ON PLEISTOCENE EVOLUTION OF THE NILE VALLEY IN SOUTHERN EGYPT

KARL W. BUTZER and CARL L. HANSEN
University of Wisconsin

CURSORY observations on the Pleistocene deposits of the Nile Valley between Gebel Silsila and the present Egyptian-Sudanese frontier go back about a century to Leith Adams, who spent three months in Lower Nubia during 1862–63.[1] The first modern survey of the Pleistocene geology of the Egyptian Nile Valley was carried out by the geologists K. S. Sandford and W. J. Arkell, who devoted the winter of 1929–30 to a study of the stretch between Kom Ombo and Wadi Halfa.[2] During the past thirty years, investigation remained dormant until the realization of the High Dam project at Aswan focused new interest on this region.

During the winter of 1962–63 the writers were attached to a Yale University expedition studying the prehistory of the Kom Ombo Plain and Egyptian Nubia. This provided opportunity for a seven-month field investigation concerned with the Pleistocene history of a 370-km.- (230-mi.-) portion of the Egyptian Nile Valley. The surficial geology and geomorphology of a 1,500-sq.-km.- (579-sq.-mi.-) area at Kom Ombo and in the lower courses of Wadis Kharit and Shait were mapped at 1:100,000.[3] In Nubia, where recent 1:30,000 air photos and excellent 1:10,000 topographic maps were made available by UNESCO, through the Centre de Documentation (Cairo), the surficial geology of a 277-km.- (172-mi.-) long, 3-km.- (1.9-mi.-) wide stretch of the valley was mapped in detail. The lowermost 30 km. (18.5 mi.) of Wadi el-Allaqi were mapped at 1:30,000. Even where air photos were available, detailed Abney traverses at 1:1,250 formed the basis for the mapping. A detailed local study of the Kurkur Oasis[4] and of selected areas in the Red Sea Hills complemented the Nile Valley work. Some 450 sediment and gravel samples were analyzed in preliminary form in Aswan, and about 300 of these are now in process of laboratory study at the University of Wisconsin.

This article attempts a brief outline of the preliminary results of our survey.

THE LATE TERTIARY SETTING

The origins of the modern Nile Valley in Upper Egypt and Lower Nubia go back to the Pontian or even the Upper Miocene. Recent borings at Kom Ombo indicate that at least 450 m. (1,476 ft.) of light grey shales overlie the Nubian Sandstone at the base of a graben-like depression. Upper Pliocene lagoonal deposits (siltstones, quartz sand, and evaporites) extend to 130 m. (427 ft.) above sea level in Wadis Kharit and Shait. In the Aswan area a buried fossil valley extends to 150 m. (492 ft.) below sea level with two distinct classes of fill: 80–110 m. (262–361 ft.) of basal sandstone, siltstone, and shale under 100–120 m. (328–94 ft.) of fluvial gravel.[5] The basal strata are highly suggestive of the Kom Omban Pliocene, whereas the gravel, extending down to 45 m. (148 ft.) below sea level, is almost certainly Pleistocene. C. Voute hints at a complex explanation by eustatic changes of base level combined with major epeirogenic movements and tectonic activity.[6] Whatever its origins, the buried valley pre-dates the Upper Pliocene Gulf, implying a considerable antiquity for the Nile River in Egypt.

THE LOWER NUBIAN PEDIPLAIN

The oldest geomorphic feature of presumed Pleistocene age is a broad pediment plain developed at 200–210 m. (656–89 ft.) elevation between Aswan/Kom Ombo and the Kurkur escarpment, fingering up the present Nile Valley to south of the Sudanese border (Figure 1). This Lower Nubian pediplain was developed in relation to a fluvial base level approximately 80–90 m. (262–95 ft.) above that of the modern floodplain. Impressive remnants can be observed above the temples of Abu Simbel and along the east bank downstream of Kasr Ibrim. No related deposits were found,[7] although red palaeosols occur on the surface.

