in "Prehistory of Arid North Africa. Essays in Honor of Fred Wendorf". Edited by Angela E. Close, Southern Methodist University Press, Dallas, U.S.A., 1987.

11

Paleoclimatic and Cultural Conditions of Neolithic Development in the Early Holocene of Northern Niger (Aïr and Ténéré)

JEAN-PIERRE ROSET

INTRODUCTION

The possibility that there might have been significant climatic changes in the Sahara within the relatively recent past has been the subject of heated debate ever since it was first proposed, by archaeologists among others. Over the last 15 years, it has been the subject of painstaking research which has allowed us to make considerable progress towards an understanding of the problem.

The early prehistorians were able to show that the Sahara had previously been humid by the presence, and often extraordinary abundance, of evidence for permanent settlement by what were probably large groups of people in regions which are, today, completely desertic. It is difficult to imagine any other explanation for the florescence of the Neolithic in northern Niger, for example, in the vast, empty plains of the Ténéré, which even the Tuareg call a desert within the desert. Here, there are huge villages littered with stone tools and flakes, arrowheads, grinding-stones for the grinding of seeds and ceramic vessels for their storage, all laid out on the sand in patterns which echo the organization of the settlement. The change which has occurred in the environment is further indicated by the remains of large fish, which have been found in comparable archaeological contexts in various parts of the Hoggar and of Mauritania, sometimes associated with fishing-gear as they are in northern Chad, and by the rock-art. There are innumerable representations of megafauna, including elephants, giraffes, rhinos and lions, painted or engraved on the rock-surfaces of all the mountainous massifs, and large herds of domestic cattle are depicted in the rockshelters of the Tassili.

In contrast, the actual reconstruction of this paleoenvironment by earth-scientists has been difficult and very time-consuming. It was not until quite recently, in the mid-

1970s, that they could demonstrate that there was a sequence of different paleoclimates and could define their principal characteristics. This has been accomplished by a combination of different approaches, derived from geomorphology, stratigraphy, sedimentology, palynology, the analysis of fossil diatoms, and, above all, by the numerous radiocarbon dates, which have meant that it is now possible for scientists to compare results obtained from throughout the vast reaches of the African continent. Thus, with the establishment of a chronological scale has come the reconstruction of climatic development in tropical latitudes over the last 40,000 years. One of the major points of interest which has emerged from this overall picture is the parallelism and, frequently, the synchroneity of the climatic sequences during this period from the Atlantic to the Red Sea.

The early research in central Africa was often carried out by individual scientists, such as Faure (1962), Schneider (1967) and Pias (1970), and served to demonstrate the importance of the desert and Sahelian regions of Niger and Chad for Quaternary studies. O.R.S.T.O.M. (Office of Overseas Scientific and Technical Research) subsequently organized an interdisciplinary research program, focused on the Chad basin, involving stratigraphy and sedimentology (by Servant), diatom micropaleontology (by Servant-Vildary) and palynology (by Maley). This resulted in the publication, between 1973 and 1980, of a series of regional monographs which, for the first time, defined the main characteristics of the local climatic evolution at the end of the Pleistocene and during the Holocene (Maley 1981; Servant 1973; Servant-Vildary 1978). Several expeditions, which were not directly involved in this program but working parallel to it, provided complementary information about the neighboring regions of northeastern Aïr (Clark *et al.* 1973) and Tibesti (Jäkel 1977, 1979). The research currently being carried out on the western bank of Lake Chad will undoubtedly refine parts of the chronology (Durand 1982; Durand and Mathieu 1979–80, 1980). Similarly, the recent PALHYDAF (paleohydrology in Africa) program of the C.N.R.S. (National Center for Scientific Research, Paris), carried out in 1985 by Fontes and Gasse on a north-south transect from Tunisia to Niger, will enrich our understanding of the mechanics of paleoclimates and of their impact on the environment. Nevertheless, it is the synthesis of the O.R.S.T.O.M. team of geologists which defines the environmental framework within which prehistoric populations developed along the southern border of the Sahara during the period under consideration.

A second O.R.S.T.O.M. team, this time composed of prehistorians and including the writer, undertook the study of the development of these prehistoric groups in eastern Niger during the sequence of climatic variations revealed by the earth-scientists. This will undoubtedly be a longer-term project, since datable archaeological sites, in a sufficiently good state of preservation to yield useful information, occur much more rarely than do the outcrops and profiles which provide our colleagues with food for thought!

Nevertheless, after the surveys and excavations of the last decade, we are now able to compare the findings of geology and archaeology and, more especially, to examine in detail those conditions which characterized the last millennia of the Pleistocene and which heralded the climatic revolution which took place after 10,000 B.P. In the last few years, we have been able to show unequivocally that there was human occupation in several parts of northeastern Niger during this period. Further, the archaeological evidence which we have recovered strongly suggests that this was, in fact, a critical period in the history of human occupation of the southern Sahara and, to a very large degree, in the establishment of the Neolithic.

CLIMATIC RECONSTRUCTION: PURPOSE, METHOD AND TYPE

We will first discuss in general outline how and on what bases the O.R.S.T.O.M. geologists have tried to make their reconstructions of the paleoclimates. This will also make it apparent what types of climates can be reconstructed.

The reconstruction is essentially based on the fact that during the course of the Quaternary there have been significant lacustrine transgressions in the basin of Lake Chad, followed and separated by temporary periods of greater aridity. It had been known since the time of Garde's work (1911) that there had been major oscillations in the level of the lake, and that at some period the lake had invaded the interdunal depressions of Manga to the northwest. In 1925, Tilho was able to trace the highest shoreline of the lake around the basin; at the time of its maximal extension, the lake had been similar in size to the Caspian Sea (Tilho 1925). Subsequently, fossil beachlines, interpreted as those of a very large fossil lake, were observed at an altitude of 320 m asl (Pias and Guichard 1957) and were dated to about 6000 B.P. (Schneider 1967). At about the same time, Faure (1962) discovered lacustrine deposits in Niger similar to those of the Lake Chad region and dating from more than 21,000 B.P. to 3000 B.P.

On the bases of a re-examination of the earlier data and, more importantly, new systematic surveys of the fossil lake-deposits of the Chad basin, Servant (1973) worked out a detailed paleoclimatic chronology for the last twelve millennia. This chronology is based upon the hypothesis that the recorded amplitude of the lake's fluctuations is a direct reflection of climatic variations in the Upper Pleistocene and the Holocene. Methodologically, the chronology is based on the study of the variability through time in the ratio of rainfall to evaporation; according to Servant, the variation in this ratio is sufficient to define local climatic conditions. There is considerable variation from one area to another in the sources of water and Servant distinguished three types: run-off into the piedmont lakes; groundwater for the interdunal lakes; and the drainage of huge, internally drained basins into the hydrographic lakes. In spite of this, comparative analysis of the deposits through time shows that the levels of water throughout the Chad basin varied synchronously. This means that the overall effects of run-off from local topographic features are negligible. In addition, it is possible to detect changes in the type of rainfall from study of the lithological sequences.

The various transgressive and regressive lacustrine episodes, for which the chronological limits have been established by radiocarbon, thus correspond to an equal number of well-defined climatic phases. Servant groups all of those within the last 12,000 years into the "Nigero-Chadian." This alternation of positive and negative oscillations, of which eight have thus far been defined, makes clear how unstable the climate of the southern Sahara has been throughout the Late Quaternary.

For each of these phases, paleoecological data have confirmed and refined the climatic milieu thus reconstructed. The changes and development of the lacustrine environments were functions of the depth of the water. Diatoms were deposited on lake-beds during periods of transgression, and the study of the diatom assemblages is complementary to the sedimentological studies. According to Servant-Vildary (1978), diatoms are good paleolimnological indicators of a variety of parameters, including the depth, salinity, trophic characteristics and, occasionally, the temperature of Quaternary lakes.

The stratigraphic sequences in the central part of the Chad basin and in eastern Niger, which have been the subject of research into diatoms, have seen parallel analyses by Maley (1977a, 1977b, 1980) into their palynology. Study of the fossil pollen has provided interesting additional information about the sources of water in the lakes during the Holocene. By comparing the variation in the lake-levels as determined by the diatoms with variation in the pollen diagrams, Maley was able to determine the relative importance in the overall supply of water of local rainfall as opposed to rivers flowing in from some distance. Significant changes in the terrestrial vegetation correlated with equivalent changes in the lacustrine flora. We refer the reader to these detailed studies, of which the principal results for the period under consideration will be given below.

It is important to bear in mind that the climatic chronology for Chad and Niger established by Servant is based on a paleohydrological interpretation. The Quaternary paleoenvironments defined by the work of Servant-Vildary and Maley on the sedimentary environments are important and original contributions to stratigraphic methodology. However, if we are careful to refer to the climates they have reconstructed as "hydrological," this will provide a useful reminder of exactly what types of phenomena they are studying and what are the limits of their fields of research.

CLIMATIC SETTING OF THE LOWER NIGERO-CHADIAN (12,000–8000 B.P.)

Servant's work has demonstrated that about 12,000 years ago there was a climatic revolution which led to the rapid and simultaneous appearance of numerous lakes in the Chad basin. This paleogeographic change is the local reflection of a more general phenomenon which affected the whole southern edge of the Sahara at that time. Various scholars (notably Butzer *et al.* 1972; Gasse 1975; Hébrard 1972; Michel 1969) have made comparable observations which indicate a reversal of climatic trends from the Atlantic to the Red Sea during the last millennia of the Pleistocene, when humid conditions became generally and rather suddenly established after a long period of extreme aridity. This arid period, which is called the Kanemian in central Africa (Servant 1973) and the Ogolian in West Africa (Michel 1977) began about 20,000 years ago and resulted in a significant desertification of all the Sahelian region south of the Sahara. The return of humidity, which Servant has named Nigero-Chadian I, is the beginning of the series of oscillations which have characterized the Holocene up to the present day.

