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# *UPPER PLEISTOCENE STRATIGRAPHY IN SOUTHERN EGYPT*


RESUME

On peut distinguer dans le Pléistocène tardif de la Nubie égyptienne et de la plaine de Kom Ombo, trois unités sédimentaires nilotiques: (*a*) les sables et marnes de base, déposés par une rivière anastomosée coulant très rapidement, pendant une période d'activité accélérée dans les wadis des déserts de l'Egypte; (*b*) les silts anciens de la plaine d'inondation, déposés par un régime fluviatile d'été analogue au régime actuel, mai un peu plus vigoureux; wadis locaux inactifs; (*c*) les silts récents dans les chenaux, trois stades ou plus d'alluvionnement nilotique, déposés par un Nil changeant rapidement de lit, et simultanés d'une activité accélérée des wadis locaux. Les unités (*a*) et (*b*) ont chacune plus de 40 m d'épaisseur, et étaient chacune suivies d'un enfoncement de la rivière jusqu'à un niveau en-dessous de la plaine d'inondation actuelle. L'unité (*c*) est représentée par au moins 25 m de sédiments, dont l'accumulation fut interrompue par au moins deux périodes de dissection, courtes mais significatives. Contemporaines du Sébilien, plutôt variable, et d'autres industries du Paléolithique tardif à Kom Ombo, les couches les plus anciennes de l'unité (*c*) datent d'environ 15.000 ans avant J.-C.; les couches les plus récentes en Nubie datent du milieu de l'Holocène. Des interprétations paléoclimatiques de ces sédiments et paléosols associés sont proposées.


## *INTRODUCTION*

The Nile Valley in Egypt and the northern Sudan is eminently suited for palaeoclimatic correlation between the poleward and equatorward margins of the subtropical high-pressure belts. The modern river derives some 80 per cent of its waters from Ethiopia, where the Atbara, Blue Nile, and Sobat are fed by the summer monsoonal rains (June through October). These rains give rise to the Nile flood which reaches its crest in Egypt between mid-August and mid-October, leaving an annual increment of silt on the alluvial flats of its extenuated floodplain. Pleistocene fluctuations of climate in Ethiopia could therefore be expected to leave a sedimentary record far downstream along the desert tracts of the Nile Valley.

At present the tributary wadis of Egypt contribute practically no sediments to the Nile floodplain. The rare rainstorms and local wadi floods, related to westerly frontal-cyclonic disturbances (November through March) north of the Sudanese border, or to various monsoonal disturbances (July–August) south of the border, perform little more than local redeposition of wadi bed materials. With annual rainfall means of 1 mm at Luxor, 3 mm at Aswan, and 5 mm at Wadi Halfa, the modern hydrography of the desert wadis is indeed almost defunct. But the prevailing hyperarid climate of Egypt was interrupted by several moist Pleistocene "pluvials." These were accompanied by deposition of local sands and gravels in the form of wadi terraces, wadi fans at the edge of the valley, and wadi materials redistributed far downstream along the bed of the Nile itself.

From the point of view of Pleistocene palaeoclimates it is important to establish whether or not the subtropical pluvials of Egypt (related to the planetary westerlies) were synchronous with the tropical pluvials of Ethiopia (related to the equatorial easterlies). This question should be susceptible to geological study in Egypt, where the interrelationships of nilotic and wadi sediments must somehow be evident. The fairly complete late Pleistocene record is most suitable south of about latitude 25° N—where the Nile Valley is moderately narrow, where both the nilotic and wadi deposits lie above present floodplain level, and where eustatic fluctuations of base level have had little or no impact in late Pleistocene times (see Butzer 1959*a*).

### *PREVIOUS WORK*

Early field work on the Pleistocene of southern Egypt goes back to Adams (1864), who made fairly extensive observations on ancient nilotic deposits to 30 m or more above the modern floodplain as well as some faunal collections. Further information accumulated during the 1890's, a consequence of the planning of the first Aswan Dam. These nineteenth-century observations were synthesized by Blanckenhorn (1901), who considered the high nilotic silts of Kom Ombo and Lower Nubia pertinent to an early Pleistocene pluvial phase—solely on the basis of their relative elevations.

More informative were the studies of Schweinfurth (1901) in the northern reaches of the Kom Ombo Plain, and the 1:20,000 geological mapping of the Aswan area by Ball (1907). Vignard (1923) also contributed to an understanding of the Pleistocene deposits around Kom Ombo.