Higher, badly dissected erosional surfaces occur in both the Eastern and Western deserts but these are of peripheral interest here. More significant are younger pediments which are extensively developed on both flanks of the valley in Egyptian Nubia, and which presumably are related to local base levels of the Nile. Near the Sudanese border, for example, distinct pediment surfaces which are developed in horizontal sandstones occur at 190, 180, and 160 m. (623, 591, and 525 ft.) above sea level. Whether these pediments have chronological significance is uncertain, because in some cases at least minor block faults have offset segments of one and the same pediment. Each of the pediments was subjected to ferruginization ("ironstone") prior to later gravel aggradation in the Nile Valley. Although there are frequent convergences between true fluvial platforms (often with gravel) and the pediment surfaces, the latter are distinctive (particularly on aerial photographs) and may be considerably older.

AUTOCHTHONOUS NILE GRAVELS

The general downcutting tendency of the Pleistocene Nile was interrupted by temporary aggradations of coarse, rounded gravel. These *autochthonous Nile gravels* are of local lithology, primarily macrocrystalline quartz, with igneous and metamorphic materials at the embouchures of the large Eastern Desert wadis, and with a local component of ferricrete sandstone. There is no clear evidence of minerals which are not derived from Egypt and the northern Sudan.

Several distinct stages were identified (elevations given in relation to the modern Nile floodplain): at +50–55 m., +48 m., and +42 m. (164–80 ft., 157 ft., and 138 ft.) where the surface was weathered by deep, red palaeosols, and at 32 m. and +24 m. (105 and 79 ft.) where the surface was moderately rubefied (see Figure 2). Fossils and human artifacts were not found *in situ*, and there seems to be no significant variation in petrography or heavy minerals. Stratigraphic criteria are consequently indirect.

Wherever the autochthonous Nile gravels are well developed, contemporary deposits can be subcontinuously followed in the field or by aerial photography. The