However spectacular it might seem, the appearance of lakes in the arid lands was not completely unheralded. In the Chad basin, Servant noted that run-off began at about 13,000 B.P. and was sufficient to bring about the cutting of the Bahr el Ghazal valley, which is a natural outlet of Lake Chad toward the northeast. Maley (1980) noted the occurrence of brackish surface-water of a similar age, associated with a shallow water-table, in an arid environment north of the thirteenth parallel. In a more detailed investigation of this subject, Durand and Mathieu (1980) have estimated that the period of maximal aridity was between about 20,000 and 17,000 B.P., but that surface run-off never, in fact, really stopped during the Kanemian, even during the driest phase. Evidence for this lies in the fluvio-deltaic formation which was built up in the Chad basin before 17,000 B.P. and which indicates the local existence of more humid conditions, even though aridity persisted farther north in the Kanem and the Nigero-Chadian Manga. The contemporaneity of the humid event on the southern side of the lake with the rainfall of Mediterranean origin observed by 16,500 B.P. in the Tibesti (Jäkel 1977) and other central Saharan massifs (Faure 1969; Rognon 1967) led Durand and Mathieu to suggest that the desertic zone was already retreating after about

17,000 B.P. "under the combined effects of tropical rainfall in the south and Mediterranean rainfall in the north" (1979–1980:198). Numbers of observations made in neighboring regions support this suggestion. The analysis of a series of cores taken from the delta of the Niger confirms that there was a significant increase in global rainfall after 14,500 B.P. (Pastouret *et al.* 1978). To the north in the Tibesti, Maley (1981) notes the existence of a high lake-level in the natural rain-gauge of the Trōu au Natron at about 14,000 B.P. To the south in northern Cameroon, Hervieu (1970, 1975) has described an episode of sedimentation with soil-development after about 15,000 B.P. To the east in the Jebel Marra, a high lake-level has been observed at about 14,000 B.P. (Williams *et al.* 1980). It therefore seems, according to Durand (pers. comm.), that the end of the Kanemian was very gradual and that the period of transition into the Nigero-Chadian lasted more than 4000 years. This model may be of great importance for the available archaeological evidence, as will be seen below.

In any case, at about 12,000–11,000 B.P., lakes came into existence throughout the region under study, independent of local topography and thus of orographic rainfall and run-off; this indicates a significant improvement in climate after the Kanemian period. The critical fact according to Servant, as we have indicated above, is that the inflow of water which led to this, whether it was from rainfall, run-off, rivers or groundwater, was greater in volume than the loss to evaporation. Servant's Nigero-Chadian I is thus the first period of lake-expansion in the paleo-hydrogeographic chronology which he has proposed for the Chad basin; it is dated between about 12,000 and 10,620 B.P. In the Kanem, there was a rapid and synchronous expansion of the interdunal lakes at about 11,000 B.P. Farther west, in the Kadzell of Niger, the chronology of this transgression is confirmed by a lacustrine shoreline at 280–281 m, with radiocarbon dates of 11,435 B.P. ± 200 years at the base and 10,625 B.P. ± 300 years at the top (Durand 1982).

According to Servant, this was followed by a short period of regression in Chad and eastern Niger, Nigero-Chadian II, with radiocarbon dates ranging from a little before to a little after 10,000 B.P., according to area. This period is well characterized by marsh sediments in the Kanem, by aeolian sands at Termit and, perhaps most importantly, by an erosional surface in the Bahr el Ghazal, separating two lacustrine series with dates of 10,900 B.P. ± 300 years and 10,300 B.P. ± 300 years.

After this brief interruption, conditions changed again and soon became wetter than they had been before. Nigero-Chadian III was a new phase of lake-expansion, greater than the previous one, which Servant has been able to recognize in almost every depression in the Chad basin and for which he has a consistent series of radiocarbon dates ranging from 10,160 B.P. ± 160 years at the base of the Angamma delta to 7450 B.P. ± 140 years at the top of the Bilma sequence. We have been able to date the Nigero-Chadian III transgression at several localities in eastern Niger, and have obtained radiocarbon ages falling well within the limits proposed by Servant:

9080 B.P. ± 230 years at Tin-Ouaffadene (20°10′40″N, 9°11′30″E)
9460 B.P. ± 120 years at Temet (19°58′0″N, 8°40′25″E)
8565 B.P. ± 100 years at Temet
8060 B.P. ± 250 years near Rocher Toubeau (21°18′40″N, 9°8′0″E).

In addition, Servant has recorded the highest values for the rainfall: evaporation ratio at about 9000–8000 B.P. and so would date the highest levels and maximal expansion of the lakes to that period.

The wetter conditions which began at the end of the Pleistocene and prevailed during the Early Holocene along the entire southern border of the Sahara also affected the interior massifs, such as the Tibesti (Hagedorn and Jäkel 1969) or the Hoggar (Rognon 1967), as well as regions like the Saoura, the Erg Chech and Tanezrouft (Conrad 1969). These all have particular paleohydrological and paleoecological features which permit a better understanding of the climatic conditions they represent.

A general outline of the hydrological regime can be deduced from observations of the types of river alluvia deposited during this period. In the valleys of the small massif of Takolokouzet in the eastern Aïr, Servant (1973) observed fine, well-sorted deposits, which were generally well stratified and often loamy, spread extensively over the valley bottoms, in spite of their steep longitudinal profile. Fine and well-bedded sediments have also been observed in the Hoggar (Rognon 1967), where they have been dated to 11,580 B.P. ± 350 years and 8380 B.P. ± 300 years (Delibrias and Dutil 1966). In the Tibesti, they form the "middle terrace" of the German scientists, which has been dated by radiocarbon to between 15,000–14,000 and 7000 B.P. (Hagedorn and Jäkel 1969; Jäkel and Schulz 1972). This was, therefore, probably a widespread phenomenon. These concordant observations suggest to Servant that, at the end of the Pleistocene and in the Early Holocene, streams flowed sufficiently slowly to allow the deposition of fine alluvia. He believes that the slowness of the stream-flow must mean that there was a continuous and regular influx of water without any pronounced floods; this, in turn, would strongly suggest that precipitation was quite even and gentle throughout the year, and rarely torrential. He further believes that the absence of coarse detrital deposits along the shores of the piedmont lakes of Nigero-Chadian III supports the hypothesis of gentle rainfall, rather than implying the existence of a thick vegetational cover, which would have prevented any significant erosion of the hills.

As part of the O.R.S.T.O.M. group's parallel research into Quaternary paleoenvironments, Servant-Vildary created a classification of the diatom assemblages found in the lacustrine deposits of the Chad basin. Although the temperatures of these ancient lakes cannot be determined precisely, estimates can be made on the basis of the diatom populations which developed there, since they include species which are very characteristic in terms of biogeography, and thus can serve as local climatic indicators. According to Servant-Vildary, those species which live preferentially in colder waters predominated between about 12,000 and 7,000 B.P.; today, these psychrophilic diatoms are characteristic of the flora of temperate zones. They are equally dominant in the lacustrine deposits overlying archaeological layers which we have observed and dated in northeastern Aïr. At Temet, Tin-Ouaffadene and Rocher Toubeau Site 14, they date between about 9500 and 8000 B.P. (see above; the samples are currently being studied by F. Gasse).

As far as the vegetational cover is concerned, it has long been recognized that a Mediterranean or Sudanese type of vegetation developed in the massifs of the central and southern Sahara (Hoggar, Aïr, Tibesti and Ennedi) during the Late Quaternary, since some relict patches of it still survive today (Gillet 1967; Quézel and Martinez 1958). In February 1982 in the Bagzanes (Aïr), very close to the archaeological site of Tagalagal (discussed below) and at an altitude of more than 1850 m asl, we ourselves collected samples of southern Sahelian and northern Sudanese plants, which optimally grow in zones with about 500 mm of rainfall; these included *Boscia salicifolia* Oliv. and *Grewia flavescens* Juss. (identifications by H. Gillet of the Natural History Museum, Paris). Unfortunately, the rainfall in the Aïr mountains is still essentially unmeasured. For the Bagzanes, there are only five years' records available, which were made by

O.R.S.T.O.M. (1976–1980), as part of a detailed hydrological study, at four stations in the southern part of the Bagzanes at altitudes of about 1500 m asl. The mean for three of these stations from 1977 to 1980 is to 106.3 mm per annum (R. Gallaire, pers. comm.). It seems evident that these plants became established in the Aïr at a time when the climate was more humid than it is today, and that they still survive in areas where men and animals have little impact because the effect of aridity is mitigated by the altitude. The nights are cooler and dews more frequent, especially at the end of the rainy season, than they are at the same latitude on the plains.

The problem of when this vegetation became established is very difficult and seems still to remain unresolved. As far as the relict plant species of Mediterranean type in the Tibesti are concerned, pollen analyses of sediments from the area (Maley 1981) have showed that there was no real difference between the vegetation of the massif at the end of the Pleistocene or in the Early Holocene and the modern vegetation. According to Maley and in contrast to the hypothesis previously put forward by Schulz (1974), there is therefore no reason to suppose that there was a zonation of Mediterranean type in the Tibesti at the time when the middle terrace was formed. In the Sahelian zone farther south, Maley has carried out an intensive palynological study of the lacustrine series of Tjéri (13°44′N, 16°30′E), which showed that there were only very low percentages of pollen originating in the Mediterranean or temperate zones. Maley therefore considers that a vegetation of northern type could not have grown at these latitudes during the period in question.

On the contrary, the evolution of the assemblages of tropical pollens observable at Tjéri (Maley 1977a, 1977b, 1981) correlates well with the fluctuations of the lake between 13,000 and 7000 B.P. as shown by analysis of the diatoms (Servant-Vildary 1978). The first sequence, L_1, from about 13,000 to 9200 B.P., is marked by three minor transgressions and is characterized by the predominance of Sahelian pollen of local origin. There were three more transgressions at the beginning of the L_2 sequence, between about 9200 and 7300 B.P., which were caused primarily by inflow of river-water from the south, so that they are characterized by increasing amounts of Sudanese and Sudano-Guinean pollen (Maley 1977a, 1977b, 1981). Working on the basis of the ecological characteristics of the various taxa included in the Sahelian and Sudano-Guinean pollen, Maley finds that the pollen diagrams of Tjéri provide a good reflection of the fluctuations in climate, which are also witnessed in the sedimentological studies.

In short, these several complementary approaches, of which we have briefly discussed the aims, methods and principal results, combine together to provide a reconstruction of the main outlines of the paleoclimate prevailing in the period from 12,000 to 8000 B.P. It has been shown that the marked oscillations, which characterized the final millennia of the Pleistocene, led up to the establishment of very humid conditions in the northern regions of Niger and Chad, with a maximum humidity at about 9000–8000 B.P. This resulted from the rate of precipitation being higher than that of evaporation, as well as its being rather evenly distributed throughout the year. Local temperatures were therefore lower than those of today (Servant 1973).

HUMAN OCCUPATION OF NORTHEASTERN NIGER IN THE EARLY HOLOCENE

One of the most significant results of the systematic surveys and excavations we have carried out in northeastern Niger over the last ten years has been to date the human occupation of these now-desertic regions to the Early Holocene. We investigated four *in situ*, archaeological sites, at which it was possible both to maintain good stratigraphic control and to obtain radiocarbon dates. As our research progressed, we learned from these how much of the material culture remained of the people who had lived there during the tenth millennium B.P. under the climate we have just described. The site of Tagalagal was the first to be discovered, in 1978, and its archaeological significance is such that we will describe its principal characteristics.