Modern investigation dates back to the systematic Pleistocene survey of the Nile Valley from Luxor to Wadi Halfa by Sandford and Arkell (1933) during the winter of 1929–30, with revisions by Sandford during the spring of 1931. These authors recognized a series of gravel terraces and related platforms at +90 m, 60 m, 45 m, 30 m (with "Chellean" implements) and 15 m (with Acheulian artifacts) throughout the area south of Gebel Silsila. Wadi terraces of 8–9 and 3–4 m with "Mousterian" industries were identified around Luxor, but were thought not to occur in the more southerly Nile Valley. Sandford and Arkell distinguished a terminal Pleistocene siltation stage, recorded by the first appearance of Ethiopian flood silts. These were believed to attain +30 m at Wadi Halfa, dropping in level to +5 m near Luxor, north of which they are suballuvial. "Mousterian" and "Lower Sebilian" (Late Palaeolithic) artifacts were found within these silts, later Palaeolithic industries on their surface. In general, Sandford and Arkell imply the existence of a single phase of extended pluvial climate, terminating in Nubia with the onset of the siltation stage.

More recently the planning of the Aswan High Dam promoted renewed field work in the area. Brief observations on the surficial geology of the Dakka-Seiyala and Ballana sectors were made by Shata (1962) and Said and Issawy (1965), while a much-needed, detailed study of Lower Nubia south of the Sudanese border has been described by de Heinzelin and Paepe (1965). Further field studies by R. Geigengack and R. Said were under way in several parts of Egyptian Nubia during the winter of 1964.

### *OUTLINE OF THE FIELD AND LABORATORY WORK*

A field season of almost seven months (1962–63) provided the writers with ample opportunity for a detailed study of Egyptian Nubia (south of the High Dam site), the Kom Ombo Plain (Butzer, in press), with ancillary work in the Red Sea Hills, the Libyan Desert (Butzer 1964*b*, 1965), and on the Red Sea coast.

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 277-km-long, 3-km-wide stretch from the

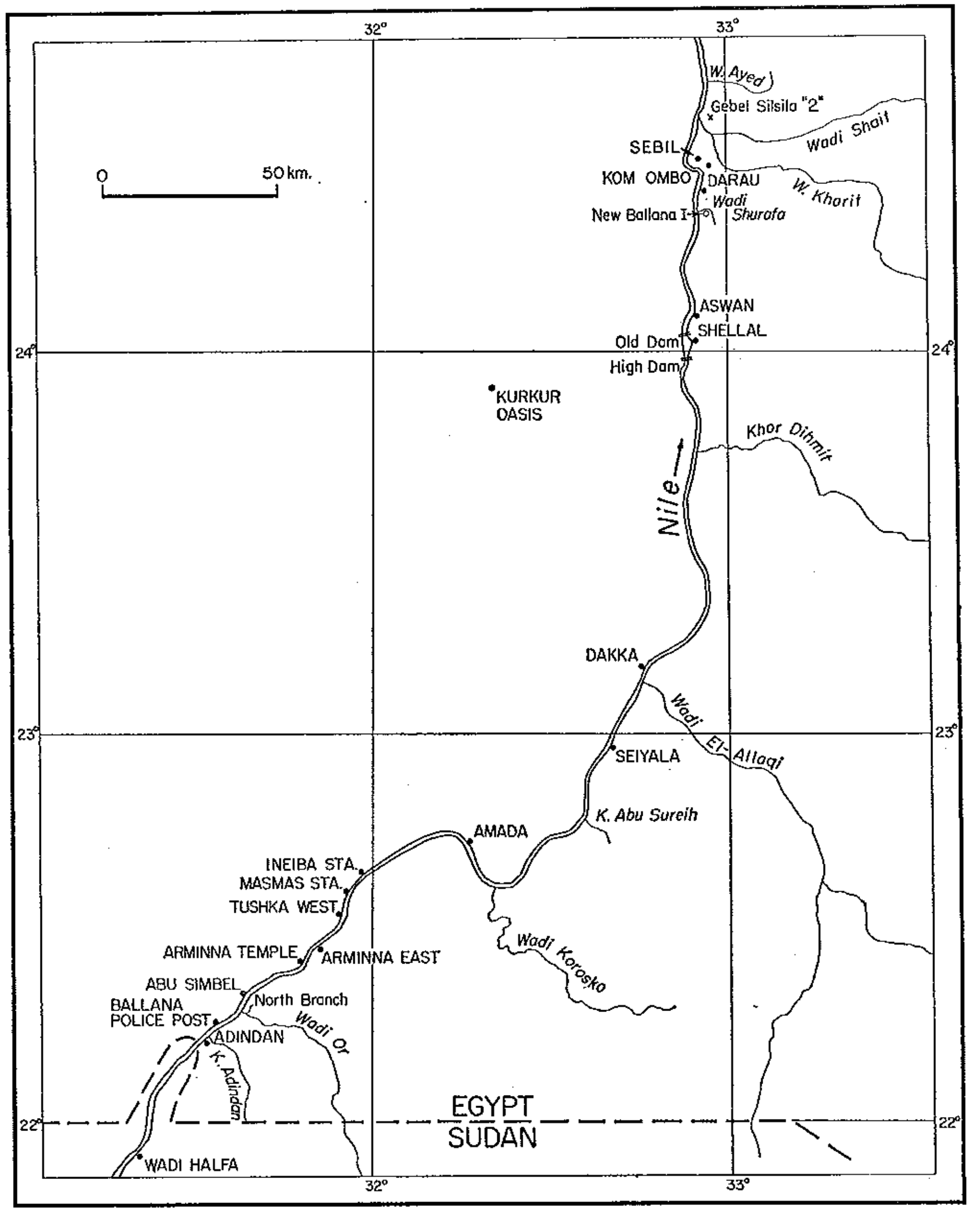


FIG. 1.—Lower Nubia. (All figures in this chapter courtesy of University of Wisconsin Cartographic Laboratory.)

