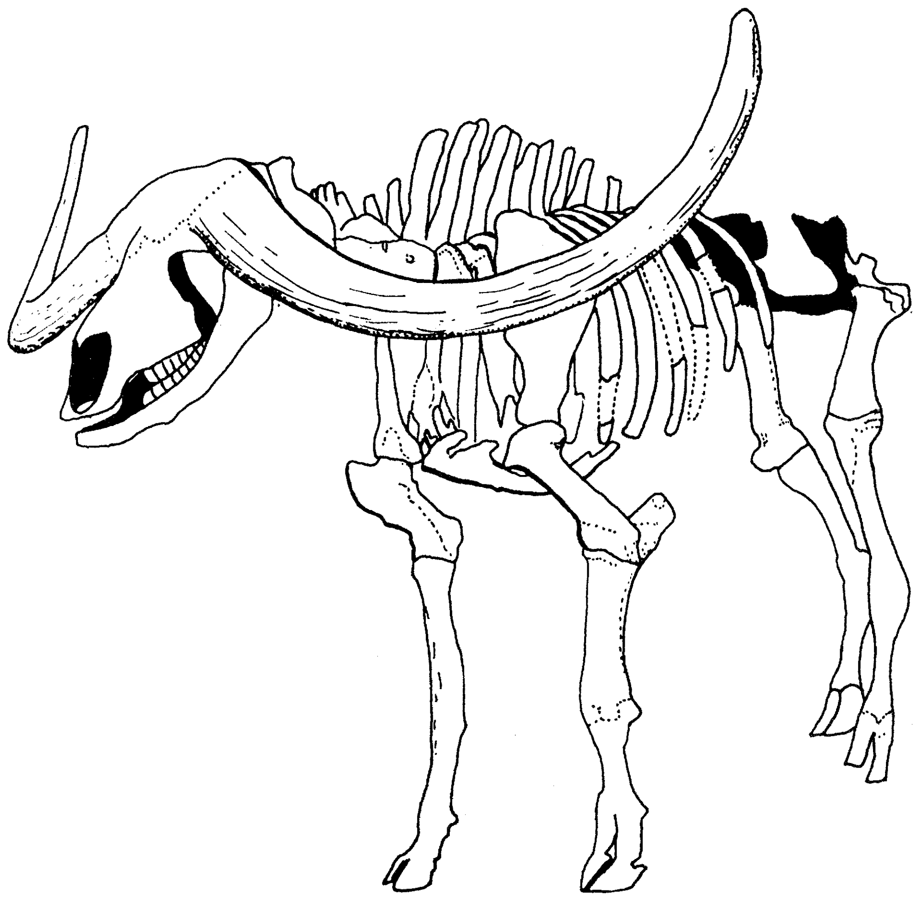


Fig. 8. Reconstructed skeleton of *Homoioceras nilssoni* from Gamblian deposits, Naivasha Rift, Kenya. [After Nilsson, 1964]

and Rhodesia, eastward into southern Tanganyika and the east coast itself, and down the southeast side of the continent to southern Mozambique and Natal.

Some time around 50,000 B.C. or earlier, small groups of Acheulian hunters had penetrated the Congo basin down the corridors of open bush on the Kalahari sands along the interfluves. Soon after becoming established there, the material culture underwent an important change; the hand axe and cleaver elements died out and their place was taken by several crude and heavy forms known as core-axes, picks, and chisel-like bifaces and choppers. A study of the core-axe element leaves no doubt that these were tools for working wood. Core-axes often possess the plan form of the hand axe and are often parallel-sided like the cleaver, but there the similarity ends. They were carefully worked bifacially only at the working end, which was usually rounded, and they were thick and untrimmed at the butt in order to give weight when they were used for adzing and axe work. When they became blunt from use they were sometimes resharpened by removal of a tranchet-like flake from the end (*22*). Commonly associated are polyhedral and more perfectly rounded spheroids, heavy core scrapers, chisels, proto-burins, and numbers of small serrated and notched scraping tools on flakes and chunks. Also present are choppers and, more rarely, pointed, high-backed, pick-like tools.

The Sangoan is named from the type site in the hills above Sango Bay on the west coast of Lake Victoria. It has been assigned a date earlier than 41,000 B.C. at Kalambo Falls and is older than 40,000 years at Mufo. A Sangoan from the lower levels of a cave at Pomongwe in Rhodesia is more than 42,000 years old (Fig. 6). The Sangoan tool kit reflects the technical adjustment that had to be made by populations which were now occupying these regions of interdigitating forest and grassland. They had not been there long before a form of elongated lanceolate tool with bifacial retouch was evolved, which marks the beginning of the earlier Middle Stone Age and the lower stage of what is known as the Lupemban culture, named after the type site near Tshikapa in the Kasai. This stage (Fig. 11) is dated at 38,750 B.C. at Kalambo Falls (Land Surface II) and at 38,000 ± 2500 years at Mufo.

With the lanceolate and core-axe forms at Kalambo Falls are probably associated large parallel-sided blades and broad flakes with faceted striking platforms. The prepared-core technique is, however, rare in the Congo basin until the later stages of the Lupemban. In these later stages, usually found on temporary land surfaces within the redistributed sands on the flanks of the valleys, we see some of the finest examples of Paleolithic stoneworking in the continent. Symmetrical-, parallel-, and biconvex-sided core-axes with axe-, adze-, and gouge-type working ends are associated with often very finely made, lenticular-sectioned lanceolates worked by a controlled form of free flaking probably done with a punch. In the latest Lupemban stage in the Congo basin, fully bifacial, tanged forms make their appearance. This stage has not yet been dated, but it is certainly no later than 11,000 B.C. and probably lies between 15,000 and 11,000 B.C. at a time when Lupemban and Aterian populations may well have been in contact in the eastern and southern Sahara.

Lupemban industries are also found in the Lake Victoria basin (in Kavirondo and the Kagera drainage), the Lake Kivu area (Ruwindi), and probably the whole of the Lake Tanganyika drainage—all habitats similar to that of the Congo, a combination of forest and open bush with adequate rainfall and shorter dry seasons.