Tagalagal is the name given by the Tuareg to an inselberg which lies in the northern part of the Bagzanes massif at 17°50′50″N, 8°46′15″E. The Bagzanes massif itself is a vast and high granite formation, rising out of the ancient substratum of the Aïr as a high plateau, more or less oval in shape, with escarpments all around its edge and rising from the south toward the north to an altitude of more than 1800 m asl. As far as the eye can see, its surface consists of a succession of granitic domes and ridges, as well as evidence of more recent volcanic activity. It is cut by deep valleys, which are frequently blocked by basaltic flows and sometimes expand out into flat-bottomed basins where sand has accumulated. It is in these basins that one finds both concentrations of vegetation and several villages occupied by the Kel Owey Tuareg (Morel 1973).

It takes several days of camel-riding, walking and, finally, climbing to reach the inselberg. The site lies on a shoulder at the foot of it, at an altitude of about 1850 m asl. There, enormous granite balls surround a small empty area, which is about 40 m long from north to south and about 20 m wide; it is a sheltered glade in the middle of the rocks, where people came and settled (Figure 11.1). The soil is littered with potsherds, stone tools and flakes, and upper and lower grinding-stones, all mixed with fossilized bones. In the southern part, several of the large blocks form a shallow rockshelter, which has protected the archaeological deposit from erosion over an area of about 5 m^2.

The excavation of this deposit did not yield any real, organized features, by which we might have characterized it, but it did yield an abundance of the same materials as occurred on the surface, buried in a blackish sediment down to a maximum depth of 0.7 m (Figure 11.2). We thus have a good stratigraphic basis for associating the pottery, grinding-stone fragments and stone tools with each other. In addition, two radiocarbon dates run on the charcoal fragments studded throughout the sediment gave very similar ages of 9330 B.P. ± 130 years, for a sample taken from the top of the sediment, and 9370 B.P. ± 130 years, at a depth of about 0.3 m (results kindly communicated by J.-C. Fontes, Laboratoire d'Hydrologie et de Géochimie Isotopique, Université de Paris-Sud, Orsay, 1980).

Simply in terms of radiocarbon measurements, these dates are among the oldest ever obtained in the Sahara for a site with ceramics. However, even at this early date, ceramic technology seems to have been fully mastered at Tagalagal. Both open and closed vessel-forms exist, the former being more common among the sherds found *in situ*; all the reconstructions that we have made show that they are types of bowls, either simple hemispheres or with a slightly recurving lip. The closed forms have a very short and slightly out-turned neck (Figure 11.3). However, the most striking aspect is the diversity of techniques used to decorate these vessels, usually over their entire surface. One of the most common is that which is used to create the famous "dotted wavy-line" motif, a flexible comb (Camps-Fabrer 1966), usually deeply impressed into the paste. These lines of deep impressions may be either only slightly wavy and parallel to the opening, or very sinuous—even so much as to cross back on themselves—or else be arranged in contrasting bands (Figure 11.4).

Rocker-stamping (Camps 1958) was also frequently used and thus seems to be as old a decorative technique in the southern Sahara as that which produced the dotted wavy-

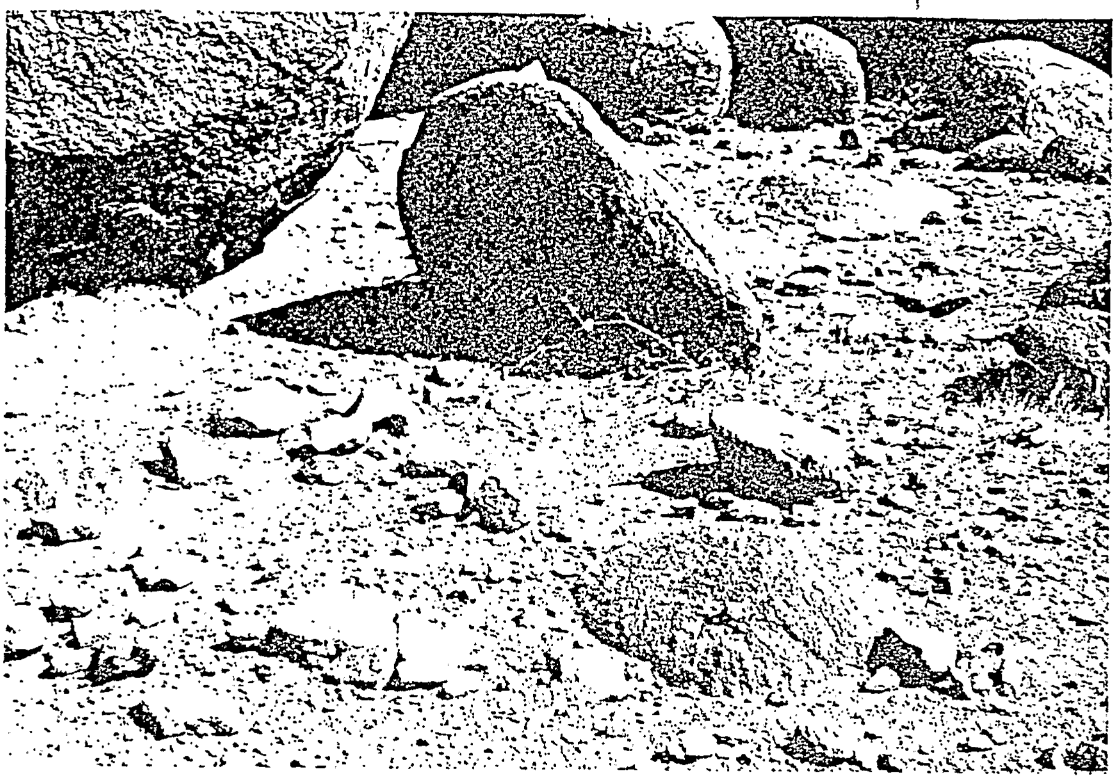

Figure 11.1 The open-air site of Tagalagal.

line motif; rocker-stamping was done with the straight or curved end of a spatula, producing the characteristic flame-shaped decoration, or, again, with a comb (Figure 11.4). Semi-rocker-stamping was also used to decorate some of the exterior thickened rims. Various other types of impressions were contemporaneous (Figure 11.5): lines of dots, angle-impressions, incised parallel lines, and even a very peculiar motif, which we already knew from having found it in the more recent sites of Adrar Chiriet, and which is composed of small and very acute chevrons arranged point-up and point-down in alternate horizontal rows, and made by direct impression of a spatula with a straight, narrow end (Roset 1978).

The associated lithic assemblage (Figure 11.6) is much less rich and even rather crude, which seems to result from the poor flaking qualities of the rock most commonly used, a rhyolite with phenocrystals. It is composed mainly of rather short, thick flakes, struck from discoidal or polyhedric cores and rarely retouched. However, the excavation yielded flakes retouched to form endscrapers, sidescrapers (often transverse), a few pointed blades, and single and double angle-burins (which sometimes show resharpening). A distinctive element in the assemblage are the burin-like flakes, which have a burin-like facet on the platform that shows the same use-wear as a true burin (Figure 11.6: 12–15); they are quite common and seem to have been a desired type. All of these tools are rather rudimentary, but this should not lead us to underestimate the technical competence of the Tagalagal craftsmen, which is revealed in the manufacture of arrowheads. The arrowheads, which are always made on rocks of finer texture, are so delicately worked on both faces that one might think they came from a site of the Ténéréan Neolithic. However, their contemporaneity here cannot be doubted, since all of them were found within the cultural layer.

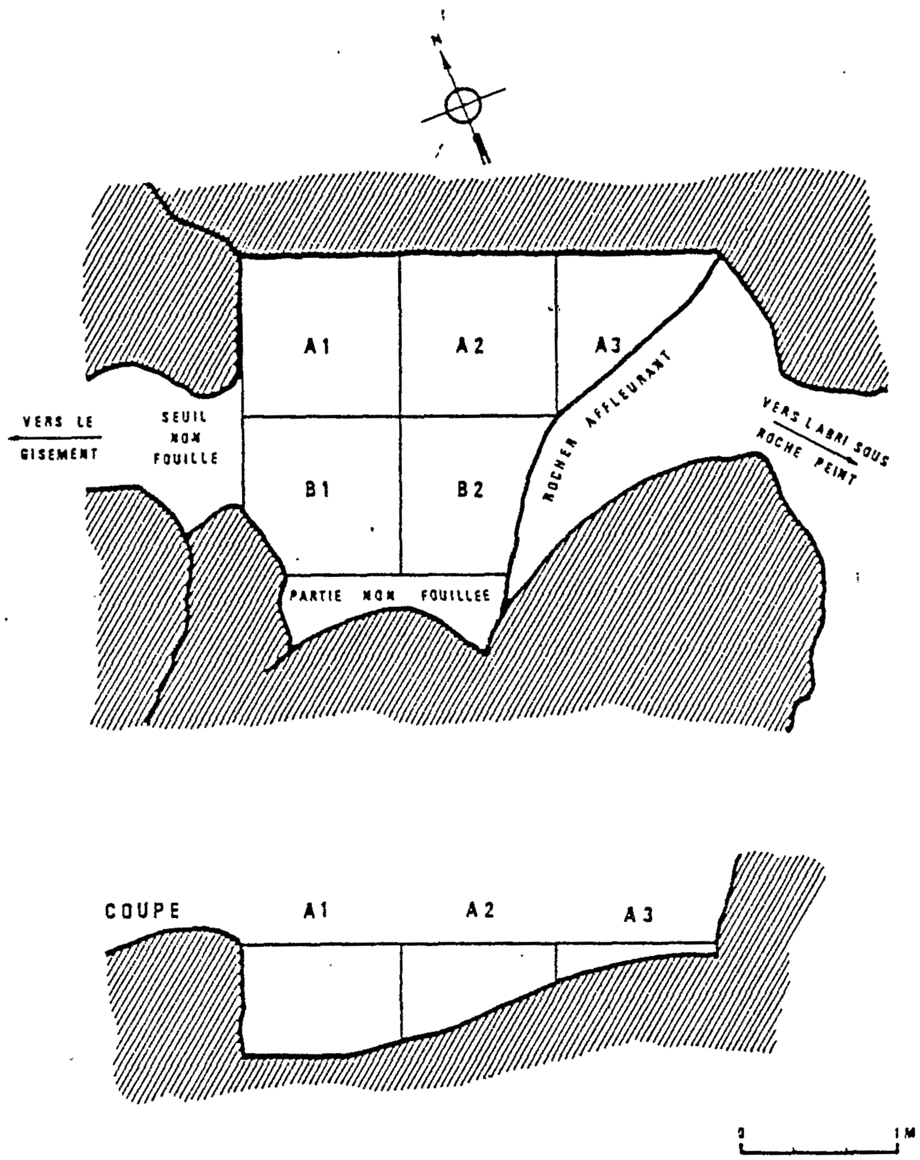

Figure 11.2 Tagalagal. Plan and cross-section of the excavation of the rockshelter.

As well as the potsherds and flaked stone, there is also a considerable quantity of grinding equipment. Various rocks were used for the manufacture of upper and lower grinding-stones, which occur, both whole and broken, over the entire surface of the site; fragments of them also occur throughout the cultural deposit.

