GEOARCHAEOLOGY AND ARCHAEOLOGICAL VISIBILITY IN THE NORTHERN MANDARA MOUNTAINS AND MORA PLAIN (CAMEROON): PRELIMINARY RESULTS

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INTRODUCTION

The author has for more than a decade studied archaeological visibility, which is an expression of our ability to recognize, recover, and optimally interpret paleocultural patterns from the archaeological record. This record is overtly patterned, but many perceived patterns of distribution and morphology are complicated interference patterns between those of paleocultural origin and those superimposed by site deformation processes. Models for recognition of those processes allow their effects to be factored out, the remaining information to be fed into paleocultural reconstructions.

Geological processes are foremost among factors that deform cultural patterns in the archaeological record. The author is involved in development of models that assess the extent of geological influences on archaeological visibility.

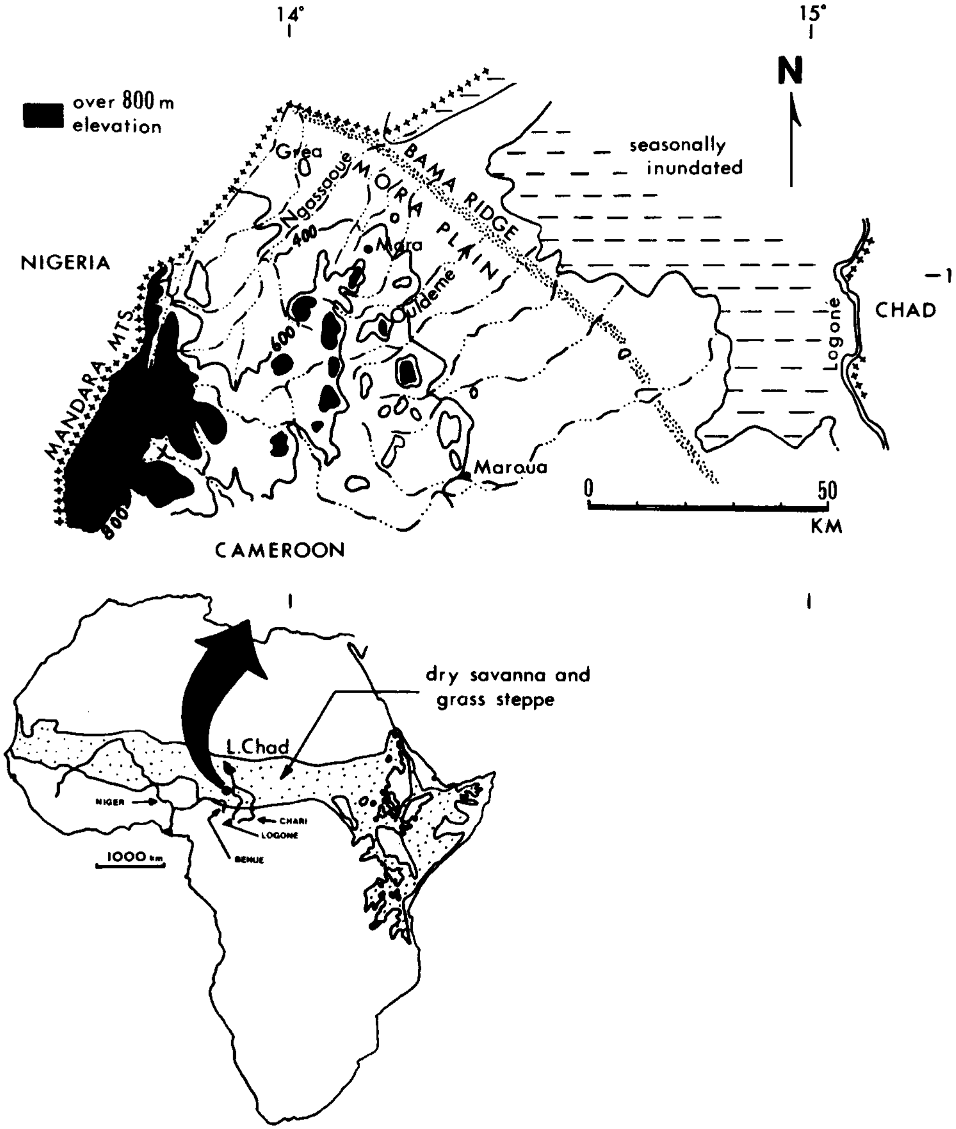

Figure 1. Key map of Africa (below) and study area (above), showing localities and features discussed in text. Contour values are in metres above sea level. The name Ouldémé properly applies to upper portions of the indicated drainage ; river names in Extrême-Nord, Cameroon, frequently change along the course.

Even the seemingly simple archaeological surface survey is fraught with complex geological biases, an understanding of which will lead to more productive sampling strategies. Such information will also facilitate development of strategies for discovery of materials of specific ages or site types.

The Mandara Project

The author undertook preliminary field studies in Cameroon in May-June, 1984 as part of the Mandara Archaeological Project, with Prof. Nicholas DAVID (University of Calgary). This ongoing project seeks to recognize and understand stylistic continuities and discontinuities in the archaeological record, in a region of great ethnic diversity. Work is coordinated with the Cameroonian Institute of Human Sciences, under an agreement between the University of Calgary and the Office de la Recherche Scientifique et Technique Outre-Mer, Paris. The present paper is offered as a progress report and points out directions for further research in the study area. It also dwells at some length upon the philosophical background of archaeological visibility studies.

The study area is located in Extrême Nord province, Cameroon, between 11° and 12° N Lat., 14° and 15° E Long (Figure 1). Modern Lake Chad lies 250 km north of the study area, which includes the northern Mandara Mountains and the adjacent Mora Plain to the north and east, dotted with inselbergs. The area of detailed study includes the Bama beach ridge, marking an important high stand of Lake Mega-Chad, and lies entirely within the drainage basin of Lake Chad.

The Mandara Mountains rise to 1500 m above sea level, with most of the massif between 1000 and 1200 m. With the Mora Plain dropping to 320 m the topographic contrast is considerable and the mountains influence the pattern and extent of rainfall. Mora, near the north extreme of the mountains, experiences 750 mm rainfall despite an eight-month dry season;

depending upon the definition used this places it near or within the Sahelian zone (BOUTRAIS 1984 : 20-23). Vegetation is thornbush steppe to savanna dominated throughout by *Acacia* species but with variations dependent upon groundwater supply. Continuous vegetative cover is largely restricted to the margins of watercourses. Interfluves on ancient alluvium tend toward halomorphic soils and, being deficient in groundwater, support a discontinuous vegetation of Sahelian species (BOUTRAIS 1984 : 51). Rainfall increases rapidly upslope, reaching 1100 mm in the mountains along the Nigerian frontier. Drainages in the area receive virtually all of their input from the mountains, and as a result several sink into their beds entirely before reaching the Bama Ridge. All rivers in the Mora area dry up annually, even Mayo Ngassaoué (Ngéchéwé), which is the largest. Much of the area northeast of the Bama Ridge, known as Le Grand Yaéré, is seasonally inundated by flooding of the Logone River (BEAUVILAIN 1981).

Extrême Nord Province is among the most ethnically diverse areas in the world (BOUTRAIS *et al.* 1984), and the Northern Mandara region is the focus of the diversity, with dense populations (44 persons/km^2). The area is comparatively low in incidence of such diseases as malaria and schistosomiasis. The highlands may have functioned as a center of innovation and of population expansion for 6000 or more years (DAVID 1985a, 1985b), but the archaeological record is challenging to interpret in view of the possibility that prehistoric ethnic diversity rivalled that of today. The Mandara Project includes a stratified sampling program for site survey based upon the distribution of modern ecological zones, closely tied to landform classes (DAVID 1985a) and thus indirectly to depositional and erosional settings. Early efforts were devoted to site inventory in both the mountains and adjacent plains. The author's goal was to interpret the dominant geological processes and environments of survey blocks, and thereby to achieve insights as to their influences upon archaeological visibility. The Mandara Mountains and Mora Plain constitute an ideal natural laboratory for the study of such geological influences. Cultural processes, in the form of late

Holocene land-use practices (deforestation, terracing of slopes), have initiated a cycle of geomorphic change that has influenced the visibility of earlier paleocultural phenomena. An analysis of archaeologically significant geological deposits and development of a firm stratigraphic chronology for the area will contribute not only to a visibility model, but also to the reconstruction and chronology of late Holocene land-use practices.