The Sangoan culture provides the earliest evidence of widespread distribution of population in the West African rain-forest zone. There is some slight evidence of a Lower Lupemban (Kalinian) stage, but the main Middle Stone Age industries of this region appear never to have developed the degree of specialization found in the Upper Lupemban of Equatoria, although, as yet, they are imperfectly known. Sangoan/Lower Lupemban influence can be seen to have reached Dakar in the west, and more generally to have reached the northern limits of the Guinea-type savanna at approximately 15° north latitude. However, in the east the Sangoan/Lupemban tradition is found in the Nile Valley as far north as Nubia, showing, that during the Gamblian, the Equatorial climatic zone extended further to the northeast and included much of the southern part of the Sudan.

Outside the Congo drainage, in the drier woodland habitats, industries of Lupemban type are found, but they do not usually show the degree of specialization exhibited by those within the Congo. Instead, they preserve the ancestral Sangoan form, so they have often been referred to as Upper or Later Sangoan. Industries of this type are known from the northern part of South West Africa (Sambio and Pepperkoraal), from the upper and middle Luangwa River, from northern Malawi, and even, perhaps, from as far south as Johannesburg, an area where the Primrose Ridge Middle Stone Age industry has been described as an incursive Later Sangoan or Lupemban (*23*, p. 232).

The most characteristic tools in these industries are unifacial and bifacial core-axe forms of Sangoan and Lupemban type and, more rarely, lanceolates.

Elsewhere, in the savanna with a long dry season, as in Zambia, Rhodesia, Bechuanaland, Mozambique, and Natal, the ancestral Sangoan form sometimes persists into the earlier part of the Middle Stone Age and heavy core-axes, some picks and hand axes, and numbers of informal flake-tools, often with denticulate edges, are usual. In Bechuanaland and south of the Zambezi, rare cleavers also occur, and the technical differences between the Sangoan and Fauresmith are minimal.

The dry savanna and high grassland zones. The high, well-watered grasslands of Ethiopia and East Africa and of South Africa west of the Great Escarpment formed by the Drakensberg Mountains and their extensions supported, in the earlier part of the Gamblian, industries that retained many of the features of the late Acheulian. The essential nature of this habitat, which, in the Karroo, South West Africa, and the Kalahari, had at best only a semiarid climate, seems to have been that it was open but not particularly dry and that it supported large herds of game. The populations living there were thus able to continue the old Acheulian way of life and to improve upon it, with the added technical advantages that became available at this time.

These industries can best be compared with the Mousterian of Acheulian tradition of Europe or the Jabrudian of the Levant, and, indeed, they belong to approximately the same period. They constitute what is known as the Fauresmith culture, after the town of that name in the Orange Free State in the vicinity of which the characteristic artifacts were first recognized (Fig. 12).

At least two stages of the Fauresmith are found stratified in the Vaal basin near Barkly West (Neumann's Pont site, River View Estates). It is common generally in the eastern Free State and Basutoland, where the sites are frequently sealed by accumulations of red sand (*24*). Saldanha man at the Cape was the maker of industries of Fauresmith type and is associated with one of the best-known faunal assemblages of this time (*25*). In the Transvaal, caves were first occupied, as distinct from visited, in terminal Acheulian and Fauresmith times. The Cave of Hearths, Makapansgat, preserves in some 9 meters of brecciated deposits (Fig. 5) the evolutionary development of the Fauresmith out of the Final Acheulian (*23*, p. 159). In the northern Cape, the Fauresmith is the earliest culture present in the Wonderwerk Cave at Kuruman, and in the southwestern Cape, Montagu Cave, in process of being excavated by C. M. Keller, preserves a succession similar to that at the Cave of Hearths.

The Florisbad skull from the lowest peat layer at the thermal spring of that name also dates back to this time (about 40,000 years ago). The industry has as yet been only briefly described, but apparently it anticipates the earliest Middle Stone Age in the High Veldt.

Other high grassland areas where Fauresmith industries are found are South West Africa and the East African Rift, notably on the slopes of Mount Kenya and on the Kinangop plateau. One Ethiopian occurrence has already been noted—from Gondar—and a similar industry is present also at Mega in the southwest (*26*, p. 39).