We will now leave the interior of the Aïr and turn to the Ténéréan edge of the massif, more than 200 km toward the northeast, where there are three other sites earlier than 9000 B.P. and contemporaneous with Tagalagal. These are the sites of Temet (19°58'0"N, 8°40'25"E), Adrar Bous 10 (20°19'50"N, 9°2'0"E) and Tin-Ouaffadene (20°10'40"N, 9°11'30"E) which were discovered between 1978 and 1980 and have been investigated since then. All three of them are archaeological sites *in situ* beneath lacustrine sediments.

At Temet, at the southeastern foot of Mount Gréboun, the cultural layer lies on the surface of colluvial sands, covered by diatomite deposits which are more than 6 m thick

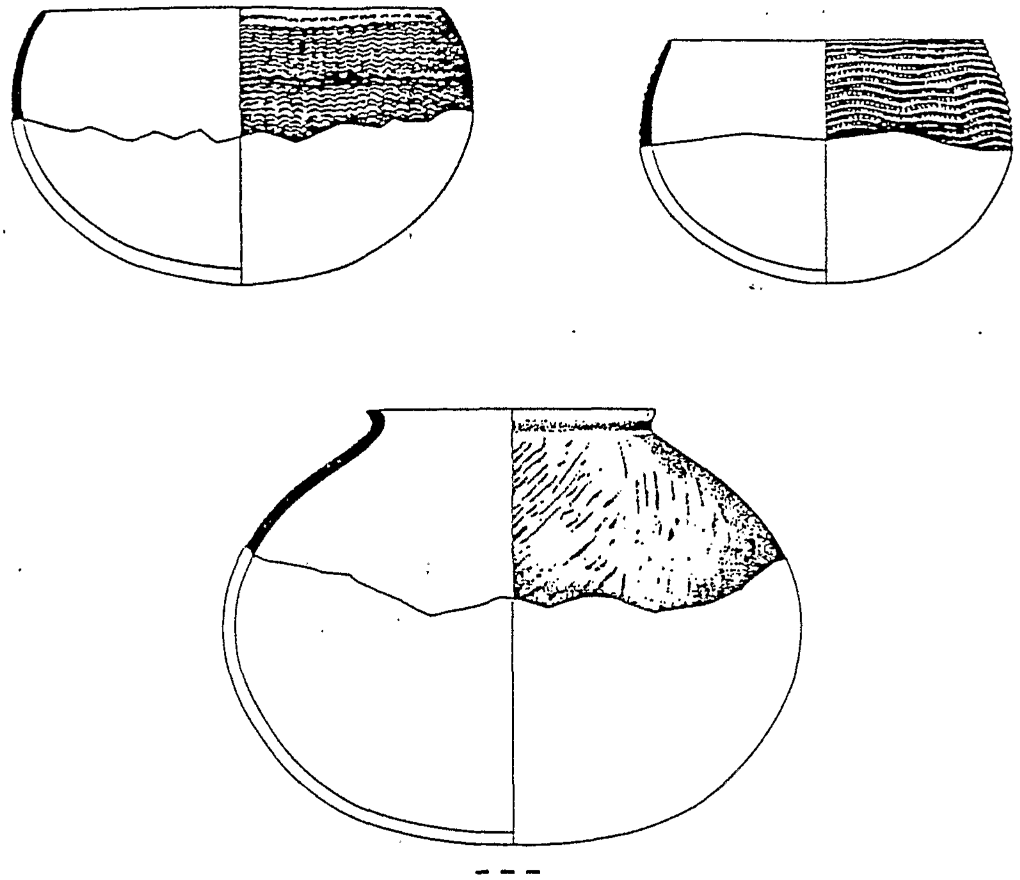

Figure 11.3 Tagalagal. Different types of ceramic vessels reconstructed from sherds recovered during excavation of the rockshelter.

just back from the area of excavation (Figure 11.7). We have obtained two dates for the transgression: the first, 8565 B.P. ± 100 years, is on the diatomite overlying the archaeological layer (by J.-C. Fontes in 1980) and the second, 9460 B.P. ± 120 years, is also from the base of the diatomites but some 500 m west of the site itself (by J.-F. Saliège, Laboratoire de Géologie Dynamique, Université de Paris VI, in 1985). During the excavations carried out from 1979 to 1983, the diatomites were removed from an area of about 20 m² and the underlying material has been dated to 9550 B.P. ± 100 years on the associated charcoal (by J.-C. Fontes in 1980). The sequence is, therefore, perfectly consistent in terms of both stratigraphy and radiometry. It may be observed that the Nigero-Chadian III transgression followed very soon after the human occupation of the site.

On the other hand, the archaeological material recovered from the site is very different from that of Tagalagal, and, in this respect, it is the lithic industry which is worthy of note. Most importantly, in this horizon we can see the coexistence of an industry made on blades and bladelets, which yielded a varied tool-kit that has been described elsewhere (Roset 1983), and of a microlithic component which includes a significant number of geometric pieces (Figures 11.8 and 11.9). This means that in this area there are no grounds for distinguishing between an Epipaleolithic, as defined by Clark (1976), and a more recent microlithic industry (Smith 1976). This distinction

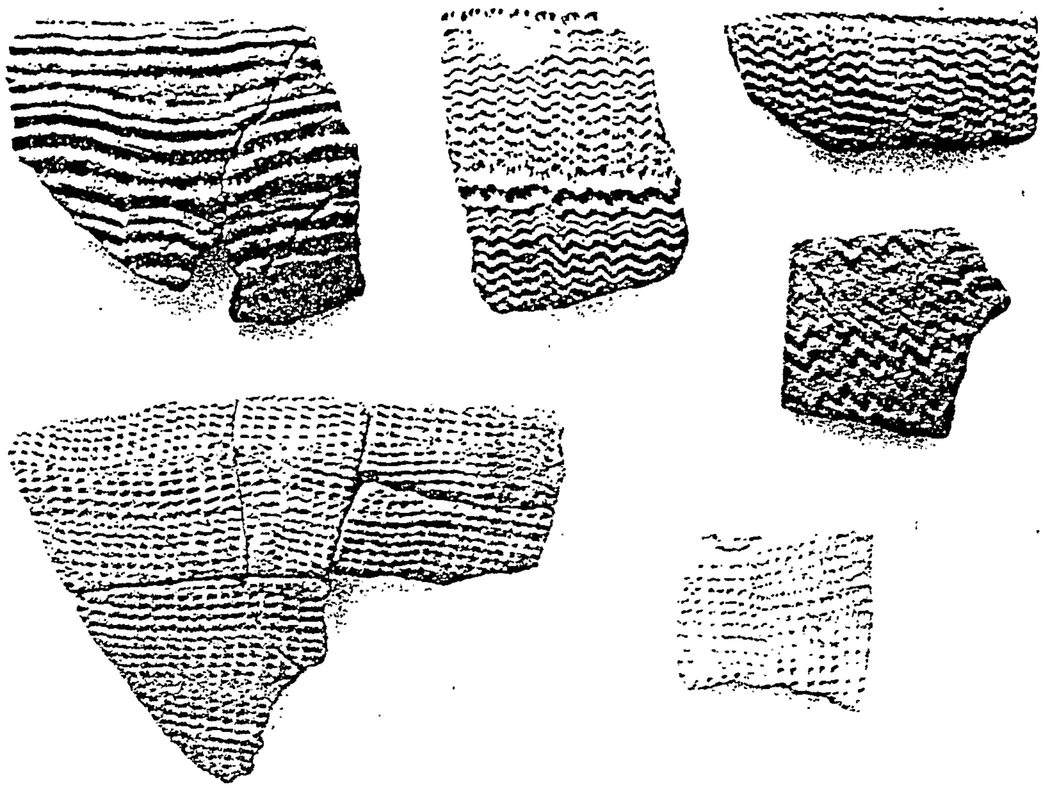

Figure 11.4 Tagalagal. Various types of dotted wavy-line decoration and comb-impressed motifs.

was based on an incomplete study and on material collected only from the surface; the two are in fact one and the same culture.

The flaked stone tools are associated with several vessels carved out of blocks of fibrolite and polished (Figure 11.10). On the other hand, the excavation did not yield a single potsherd. However, a knowledge of ceramics is unequivocally demonstrated by the occurrence, *in situ*, of a potter's comb carved out of a thin plate of fibrolite (Figure 11.11). As at Tagalagal, all of this material is associated with fragments of upper and lower grinding-stones.

The main site of Adrar Bous 10 is in a similar position. The exposed part of this site covers an area of about a hectare on the surface of a fossil dune. The lower parts of the dune were covered by the deposits of a later episode of lacustrine transgression (Figure 11.12). Between 1982 and 1985, the diatomites downslope were removed from an area of 144 m², which revealed that the archaeological layer continued for some depth beneath the lacustrine deposits. The industry recovered from this layer is very similar to that of Temet. In addition, it is associated with numerous potsherds, on which we have found multiple examples of almost all the decorative motifs known in the Tagalagal repertoire, as well as with the usual large numbers of fragments of upper and lower grinding-stones. The site has three radiocarbon dates, on fragments of charcoal found *in situ*. The ages obtained are 9030 B.P. ± 190 years (which was measured on a very small charcoal sample by A. W. Fairhall, Department of Chemistry, University of Washington, in 1982), 9130 B.P. ± 65 years (by the same laboratory on a larger sample in 1983) and 9100 B.P. ± 150 years (by J.-F. Saliège in 1985).