An understanding of the distribution and chronology of geological deposits will ultimately allow development of strategies for the isolation of areas in which sites of specific ages can be sought. It is vital that we seek to understand the means and processes by which sites of specific types are revealed to us, while others remain hidden from view and still others have been lost forever. Geological deposits in the region afford not only this potential but also contribute to our understanding of the sequence ol Late Quaternary paleoenvironmental changes in the Sahel. Aside from their paleocultural context, archaeological remains are "index fossils" that are important in dating the enclosing deposits, once a local cultural chronology has been established.

During the month in which the author was in the field, the Mandara Project was directed toward site inventory in the area accessible from Mora. The area includes rugged mountainous terrain (Figure 2a), alluvial fans and colluvial aprons (Figure 2b), inselbergs (Figure 2c), river terraces and alluvial fills (Figure 3a), plains of seasonal inundation, the Bama beach ridge (Figure 3b), and sand dunes. Alluvial fills and terraces were investigated because of their potential in revealing paleohydrologic changes related to baselevel fluctuations with the rise and fall of Lake Mega-Chad. Fills and terraces have promise as correlatable entities over wide areas of the Lake Chad basin because of their common baselevel control. Field work was supplemented by use of Landsat images of the study area to assist in production of preliminary maps. Although Landsat images are not photographs they nevertheless provide much useful information bearing on a wide variety of classes of information (GREGORY 1985), as has been demonstrated elsewhere in Cameroon (MORIN 1981).

The extent of late Holocene artificial terracing in the mountains for horticultural purposes made examination of earlier Quaternary deposits there virtually impossible, but cultural modification of slopes by hill refuge peoples is of direct interest because of its implications regarding sediment supply for colluvial aprons built out from the mountains and inselbergs. A case can be made for strong and direct human influence in development of these deposits. Deforestation and terracing of slopes have been profound, and in the space of a few thousand years enormous quantities of soil have been stripped from the slopes, as has the underlying weathered granitic and gneissic eluvium.

THEORETICAL CONSIDERATIONS

It is important to consider not only approaches to *sampling* of an area, but also the development of programs for *discovery* of specific classes of archaeological materials (FLANNERY 1976). Studies by the author in the plains and foothills of western Canada show not only that there is markedly differential visibility of material from various Quaternary time levels, but also that it is feasible to develop strategies of visibility enhancement to overcome these problems in surveys and excavations (WILSON 1983a, 1983b, 1983c, *in press*). Limited tests of programs for site discovery have been successful.

Study of archaeological visibility is here advanced as unifying theory that pulls together the increasingly disparate "boundary disciplines" that surround archaeology. Archaeology exhibits elements of science, social science, and the humanities. Archaeologists draw heavily upon other disciplines for techniques and insights ; yet there is arguably

Figure 2. Physiography in the study area. 2a, mountainous terrain near Gagadama, south of Mora in the northern Mandara range. 2b, cut section across toe of alluvial fan in Ndango valley, tributary to Mayo Ngassaoué, examined by Prof. Nicholas DAVID and guide Oumaté MOHAMAN. 3c- inselbergs north of Mora, with town of Mora in foreground.

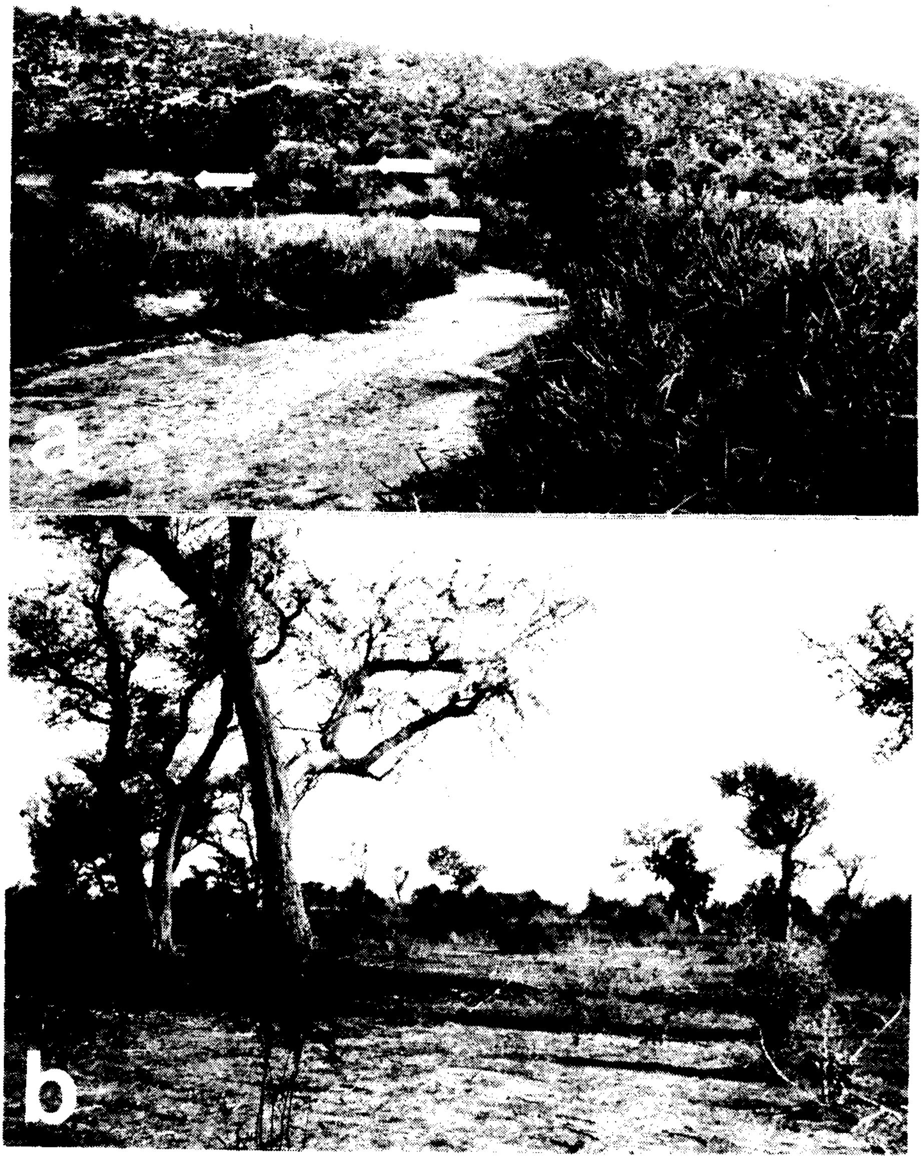

Figure 3. Physiography and vegetation in the study area. 3a, alluvial terraces (see arrows) along Miléoyom Mada (Ouldémé drainage) south of Mora. 3b, rolling semiwooded topography on Bama Ridge near Boulmaderi, northeast of Mora.

a core of paleocultural theory and laws that sets archaeology apart from them (BINFORD 1972 ; SCHIFFER 1976). Difficulties in using ethnographic data to generate and test laws about long-term processes of culture change (WOBST 1978) stimulate archaeologists to seek laws from other disciplines, promoting vigorous interdisciplinary borrowing (CLARKE 1968 ; SCHIFFER 1976). A drawback of this interdisciplinary binge is that boundary areas tend to become defined as new "disciplines" in their own right ("Archaeozoology", "Geoarchaeology", etc.), with their own societies and specialized journals. One effect is to draw the output of these specialized practicioners away from "mainstream" journals, which can reduce communication with the general archaeological community. Thus there remains a need for cross-disciplinary efforts that transcend these boundaries and rise to general archaeological theory. SCHIFFER (1976) argues usefully that the "boundary disciplines" are better viewed as *strategies* , employed by archaeologists to derive relational laws of use in cultural reconstruction. The fact that this view is not universally held underscores the continuing need for development of unifying theory to reinforce and integrate interdisciplinary relationships. This is the role of archaeological visibility (DEETZ 1968 ; GIFFORD 1978 ; WILSON 1983a), which deals with the overall ability of archaeologists to recognize, recover, and optimize the interpretive potential of archaeological remains and other evidence bearing upon paleocultural patterns. The bulk of our information comes from what is manifestly a geological environment. Archaeological visibility is concerned with pattern recognition at any culturally relevant level of integration ; such patterns range from individual artifact attributes to and beyond the level of regional settlement patterns. Patterned infrasite as well as suprasite characteristics are of equal interest, and all are vulnerable to superimposition of geological patterns upon those of paleocultural origin. For example, a continuous cultural presence could be made to appear discontinuous because of alternating episodes of erosion and deposition. Archaeological visibility legitimately includes consideration of techniques for enhanced recovery of information (WILSON 1983a, 1983b). It is a function in part of depositional and post-depositional pattern distortions in the fluid site environment (*cf.* SCHIFFER 1976), but extends beyond this, to our ability to recognize even the least distorted patterns as cultural. It draws upon all disciplines for theory, techniques, and observations but remains steadfastly "mainstream" archaeology. Such approaches as geoarchaeology and archaeozoology are seen as strategies of visibility enhancement in the provision of paleocultural information. Thresholds of visibility are definable for paleocultural patterns but are in continual retreat as new methods for enhanced recovery are devised.