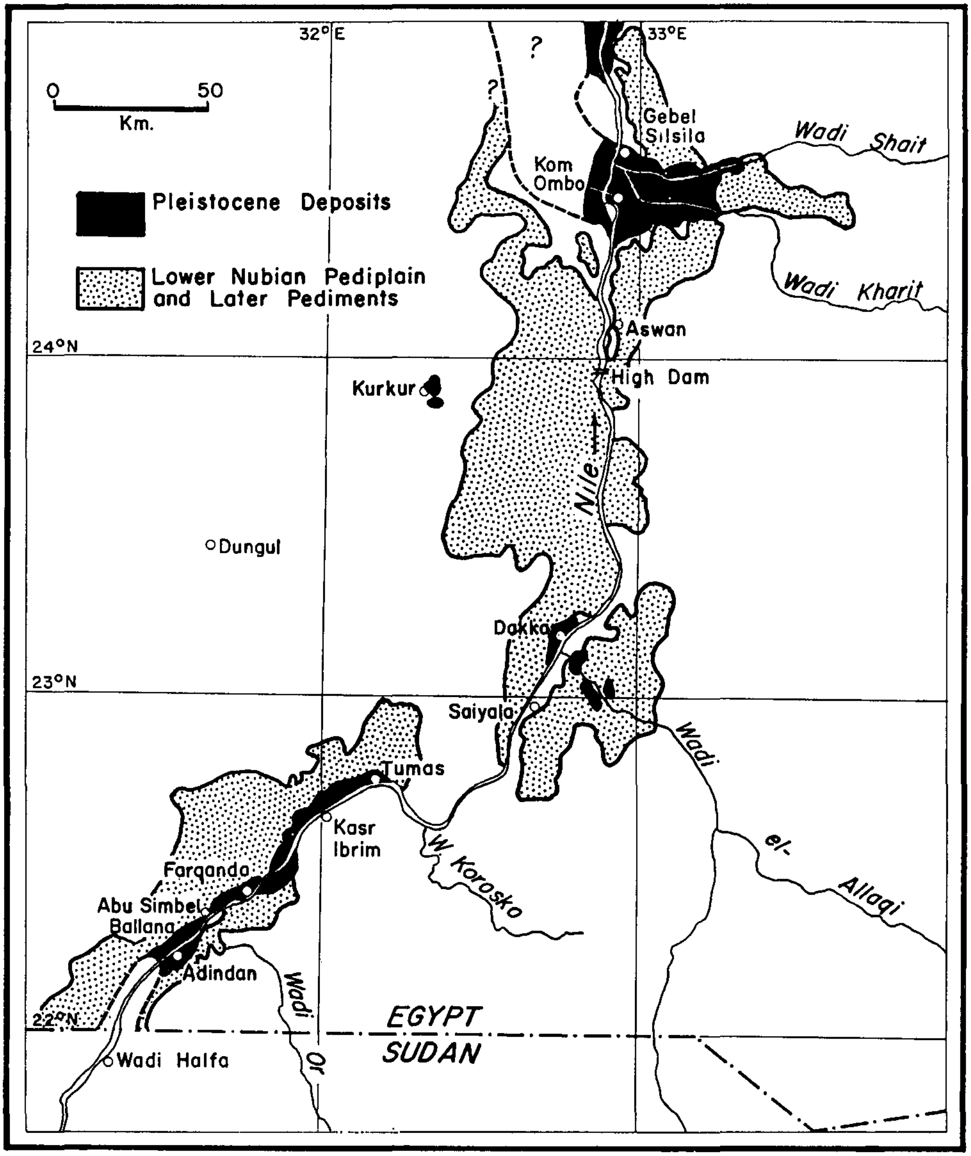

FIGURE 1. Southern Egypt, showing the extent of Pleistocene deposits (as mapped or field checked by the writers) and the lower Nubian pediplain.

authors have no reservations concerning the internal validity of correlation and differentiation within these restricted areas: Adindan to Ballana, Farqanda to Tumas, Wadi el-Allaqi to Dakka and the Kom Ombo Plain. Regional correlation through southern Egypt is more tenuous. The relative geomorphic significance of terraces, the degree and character of surface rill erosion, and the depth of weathering proved to be rather useful criteria in checking simple altimetric correlations.[8]