In this region of dry, deciduous

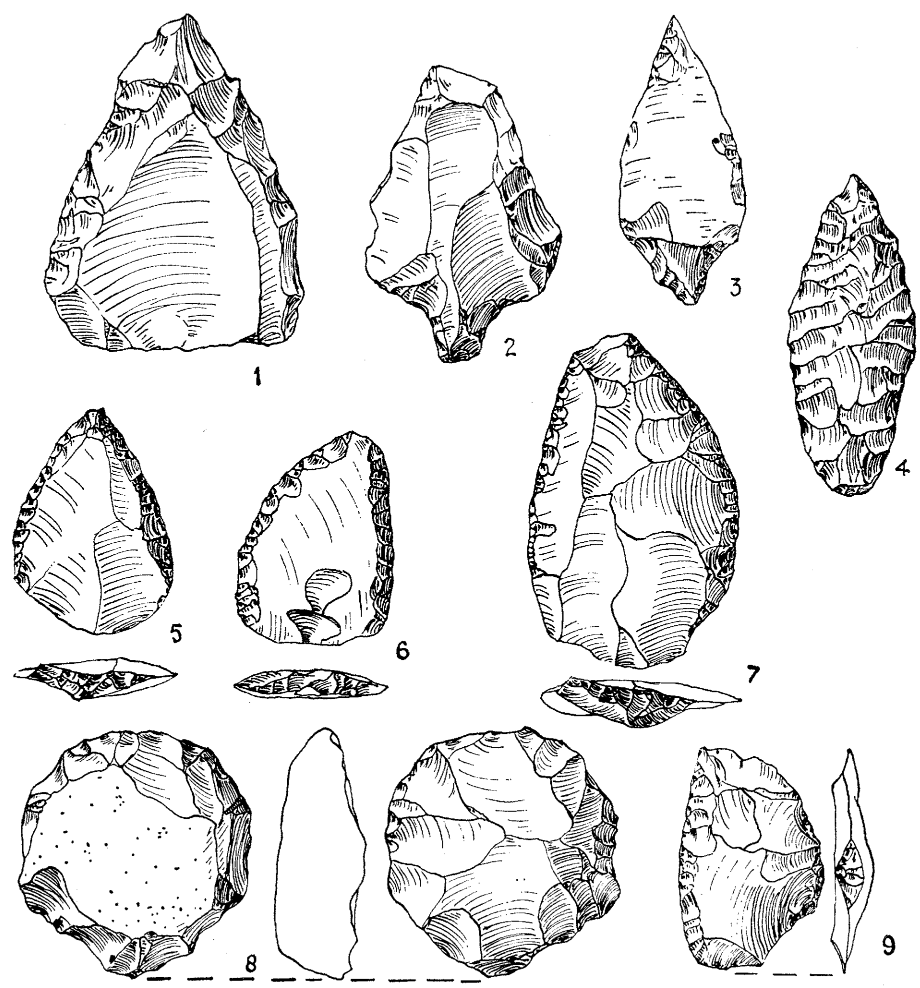


Fig. 9. Implements of the Levallois-Mousterian and Aterian cultures. (1–4, Aterian): 1, subtriangular Levallois core; 2, 3, tanged points; 4, bifaced foliate point (Nos. 1–4, about × 1/2. [After Caton-Thompson, 1952] (5–9, Levallois-Mousterian): 5, 6, "points"; 7, 9, scrapers; 8, discoid core (Nos. 5–9, about × 2/5). [After McBurney and Hey (*4*)]

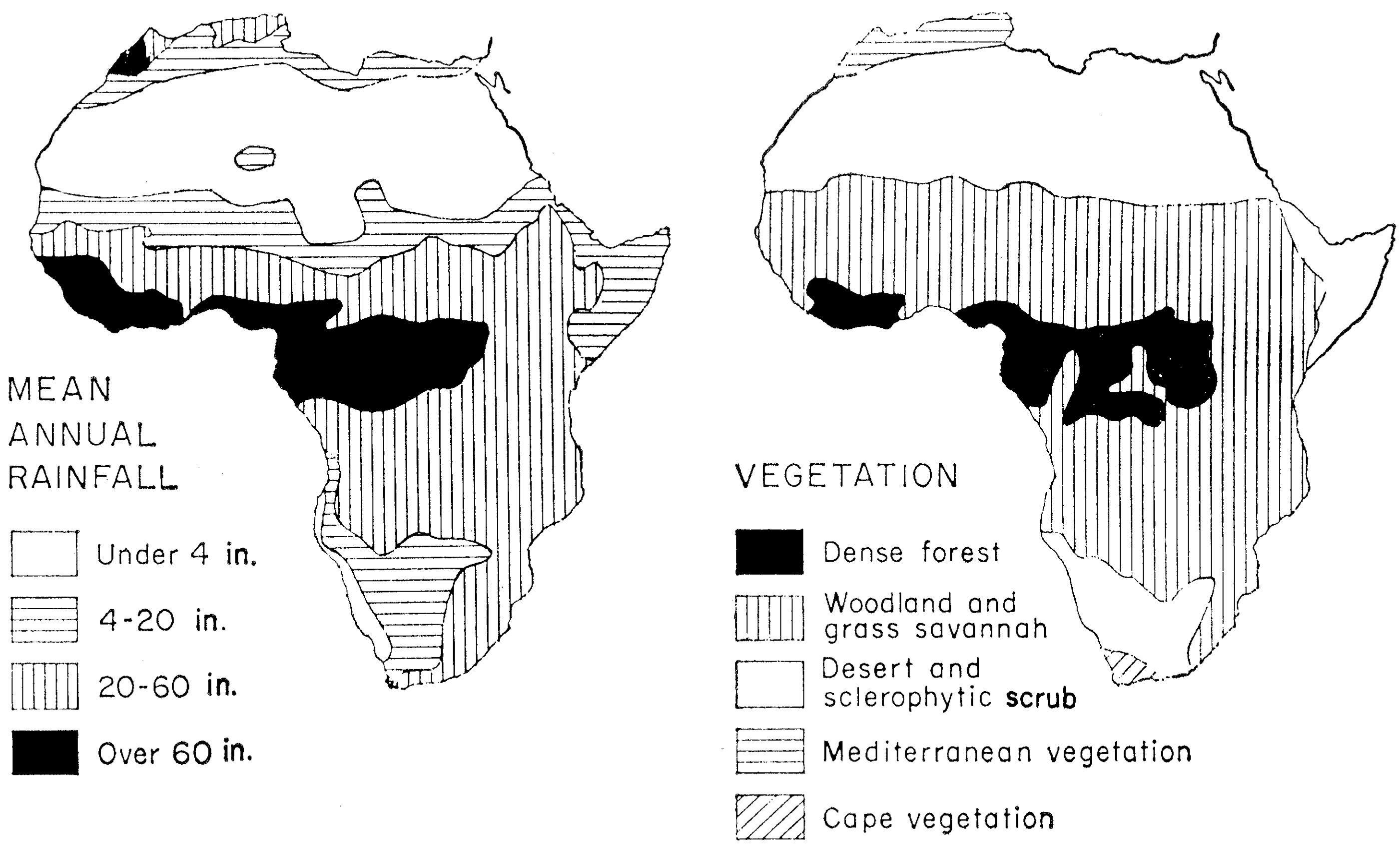


Fig. 10. Main vegetation and rainfall zones in Africa.

savanna and semiarid and high grassland, the Fauresmith evolved into a number of Middle Stone Age variants which are distinguished on the basis of the dominant attributes of their lithic industry (Fig. 12). All of them give emphasis to light equipment, and the only heavy-duty tools are an occasional chopper or grinding or pounding stone. Although behavior based upon the resources of the habitat must have been the underlying factor in determining the composition of the industry, raw material played a major part in fashioning the tradition.

One of the earliest of these Middle Stone Age industries to be recognized was found at the coastal site of Stillbay in the western Cape. The characteristic tools were thin-sectioned bifaced and unifaced foliate points, together with side scrapers and end scrapers made on flakes. The primary technique was based on the prepared core —both Levallois type and discoid—and the points were retouched by controlled percussion flaking. The materials used were mostly fine quartzites (silcrete), chalcedonies, and cherts.