The behavior of human groups who left behind detectable traces is clearly not the only determinant of distribution and accessibility of the archaeological record. Site formation processes of many kinds intervene between discard and collection (*e.g.* SCHIFFER 1976 ; MORLAN 1980). Survey archaeologists cannot systematically acquire or evaluate representative samples without consideration of local visibility filters through which paleocultural patterns may have passed since their generation.

DEETZ (1968) introduced archaeological visibility in a discussion of initial site formation. He observed that the Bushmen left few traces of occupation, therefore falling close to (if not below) a threshold of visibility ; yet, inexplicably, many have chosen the Bushmen as an analogue for archaeological cultures that left behind large and highly visible quantities of trash. Papers from a 1976 symposium revealed other aspects of archaeological visibility ranging from number and productivity of individual sites (NOBLE 1977) to the author's theoretical biases in recognizing patterns (SHINKWIN 1977) and the difficulty of finding archaeological sites in specific study areas (WORKMAN 1977). GIFFORD (1978 : 38) saw archaeological visibility as "an abstract concept that relates ethnographic reality at one time level to its probable material evidences on some future time level". WILSON (1983a : 4) drew together these threads and provided a more concrete connation in a definition stated in the reverse time perspective of practical archaeology rather than the ethnographic present and future. WILSON defined archaeological visibility as "the extent to which archaeologists have access, in or for a given study area or sampled universe, to a recognizable cluster representative of any definable ethnographic or archaeological entity or construct". Archaeological visibility depends in part upon the c-transforms (cultural formation processes) and n-transforms (natural formation processes) of SCHIFFER (1976) as well as those factors classed by paleontologists as taphonomic (VOORHIES 1969 ; MORLAN 1980, 1982). Unlike taphonomy, however, archaeological visibility can consider such a problem as the differentiation of closely similar archaeological assemblages or artifact types (typological visibility).

Techniques for enhancement of archaeological visibility are varied in reflection of the many visibility factors or filters encountered. For example, the surface archaeological record could include 12,000 years of prehistory in an erosional area, or 50 years of minimal antiquity in a strongly depositional setting.

Archaeological visibility zones should be mappable in a variety of ways to aid in interpretation of survey results. *Surface visibility zones* could be defined and coded on the basis of the oldest remains observed or expected on any modern geomorphic surface in the study area. Time-datum surface distributions, or *paleosurface maps*, would be contoured portrayals of depth of a given dated surface (paleosurface) below modern surface in depositional settings and of projected height above modern surface in erosional settings (WILSON 1983a). The relationships between such a paleosurface and the modern land surface would dictate the appropriate responses needed to allow exploitation of this segment of the archaeological record. Visibility zones could be erected on the

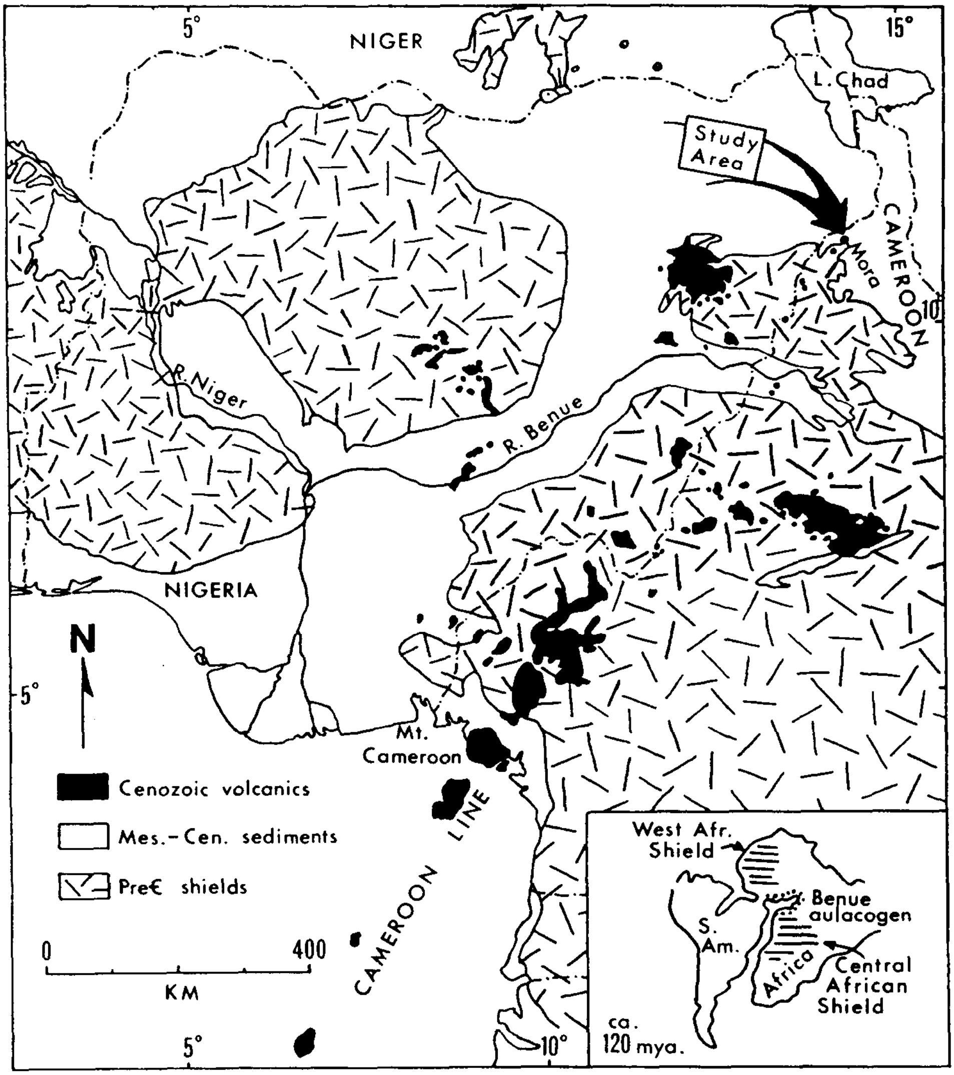

Figure 4. Generalized geology of Cameroon and eastern Nigeria, showing distribution of major terraces (see text). Inset, Africa and South America in Cretaceous times at the onset of rifting.

basis of *geomorphic process* , in which case a visibility map would be a transform of a geological map of the study area, distinguishing terraces, erosional surfaces, slump-block areas, and so on. Finally, maps could be produced showing the *potential of various sectors of the study area for recovery of specific material* (site classes, temporal classes, and so on) at or within a certain distance of the surface.

GEOLOGIC SETTING

Bedrock Geology

The rugged highlands of central and northern Cameroon give way northward to scattered inselbergs on extensive plainlands. Physiography reflects the tectonic history of the region as well as local variations in bedrock lithology. Cameroon lies at the northwest extreme of the Central African Shield (FURON and LOMBARD 1964 ; GOODWIN 1985) (Fig. 4). The "basal complex" typical of the Mandara region is comprised of granites as well as migmatites and gneisses, including both orthogneisses (metamorphosed granites) and paragneisses (metamorphosed sediments).

Regional fracture patterns reflect more recent plate-tectonic events. Splitting of South America and Africa took place in Cretaceous times with development of a triradiate rift at the site of the present Gulf of Guinea (BURKE *et al.* 1972 ; BURKE and DEWEY 1973). Two arms developed into major rifts that separated the continents ; the third became the Benue aulacogen, or failed rift (Figure 4). Igneous rocks emplaced at this time along the Benue Trough included both intrusive and extrusive rocks. A minor orogenic episode took place in the Late Cretaceous (Santonian) as the aulacogen closed, producing folds with axes parallel to the trough (BURKE *et al.* 1972). The volcanic province of Nigeria and Cameroon originated at this time, but activity was renewed in the Tertiary and continues today, centered about the

Figure 5. Landsat image of a portion of the study area (scale bar in upper left = 10 km). a, Mora ; b, Mayo Ngassaoué ; c, Bama Ridge ; d, Mandara Mountains ; e, inselberg of Gréa. Image of Landsat 2, 06 Jan. 1976, bands 4, 5 and 7.