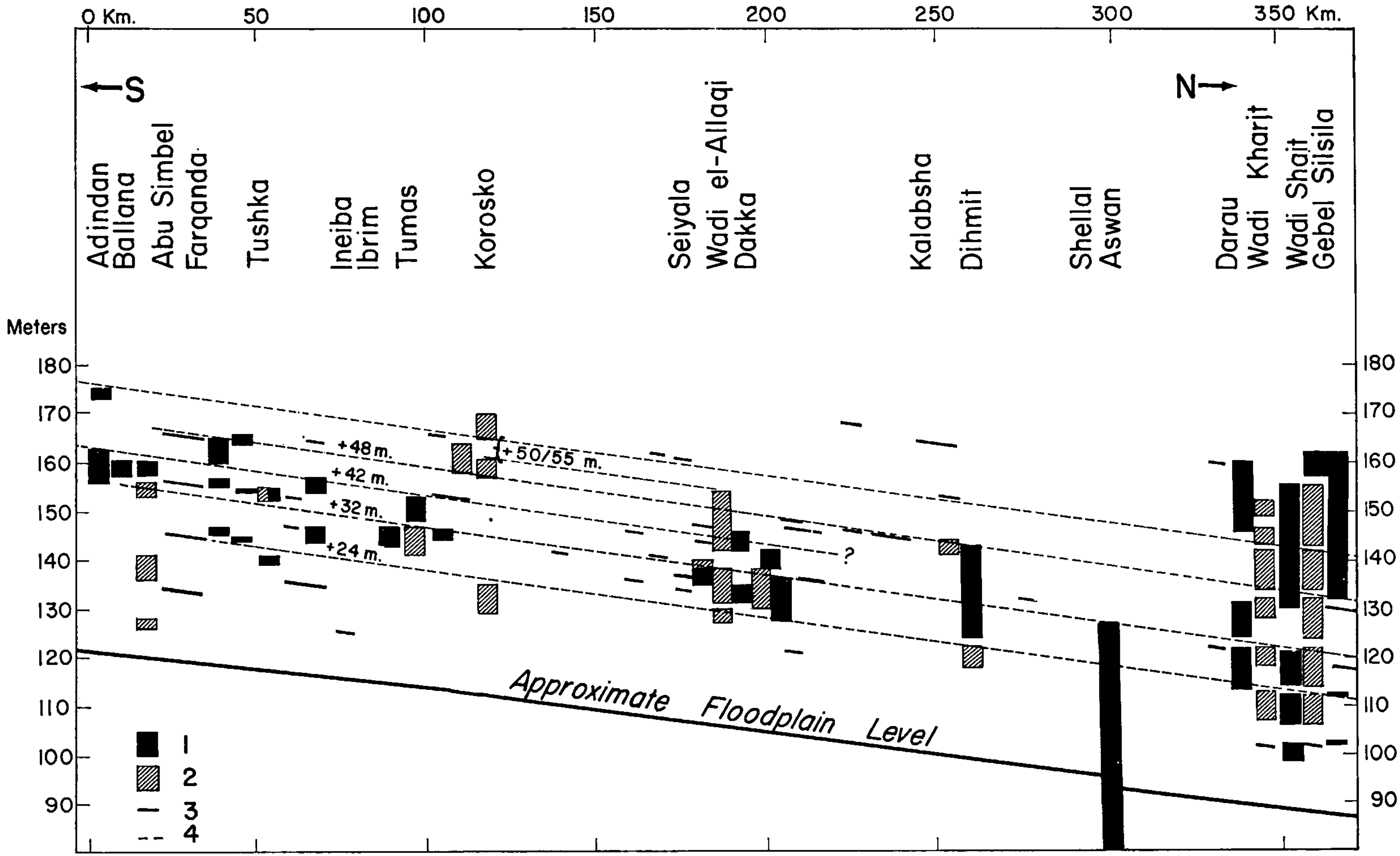

FIGURE 2. Autochthonous Nile gravels and wadi deposits in Southern Egypt.

1 Nile gravels, indicating maximum elevation and thickness recorded
2 Wadi gravels
3 Fluvial platforms
4 Reconstructed Pleistocene floodplain levels.

Technical errors of measurement were largely precluded by the use of Abney levels (rather than aneroid barometers) and the availability of good topographic maps and third-order survey bench marks. Denudation provided a more serious error for practical measurement, because maximum elevations of homogeneous deposits frequently varied by 2–5 m. (6.6–16 ft.) along a 5-km.- (3-mi.-) longitudinal stretch, and local relief on a "level" gravel surface could exceed 5–10 m. (16–33 ft.) within a 500-m.- (1,640-ft.-) square. Altimetric correlation was further complicated by the presence of multiple minor stages.

All in all the writers feel that while the sequences shown in Figure 2 are reliable within local areas of good development and preservation, the general correlation suggested above is not established beyond a doubt. If we can, however, assume a broad parallelism of floodplain gradients and an absence of recent tectonic deformation, the over-all sequence of gravels at least seems reasonable.[9]

THE QUESTION OF PLEISTOCENE TECTONICS

The tectonic character of the Kom Ombo Plain has long been recognized, and Yallouze and Knetsch have shown the existence of linear structures dominating the drainage patterns of the Eastern Desert sedimentaries north of Aswan. Tectonic deformations are also evident in Nubia.[10] Many of the Nile Valley pediments are bounded by fault zones of limited vertical displacement, related to gentle flexures and linear structures within the Nubian Sandstone. These features were in part transmitted from joint patterns and fracture lines in the underlying Basement Complex, and in part resulted from the revival of fractures along old lines of weakness during the Alpine orogeny.

The dimensions of vertical displacements evident in Egyptian Nubia are very modest, and often do not exceed a few meters. There is no evidence for major vertical faults or horizontal tear-faults, such as have been postulated by Said and Issawy for the Dakka area.[11] And above all, such deformations as are visible predate the autochthonous Nile gravels. These deposits have been observed to cross minor fracture zones without disturbance.

RED PALAEOSOLS

Vestiges of Pleistocene soil development are best preserved as relict or buried soils on ancient alluvial beds. Most such palaeosols have been truncated through surface denudation, and fine-grained, non-stoney (B)-horizons are generally absent. Deflation during hyperarid phases without vegetation has obviously been significant as a result of total soil desiccation and structural deterioration. It is common for these palaeosols to exhibit one or more generations of surface wash, in particular a coarse lag horizon typically found overlying a fine-grained powdery horizon rich in carbonates and evaporites. These fine horizons are 10–20 cm. (4–8 in.) thick and represent a wash derived from sand or granule lag of the former topsoil and wind-borne dust of later date. The pebble lag of the surface, on the other hand, is mainly a result of extensive sheetflooding.