Sudanese border to Dabud was mapped in detail at 1:10,000. The lower 30 km of Wadi el-Allaqi were mapped on a similar scale. Our maps distinguish various stages of Lower and Middle Pleistocene wadi and autochthonous Nile gravels, three major stages of Upper Pleistocene nilotic aggradation, Upper Pleistocene colluvial wash, and Holocene dune and wadi sands. In addition pediments and fluvial platforms were mapped. Thus although the greater part of the Pleistocene deposits of Egyptian Nubia will have been permanently flooded by the High Dam in January, 1966, they have been fairly adequately documented. Publication of these materials is planned for a comprehensive report.

In the Kom Ombo Plain the only Upper Pleistocene record was threatened by land-grading and irrigation, terminated in 1964–65. For military reasons nothing but 1:100,000 topographic maps were available here, so that the Pleistocene deposits of a 1,500 sq km area were mapped at that intermediate scale (see simplified map in Butzer, in press).

Since the field work was focused on the Palaeolithic archaeology of the above areas, prehistoric associations were established, particularly in the late Pleistocene time range. Prehistoric artifacts are described on the basis of field notes by the senior author. The artifacts in question were collected in large part, but remain in possession of the Yale expedition. To the best of our knowledge their typology has not yet been systematically studied.

Altogether some 500 sediment and gravel samples were analyzed in preliminary form in Aswan, while laboratory study of 300 of these is nearing completion at the University of Wisconsin. Techniques include hydrometer and wet-sieve grain-size analyses, volumetric calcium carbonate determinations, pH values found electrometrically in distilled water, heavy mineral analyses, X-ray diffraction studies of clay minerals, and quartz-grain micromorphology. All the section descriptions are based on sedimentological analyses, although few quantitative data are given for space reasons.

This paper attempts to delineate the Upper Pleistocene stratigraphy of southern Egypt, following earlier summaries (Butzer 1964*a*, pp. 304–5; Butzer and Hansen 1965) and a regional study of late Pleistocene environments of the Kom Ombo Plain (Butzer, in press).

### *THE GEOMORPHIC SETTING*

Between the Sudanese border (22° 13′) and Gebel Silsila (24° 38′ N) the modern Nile traverses a distance of 375 km, fringed by a narrow discontinuous floodplain averaging some 500–1,000 m in width. In many sections bedrock faces rise abruptly from the river banks. Along other stretches a variable width of floodplain silts merges with extensive older nilotic beds developed on ancient pediment plains. The regions between the Second Cataract and Ballana, or from Abu Simbel to Ineiba, are examples of such low erosional surfaces with later Pleistocene sedimentary mantles. The Kom Ombo Plain, by exception, is a tectonic depression somewhat modified by Plio-Pleistocene fluvial sculpture. In addition to these three major sedimentary areas, Pleistocene nilotic deposits are also locally preserved in several wadi embouchures. Local alluvium of late Pleistocene age is common enough, but older terrace sequences are generally confined to the lower courses of large wadis.

Although metamorphic and igneous rocks of the pre-Carboniferous Basement Complex are exposed around Aswan and at Kalabsha, the bedrock of the areas considered here is the Upper Cretaceous sandstone of Nubian facies (see McKee 1963). Broadly horizontal and lithologically similar, these coarse-grained, white to very pale brown sandstones show subtle differences of facies and resistance to erosion. Of particular interest are the ferruginous sandstone strata or ferruginized surface materials known as "ironstone."

The extent of tectonic deformation has been considered elsewhere (Butzer and Hansen 1965), but in general it appears that none of the Pleistocene deposits of southern Egypt have suffered deformation or tectonic displacement of any sort.

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 (see Butzer and Hansen 1965). These pluvial gravels have been affected by two or more periods of rubefaction. Fossil red soils of *general* occurrence and significance last developed on the +24-m gravels. The latter deposits are therefore probably no younger than the +10–13-m (Tyrrhenian-II age) rubefied eustatic gravels of Lower Egypt (Butzer 1959*a*). This 24-m stage, best represented by local wadi terraces at relative levels of +8–15 m, forms the stratigraphic base to the Upper Pleistocene as here defined for southern Egypt.