Cameroon line (Figure 4), extending from islands in the Gulf of Guinea onshore to Mount Cameroon. The Bamenda Highlands continue this line toward Lake Chad but there is no active volcanism inland from Mt. Cameroon today. In the Mandara Mountains volcanoes of Pliocene and Quaternary age are marked by resistant plugs, ring complexes and radiating dikes. Although the region seems tectonically quiet, TURNER (1978) has suggested a structural control for earth movements associated with formation of the Chad Basin in the Pleistocene, so that earlier Quaternary sediments could show evidence of regional deformation. BURKE *et al.* (1972 : 202) suggest that the Cameroon line is a new ridge/rift feature along which separation has yet to occur.

Regional fracture patterns and densities as revealed in Landsat coverage (Figure 5, Figure 6) have played a role in the localization of erosion in the mountains and to some extent in the development of inselbergs. Fractures are oriented more or less parallel to the Benue Trough in one set, and in a second set are at high angle to the trough. The fractures (joints) have influenced the location and morphology of major river valleys.

The major inselbergs are igneous bodies of uniform composition, typically granitic. Such bodies intrude the gneisses and migmatites and the prominence of the inselbergs relates in part to differential resistance to erosion based on lithology. However, metamorphic rocks accompany igneous bodies in the Mandara Mountains and here the development of considerable relief must depend not only upon lithology but also on the fracture patterns and the relative age (and hence, differential weathering) of intrusions. In the piedmont area surrounding the Mandara Mountains, fresh bedrock is largely hidden beneath a layer of *in situ* eluvium, unconsolidated arkosic sand. Thickness of the weathered zone depends strongly upon rainfall and thus it decreases northward (BOUTRAIS 1984 : 21).

The plains flanking the Mandara Mountains have been subdivised into piedmont and aggradational plains (BOUTRAIS 1984 :

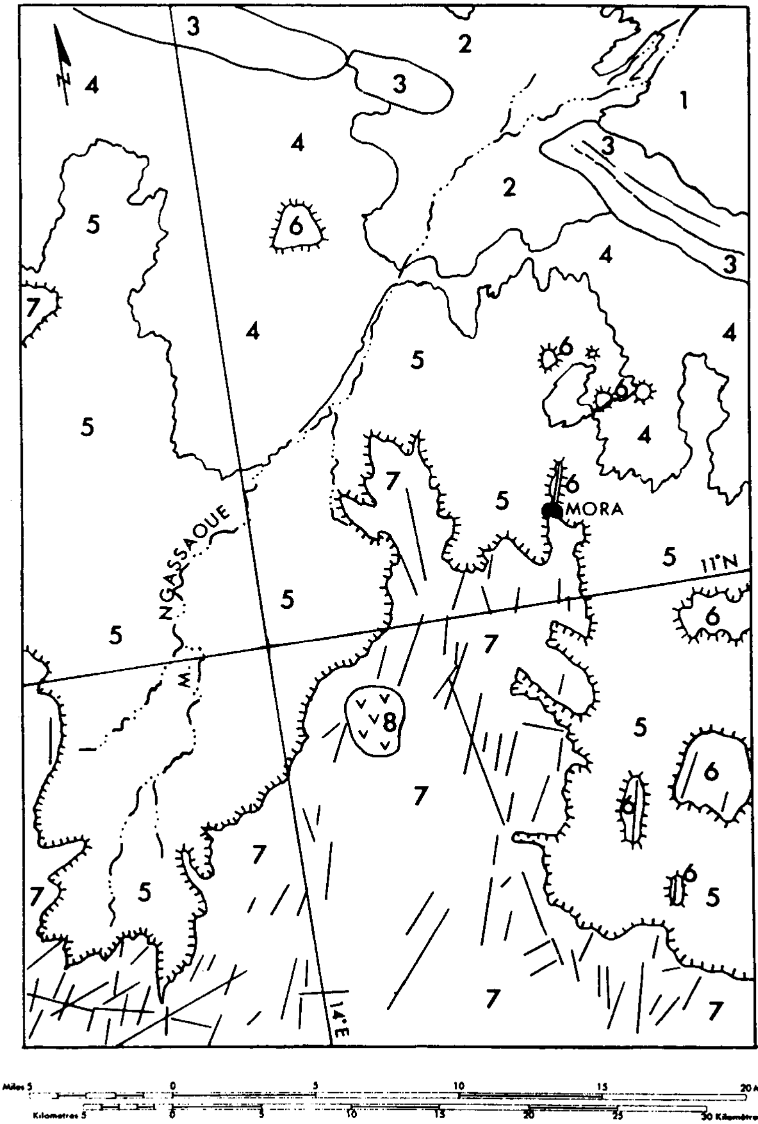

Figure 6. Preliminary geomorphological map of a portion of the study area, based upon Landsat image and ground reconnaissance. Area covered is the same as in Figure 5. 1, Lake Mege-Chad plain ; 2, deltaic deposits associated with Mayo Ngassaoué ; 3, Bama Ridge ; 4, outer portion of Mora Plain with little recent deposition ; 5, inner portion of Mora Plain, carpeted with recent colluvium and alluvium derived from denuded slopes ; 6, inselbergs ; 7, Mandara Mountains with major structural lineaments indicated ; 8, volcanic complex.

34-62), the piedmont area being erosional (a pediment) and the aggradational plain being subject to alluviation. Bedrock is only a few metres from the surface in the piedmont area, dropping away to 30 or 40 m at the Bama Ridge. However, this is a long-term development that draws attention away from the relatively recent age of colluvium in the piedmont. As will be shown below, the denuded slopes of the Mandara Mountains are contributing sustantial volumes of sediment to the fans that carpet the piedmont. The erosional pediment appears therefore to be a relict feature, now being covered by the fans. If the fans were to be removed, a lateral change would be seen from erosion on the piedmont to deposition on the aggradational plain. Beyond the Bama Ridge the bedrock surface drops away more rapidly (BOUTRAIS 1984 : 50). In neighbouring northeast Nigeria, the Chad Formation reaches a thickness of 600 m and spans much of the Quaternary (BURKE and DUROTOYE 1972 : 327).

Quaternary Geology

The depth of unconsolidated fill over bedrock in the Mora area ranges up to 40 m but is generally less. BOUTRAIS (1984 : 50) reports that modern rivercourses in the area, including that of Mayo Ngassaoué, do not correspond with the valleys incised into the underlying bedrock surface. Some lateral displacement with aggradation is therefore indicated. However, borehole records reported by TILLEMENT (1970) reveal a continuous sand section beneath the Mayo Ngassaoué as opposed to interbedded sands and clays elsewhere, suggesting maintenance of the channel in one place for a considerable time.

The Quaternary history of the plainlands flanking the Mandara Mountains was tied to fluctuations in the level of Lake Chad, which rose repeatedly to levels much higher than the <280 m stand of today. Absolute dates are few for these climatic and hydrologic events. PIAS (1967) has postulated a high stand of Lake Mega-Chad at 380 to 400 m, well above the present 320 m spillway from the Logone River (Chad system) into the Kabi tributary of the Benue (Niger system). If this was the case, the spillway was therefore much higher in the past (GROVE and WARREN 1968). On the basis of dates from other areas PIAS suggests a possible date of 55,000 yr B.P. for such a high stand, which would have inundated previously lateritized plains (cuirasses). We encountered no field evidence for such a stand but will continue to search for it.

The high stand, if it reached such a level, was followed by a period of alluviation characterized by sandy clay deposits in which calcareous nodules developed. These deposits are distributed along valleys incised into the lateritized plains. During or following this period one or more arid intervals occured, with development of dune systems from NE to E winds (GROVE and WARREN 1968 ; PIAS 1970). These winds were impeded by highlands, with development of streamlined sand-starved hollows in the lee of hills. This could be the dry period around 20,000 yr B.P. described by BURKE *et al.* (1971), but local chronologic control is needed. The red colour of these sands testifies to a subsequent humid climatic episode (PIAS 1970). At some point in the Late Pleistocene Lake Chad must have nearly disappeared ; at present the lake is shrinking dramatically and old dunes are being exposed in the bed of the southern basin (WOOD and HELFERT 1985).

After the dry period Lake Mega-Chad rose to 320 m, spilling over the bedrock sill into the Kabi tributary of the Benue system. Because it apparently did not exceed this level, any downcutting of the sill (or tectonic deformation) must have occured in the previous high stand. This is of considerable importance, because it means that the lowering of this previous high stand would have been occasioned by erosion or tectonism and not climatic change. Radiocarbon dates, mostly on carbonates from modules and lacustrine deposits, suggested to GROVE and WARREN (1968) that the last 320 m stand peaked around 10,000 yr B.P., persisting until shrinkage at 5000 yr B.P. However, recent studies by SERVANT and SERVANT-VILDARY

(1980) suggest a more complex early Holocene history.

At 320 m a prominent beach ridge complex was built. Along the southwestern margin of the basin this complex is referred to as the Bama Ridge, a prominent sandy feature in the present study area (Figure 1, Figure 3b). The degree of its construction reflects the influence of prevailing north-easterly winds, to which it is approximately transverse (PIAS and GUICHARD 1957).