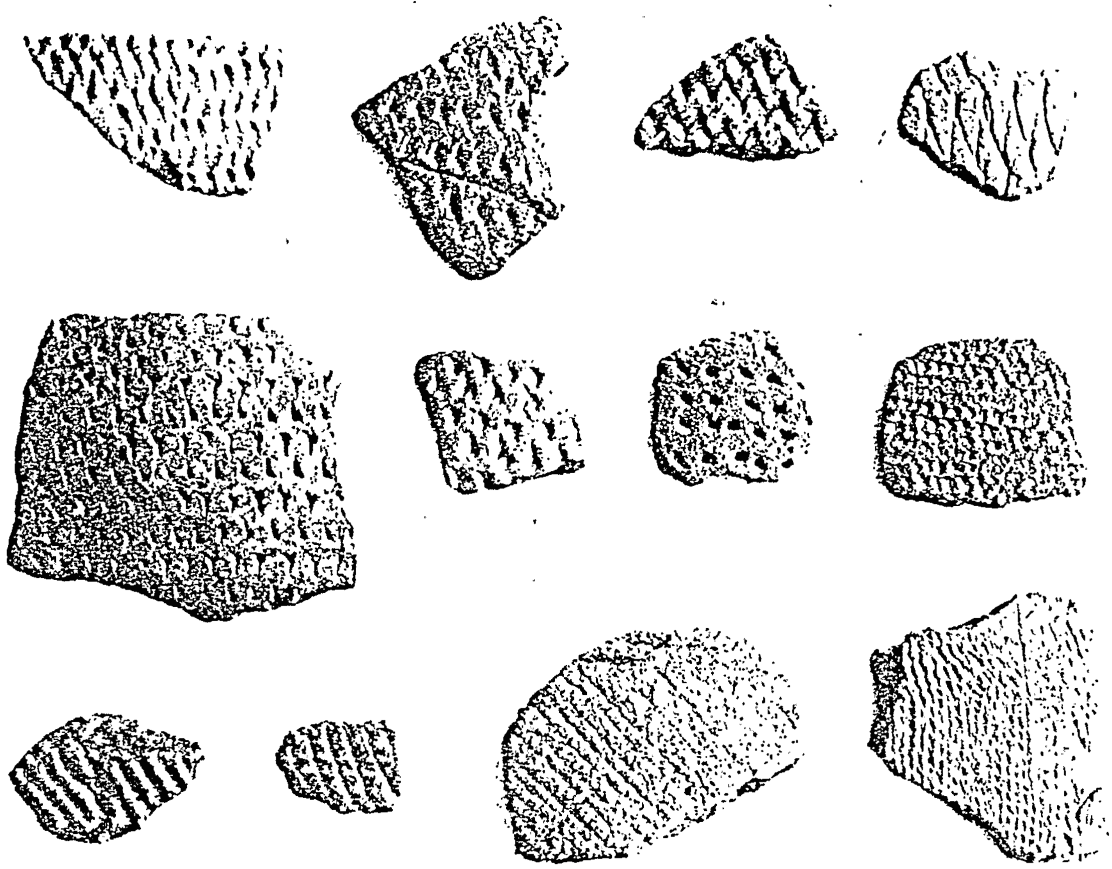

Figure 11.5 Tagalagal. Top row: rocker-stamped motifs made with curved and straight spatulae. Middle row: opposed rows of chevrons (compare the sherd on the left, from a Ténéréan Neolithic site at Adrar Chiriet [4500–4000 B.P.], with that on the right, *in situ* in the Tagalagal rockshelter); lines of dots; straight comb-impressions. Bottom row: impressed motifs; incised parallel lines; roulette-impressions.

The site of Tin-Ouaffadene, about 25 km southeast of Adrar Bous in the middle of the Ténéré, is in an identical geomorphological position: a living-site on a fossil dune which was drowned by a later transgression, here dated on carbonaceous sediments to 9080 B.P. ± 230 years and on shells to 9060 B.P. ± 240 years (by J.-F. Saliège in 1985). Access to the underlying archaeological layer is extremely difficult and it has been reached only over an area of some twenty square meters from which the diatomites have been removed. The layer has yielded limited quantities of an industry identical to those of Temet and Adrar Bous 10, plus several fragments of lower grinding-stones and, most importantly, a significant faunal assemblage. The fauna was concentrated around a hearth from which charcoal has been dated to 9220 B.P. ± 140 years (by J.-C. Fontes in 1983). The excavated fauna is still being studied, but it already seems that among the hunted animals, which were primarily various antelopes, there are the remains of a large bovid. This has not yet been identified precisely, but it was also found at the sites of Tagalagal and Adrar Bous 10 (F. Poplin [Natural History Museum, Paris] pers. comm.). In contrast, not one sherd had been recovered by the time the excavations ended in 1985.

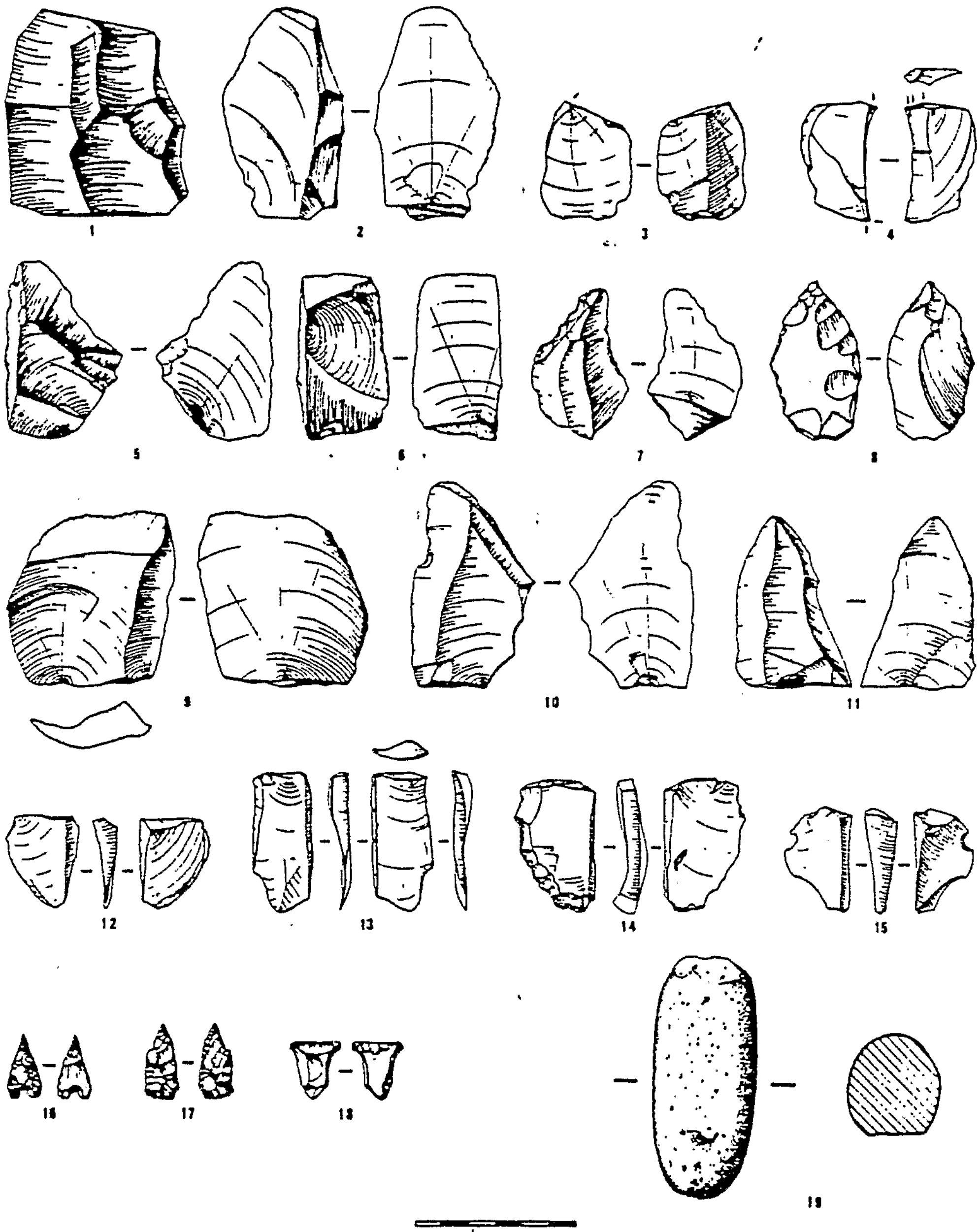

Figure 11.6 Tagalagal. Lithic artifacts. 1, tabular opposed-platform core; 2, preparation flake; 3, 4, burins; 5, sidescraper; 6, atypical backed piece; 7, shouldered scraper; 8, retouched point; 9–11, unretouched flakes; 12–15, burin-like flakes (14, with side- and endscraper, 15, notched); 16–18, arrowheads (17, unfinished, 18, transverse); 19, pestle.

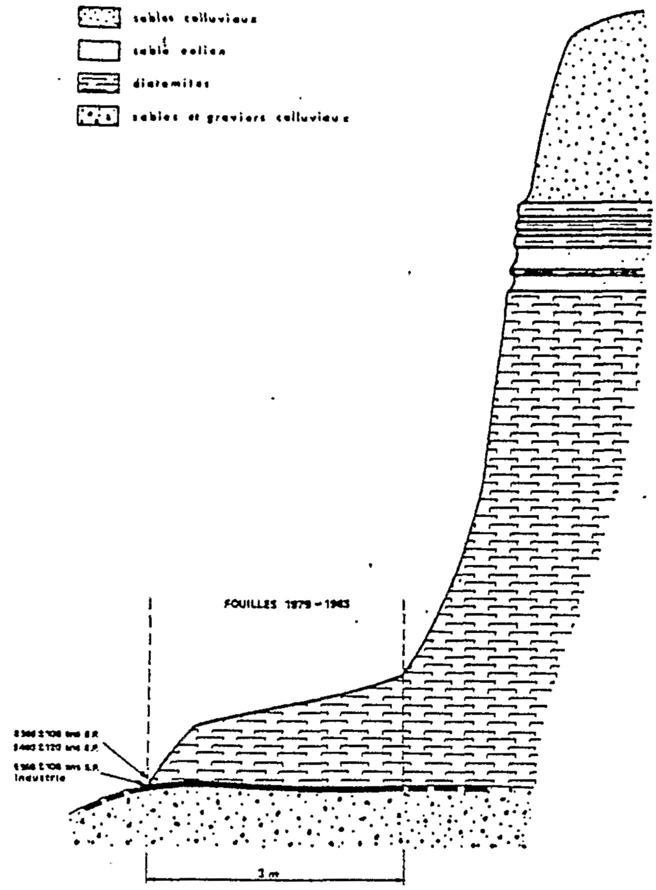

Figure 11.7 Temet. Cross-section.