Industries with similar characteristics were later found in other parts of the continent—on the Natal coast, in Rhodesia, Zambia, Kenya, Ethiopia, and the Horn, for example—and they have been described as "Stillbay," being distinguished by the regional prefix (for example, Kenya Stillbay). On stratigraphic grounds they are usually divisible into an earlier, Lower, or Proto stage and a later, Upper, or Main stage.

In Rhodesia the Middle Stone Age development is now well known from a number of cave sites, in particular the important succession in Pomongwe Cave (Fig. 6), where the stages are well dated by the radiocarbon method to between about 33,750 and 19,700 B.C. (*27*). Industries of light flake equipment found stratified below the Stillbay proper in the lower levels of the cave and rock-shelter deposits in Tanzania, Zambia, and Rhodesia, have been described as Proto-Stillbay. The recent work at Pomongwe and Tshangula caves and a review of the Bambata Proto-Stillbay industry (*28*) show that there is, in fact, a small percentage of heavy-duty equipment that links these industries also with the Sangoan. Indeed, at Pomongwe, the basal industry is described as Sangoan-like and dates back, as I have said, more than 42,000 years. Selective collecting on the part of the excavators and differences in activity as between open sites and cave sites may have been largely responsible for obscuring the relationship between the Proto-Stillbay and the Sangoan. The analysis of sites in Zambia (Kalambo Falls; Twin Rivers) also confirms this indivisible association of heavy and light equipment.

There can, thus, be little doubt as to the ancestry of the Middle Stone Age industries in central Africa, some of which preserved, whereas others lost comparatively quickly, these Sangoan traits. The Proto-Stillbay industry associated with *Homo rhodesiensis* at Broken Hill, which is known only from small, selected collections (*29*), might date back more than 40,000 years, while an industry from breccias at Twin Rivers near Lusaka, which combines with the flake and prepared-core equipment some choppers, hand axes, and thick-sectioned, bifacial, lanceolate forms, has been dated to about 20,800 B.C. (*30*). If the date is acceptable, this Twin Rivers industry is, thus, contemporary with a fully developed Stillbay in the Matopos Hills in Rhodesia which has thin-sectioned, laurel-leaf points, backed flakes, burins, side scrapers, and end scrapers.

The Stillbay industries of East Africa

and the Horn are broadly the same as those of South Africa, though different emphasis in one or other form is shown by the varying proportions of the tool classes.

Stillbay forms are found as far north and west as the Jos plateau in northern Nigeria, though here the more specialized end products appear to be absent.

A variant called the Pietersburg, after the northern Transvaal town of that name, is found there and on the plateau in the eastern parts of Natal, in Swaziland, and in the Lebombo Mountains on the border of Mozambique. The three developing stages of the Pietersburg culture that have been recognized from stratigraphical evidence are well known from Mason's work in the Transvaal (*23*, p. 232), and all are present in the Cave of Hearths (Fig. 5). The earliest is estimated to have begun about 37,000 years ago and comprises often large, quadrilateral, subtriangular, and oval flakes, not unlike those from Kalambo Falls. This stage is also distributed further west, as shown by the Koedoesrand site at Kimberley.

The Middle Pietersburg stage is the most widely distributed and is found in a number of caves and rock-shelters. The points are usually made on subtriangular flakes, a common form being unifacial with the bulb and platform carefully removed by flat flaking to facilitate hafting. There are end, side, and hollow scrapers, backed flakes, small core scrapers, well-made spheroids, and rubbing and grinding stones, and utilized, flat, discoid cores are commonly found. The raw material was usually felsite or indurated shale.

In the Later Pietersburg stage the tools are smaller; short and broad subtriangular points, unifacially worked, are common, as also are ribbon-like blades, sometimes with retouch. The most characteristic primary technique is still that of the prepared core, though blade cores now make their appearance.

Two other Middle Stone Age variants have been recognized in South Africa. The one, based upon the exclusive use of indurated shale, is found in the Orange Free State and is known as the Mazelspoort Variant (Fig. 12). The other, based upon the use of hard quartzite, is found in the southern mountain region of the Cape and is called the Mossel Bay Variant (Fig. 12). The Mazelspoort industries are characterized by blade-like flakes, and the Mossel Bay Variant contains some rare, hollow-based points. In the western Cape, tanged forms similar to the Aterian forms are found with the Stillbay, and shanked forms of unifaced point are also, though rarely, present in the Later Pietersburg industries in the Transvaal; such findings indicate that these and other implements must have been regularly hafted by this time.

All these Middle Stone Age industries are regionally specialized, depending often on one or two main animal sources of food. Some of them were occupying new territory, and even those occupying the traditionally favorable habitats were more numerous than before. The populations who made these industries, although receptive to the transmission of technological improvements or of new, improved ways of getting food, were, nevertheless, sufficiently isolated to develop independently, both physiologically and culturally.

Behavior Patterns and Technology

Less is known about distribution of the occupation materials on the living sites of Middle Stone Age times than is known for Acheulian times. Most of the sites that have been excavated are caves and rock-shelters, and the scat-