The palaeosols of the older Nile and wadi gravels frequently retain (B) and

(B)C-horizons 3–5 m. (10–16 ft.) deep. (B)-horizon colours are commonly red (2.5 YR 4–6/6 on the Munsell scale); matrix textures range from sandy silt to silty clay; carbonates average somewhat under 10 per cent; and pH values lie under 7.2. The quartz pebbles in the Nubian terraces show considerable corrosion of surfaces and along microfractures, and, wherever igneous or metamorphic rock is present, decomposition is conspicuous. Sometimes only the quartz pebbles may be preserved in the upper 100–150 cm. (3–5 ft.) of the (B)-horizon, and selective "rotting" of basalt, diorite, granite, and schist may be effective well into the C-horizon. Commonly the clay minerals have been somewhat eluviated, but the evidence is sufficient to permit identification of the climax soils on the +42-m.- (138-ft.-), +48-m.- (157-ft.-), and +50–55-m.- (164–80-ft.-) gravels as *rotlehms*.[12]

The palaeosols present on the +24-m.- and +32-m.- (79-ft.- and 105-ft.-) gravels are more shallow and the combined (B) and (B)C profile depth probably did not exceed a meter or so. Colours are less reddish (5 YR hues on the Munsell scale) but texture and chemical properties are similar. Pebble decomposition is limited and evidence for secondary eluviation from the subsoil is absent.

Intensive rotlehm development clearly occurred between the deposition of the +42-m.- and +32-m.- (138-ft.- and 105-ft.-) gravels, and one or two later phases of moderate rubefaction are also attested to. Fossil red soils of general occurrence and significance last developed on the +24-m.- (79-ft.-) gravels. The latter deposits are, therefore, probably *no younger than* the +10–13-m.- (33–43-ft.-) rubefied Tyrrhenian-II age (eustatic) gravels of Lower Egypt.[13] This 24-m.- (79-ft.-) stage, best represented by local wadi terraces at relative levels of +8–15 m. (26–49 ft.), forms the stratigraphic base of the Upper Pleistocene as here defined for southern Egypt.

Apart from their obvious stratigraphic interest, the red palaeosols convey palaeoclimatic information. Effective chemical hydration and hydrolysis at considerable depth and thorough oxidation with formation of anhydrous ferric oxide (haematite) all imply a fairly moist rainy season and a considerable mat of vegetation. At the same time this evidence for deep chemical weathering during several Pleistocene intervals is pertinent for an understanding of denudation processes.

THE LATE PLEISTOCENE SETTING

The periods of dissection and rubefaction immediately following the +24-m.- (79-ft.-) stage left the Nubian Nile Valley with approximately its present morphology. The Nile and its tributary wadis had either exhumed their late Tertiary fill or cut primary valleys to modern dimensions, leaving a series of informative but otherwise insignificant gravel terraces along their peripheries. Major Nile incision had, in fact, preceded the +32-m.- (105-ft.-) stage, whose deposits fill the ancient channel bed recorded to 45 m. (148 ft.) below sea level near Aswan. Whatever the obscure details of valley sculpture, however, the late Pleistocene deposits of southern Egypt indicate that bedrock cutting has been quite negligible since at least the beginning of the last pluvial period.

As Sandford first stressed, important hydrographic changes occurred in late

Pleistocene times,[14] although his uniform nilotic siltation stage, following a phase of wadi alluviation, appears to be oversimplified. Nevertheless, the late Pleistocene sequence certainly is unusual when compared with the autochthonous Nile and wadi gravels. True floodplain silts, derived from the Blue Nile and Atbara systems, made their first appearance in the sedimentary record. Also, augite, the characteristic heavy mineral derived from the vulcanics of Ethiopia, is relatively scarce in the autochthonous Nile gravels[15] but prominent in the late Pleistocene and Recent silts. There is then some reason to believe that the annual late summer floods, as we know them today, may be a comparatively recent phenomenon.

LATE PLEISTOCENE SEDIMENTS

The late Pleistocene sediments of southern Egypt[16] can be reviewed as follows:

(*a*) *Wadi floor conglomerate.* At the base of the sequence, up to 5 m. (16 ft.) of ferricreted, cobble conglomerates overlie the bedrock and are graded to a floodplain level at least as low as that of today. They suggest major wadi activity and a pluvial climate, and were followed by a period of erosion and consolidation.