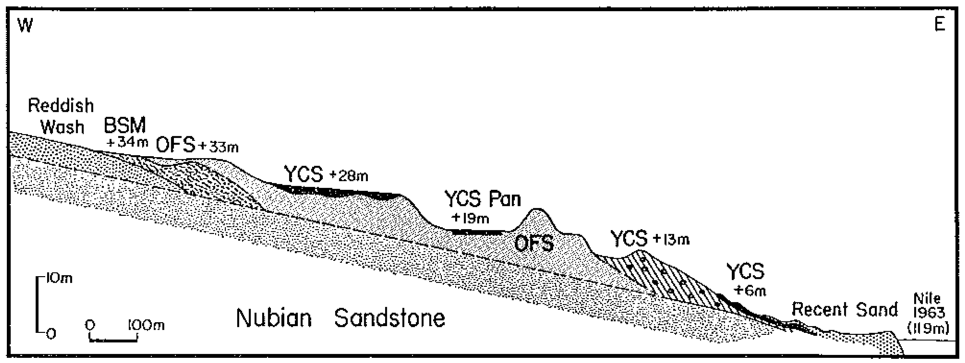


FIG. 2.—Stratigraphic cross-section near Ballana Police Post

## *LATE PLEISTOCENE NILOTIC DEPOSITS OF EGYPTIAN NUBIA*

Typical Nilotic sediments, related to the summer flood regime of Ethiopian origin, are best developed between the Sudanese border and Ineiba, and on the Kom Ombo Plain. The basic pattern can be illustrated by a section from the west bank locality of Ballana.

### BALLANA

About 300 m north of the Ballana Police Post modern floodplain level is 121 m (see Fig. 2). Beyond a fringe of recent dunes, pale brown (Munsell color 10 YR 6/3), sandy silts occur in a series of shallow ridges running about parallel to the Nile, with linear concentrations of mammalian and fish bone, bovid teeth, and Late Palaeolithic–type artifacts. These youngest nilotic beds attain 127 m (+6 m). Farther west, a long slope of similar silts with rounded medium gravel culminates in a silt and gravel ridge at 134 m (+13 m). The gravel is mainly quartz, with an appreciable exotic component of flint, chert, chalcedony, agate, jasper, and carnelian. Deflation has concentrated the gravel and included calcareous concretions as a surface lag, while excavating a depression behind the ridge. The sediments exposed immediately beyond this hollow are semiconsolidated, brown (10 YR 5/3), sandy silts without gravels but interspersed with a fine network of dehydration cracks and secondary sand fillings. Just as the lower-lying silts, these have a high content of heavy minerals, including pyroxenes. The brown silts are archaeologically sterile. They form a ridge at 143 m (+22 m) and, under a discontinuous veneer of wash and younger sandy silts, rise to a maximum elevation of 154 m (+33 m), where they rest disconformably on patches of older, medium-grained river sands (Fig. 2). These very pale brown (10 YR 7/3), fluvial sands attain 155 m, are well sorted, and contain considerable, massive root drip. Although pyroxenes are substages, the YCS are rather complex. In addition to well-developed river bank ridges at +6 m and +13 m, a higher stage is represented by desiccation-pan deposits found in a lagoon excavated within the OFS (Fig. 2). These calcareous sandy silts with root drip and planorbid snails attain 140 m (+19 m). Diminutive flakes and blades in flint or chert are being deflated in abundance. They pertain to a Late Palaeolithic industry. Nearby, a surface site of ironstone flakes (3–5 cm in length) and a

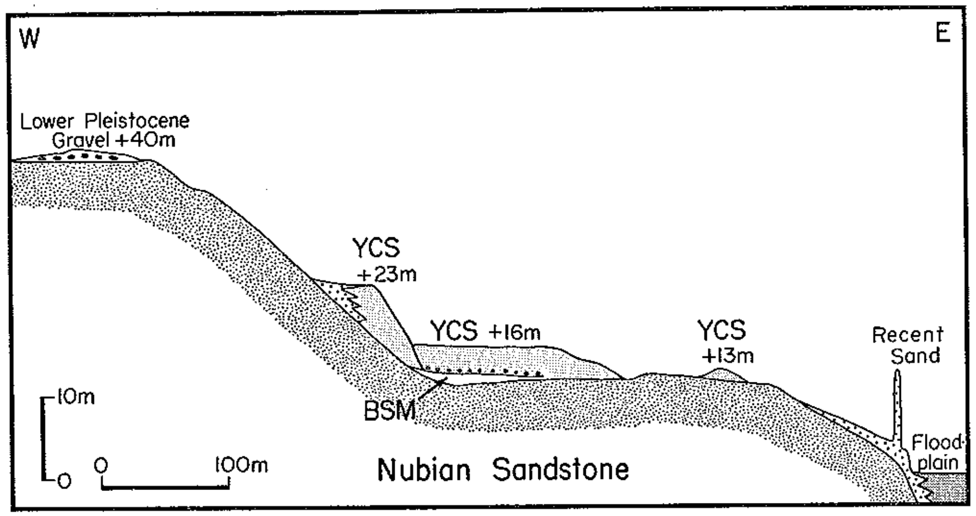


Fig. 3.—Stratigraphic cross-section near Arminna Temple

scarce and the quartz sand is largely of local origin, this is a nilotic deposit. It overlies shallow fans of coarse alluvial wash with local proliferations of the terrestrial snail *Zootecus insularis* (Ehrenberg), identified by C. A. Reed.