LOCAL DEVELOPMENT OF THE NEOLITHIC

This is, therefore, a previously unknown archaeological industry, for which we now have good radiometric and stratigraphic controls. Its principal characteristic is the association of a blade and bladelet industry with pottery and with equipment for grinding seeds, an association which also occurs in many of the open-air sites inventoried during our surveys of the region. In addition to the four sites described above, more than twenty other surface occurrences have been discovered. They are distributed in a band over 100 km long north of the Adrar Bous, mainly toward the northwest, and they frequently occur on fossil dunes of white sand analogous to the dune of Tin-Ouaffadene. They can be of impressive size: they may be masked in parts by a thin veil of recent sand, but it is still often possible to trace a site for several hundred meters in every direction, or sometimes even more. For the most part, the density of material on the surface is very similar to that of Final Neolithic sites in this region; that is to say, the number of stone tools, flakes, potsherds and other objects brought in or modified by man amounts to dozens per square meter. One must obviously keep carefully in mind the risks inherent in open-air sites and the very real possibility of admixture from more recent periods of prehistory. In the end, however, after one has

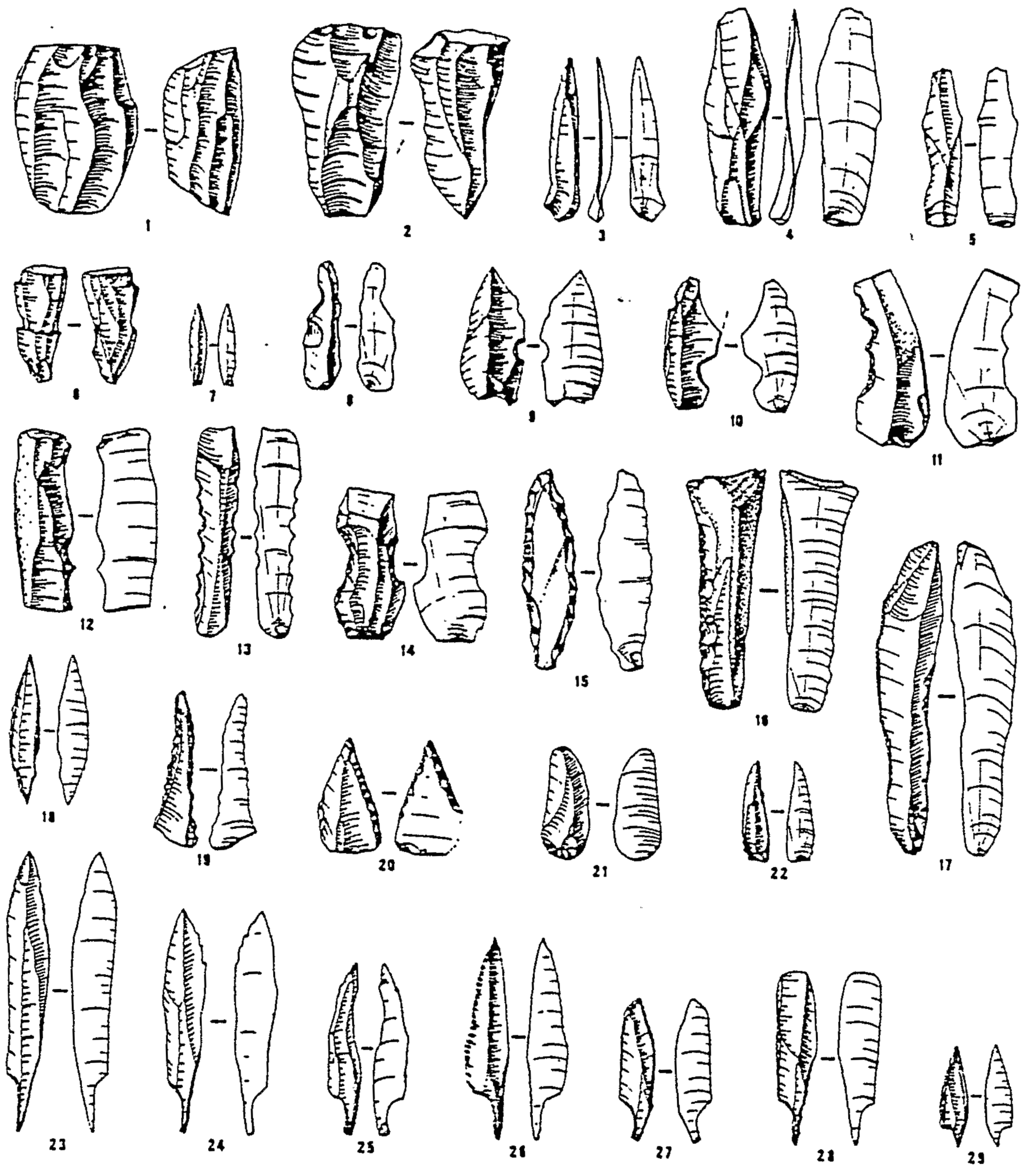

Figure 11.8 Temet. Lithic artifacts. 1, 2. 6, prismatic cores; 3–5, 7, unretouched blades and bladelets; 8–10, notched blades and bladelets; 11–13, denticulated blades; 14, strangled blade; 15–17, 22, backed blades and bladelets; 18, 19, perforators; 20, retouched point with modified base; 21, endscraper on a blade; 23–29, Ounan points.

surveyed these sites at length and has examined them very carefully and systematically, excavation not always being possible, one gradually develops the impression of a very well-established human occupation of this region during the Early Holocene. On the other hand, it remains very difficult to determine the nature of this occupation and the level of economic development reached by these populations; we are still dealing primarily only with working-hypotheses.

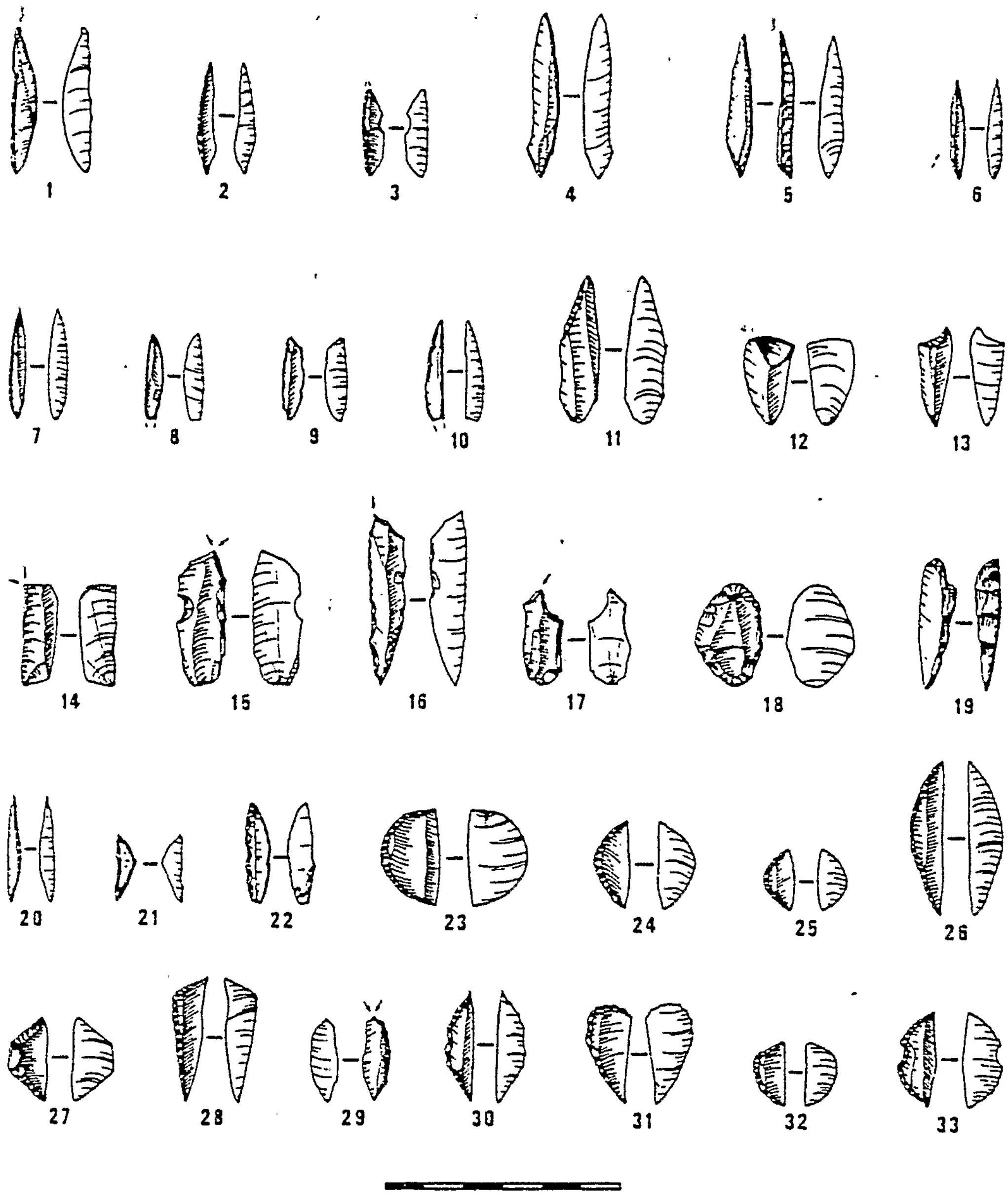

Figure 11.9 Temet. Lithic artifacts. 1–10, pointed, backed bladelets with plain or modified bases; 11–13, truncated bladelets; 14–16, burins; 17, microburin; 18, 19, scrapers; 20–22, perforators; 23–26, 29–33, segments (29, with burin, 30, with perforator, 31, with scraper, 32, truncated, 33, notched); 27, trapeze; 28, scalene triangle.

Our research has, however, established one fundamental point beyond any doubt: that pottery was known in Africa in very ancient times. We noted above that the radiometric ages we cited are among the highest ever obtained for Saharan sites with pottery. Furthermore, they fully support other comparable, or slightly more recent, radiocarbon dates obtained from sites with pottery elsewhere in the Sahara. In the Hoggar, as long ago as 1967, our late colleague J.-P. Maître obtained a date of 9210 B.P. ± 115 years for the base of the fill of the Launey site; this was an isolated reading

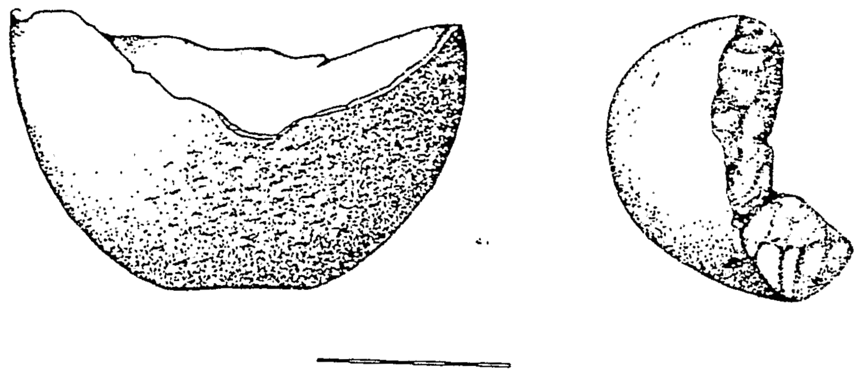

Figure 11.10 Temet. Polished fibrolite bowl and fragment of a handstone.