(*b*) *Basal sands and marls.* Extensive spreads of coarse quartz sands and marls were deposited by a rapidly aggrading, braided Nile to +33 m. (108 ft.) near the Sudanese border and to +20 m. (66 ft.) at Kom Ombo. Local wadis injected great quantities of sand and gravel into temporary lacustrine environments along the valley margins. It seems that summer floods of Ethiopian origin, in the main, redeposited local materials made available by local wadi discharge during the winter months. Coarse faceted-platform flakes and side- and end-scrapers of Middle Palaeolithic aspect appear contemporry with these deposits in Egyptian Nubia.

The subsequent period of Nile and wadi incision lowered the local base level to below the modern floodplain, prior to renewed aggradation.

(*c*) *Older floodplain silts.* Extensive horizontal flood silts rich in Ethiopian heavy minerals filled the Nile Valley to +33 m. (108 ft.) in Nubia and to +23 m. (75 ft.) on the Kom Ombo Plain. The sedimentary environment indicated pertains to a floodplain (alluvial flats or backswamps), and only rarely to channel or levee beds. Local wadi activity persisted on a limited scale. Much of the included sand and all the dispersed gravel are of local origin. These are the classical "high-silts," attaining a thickness of over 40 m. (131 ft.) at Kom Ombo, and extending from the Sudanese border to Luxor.[17] They suggest an intensified summer flood regime. Radiocarbon dates are pending but meaningful archaeological associations are unavailable.

During a subsequent period of Nile downcutting (to below present floodplain level) the local wadis dissected the older floodplain silts. At about this time or shortly thereafter slickensides, salt duricrusts, and epigenetic dehydration cracks developed within these deposits. The latter take the form of large polygons and minor crack networks, penetrating to depths of 1.5 m. (5 ft.). These phenomena suggest development of a tirsified soil or vertisol[18] under arid conditions.

(*d*) *Younger channel silts.* The third and final episode of nilotic alluviation includes a sequence of fine gravels, silts and sands related to channel and levee environments of a vigorous but meandering Nile. Horizontal flood silts are rare;

instead, former shoals of bed gravels or sands interfinger with laterally embanked topset and backset strata. In addition to the Ethiopian heavy minerals, the gravels are marked by an influx of exotic flint, chert, chalcedony, agate, jasper, and carnelian—most of which are totally absent from all earlier deposits. In Egyptian Nubia these younger channel silts attain +23 m. (75 ft.) (and possibly more), on the Kom Ombo Plain +13 m. (43 ft.). Similar deposits have not been recorded further north.

Dating from approximately 17,000 to 10,000 B.P.[19] these youngest late Pleistocene beds are correlated with geologically stratified Sebilian and other Late Palaeolithic sites on the Kom Ombo Plain. Broadly contemporary was a general period of wadi alluviation, recorded by fine-grained terraces at relative local elevations of +2 or 3 m. (7 or 10 ft.) upstream, grading onto a somewhat higher floodplain base level near the wadi mouths. Sediment characteristics suggest a vegetation mat in the wadi bottoms and a period of fairly frequent rains, probably of moderate intensity only.

Prior to renewed wadi alluviation in Neolithic times, the younger channel silts and related wadi alluvium were dissected. During this same interval, vertisol phenomena once again developed on the Kom Ombo Plain.

CONCLUSIONS

The Pleistocene evolution of the Nile Valley in southern Egypt was chiefly characterized by denudation and dissection, in part of late Tertiary fill, in part of Nubian Sandstone. The most prominent landforms are a widespread pediplain at about 200–10 m. (656–89 ft.) (above sea level) with younger pediments at lower levels. Such surfaces are present in any stage of dissection, grading from plateau-like surfaces to rough hill country or erosional plains with buttes and mesas. Although these sculpturing effects of local runoff are clearly rather ancient, subsequent aeolian sculpture has equally clearly led only to superficial remodelling of this landscape.