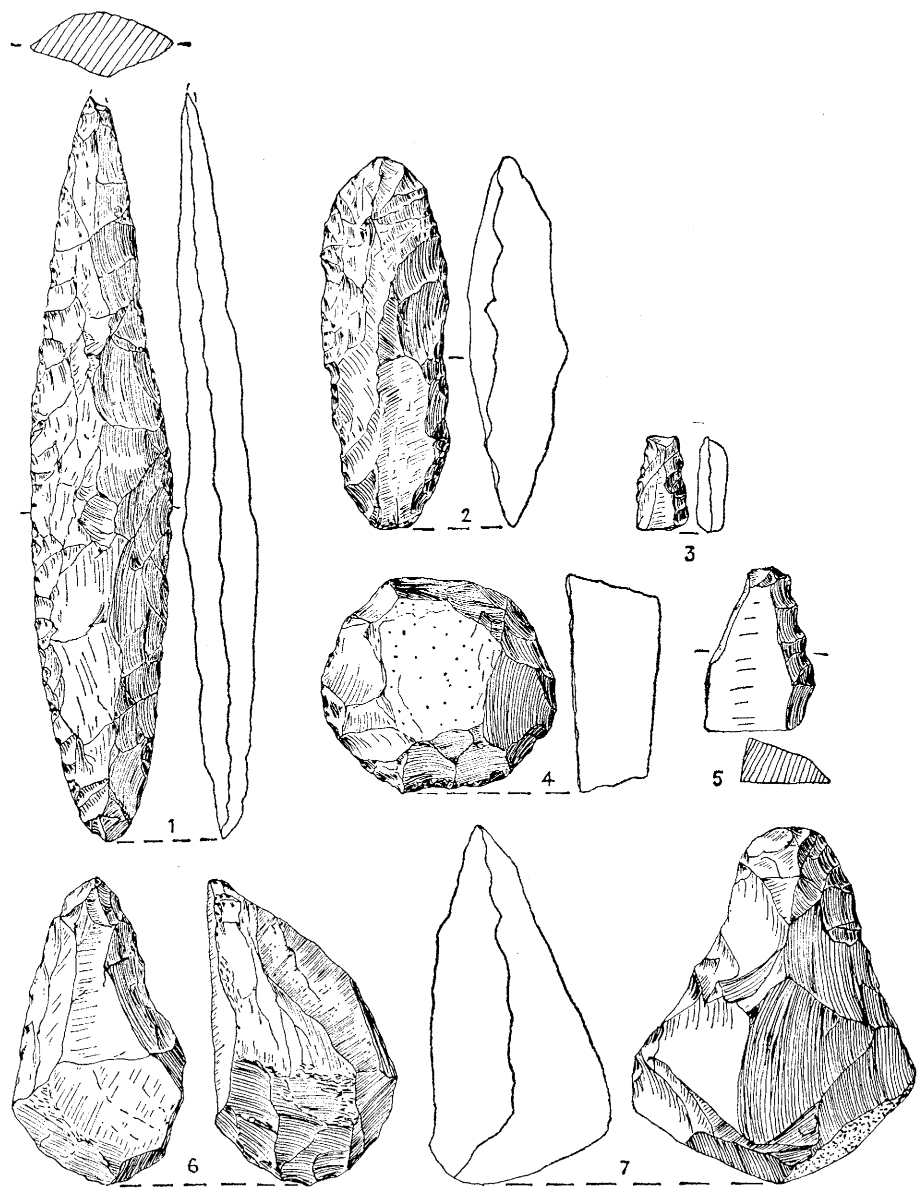


Fig. 11. Implements of the Sangoan and Lupemban cultures. (1, 2, Lupemban): 1, lanceolate; 2, core-axe. (3–7, Sangoan): 3, 5, small denticulate tools; 4, core scraper; 6, pick; 7, core-axe. (No. 2, about × 1/4; Nos. 1, 3–7, about × 1/5) [No. 2, after Alimen, 1957; Nos. 1, 3–7, after Clark (*22*)]

ter patterns have rarely, if ever, been recorded. The only open site that is also a living site which has provided a partial floor pattern is Kalkbank in the Transvaal, excavated by Mason (*31*). Here a group of Later Pietersburg hunters, living by a pan, or depression, in typical "bushveld" country, had piled up the bones of the animals they killed, which included a large zebra, the buffalo *Homoioceras*, a large hartebeest, and warthog. Hunters of the Middle Stone Age cultures in southern Africa almost invariably obtained their regular meat supply from a few species of animals—notably pig, zebra, wildebeest, and hartebeest—thus showing that man was now a specialized predator. In addition, the depths of deposit in the caves and rock-shelters show that he now used permanent camping sites to which he returned with regularity. At some of these places burials have been found, both in caves and at open sites.

There is little evidence of any artistic ability such as is shown in the Franco-Cantabrian art of western Europe, but the regular presence of rubbed and faceted pieces of red and yellow ochre, hematite, and other minerals indicates that paint was, nevertheless, used, no doubt for decoration of the body and of an individual's personal belongings.

The stone equipment is of two kinds —heavier-duty tools such as axes and adzes, core scrapers, and choppers, usually present in quantity only in regions of heavier vegetation, and light equipment consisting of projectile points and knives of various kinds, carefully rounded stone balls, grooving tools, borers, chisels and scrapers with regular retouch (suggesting use on skins), and denticulated or notched chisels and scrapers (suggesting use on wood or bark). There is little doubt that many of the tools were adapted for hafting, presumably with the use of mastic. In addition to the tanged Aterian implements, the sub-Saharan Middle Stone Age industries not uncommonly show tools with evidence of careful retouch to remove the bulb and striking platform and sometimes to form a shank. Such tools were presumably mounted as spears or darts, and although there is no convincing evidence of the spear-thrower, it is possible that it was in use in the more open country. The Lupemban lanceolate forms are more likely to have been the points of stabbing spears for use in closed bush or forest.

It is not known when the bow and arrow were introduced into Africa, but they may well have been in use among the later Aterian populations by about 20,000 to 15,000 B.C., for the "*pointe marocaine*" strongly suggests use as the head of an arrow. The Middle Stone Age stone balls are about the size of a tangerine or smaller and are especially typical of the industries of the savanna in central and south-central Africa; their possible use as a bolas or, hafted, as a throwing-stick has been mentioned.

Bone, it appears, was not intentionally shaped into tools in Africa until the Later Stone Age; various hardwoods were used instead. However, unshaped bone was sometimes used, and occasionally these bone fragments show minimal modification, as evidenced by gouges and a point from the Broken Hill cave. It is also claimed that some of the Kalkbank bones show evidence of such utilization.

Although wood must have been the commonest material for tools, it is very rarely preserved. However, the lowest peat layer at Florisbad has yielded the upper end of a curved and shaped stick with cut marks on both faces at the tip. This shows close similarities with the grip ends of Australian throwing-sticks and has been identified as such a weapon (Fig. 7*c*). A second apparently worked fragment was found recently, on a horizon with an Upper Lupemban industry buried by redeposited Kalahari sands, at Chambuage Mine in the Lunda Province of northeastern Angola. No other wood was present at the site, and it is possible that this single specimen was also part of some form of throwing-stick or boomerang.