The three facies of nilotic alluviation recorded near Ballana Police Post are typical of the three late Pleistocene aggradation units in southern Egypt: sands, marly sands, and marls (basal sands and marls [BSM]); sterile flood silts and clays (older floodplain silts [OFS]); and sandy silts, sands, and medium gravels (younger channel silts [YCS]). Whereas the BSM and OFS both attain about +33–34 m, apparently without single core in diminutive Levalloisian technique seems to be related to a shoreline at 141 m. Similar sandy silts with some petrified roots underlie surface wash up to 149 m (+28 m). It would seem, then, that four substages in 6, 13, 20, and 28 m can be locally assigned to the YCS, each successively lower stage embanked against the next higher.

The interrelationships of the three nilotic alluvia are well illustrated in many of the sections studied by the writers, in the Nile Valley proper as well as in the wadis of the east bank. The more important Nile Valley exposures will be discussed first, as examples of the nilotic series. Subsequently, several selected wadi sequences will be outlined to illustrate the interdigitation of nilotic and wadi deposits.



ARMINNA TEMPLE

Some 500 m upstream of the site of Arminna Temple, there is a broad bedrock platform at 130 m (local floodplain level 118 m) along the west bank of the Nile. A series of late Pleistocene deposits rests on this bench (Fig. 3). These are partially exposed in a large pit:

*a) 45 cm.* Base not seen, but presumably resting on bedrock in 120 cm. Consolidated, pale brown (10 YR 6/3), stratified but poorly sorted, silty medium-grained sand. There are dispersed quartz granules throughout, angular detritus near the base, and occasional rounded pebbles at the top. Rich in colloidal silica, and there also are some limonitic stains. BSM.

—disconformity—

*b) 10–15 cm.* Crudely stratified, unsorted, coarse gravel of rounded quartz and subrounded ironstone, with a salt-cemented matrix of light yellowish-brown (10 YR 6/4), silty, coarse sand. The upper part is rich in *Cleopatra bulimoides* (Olivier), *Corbicula fluminalis* (Müller), and *Unio willcocksi* (Newton), with rolled fragments of the Nile oyster (*Etheria elliptica*) (Lamarck), patinated Late Palaeolithic artifacts, and waterworn Middle Palaeolithic flakes.

*c) 5–20 cm.* Eluviated cobble conglomerate of sandstone and ironstone, coated with salts. *Cleopatra* shells and artifacts are concentrated in the contact zone of *b* and *c,* while oyster shells are attached to the individual rocks. A radiocarbon determination from such attached oyster shell gave 11,090 ± 200 B.P. (Y-1526) (Stuiver, in press).

—disconformity—

*d) 260 cm.* Unconsolidated, pale brown (10 YR 6/3), well-stratified and partly current-bedded, sandy silts, silty sands, and clayey silts. Mica, hornblende, and pyroxenes abundant. Several of the strata represent backset levee beds. Root drip and other, unidentified, organic impressions are common. Surface in 133 m (+ 15 m).

Bed *d* is a mixed floodplain and river bank deposit, succeeding the channel bed deposits recorded by beds *b* and *c*. The date of approximately 9140 B.C. marks the beginning of a YCS substage, which attains +15 m in this sheltered location. Nearby there are banks of higher and older YCS, intercalated with aeolian sands to about +23 m, as well as pockets of OFS resting on BSM.

TUSHKA WEST

Another section will be described as exposed along the southern bank of the wadi emerging near the boat station Tushka West:

*a) 5 m,* base not seen. Pale to grayish-brown (10 YR 5/2–3, 6/3), stratified clayey silt with considerable hornblende and pyroxenes, calcareous salt concretions, and limonite or pyrolusite stains. The eroded surface attains 125.5 m (+ 8 m). These typical OFS are sterile.

—disconformity—

*b) 35–45 cm.* Stratified and sorted coarse, rounded quartz gravel with flint and rare exotic as well as metamorphic rocks. Matrix of coarse sand with pyroxenes present. Rich in waterworn or rolled diminutive artifacts, including ironstone flakes and cores as well as small flint cores of Late Palaeolithic types. Blades, burins, microliths, and geometric forms are absent. YCS.

—semidisconformity—

*c) 350 cm.* Pale brown (10 YR 6/3), stratified, coarse sand with dispersed quartz granules or pebbles and rich in mica, hornblende, and pyroxenes. In addition to some *Corbicula fluminalis* shells and bone fragments, there are rolled ironstone flakes of Middle Palaeolithic type and partially waterworn flints of more advanced Late Palaeolithic type. YCS.

Locally beds *b* and *c* attain +15.5 m, but they can be traced 750 m upstream to a conspicuous ridge in +21.5 m. This general section had already been illustrated by Sandford and Arkell (1933, p. 41, Fig. 8). Similar materials almost attain +22 m a little farther north. Patches of BSM are preserved in another local wadi to +30 m, while low YCS ridges in +6 m accompany the Nile banks.