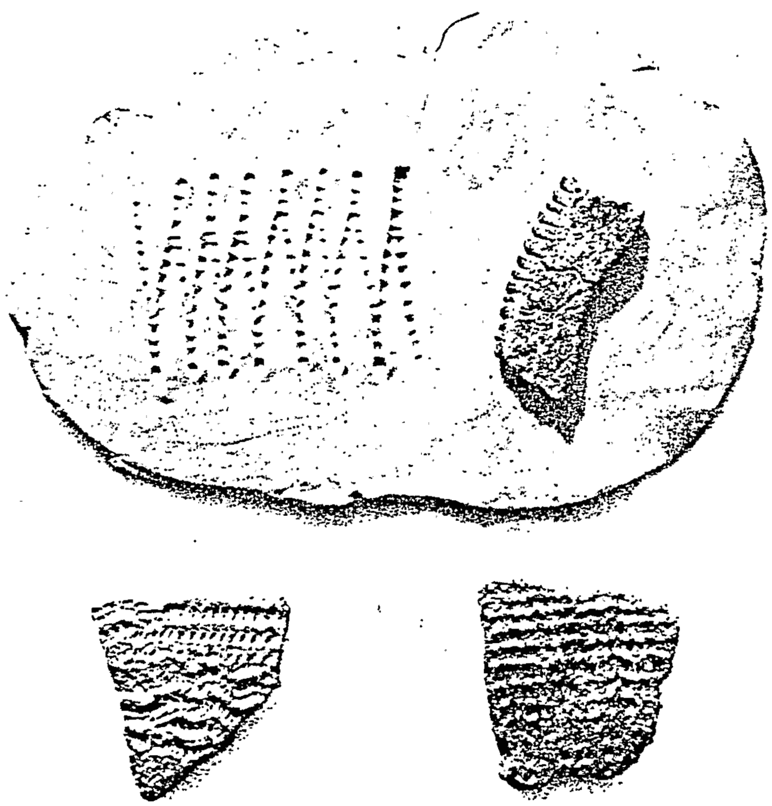

Figure 11.11 Temet. Top: fibrolite potter's comb and rocker-stamping made by it. Bottom: l dotted wavy-line sherd; right, comb-impressed sherd (both sherds probably eroded out of cult layer).

and at that time was considered to be too old (Camps *et al.* 1968). In the Tadrart Acacus, the oldest date for the remarkably long and consistent sequence of Ti-n-Torha is 9080 B.P. ± 70 years (Barich 1974). In the Bir Kiseiba region of the Eastern Sahara, Site E-79-8 has a series of seven radiocarbon dates, from 8920 B.P. ± 130 years to 9820 B.P. ± 380 years (Wendorf *et al.* 1984). It seems, therefore, to be firmly established that populations who knew how to make pottery lived in some parts of the central and southern Sahara as early as the second half of the tenth millennium B.P. This, in turn, indicates that these regions were probably one of the centers for the invention of pottery, independent of the Middle East. In the latter area, it should be observed that none of the dates thus far obtained from ceramic sites is earlier than 9000 B.P., except for the lower level of the Syrian site of Tell Mureybet which, after Cauvin's work, is now attributed to the first three centuries of the tenth millennium B.P.

The variety of vessel-forms and of motifs, which we have seen at both Tagalagal and Adrar Bous 10, is somewhat surprising for a period when one might reasonably think that the manufacture of pottery had only recently been mastered. It seems difficult to imagine that a new technique could appear with so many of its eventual developments already discovered. This is a very important point: these sites already have most of the elements which we will find, over the course of the millennia, in the pottery-manufacture of the various later Neolithic facies of this region (Delibrias and Hugot 1962). This could suggest two very different explanations. First, one cannot exclude the possibility that the real beginnings of pottery-making may have been much older. In this respect, geological research, as was noted above, has shown that the last millennia of the Pleistocene were not so markedly arid as completely to preclude the possibility of human occupation in these latitudes. The first attempts to master ceramic technology could, therefore, have been much earlier than 9500 B.P. and we might, some day, find some evidence of this.

It might also be suggested, and this is, perhaps, more likely, that once the underlying principle had been mastered, ceramic technology evolved very rapidly. In fact, there is nothing within this domain of human activity which is comparable to the gradual development of flaking-techniques, where advances were slowly added, little by little

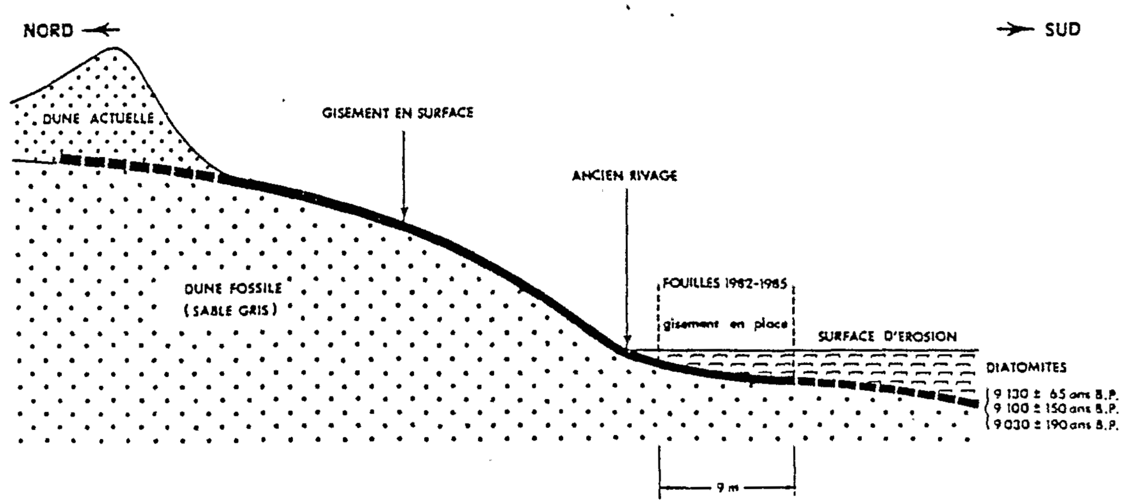

Figure 11.12 Adrar Bous Site 10. Cross-section.

and one by one through the course of time, until finally the hand of a craftsman could create well-made and designed tools from a block of stone. On the contrary, one might hypothesize that people probably advanced relatively quickly from the stage of complete ignorance to that of knowing full well how to make pottery. Instead, it was the actual need for water-tight and easily made vessels that was a long time in coming. This need marks a critical stage in the economic evolution of society and it probably results from multiple causes, both internal and external to the societies in which it arises. We do not find it surprising that, once the need has been felt, the technological response to it—that is, pottery-making—should follow very soon, and that the full range of the technique's potential should immediately become available. We would therefore prefer to explain the diversity of vessel-forms and motifs observed at Tagalagal and Adrar Bous 10 as representing the immediately available, technological minimum. As far as decoration is concerned, it may be observed that there is no indication that there was such a thing as a primordial motif predating all the others at about 9400–9300 B.P. However, the most important point is that the appearance of pottery, as it is seen in the sites of eastern Niger, is fundamentally linked to an indisputable change in the economy.

Whatever might be the interest and future of research into the antiquity of Saharan pottery, one cannot discuss its occurrence after 9500 B.P. without mention of its consistent association with seed-grinding equipment. This association is a crucial piece of evidence: it clearly indicates that the harvesting, preparation and storage of edible grasses were integrated into the subsistence practices of the prehistoric populations of the southern Sahara at a very early date. However, it would probably be rather premature to draw conclusions about the ways of life and economic systems of these groups on the basis only of this evidence. The practice of hunting or fishing is obvious as soon as one finds projectile-points or other specialized equipment, especially in a lacustrine environment, but pottery and grinding-stones are somewhat ambiguous. They attest equally well to the casual consumption of wild plants, obtained by gathering or foraging, as to a type of subsistence based upon true agriculture and thus, paradoxically, they are indicators of two completely different economies, one of food-extraction and the other of food-production.

Nonetheless, recent petrographic analysis of a series of sherds collected at Tagalagal and Adrar Bous 10 (Echallier and Roset 1986) has yielded results which may allow us to be more precise in some aspects of our idea of how these groups lived in the tenth millennium B.P.

For the moment, this analysis refers to two situations which are not quite the same. At Tagalagal, in the mountains, pottery was always manufactured elsewhere, from weathering soils which occur within a radius of less than 75 km and usually less than 25 km; the archaeological site does not, therefore, seem to have been permanently occupied. In contrast, at Adrar Bous 10, a rather high proportion of the ceramics (one third) were most probably made at the site or else in the immediate vicinity, thus suggesting an occupation which was at least long-term, even if not permanent. However, there is also evidence at Adrar Bous 10 of some movement within a relatively limited radius, about 15–20 km, as well as of some contacts over a much greater distance. What we have in both cases is a picture of semi-nomadic groups living in a well-defined territory on the edge of the rocky massifs, and not one of human groups wandering at random across vast expanses. These results are significant insofar as the extent of a territory used by a group is directly linked to its subsistence economy.

Data of the type outlined above are not yet, in themselves, sufficient to indicate the existence of a Neolithic, agricultural economy, and all the less so since the persistence of a certain degree of mobility, as shown by the analyses of the ceramics, would be inconsistent with a type of economy for which sedentism is a necessary condition. However, it should be observed that further petrographic analyses of the pottery are essential. The conclusions which can be drawn from the initial results are not at all consistent with what one would have supposed on the basis of the large size of the sites; it is difficult to imagine that they represent nothing more than the remains of temporary camps. Of course, the same localities could have seen periodic reoccupations by small groups, who juxtaposed their successive settlements of the dunes so as to give a final impression of large, established villages, but, in practice, such a system would be very difficult to control.

As far as an academic definition of the Neolithic is concerned, we should not use this term to characterize the possible way of life of these groups without giving some tangible proof of it, such as conclusive pollen analyses, or the discovery of the seeds of cultivated plants, or the existence of specialized agricultural tools. In the current state of our research, we have no such irrefutable evidence.

The archaeological data which we have outlined must now be placed within the environment in which they developed and to which they are indissolubly linked. This environment, as we have seen, was propitious; the humidity which still prevailed in the southern Sahara would undoubtedly have been favorable to an incipient agriculture. The auspicious climatic conditions reconstructed by the soil scientists give significance to the various elements revealed by archaeology, and these elements show that a radical change in economy was either taking place or had already been achieved. By way of conclusion, therefore, and as a minimal hypothesis, we believe that the observations we have made argue in favor of a local and normal evolution from the simple collection of seeds (and it is to this stage that we will, for the moment, assign the occupations of all these sites) to the organized production of cereals. In other words, the way seems to have been open for a completely African development of the Neolithic.

REFERENCES

Barich, B. E.

1974 La serie stratigrafica dell'Uadi Ti-n-Torha (Acacus, Libia). Per una interpretazione delle facies a ceramica saharo-sudanesi. *Origini*, Vol. 8. Pp. 7–184.

Butzer, K. W., G. Ll. Isaac, J. L. Richardson and C. Washbourn-Kamau

1972 Radiocarbon dating of East African lake levels. *Science*, Vol. 175. Pp. 1069–1076.

Camps, G.

1958 Le grand vase de Zouzoudinga. Remarques sur une technique de décoration ancienne. *Travaux de l'Institut de Recherches Sahariennes*, Vol. 17. Pp. 195–201.

Camps, G., G. Delibrias and J. Thommeret

1968 Chronologie absolue et succession des civilisations préhistoriques dans le nord de l'Afrique. *Libyca*, Vol. 16. Pp. 9–28.