Fluctuating levels of Lake Mega-Chad exerted two kinds of influences on drainages in the Mora area. Rising and falling baselevels promoted aggradation and incision, respectively. In addition, construction of the Bama beach ridge as high as 12 m had the effect of damming smaller drainages, leading to widespread lagoonal conditions on the upslope side of the ridge. A few residual plains of seasonal inundation persist along the smallest drainages today because of continued damming by the ridge. There is evidence for lagoonal conditions at some time in the past along the Mayo Ngassaoué (MARTIN 1961 ; BOUTRAIS 1984 : 50), though it is doubtful that a vigorous stream could have been impeded for long by the beach ridge during its construction. Evaporation from the lake alone would have meant higher local rainfall and higher discharge (MORGAN and PUGH 1969 : 262). If the mouth of the Mayo Ngassaoué was open to Lake Chad, as I believe likely, it is conceivable that wind-driven waters of the lake periodically (perhaps seasonally) pushed upstream to cause local inundation of bordering plainlands.

Persistence of a streamlined hollow (Figure 7) in the lee at inselbergs of Waza, on the lake side of the Bama Ridge, either indicates that the hollow postdates the last high stand, or (more likely) that inundation cannot have been lengthy. Thus the reinterpretation of lake levels by SERVANT and SERVANT-VILDARY (1980) is reasonable : instead of a long high stand they suggest a series of fluctuations with highs 12,000, 9000, 6000, and 3000 yr ago, separated by near-modern low lake levels 10,500, 7500, 4000 yr ago (Figure 8). Interes-

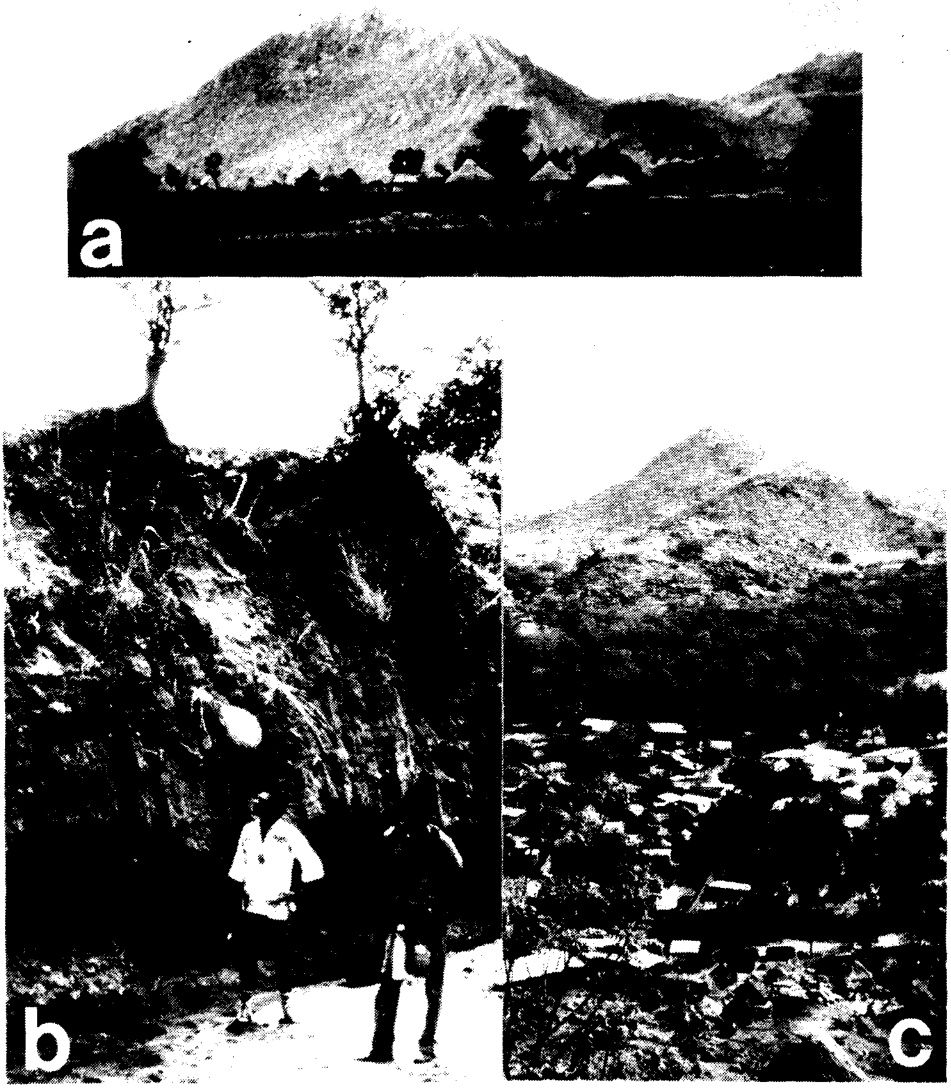

Figure 7. Landsat image of inselberg at Waza (c) with trailing dune and sand-starved lee hollow (a), all within the bounds of former Lake Mega-Chad ; b, Bama beach ridge. The lower half of this photograph adjoins the upper half of Figure 5, which lies to the west (follow Bama Ridge to join photographs).

tingly, results of studies in Ethiopia (GILLESPIE *et al.* 1983, also shown in Figure 8) reveal what appears to be a nearly opposite pattern in the late Holocene after a nearly-identical pattern from 13,000 to 4,000 yr ago. The synchroneity of changes (regardless of their direction) reinforces the case for the value of these curves in climatic reconstruction and prediction. In the case of Lake Mega-Chad, the 6000 B.P. stand was highest and reached the Bama Ridge. It was followed by a rapid drop in level with the onset of an arid interval widely documented across the Sahel (MALEY 1973 ; HAYNES *et al.* 1979). Dunes in the bed of modern Lake Chad (WOOD and HELFERT 1985) could relate to his interval if not to the preceding Late Pleistocene arid period.

GAVAUD (1972) has adopted HERVIEU's (1969) chronology for the Cameroon sector of the Lake Chad basin in an attempt to correlate past climatic events over a wide area of West Africa. The findings are of great interest but rest on few absolute dates. For the time being, the present author is inclined to be conservative in the telecorrelation of events, preferring instead to investigate the local factors involved and to augment the local chronologic control.

STUDIES IN THE MORA AREA

Background

A survey of the Quaternary of northern Cameroon was conducted by HERVIEU (1967, 1969) and included investigations in and around the Mandara Mountains. HERVIEU examined soils in detail and described in preliminary fashion sequences of alluvial terraces and capping pediments, some thought to be as old as mid-Quaternary. More recent studies by MARLIAC (in press) have added substance to these formulations and reinforce the belief that early terraces are present ; it appears certain that they can be prospected fruitfully for Paleolithic industries. These authors have recognized an