INEIBA

In the small wadi 4.5 km south of Ineiba Station the relationship of all three late

Pleistocene nilotic units can be seen in a single exposure at the Cairo University excavation (Fig. 4). The BSM consist of alternating calcareous, light brownish-gray (2.5 Y 6/2), sandy silts and pink (7.5 YR 6/4), coarse sands with dispersed gravel. These beds attain +11 m (125.8 m), dipping 1 per cent Nileward to the east, with reverse dips of 1–3 per cent to the west. Here the BSM are laterally conformable with wadi sands and gravel, intermixed with derived or primary nilotic silt. Overlying these different facies disconformably are 1.5 m of grayish-brown (2.5 Y 5/2), clayey silt with slickensides and dehydration crack networks suggesting development of a vertisol (Smith *et al.* 1960, pp. 124–25). These sterile OFS attain +10.5 m. In their turn they are disconformably overlain by 30 cm of unconsolidated, very pale brown (10 YR 7/4), coarse sands with dispersed pebbles and Late Palaeolithic blades, to +9.5 m.

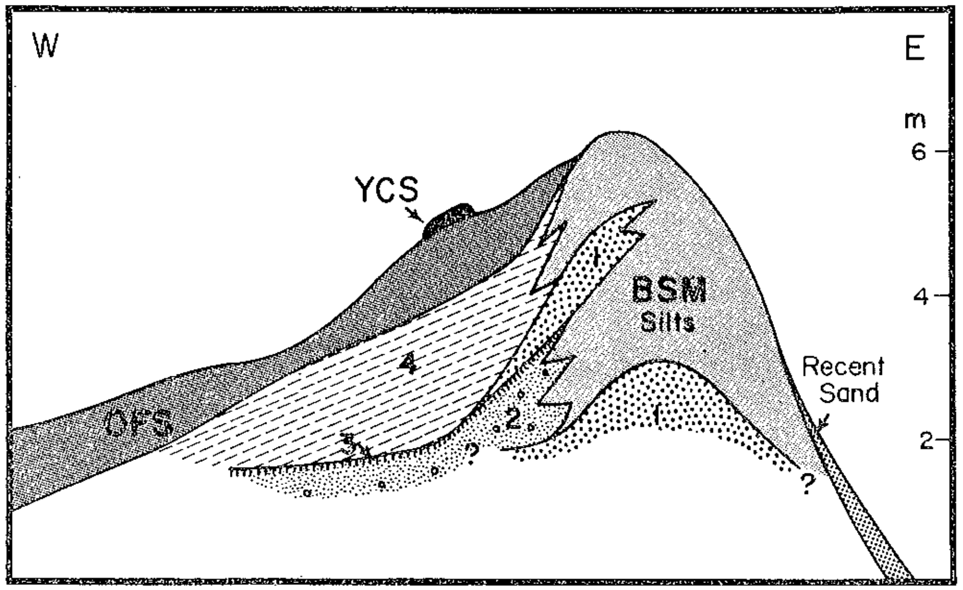


FIG. 4.—Nilotic alluvia in wadi south of Inciba. *1,* Coarse nilotic sands. *2,* Gravelly wadi sands. *3,* Calcareous crust. *4,* Alternating wadi sands and nilotic silts. To scale. Vertical exaggeration 16 ×.

Farther north, multiple exposures of the nilotic alluvia in Egyptian Nubia are last seen at Dakka. Between Dakka and Shellal the second raising of the old Aswan Dam (1929–34) appears to have drowned most of the Upper Pleistocene deposits. Some of these were still recently visible under a veneer of modern silt when the sluice gates were opened during flood stage. In particular, three alluvial terraces of unknown facies are graded to floodplain levels of 122, 117, and 112 m in Khor Dihmit (modern floodplain about 99 m). The extensive nilotic beds of the Shellal–Aswan area were already mapped and studied by Ball (1907) and by Sandford and Arkell (1933, pp. 43, 57–59). Although BSM sediments may exist under the dam level near Shellal, only the OFS appear to be exposed today. Farther north, OFS are sporadically preserved along the eastern margins of the valley until the Kom Ombo Plain is reached.

### *LATE PLEISTOCENE NILOTIC DEPOSITS OF THE KOM OMBO PLAIN*

The deposits of the Upper Pleistocene Nile are very extensive on the Kom Ombo Plain. But whereas the OFS of Egyptian Nubia are rarely exposed at the surface, they are really the most significant lithostratigraphic unit at Kom Ombo. The BSM are only recorded in artificial pits and natural sections along the peripheries of the plain, very much as in Egyptian Nubia. The YCS are preserved in the form of several minor Nile branches winding across the western half of the plain. The facies characteristics correspond closely to those of Nubia and have already been described (Butzer, 1967). Attention will here be devoted to a limited number of representative sections.