The greater part of the food of Middle Stone Age man must have come from vegetable sources; this is indicated by the grinding, pounding, and rubbing stones that are present in the cultural horizons. These stones often show one

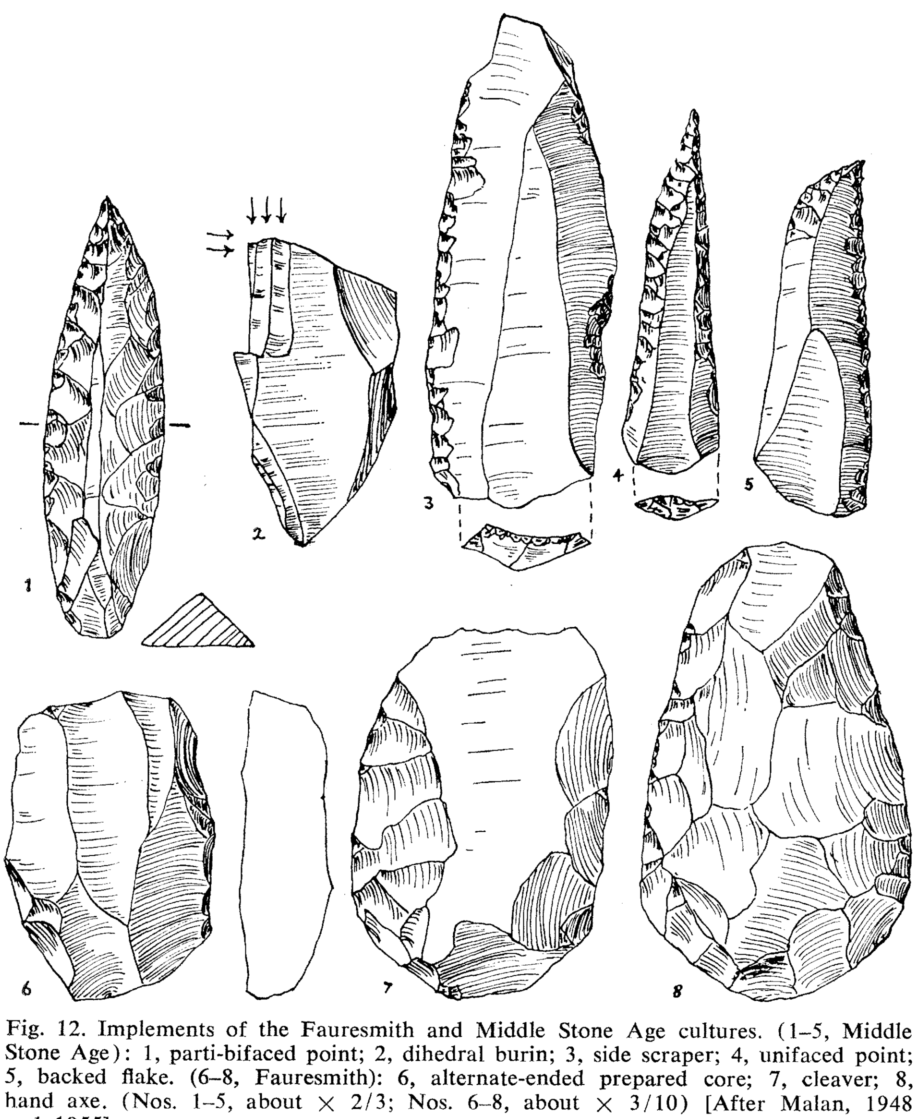


Fig. 12. Implements of the Fauresmith and Middle Stone Age cultures. (1–5, Middle Stone Age): 1, parti-bifaced point; 2, dihedral burin; 3, side scraper; 4, unifaced point; 5, backed flake. (6–8, Fauresmith): 6, alternate-ended prepared core; 7, cleaver; 8, hand axe. (Nos. 1–5, about × 2/3; Nos. 6–8, about × 3/10) [After Malan, 1948 and 1955]

or more flat grinding facets with a dimple scar in the center, and sometimes deeper scarring resulting from their having been used to crack nuts. Simpler forms of grinding and pounding stones are present at earlier sites, but they rarely, if ever, show the degree of wear that the Middle Stone Age specimens do. No doubt this is because these later tools were used again and again as the band reoccupied the seasonal camps. Such stones are more common in the Lupemban and central African savanna industries, and this perhaps reflects the increased use that may have been made of vegetable resources in these areas.

The extent to which the Middle Stone Age populations exploited the food resources of the rivers and lakes is inadequately known, but at the seacoasts, it appears, they made little or no use of sea foods until the very end of the Pleistocene, when shellfish became important. It is probable that fish were eaten in the basins of the Congo and Nile, if the unusually large concentrations of artifacts on some of the living sites of the terminal Pleistocene adjacent to the rivers in these regions can be taken as an indication of more permanent occupation of camping sites by this time. Certainly there was fishing by the 7th millennium (if not before), as evidenced in the bone harpoons of the Ishango culture and similar Mesolithic sites.

Blade-Tool Industries

The Mediterranean littoral, the northern parts of the Horn, and the Rift Valley in Kenya saw the establishment of blade industries related to the blade-tool traditions of Europe and southwest Asia (Fig. 13). Whereas the makers of these industries replaced the Middle Stone Age populations in some localities (for example, Cyrenaica), they appear to have existed in symbiosis with them in others (for example, East Africa and the Horn), with remarkably little effect on the stone technology of either group until the closing stages of the Pleistocene, when the Mesolithic microlithic technique also became widespread and led to another readjustment in the way of life.

Apart from the much earlier Pre-Mousterian ("Pre-Aurignacian") known only from Haua Fteah, the earliest blade-tool industry in Africa is the Dabban, first recognized at the cave of Ed Dabba in the Gebel Akdar. The tools comprise backed blades (mostly of Gravette type, with some of microlithic proportions), end scrapers, and burins (including a special form known as a transverse burin). It seems probable that the Dabba culture is connected with the Upper Paleolithic of southwest Asia, and recent work in Egyptian Nubia has brought to light evidence of blade industries there contemporaneous with the Epi-Paleolithic of Levalloisian tradition (Sebilian) which may provide the link between Cyrenaica and the Levant (*32*). This culture lasted through two stages, from 38,000 to about 14,000 B.C., when it was superseded by another, totally different blade-tool tradition named after the cave of Et Tera, near Benghazi. Burins and end scrapers became more rare, and the predominant tools were small, often curved, backed blades and microliths. In Cyrenaica this culture dates back to between 10,350 and 8600 B.C. (*11*, p. 203).