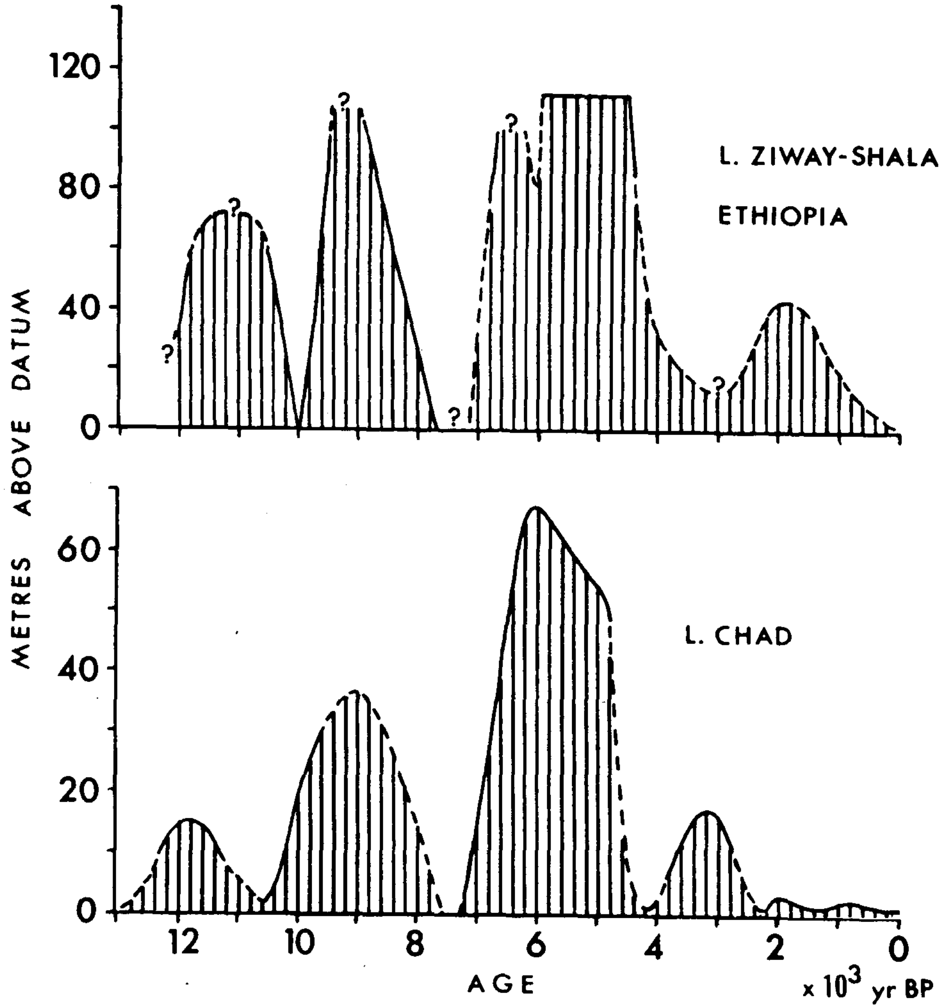

Figure 8. Lake level curves for Lake Ziway-Shala, Ethiopia (top; after Gillespie *al al.* 1983) and Lake Chad/Mega-Chad (bottom; after Servant and Servant-Vildary 1980), showing inverse phase relationship in late Holocene but coincidence of major events of change.

early period, the Douroumien, during which alluviation occurred and terraces were constructed, capped by pediments. A pre-Douroumien episode of somewhat wetter conditions is also suggested, but evidence is limited. Following the Douroumien was a wet phase, the Peskeborien, in which red soils formed on the Douroumien surfaces and during which considerable dissection of pediments occurred. During the succeeding Boussoumien phase, subdivised into arid and wet subphases, deposition of another alluvial fill occurred. After a period of further soil formation and dissection, a sequence of lower terraces was constructed.

The chronology of this is unclear. HERVIEU (1969) reports a date of *ca*. 10,000 yr B.P. for a vertisol on a Boussoumien terrace, and MARLIAC (in press) has dates of 20,000 to 15,000 yr B.P. that could apply to the Douroumien. However, associated industries suggest even greater antiquity ; for example, MARLIAC (in press) reports post-Acheulian artifacts of Middle Stone Age affinities from the surface of a Douroumien terrace, the deposits of which could therefore be even older than the industry. His radiocarbon dates are based upon calcareous nodules, the *in situ* formation of which could significantly postdate the terraces themselves (*cf*. MAGARITZ and KAUFMAN 1983).

Alluvial Deposits

The lower terraces noted by HERVIEU (1969) stood 1 to 2 m above modern river levels, while Boussoumien terraces stood 4 to 9 m up. The present author examined low terraces in view of their excellent preservation and the likelihood of their link with baselevel fluctuations as the level of Lake Mega-Chad varied. Chronologic controls are at present nearly non-existent. One can hypothesize alluviation with rising baselevel, and incision with falling baselevel. It is noteworthy that this means correlation of alluvial "events" with the trends up and down *between* high and low stands, and not with the high and low stands themselves.

Along the Mayo Ngassaoué (Figure 9) north of Kourgui (NW of Mora) two late terraces are present, one about a metre above river level and the other two metres up. The channel itself is choked with at least 1.5 m of sand and fine gravel, little of it being moved actively by the modern river. The 1 m terrace (Figure 10) reveals development of a vertisol in fine alluvium and is a surface of periodic inundation ; it is scattered with Iron Age to modern archaeological materials. On the 2 m terrace, the indurated surface is dissected and hummocky, and armoured with a lag deposit of archaeological material, including Neolithic artifacts (comb-impressed pottery, polished stone) at a site near Saré. Thus an age of a few to several millenia could be suggested for the 2 m terrace, while the 1 m terrace could fall well within the last few millenia. In each case, the archaeological remains provide only limiting dates, because buried occupations have yet to be observed. A comparison with the lake-level curve of SERVANT and SERVANT-VILDARY (1980) (Figure 8) at first prompts the suggestion that the 2 m terrace fill could have been deposited in reponse to rising lake levels 7000 to 6000 years ago (5000 to 4000 B.C.) HERVIEU (1969) felt that the low terraces postdated the last high stand of Lake Mega-Chad, but also suggested widespread erosion of uplands at the time of the stand. With such a high baselevel, extreme dissection throughout the high stand episode is improbable ; more likely there was high phytostability (to retard erosion) as a result of higher rainfall. Rising baselevels would have been associated with alluviation on the lower reaches of streams ; while falling baselevel would have been associated with incision *after* the peak of the high stand. The drop from the 320 m stand of Lake Mega-Chad was apparently major and rapid, and could have initiated strong incision by the river ; the drop from the 4-8 m group to the 1-2 m group of terraces therefore emerges as a likely candidate. In this view, the 2 m terrace would date from the subsequent rise (4000 to 3000 yr B.P./2000 to 1000 B.C.), and the 1 m terrace would relate to a more recent, minor rise about 2000 years ago. This would indicate

Figure 9. Valley of Mayo Ngassaoué north of Kourgui (NW of Mora) showing dry sandy bed (May 22, 1984) and 1 m terrace. View is looking southwest.

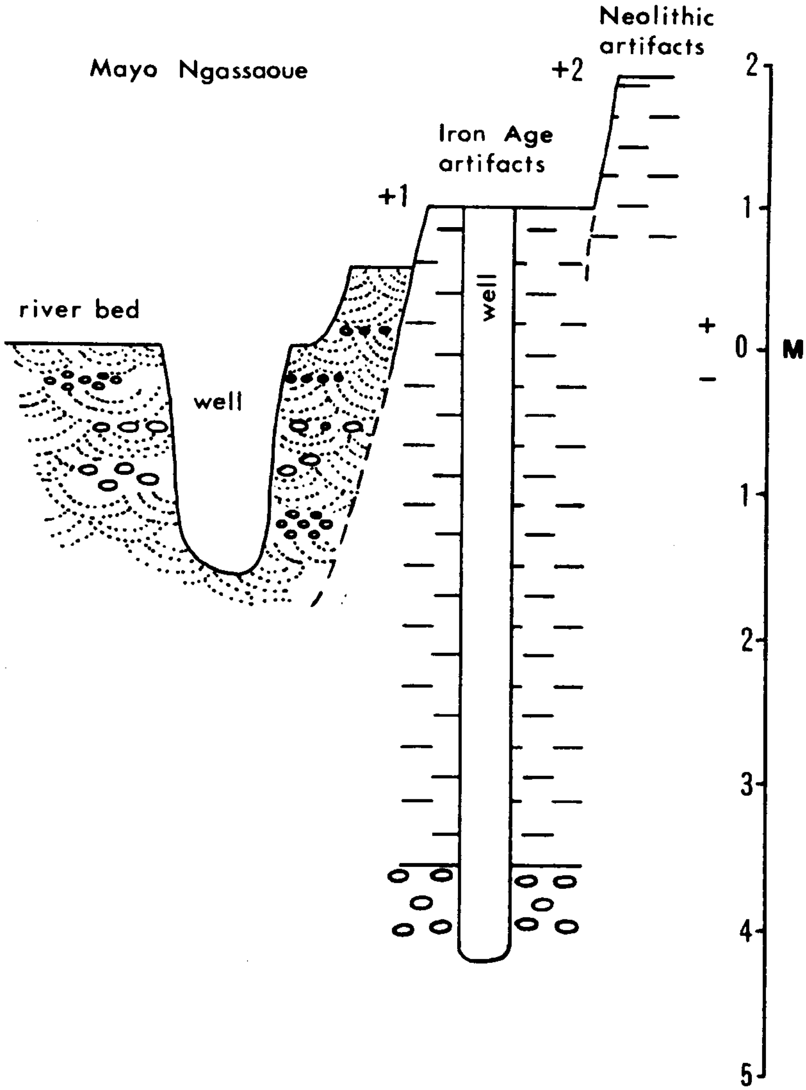

Figure 10. Generalized cross-section showing low terraces along Mayo Ngassaoué north of Kourgui.

a late date for the Neolithic pottery on the order of 3000 yr B.P. or 1000 B.C. Interestingly, this is almost precisely the maximum date suggested by CONNAH (1981 : 81-86) for sites of similar characteristics in nearby northeastern Nigeria. Comb-stamped pottery and ground stone axes were found together at Borno 38 and in basal levels at Daima, dated between about 1200 and 300 B.C. (about 3150 to 2250 yr B.P.) if the one-sigma range of five radiocarbon dates is used. While comb-impressed pottery did persist into younger levels, use of ground stone dropped off dramatically around A.D. 50 (if not earlier), with the arrival of iron. These dates would therefore support a relatively late date for deposits of the 2 m terrace at Saré, though they remain only limiting dates. Vigorous attempts must be made to secure the chronology of these late terraces by direct dating in order to provide an adequate model for the interpretation of earlier deposits and surfaces.