#### WADI SHURAFA

At the southern end of the Kom Ombo Plain, Wadi Shurafa, a shallow depression, is excavated into the OFS along the edge of the sandstone bluffs. Further Upper Pleistocene deposits are fragmentarily preserved in two southern tributary valleys, here cut into bedrock. The western of these (Wadi A) begins near the Nubian resettlement complex New Ballana I, the eastern (Wadi B) at New Ballana II.

A section from Wadi Shurafa up into Wadi A is shown in Figure 5*A*. OFS of limited facies variation, but interdigited with wadi deposts, occur through much of Wadi A. These are brown to dark grayish-brown (10 YR 3–5/2–3), poorly stratified, semiconsolidated, sandy to clayey silts, with abundant hornblende and some pyroxenes, frequent 1–4-mm salt concretions, carbonized rootlets, pyrolusite stains and dendrites, and occasional slickensides. Despite their lack of continuity, these are the same silts as constitute the bulk of the OFS sediments of the plain.

A proliferation of *Corbicula fluminalis vara* (identified by J. de Heinzelin) occurs in the highest exposure at 112 m (22 m over local floodplain land in 90 m). The sediment here is a dark grayish-brown, clayey silt with slickensides, limonitic and pyrolusite staining. Deposition in the backwaters of an extensive flood-



plain is suggested. A radiocarbon determination of 12,500 ± 120 B.P. (Y-1446) (Stuiver, in press) was obtained from surface *Corbicula* shells weathering out of the silt. Since this date is at least ten millennia younger than the estimated geological age, and several millennia younger than a spectrum of $C^{14}$ dates from the lower-lying, YCS beds of the Kom Ombo Plain, serious contamination is suspected by the writers. J. de Heinzelin (*in litt.*, Jan. 14, 1965) confirms that the *Corbiculae* in question conform in type, morphology, and preservation to those of his oldest nilotic beds in the northern Sudan. The OFS beds in question are disconformably overlain by 40 cm of brown, derived, silty sands and further 75 cm of buff, detrital, coarse wadi sands. A more reasonable radiocarbon date of 18,300 ± 310 B.P. (I-2060) has been obtained from a nilotic marl from New Korosko, near the mouth of Wadi Shait.

The bulk of the OFS in Wadi Shurafa is represented by a cross-section below the confluence of Wadi B, based on six deep pits and several natural exposures (Fig. 5*B*). BSM were found at three localities, white (5 Y 8/1, 10 YR 8/2) marly sands disconformably underlying the OFS. As in Nubia, these are fairly rich in colloidal silica, stained with limonite, consolidated, and poorly stratified. The OFS proper are interrupted by at least four subcontinuous bands of wadi alluvium, some 20–110 cm thick. These range from brown, silty sands, representing mixed nilotic and wadi aggradation, to coarse, buff, wadi sands with no nilotic materials. These sandy beds indicate that whereas annual flood silt deposition was fairly consistent, local wadi activity was limited other than during the exceptional intervals so recorded. The local vertical range of the OFS is from below 91 to 112 m.