Lower and Middle Pleistocene incision of the Nile was interrupted on at least five occasions by temporary gravel aggradations related to small fluvial platforms, frequently converging in level with older pediments. These pluvial gravels are commonly shallow, except in the wadis, strongly denuded, and composed of local materials. Several phases of palaeosol formation periodically provided a residual mantle ready for deflation and denudation during intermittent phases of total aridity. Both the stream gravels and red soils, by contrast, record moister—possibly semiarid—climates. The exact chronology of these early pluvials seems impossible to reconstruct.

Understanding of the Upper Pleistocene is considerably more satisfactory. Three phases of nilotic silt aggradation suggest three pluvial substages in Ethiopia, the last contemporary with the late Würm or Wisconsin. Local climate in Egypt was comparatively moist during the first and third of these phases. Downcutting to below the modern floodplain succeeded each aggradation. The first alluvial phase was contemporary with Middle Palaeolithic occupation in the Nile Valley, the third with the Sebilian and other late Palaeolithic cultures. Although unequivocal evidence of the modern summer flood regime is lacking prior to the late Pleistocene, the significance of local wadi discharge during the earlier Pleistocene may simply have led to a complete preponderance of bed load over suspended load sediments.

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6. *Ibid.*
7. SANDFORD and ARKELL, *Paleolithic Man and the Nile Valley*, p. 19, record quartz—with some flint and chert—gravel above Abu Simbel, and consider these pediplain segments as true river platforms. The presence of numerous residual buttes and small mesas precludes such an interpretation, however.
8. Based on the average Nile floodplain gradient between Gebel Silsila and Adindan, ignoring the temporary base levels created by the Aswan Cataracts and the old Aswan Dam.
9. SANDFORD and ARKELL, *Paleolithic Man and the Nile Valley*, identify general stages at 90 (86–94) m., 60 (58–73) m., 45., 30 m., and 15 m. (295 (282–308) ft., 197 (190–240) ft., 148 ft., 98 ft., and 49 ft.) above the modern floodplain. The highest of these clearly refers to our Lower Nubian pediplain. Our multiple levels in the +30–60-m.- (98–197-ft.-) range reflect on the field-study difficulties faced by Sandford and Arkell at a time when topographic and aerial photo coverage was non-existent beyond the edge of the cultivated land. Furthermore, Sandford and Arkell did not study the deposits of Wadis Kharit, Shait, el-Allaqi, Korosko, and Or, all of which provide rather pertinent information.
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12. In the sense of KUBIENA, W. L., *The Soils of Europe* (London 1953), particularly p. 273ff. For a discussion of analogous palaeosols on limestone parent material see BUTZER, Pleistocene Palaeoclimates of the Kurkur Oasis.
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17. In all probability these are the Late Levalloisian +7–8-m.- (23–26-ft.-) nilotic silts and gravels between Beni Suef and Cairo, with the equivalent relative Fayum lake shorelines at +34 m. (112 ft.) (see SANDFORD, K. S. *Paleolithic Man and the Nile Valley in Upper and Middle Egypt* (Oriental Inst. publ. 18, Chicago, 1934), esp. pp. 79f., 91ff.; CATON-THOMPSON, G., The Levalloisian Industries of Egypt, *Proc. Prehist. Soc.*, XII (1946), 57–120).
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RÉSUMÉ

L'évolution géomorphologique de la vallée du Nil dans la partie méridionale de l'Egypte durant le Quaternaire fut surtout caractérisée par l'érosion et la dénudation. Au début du Pléistocène, il se forma une pédiplaine au niveau de 200–210 m. et, plus tard, divers glacis d'érosion en contrebas et même sur les versants. La marche de l'érosion fut interrompue cinq fois par des phases d'accumulation de sables et de graviers d'origine locale. Ces terrasses fluviatiles ont été préservées aux niveaux de 50–55 m., 48 m., 42 m., 32 m. et 24 m. au-dessus de la ligne des inondations contemporaines. Tous ces dépôts sont rubéfiés par des paléosols rouges. Le Pléistocène supérieur fut marqué de trois phases d'accumulation nilotique : (1) des sables et marnes mêlés à des matériaux du Paléolithique moyen, (2) des limons d'inondation quasi stériles et (3) des limons et sables de chenaux mêlés à des dépôts du Sébilien et du Paléolithique supérieur. Ces formations ont chacune une épaisseur de 30–40 m. et, à l'exception des limons de la phase moyenne, elles correspondent à des crues pluviales dans les oueds locaux.