A brief examination was made of terraces on the Mayo Ouldémé and tributaries south of Mora, where HERVIEU (1969) had suggested the presence of ancient alluvial terraces. Examination of sections along the tributary Miléoyom Mada revealed a prominent terrace 6 m above river level (Figure 11), with 4.5 m of exposed alluvium overlain by up to several metres of colluvium (Figure 12). The alluvium exhibited variations in texture from gravels to silts within an overall fining upward sequence and is at present undated. Within the overall fining upward sequence are at least four fining-upward cycles, suggestive of point bar development during a period of waning discharge. Only in the colluvium was archaeological material observed, all of Iron Age affinities. A 4.5 m alluvial terrace surface would suggest a Boussoumien assignment and thus an earlier Holocene if not greater age. Exposures of this alluvium are extensive in the upper Ouldémé system and require further examination. The Ouldémé, like the upper Mayo Ngassaoué, appears to exploit a major fracture zone in the Mandara Mountains. Deep weathering would have occurred in this fracture zone, and the system is therefore ancient. Low terraces of the 1 to 2 m set are also widespread here.

Colluvial Aprons

Perhaps the most interesting class of deposits to be observed was that of the pervasive sandy to silty colluvial aprons extending outward from slopes throughout the study area. The term "colluvium" is used for "a sediment composed of poorly sorted mixtures of clay-, silt-, sand-, and gravel-sized particles" (WATSON *et al.* 1984 : 226). Wherever these deposits were encountered, they were associated with Iron Age pottery. At a site barely outside the south boundary of the town of Mora, for example, up to 120 cm of colluvium with pottery lay atop a deeply *in situ* weathered zone of rotted granitic bedrock (eluvium), which was trenched to a depth of 175 cm (Figure 13). A well at the base of the east slope of Gréa, an inselberg northwest of Mora beyond the Mayo Ngassaoué, revealed Iron Age pottery in colluvium to a depth of nearly a metre, associated with a butchered giraffe (*Giraffa camelopardalis*) metatarsal (Figure 14). The depth to the colluvium/eluvium boundary could not be determined here, although eluvium was abundant in the backdirt of nearby augered wells too dangerous and deep (10 m) to be entered without rope ladders.

It was concluded that throughout the area a major period of colluviation began during the Iron Age, and it is hypothesized that the driving forces were deforestation and terracing of slopes by hill refuge peoples (Figure 15). Terraces can be effective in reducing the slope and fostering greater infiltration of water (COATES 1985 : 258) ; however, those in the Mandara region are variably maintained and their walls, being made of rounded boulders, allow much water to pass through. Fresh deposits from storms during the field period made it clear that significant slope movement is occurring today, much of it water-assisted, in the absence of phytostability. A

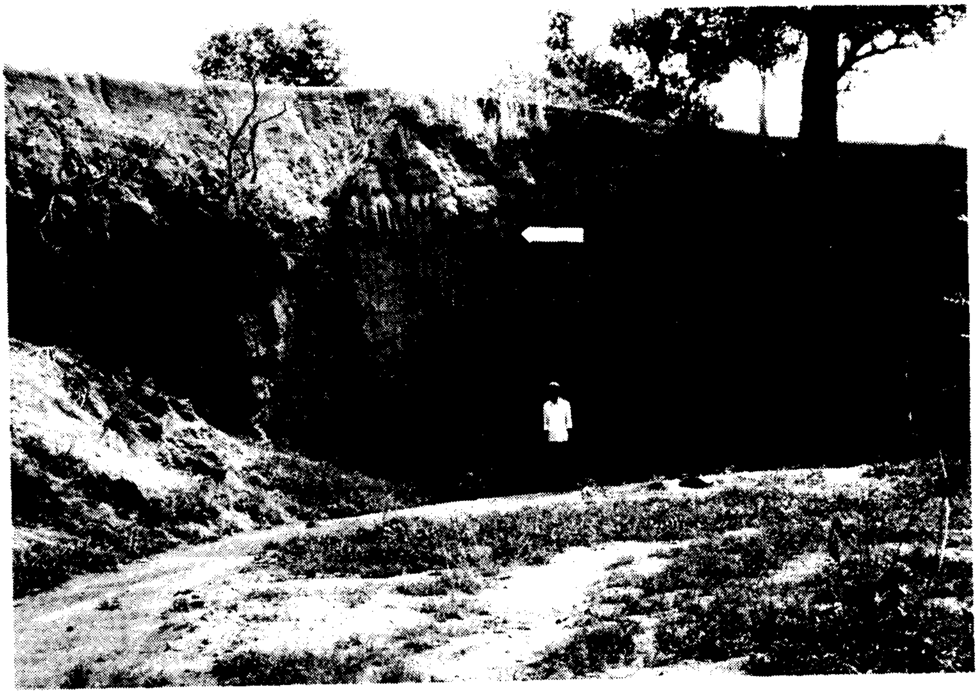

Figure 11. High terrace alluvial fill and capping colluvium along Miléoyom Mada, a tributary of the Mayo Ouldémé south of Mora. Arrow indicates unconformity between the two deposits. Section in Figure 12 was measured at the right extreme of this photograph.

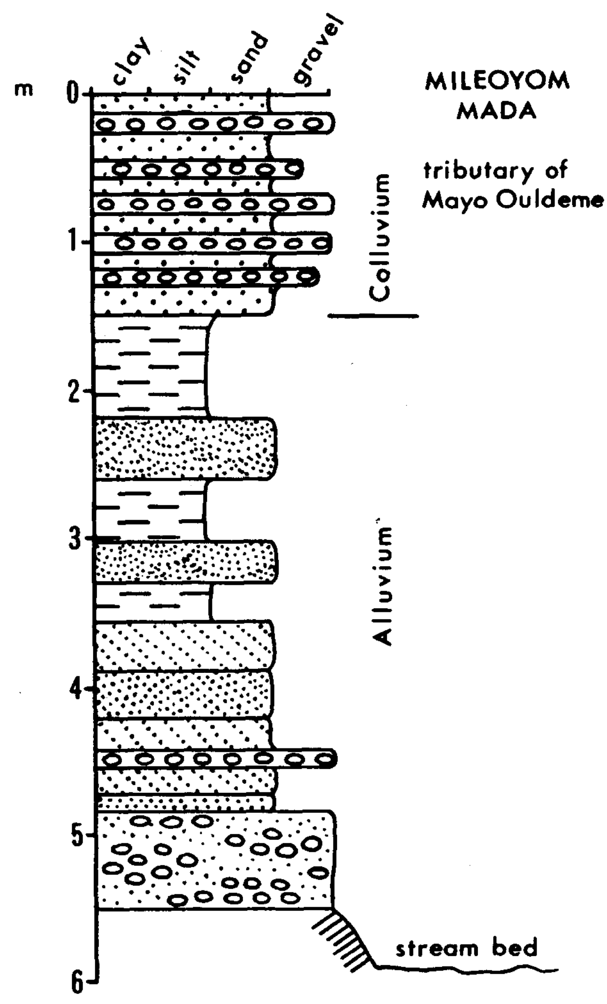

Figure 12. Stratigraphic column for high terrace alluvial fill and capping colluvium along Miléoyom Mada (see Figure 11).

Figure 13. Section just south of Mora showing colluvium (dark zone) directly over eluvium (rotted bedrock). Length of staff 1.5 m. Bouldery slope of Mandara Mountains is in background.

Figure 14. Butchered giraffe (*Giraffa camelopardalis*) metatarsal being collected by Scott MacEACHERN from colluvium in well at inselberg of Gréa. Iron Age pottery was associated.