The extent of the distribution of these blade cultures is not yet known, and this complicates the problem of their origin. Nor are their relationships to the two blade cultures of the Atlas massif properly understood. The earliest of these is the Oranian or Iberomaurusian, which appears about 12,000 B.C. at the cave of Taforalt and other sites, immediately overlying the Aterian (*33*, p. 155). It occurs generally in both cave and open sites spread over the greater part of the Maghreb from Morocco to Tunisia. The tools consist

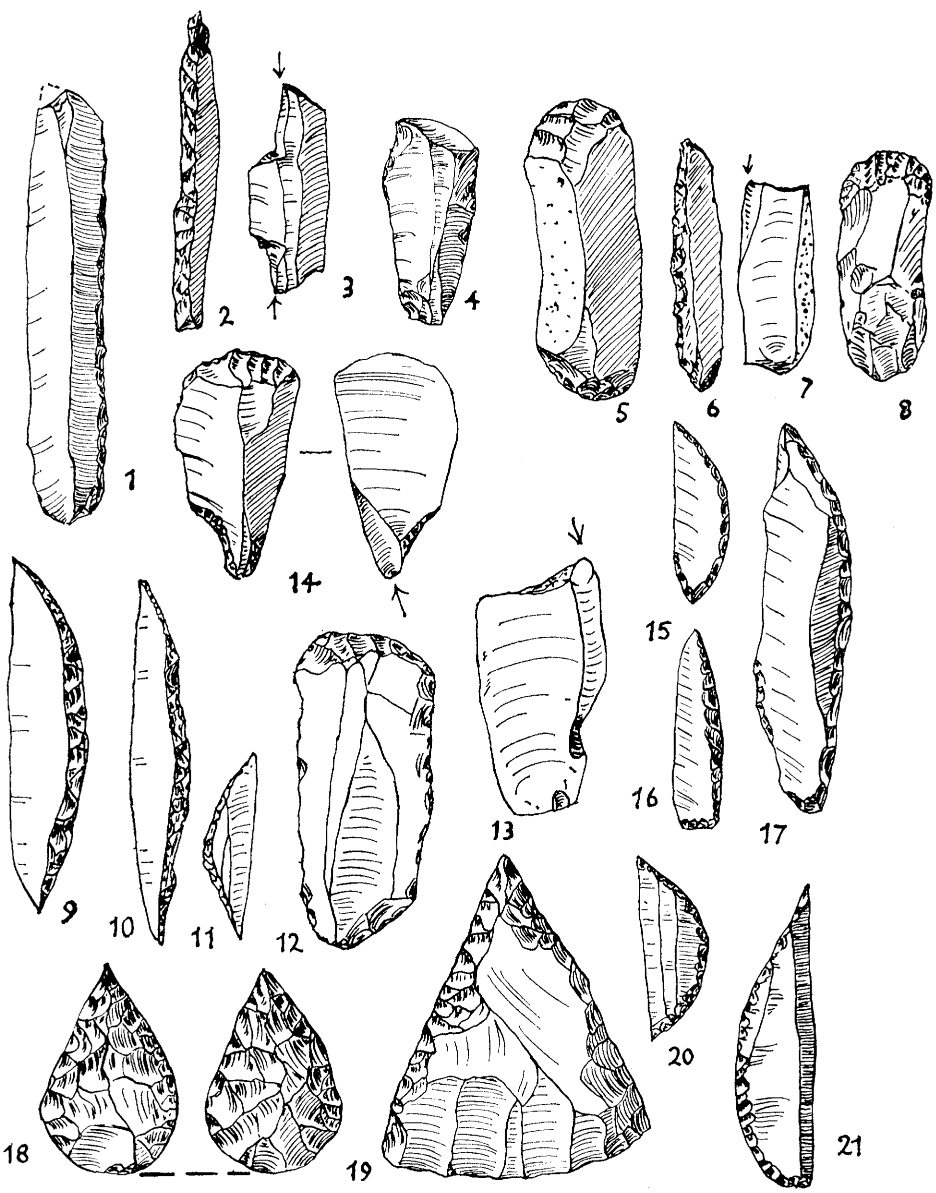


Fig. 13. African blade cultures and Magosian tools. 1–5, Dabba culture [after McBurney and Hey (*4*)]; 6–8, Hargeisan [after Clark (*26*)]; 9–13, Kenya Capsian [after Leakey, 1931]; 14–17, Iberomaurusian [after Roche (*33*)]; 18–21, Magosian [after Malan, 1949]. (No. 1, × 2/3; Nos. 6–8, about × 1/2; Nos. 2–5, 9–21, about × 1.)

mostly of numbers of small backed and truncated blades and end scrapers, together with flat blade cores similar to those of the Et Tera tradition in Cyrenaica. Indeed, it has been suggested that the Et Tera tradition represents an eastward extension of the Oranian (*11*, p. 219). If this is the case, the problem of the origin of the Oranian still remains. There is no evidence to indicate that the Oranian evolved locally from the Aterian, and McBurney is probably correct in thinking that it derives from southern Europe. The probability of such an origin is strengthened by the association of the Oranian with the Cromagnon-like Mechta-el-Arbi population, and, moreover, the composition of the Oranian is not unlike that of some of the late Upper Paleolithic industries of southeastern Spain (Magdalenian III) or southern Italy. However, similar late blade industries contemporary with the Sebilian on the Kom Ombo plain in Egypt have recently been found, suggesting probable Levantine connections, perhaps with such industries as the Skiftian, Nebekian, and Kebaran.

The arrival of the Oranian culture was followed by a fairly rapid disappearance of the Middle Stone Age Aterian tradition north of the Sahara, but there is little evidence that the Oranian influence spread into the Sahara until after the end of the Pleistocene. The other blade culture of the Maghreb—the Capsian—is restricted to southern Tunisia and eastern Algeria and, as now known, is entirely of post-Pleistocene age and so outside the scope of this article.