Camps-Fabrer, H.

1966 Matière et Art Mobilier dans la Préhistoire Nord-Africaine et Saharienne. *Mémoires du Centre de Recherches Anthropologiques, Préhistoriques et Ethnographiques*, No. 5. Paris: Arts et Métiers Graphiques.

Clark, J. D.
1976 Epi-paleolithic aggregates from Gréboun Wadi, Aïr, and Adrar Bous, North-Western Ténéré, Republic of Niger. *Actes du Congrès Panafricain de Préhistoire et des Etudes du Quaternaire, Septième Session—Addis Abéba, 1971*, edited by B. Abébé, J. Chavaillon and J. E. G. Sutton. Addis Ababa. Pp. 67–78.

Clark, J. D., M. A. J. Williams and A. B. Smith
1973 The geomorphology and archaeology of Adrar Bous, central Sahara: a preliminary report. *Quaternaria*, Vol. 17. Pp. 245–297.

Conrad, G.
1969 *L'Evolution Continentale Post-Hercynienne du Sahara Algérien*. Paris: Centre National de la Recherche Scientifique.

Delibrias, G. and P. Dutil
1966 Formations calcaires lacustres du Quaternaire supérieur dans le Massif Central Saharien (Hoggar) et datations absolues. *Comptes Rendus de l'Académie des Sciences*, Paris, Vol. 262. Pp. 55–58.

Delibrias, G. and H. J. Hugot
1962 Datation par la méthode dite du ^{14}C du Néolithique de l'Adrar Bous. (Ténéréen). In *Missions Berliet-Ténéré-Tchad*, edited by H. J. Hugot. Paris: Arts et Métiers Graphiques. Pp. 71–72.

Durand, A.
1982 Oscillations of Lake Chad over the past 50,000 years. New data and new hypotheses. *Palaeogeography, Palaeoclimatology, Palaeoecology*, Vol. 39. Pp. 37–53.

Durand, A. and P. Mathieu
1979–80 Le quaternaire supérieur sur la rive sud du Lac Tchad (République du Tchad). *Cahiers de l'Office de la Recherche Scientifique et Technique Outre-Mer, série géologie*, Vol. 11. Pp. 189–203.
1980 Evolution paléogéographique et paléoclimatique du bassin Tchadien au Pléistocène supérieur. *Revue de Géologie Dynamique et de Géographie Physique*, Vol. 22. Pp. 329–341.

Echallier, J. C. and J. P. Roset
1986 La céramique des gisements de Tagalagal et de l'Adrar Bous 10 (Air, République du Niger). Résultats des analyses. *Cahiers de l'Office de la Recherche Scientifique et Technique Outre-Mer, série sciences humaines*, Vol. 2. Pp. 151–158.

Faure, H.
1962 *Reconnaissance Géologique des Formations Sédimentaires Postpaléozoiques du Niger Oriental*. Doctoral Thesis, Faculty of Science, Paris.
1969 Lacs quaternaires du Sahara. *Mitt. Intern. Verein. Limnol.* (Stuttgart), Vol. 17. Pp. 131–146.

Garde, G.
1911 *Description Géologique des Régions Situées entre le Niger et le Tchad et à l'Est et au Nord-Est du Tchad*. Paris: Librairie Scientifique A. Hermann et fils.

Gasse, F.
1975 *L'Evolution des Lacs de l'Afar Central du Plio-Pléistocène à l'Actuel. Reconstitution des Paléomilieux Lacustres à partir de l'Etude des Diatomées*. Doctoral Thesis, University of Paris.

Gillet, H.
1967 *Le Peuplement Végétal du Massif de l'Ennedi (Tchad)*. Doctoral Thesis, University of Paris.

Hagedorn, H. and D. Jäkel
1969 Bemerkungen zur quartären Entwicklung des Reliefs im Tibesti-Gebirge (Tschad). *Bulletin de Liaison de l'Association Sénégalaise pour l'Etude du Quaternaire Ouest Africain*, Vol. 23. Pp. 25–41.

Hébrard, L.
1972 Contribution á l'étude géologique du Quaternaire du littoral mauritanien entre Nouakchott et Nouadhibou 18°–21° latitude Nord. *Publications du Laboratoire de Géologie de la Faculté de l'Université de Dakar*. Dakar.

Hervieu, J.
1970 Influence des changements de climat quaternaires sur le relief et les sols du Nord-Cameroun. *Annales Géographiques*, Vol. 79. Pp. 386–398.
1975 Evolution du Milieu Naturel en Afrique et à Madagascar. L'Interprétation Paléoclimatique du Quaternaire; Essai de Synthèse. *Initiat., Doc. Tech. Office de la Recherche Scientifique et Technique Outre-Mer*, 26.

Jäkel, D.
1977 Run-off and fluvial processes in the central Sahara as indicators in the reconstruction of a climatic history of the Tibesti mountains. *Abstracts of the Tenth International Quaternary Congress (Birmingham)*. P. 225.
1979 Run-off and fluvial processes in the Tibesti mountains as indicators of climatic history in the central Sahara during the late Pleistocene and Holocene. *Palaeoecology of Africa Volume 11*, edited by J. A. Coetzee and E. M. van Zinderen Bakker. Rotterdam: Balkema. Pp. 13–44.

Jäkel, D. and E. Schulz
1972 Spezielle Untersuchungen an der Mittelterrasse im Enneri Tabi, Tibesti-Gebirge. *Zeitschrift für Geomorphologie*, Suppl. Vol. 15. Pp. 129–143.

Maley, J.
1977a Analyses polliniques et paléoclimatqlogie des douze derniers millénaires du Bassin du Tchad (Afrique centrale). *Supplément au Bulletin de l'Association Française pour l'Etude du Quaternaire*, Vol. 50. Pp. 187–197.
1977b Palaeoclimates of central Sahara during the early Holocene. *Nature*, Vol. 269. Pp. 573–577.
1980 Les changements climatiques de la fin du Tertiaire en Afrique: leur conséquence sur l'apparition du Sahara et de sa végétation. In *The Sahara and the Nile*, edited by M. A. J. Williams and H. Faure. Rotterdam: Balkema. Pp. 63–86.
1981 Etudes palynologiques dans le bassin du Tchad et paléoclimatologie de l'Afrique nord-tropicale de 30.000 ans à l'époque actuelle. *Travaux et Documents de l'Office de la Recherche Scientifique et Technique Outre-Mer*, No. 129. Paris: Office de la Recherche Scientifique et Technique Outre-Mer.

Michel, P.
1969 *Les Bassins des Fleuves Sénégal et Gambie, Etude Géomorphologique*. Doctoral Thesis, University of Strasbourg.
1977 Recherches sur le quaternaire en Afrique occidentale. *Supplément au Bulletin de l'Association Française pour l'Etude du Quaternaire*, Vol. 50. Pp. 143–153.

Morel, A.
1973 Villages et oasis des Monts Bagzans (Massif de l'Air-Niger), *Revue de Géologie Alpine*, Vol. 61, fasc. 1.

Pastouret, L., H. Chamley, G. Delibrias, J. C. Duplessy and J. Thiède
1978 Late Quaternary climatic changes in Western tropical Africa deduced from deep-sea sedimentation off the Niger delta. *Oceanologica Acta*, Vol. 1. Pp. 217–232.

Pias, J.
1970 Les formations sédimentaires tertiaires et quaternaires de la cuvette tchadienne et les sols qui en derivent. *Mémoires de l'Office de la Recherche Scientifique et Technique Outre-Mer*, No. 43. Paris: Office de la Recherche Scientifique et Technique Outre-Mer.

Pias, J. and E. Guichard
1957 Origine et conséquences de l'existence d'un cordon sableux dans la partie Sud-Ouest de la cuvette tchadienne. *Comptes Rendus de l'Académie des Sciences*, Paris, Vol. 244. Pp. 791–793.

Quézel, P. and C. Martinez
1958 Etude palynologique de deux diatomites du Borkou. Territoire du Tchad. A.E.F. *Bulletin de la Société d'Histoire Naturelle de l'Afrique Noire*, Vol. 49. Pp. 230–244.

Rognon, P.
1967 Le massif de l'Atakor et ses bordures (Sahara Central). Etude géomorphologique. *Centre National de la Recherche Scientifique*, Paris, Vol. 9. P. 559.

Roset, J. P.
1978 Poteries néolithiques du Ténéré. I. La région de l'Adrar Chiriet. *Cahiers de l'Office de la Recherche Scientifique et Technique Outre-Mer, série sciences humaines*, Vol. 15, No. 4. Pp. 379–406.
1983 Nouvelles données sur le problème de la Néolithisation du Sahara méridional: Air et Ténéré, au Niger. *Cahiers de l'Office de la Recherche Scientifique et Technique Outre-Mer, série géologie*, Vol. 13, No. 2. Pp. 119–142.

Schneider, J. L.
1967 Evolution du dernier lacustre et peuplements préhistoriques aux pays bas du Tchad. *Bulletin de l'Association Sénégalaise pour l'Etude du Quaternaire Ouest Africain*, Vol. 14–15. Pp. 18–23.

Schulz, E.
1974 Pollenanalytische Untersuchungen quartärer Sedimente des Nordwest Tibesti. *Pressedienst Wissenschaft*, Free University of Berlin, Vol. 5. Pp. 59–69.

Servant, M.
1973 *Séquences Continentales et Variations Climatiques: Evolution du Bassin de Tchad au Cénozoique Supérieur.* Doctoral Thesis, University of Paris.

Servant-Vildary, S.
1978 Etude des diatomées et paléolimnologie du bassin Tchadien au Cénozoique supérieur. *Travaux et Documents de l'Office de la Recherche Scientifique et Technique Outre-Mer*, No. 84.

Smith, A. B.
1976 A microlithic industry from Adrar Bous, Ténéré Desert, Niger. *Actes du Congrès Panafricain de Préhistoire et des Etudes du Quaternaire, Septième Session—Addis Abéba 1971*, edited by B. Abébé, J. Chavaillon and J. E. G. Sutton. Addis Ababa. Pp. 181–196.

Tilho, J.
1925 Sur l'aire probable d'extension maximal de la mer paléo-tchadienne. *Comptes Rendus de l'Académie des Sciences*, Paris, Vol. 181. Pp. 643–646.

Wendorf, F., R. Schild (assemblers) and A. E. Close (ed.)
1984 *Cattle-Keepers of the Eastern Sahara: The Neolithic of Bir Kiseiba.* Dallas: Department of Anthropology, Institute for the Study of Earth and Man, Southern Methodist University.

Williams, M. A. J., D. A. Adamson, F. M. Williams, W. H. Morton and D. E. Parry
1980 Jebel Marra volcano: a link between the Nile Valley, the Sahara and Central Africa. In *The Sahara and the Nile*, edited by M. A. J. Williams and H. Faure. Rotterdam: Balkema. Pp. 305–337.