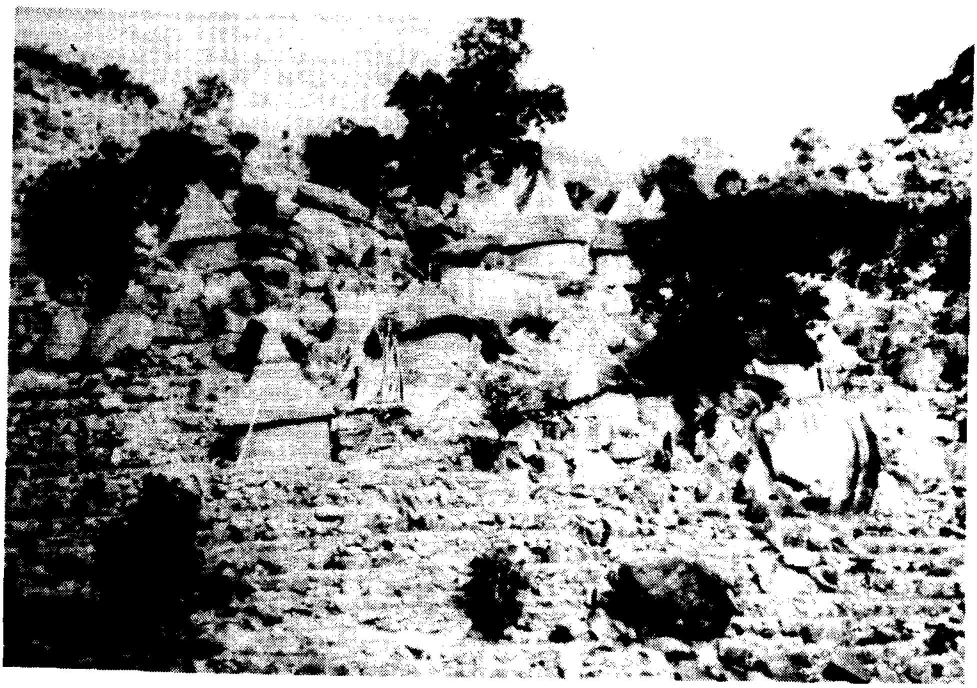

Figure 15. Hill refuge village and terracing of slopes south of Koza, in upper drainage basin of Mayo Ngassaoué.

closely similar relationship has been inferred by BUTZER (1981) at Axum, in Ethiopia, where overvigorous land use led to widespread soil and slope instability. The Cameroonian example is in effect a miniature version of the process that led to the deposits described by WATSON *et al.* (1984) from southern Africa ; in their example the loss of phytostability was tied to a period of aridity. This is probably the most extensively terraced area in West Africa (see MORGAN and PUGH 1969 : 117) ; in other areas terraces are discontinuous and less well maintained.

It is likely that this supply of sediment is sufficient to explain the sand-choked channels noted along rivers in the area today. Aggradation of rivers as a result of lowered phytostability and increased erosion of slopes has been widely documented (COATES 1985 : 238-243). In this view, the rivers are approaching a sandy braided state, undergoing aggradation that now depends not upon lake level but upon sediment supply (with or without a change in rainfall). As such, it may represent a new departure for the geomorphology of the region, and would spell future problems in terms of the raising of river beds and the flooding of wider areas.

ARCHAEOLOGICAL VISIBILITY

Recognition of periods of deposition and erosion on a regional scale leads to the conclusion that differential visibility of archaeological remains of differing ages is significant in this area. While this seems a simple-minded conclusion, it parallels the author's findings in western Canada (WILSON 1983), where predictive models for site discovery have resulted, and where sites of periods formely poorly represented have been brought to light.

Geological factors have clearly caused the selective obscuration of archaeological materials associated with specific landforms in the study area. The obvious implication is that it is not possible to rely upon surface survey as a source for an unbiased sample of archaeological materials from all time periods and site classes. While this may seem axiomatic, surface surveys remain staple archaeological fare in most areas of the world, and increasingly elaborate attempts are made to stratify the samples on the basis of *modern* landforms and/or other surface features (natural or artificial). The avowed target of such attempts is a representative sample, but unless there is a coincident effort to document the distribution of geological environments (depositional and erosional), the precise phenomenon of which the samples are representative is elusive indeed. For the study area it is arguable that an infusion of geoarchaeological theory and information will significantly enhance our understanding of the regional archaeological record. Furthermore an understanding of the distribution of deposits of known age should allow directed archaeological searches, this time with the goal *discovery* rather than *sampling* (see FLANNERY 1976), to find sites of previously unrepresented classes or time periods.

In the case of alluvial fills, aggradation during times of rising baselevel would have buried archaeological remains along the river systems and in areas of periodic inundation on the adjacent plains. The latter include areas immediately upslope from the Bama Ridge where waters of ephemeral streams are dammed by the ridge. In areas of aggradation materials from early in these periods (e.g. around 7000 yr ago and 4000 yr ago) would tend to be buried and thus selectively obscured. Materials dating from periods of downcutting would have been subject to the effects of long-term exposure, forming lag concentrates on older surfaces and suffering considerable dispersion as a result of surface processes. In between would be material from times of peak lake level, which would be buried in shallow fashion and subject to reexposure with dissection. One can readily see the implications that this would have in an area where such fluctuations occurred repeatedley, and sometimes on a grand scale.

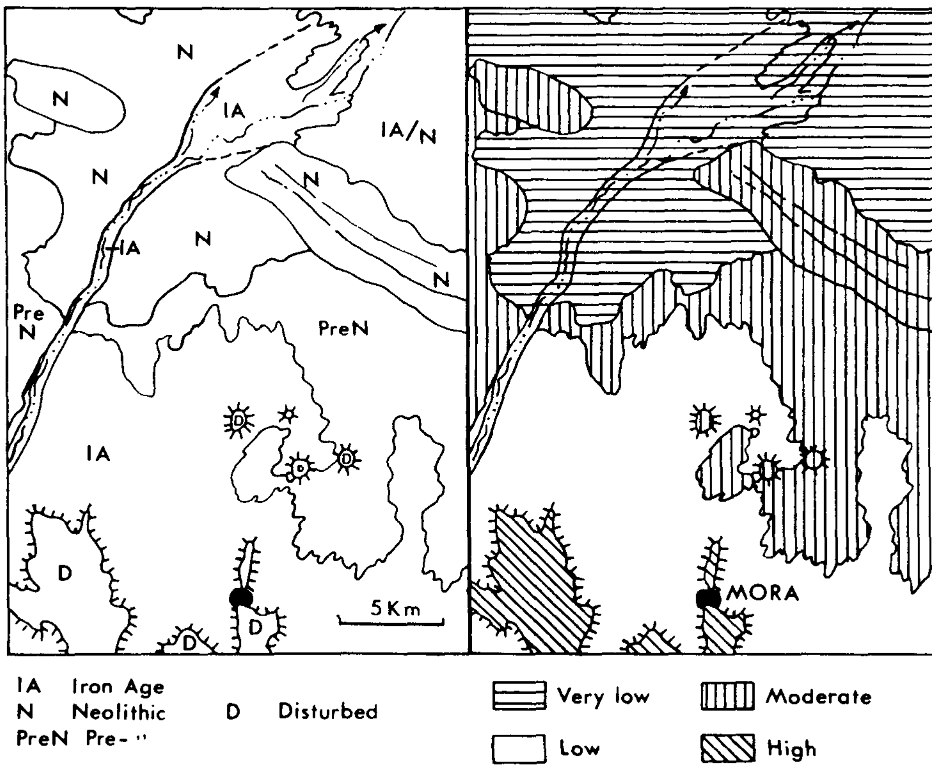

Figure 16. Preliminary archaeological visibility maps for the northeastern portion of the study area (see Figure 6 for base map). Left : tentative surface visibility zones based on maximum expected age of surface archaeological material in undisturbed contexts. Right : tentative surface visibility zones based upon relative probabilities for the discovery of surface materials older than 6000 years B.P. See text for discussion.

Colluviation around the bases of the Mandara Mountains and isolated inselbergs nas been significant and obscures most pre-Iron Age deposits from view. Colluvial aprons are extensive and tend to be continuous rather than occurring as localized fans. Thus there is to be expected a band around the bases of all such slopes and up to several kilometres in width, in which pre-Iron Age materials are undetected in surface surveys. Beyond a kilometre the thickness is not likely to be great, but air photographs and Landsat imagery suggest considerable extent. Local variations will of course occur, but the regional patterns are a significant influence on archaeological visibility. Through the development of strategies for visibility enhancement in surveys (shallow test-pitting, deep trenching, etc.) archaeological materials of previously underrepresented or even unrepresented periods will likely be brought to light.

Figure 16 presents two preliminary examples of the sort of archaeological visibility maps that could be constructed for the northeast sector of the study area. One shows tentative surface visibility zones based upon maximum expected age of surface archaeological material in undisturbed contexts, while the second is a transformation showing tentative relative probabilities for the discovery of surface materials older than 6000 years B.P. Mountain slopes are indicated to be "disturbed" because of the pervasiveness of terracing for horticultural purposes. With continued field work more detailed maps can be constructed to show local variations in the regional trends and guide archaeologists more accurately to potentially productive environments. The present study has served only to introduce this avenue of inquiry, and it is hoped that further field work along these lines will be possible.

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