Blade industries that probably date to the late or terminal Pleistocene and show characteristics of the Et Tera/Oranian complex are found also in the northern part of the Horn, in former British Somaliland, and in the Kenya Rift Valley. The Somaliland industries, termed Hargeisan after the most characteristic site, are not well known but appear to be contemporary with industries of late Stillbay type. The localities are open sites, and the tools are backed blades (some microlithic) and well-made end scrapers and burins.

The East African blade-tool culture known as the Kenya Capsian, based on the use of obsidian, is widely distributed in the Kenya Rift. At least three stages have been identified, but as yet no absolute dates are available. Probably, however, only the earlier stage is of Pleistocene age, the others, which contain pottery, being probably of later date. Burials associated with the Kenya Capsian at Gamble's Cave and Naivasha Railway Rockshelter are of special interest since they attest the presence in East Africa of a long-headed Afro-Mediterranean stock at least by the terminal Pleistocene. This is a physical type which, like the industries with which it is associated, would seem to be entirely intrusive into the African continent.

The origins of both the Hargeisan and the Kenya Capsian are quite unknown. They are clearly not a local development, and, in view of the recent discoveries in Nubia, it is not improbable that they will be found to have connections with the north African and southwest Asian blade cultures. They may thus provide evidence of a southward migration via the Red Sea hills and Ethiopia; both these regions, however, are still largely unknown from the standpoint of prehistoric archeology.

The influence of these blade-tool traditions shows itself sporadically in the final stages of the Middle Stone Age in sub-Saharan Africa in the industries termed Magosian after the type site of the Magosi rock-shelter in northwestern Uganda (Fig. 13). These Magosian industries have an irregular distribution over southern and eastern Africa and show a blending of the Middle Stone Age prepared-core tradition with a tradition based upon the production of small blades from flat blade cores. The blade element varies according to locality and, no doubt, age. The bladelets were worked mostly into microlithic, curved, and straight-backed forms, but sometimes flakes are similarly backed to form large lunates and trapezes. These last are characteristic of the new element in the Congo basin, where they are found together with small, finely made, bifacial projectile points in the earlier stage of what is called the Tshitolian culture. In the savanna the pressure technique was by now more generally applied in the manufacture of both unifaced and fully bifaced points and resulted in some extremely fine work. In northeastern Angola the Lower Tshitolian is dated at about 12,000 B.C. Dates of 7550 B.C. for a later Magosian at Kalambo Falls and of 13,850 B.C. for industries of this type at Pomongwe Cave show that, by approximately 14,000 B.C., a tradition based on blade production began to replace the old prepared-core technology. This transition in lithic culture from the Middle to the Later Stone Age results from the spread of the more efficient equipment of the Mesolithic hunter—the composite tool and the bow and arrow with, no doubt, the use of poison.

Conclusion

It was during the later Pleistocene that cultures in Africa first showed significant regional specialization. Initially the industries reflected the results of experimental readjustment to the wider range of environments that were now being occupied—the forest fringes, high grasslands, and dry savannas. After more intensive exploitation, these Sangoan, evolved Acheulian, and Fauresmith traditions of the early Gamblian gave place to a more specialized tool kit during the Middle Stone Age proper, at a time when, as shown by the human fossils, paleoanthropoid genes were being replaced by genes of modern man. In prehistoric times, as in present-day Africa, these indigenous populations were both resourceful and conservative, selecting and then adapting such intrusive cultural elements as could be used to advantage in the varied environments they were now able so successfully to occupy.

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Universities and Federal Science Policies

In distributing federal support more widely, we will retain the criteria responsible for our present success.

Donald F. Hornig

The relationship between the federal government and the universities has been a developing partnership in the public service, a partnership which has proved extraordinarily fruitful for the universities, for the government, for science, and, above all, for the nation we serve. I would like to take stock of the benefits as well as some liabilities arising from this partnership, and to look ahead at its future development.

In historical perspective it is clear that overall progress in science is marked here and there by peaks of achievement, true breakthroughs in sometimes unsuspected directions. These peaks rest on a broad and expanding base of solid growth. The central problem in fostering scientific progress, therefore, is how best to encourage the breakthroughs while maintaining the greatest possible rate of growth, in both quality and quantity, at the base. Even in the most abstract terms such considerations revolve ultimately, so far as the federal government is concerned, around the problem of financial support. In the first instance, we as a nation must decide how much of our funds to allocate to science; in the second, how to allocate them; and in the third, by what specific mechanisms to distribute the funds in order to best accomplish the goals we have set.

Such reasoning clearly implies that the future shape of science and the directions of its progress will be determined not only by the scientific community but by the nation as a whole. As in all human affairs, the people who foot the bills are entitled to decide how they want to spend their money.

Let us take a closer look at some of these problems. This relationship between science and the public, or more directly between the universities and the federal government, first became intimate during World War II and has since grown to very substantial proportions. About three-fourths of all university research, one-third of all graduate students in science, and substantially all Ph.D. candidates are now supported by the federal government, and federal funds pay for about one-third of the cost of all new science facilities. Recently this support has been extended by various new programs of the National Science Foundation to bring training and participation in research to college teachers and undergraduates. The many federal programs of support for science involve about 400 colleges and universities, including substantially all Ph.D.-granting institutions in all parts of the country.

When these programs are compared with those of any other country in the world, one notes one very striking difference. Except for those of the Department of Agriculture, they have not provided for the allotment of funds by formula, either of population or geography. They have not provided for distribution of funds by institution, as in the British university grant system. By and large they have rested on the identification of talented, promising individuals and groups of individuals, on the identification of worthwhile, creative, original, and significant researches, in large measure proposed by the individuals. In short, we have attempted to operate a system based on talent and on merit of individuals. Naturally, judgments of merit are hard to make. The evaluations of proposals have in some cases, such as in the National Institutes of Health and NSF, been carried out by study sections or panels of scientists. Such judgment by peers has been widely commended in every study which has been undertaken. I note particularly that of the National Academy of Sciences Committee on Science and Public Policy, "Federal Support of Basic Research in Institutions of Higher Learning," and the Wooldridge study of the NIH, which was undertaken

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