Near the mouth of Wadi Shurafa, at the tomb of Sidi Hammuda, YCS beds

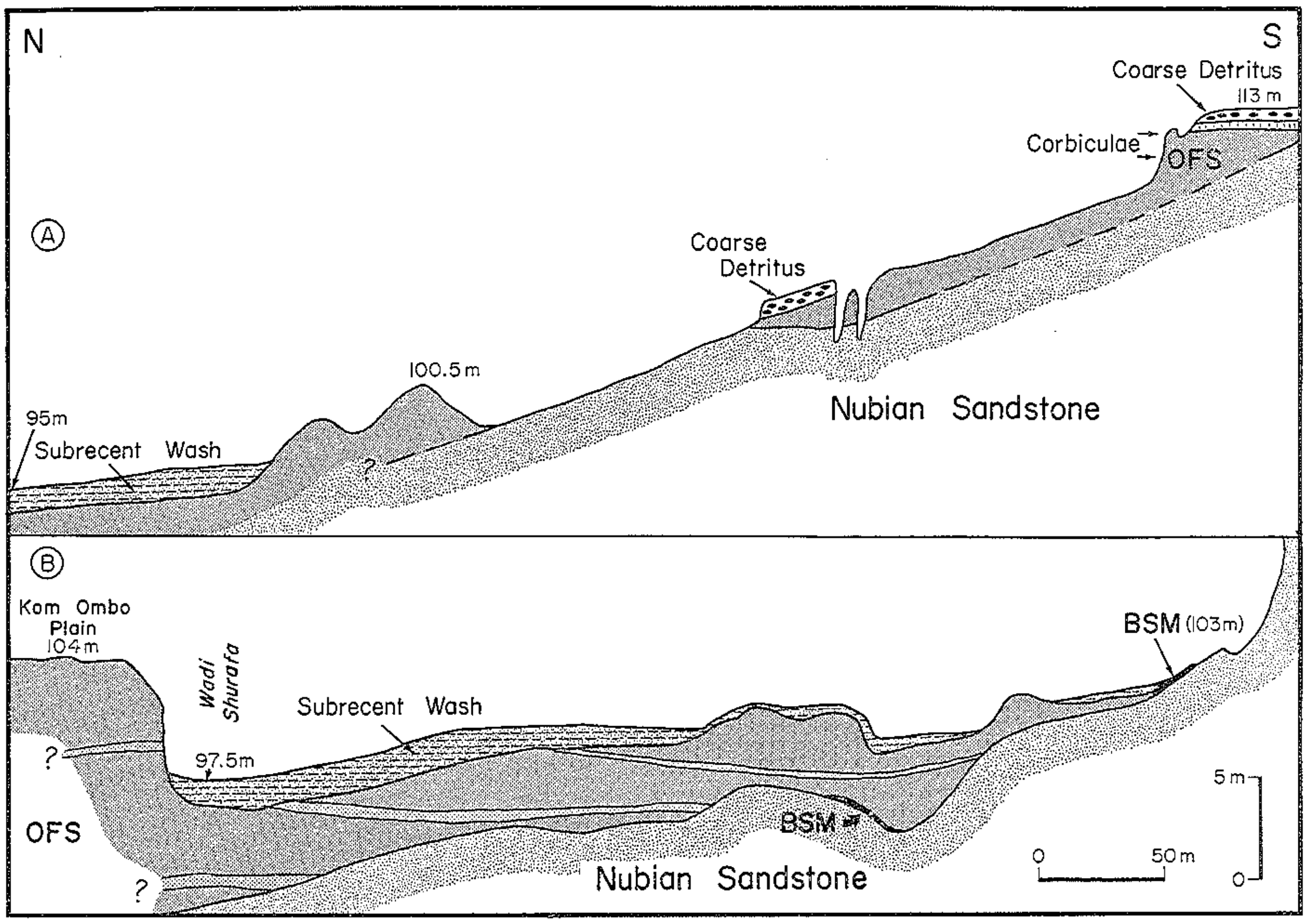


FIG. 5.—*A*, Section at New Ballana I, near Darau, showing highest exposure of older floodplain silts (OFS) in the Kom Ombo area. *B*, Section at New Ballana II, showing wadi deposits interdigited with older floodplain silts, and stratigraphic position of basal sands and marls.

are disconformably embanked against an irregular ridge of brown, sandy silts (OFS). The younger beds are very pale brown (10 YR 8/3), well-stratified, coarse quartz sands with backset beds of pale brown, medium-sandy silts, rich in mica and hornblende. These transitional channel/levee beds contain numerous waterworn flint artifacts of Late Palaeolithic type. They mark the right bank of the Nile during a YCS stage somewhat higher than 96 m (+6 m).

### GEBEL SILSILA

At the northern end of the plain, near Gebel Silsila, several successive branches of the Nile appear to have cut into and meandered across the OFS during the YCS stage. The distinctiveness of the two stratigraphic entities is abundantly clear from numerous exposures in the field and amply illustrated at the archaeological sites Gebel Silsila 2A and 2B, excavated by the Yale Expedition in 1962–63 (Reed *et al.*, in press). Their geology has been described (Butzer, 1967) and need only be summarized briefly here. The deposits of two separate YCS channels are recorded, the older to +12 m, the younger to +10 m. Late Palaeolithic archaeological horizons within the beds of the lower channel have radiocarbon determinations of 13,070 B.P. (Y-1375), 13,560 B.P. (Y-1447), and 15,310 B.P. (Y-1376) (Stuiver, in press).

The pattern of two major channel levels, one in 100–101.5 m, the other in 98.5–99.5 m, seems to be repeated in the Sebil area, where Vignard (1923) first defined three successive Sebilian industries employing a form of Levalloisian technique. Smith (1964*a*, 1964*b*) has indicated the presence of further, distinctive Late Palaeolithic industries from the Kom Ombo Plain: (*a*) the Menchian, characterized by many scrapers and burins, with Aurignacian affinities; (*b*) the Sebekian, a blade industry with some burins and end-scrapers, but lacking microburins and geometric forms; and (*c*) the Silsilian, a true microlithic industry



with burins, microburins, and bladelets. All these varied Late Palaeolithic cultures are confined to and closely circumscribed in their occurrence by the distribution of the YCS. Radiocarbon determinations, some unpublished, range from 17,000 to 12,000 B.P. (Smith 1964*b*; Stuiver, in press; Reed *et al.*, in press).

In overview, the maximum elevation of the BSM in Nubia appears to be +34 m at Ballana Police Post. In the Kom Ombo area this facies is preserved to a maximum elevation of perhaps +20 m, so that the longitudinal gradient is steeper than that of the modern floodplain (see Fig. 8). The OFS similarly drop from +33 m at Ballana to +22 m at Kom Ombo (see Fig. 8) and +5.5 m at Luxor. The modern gradient from the border to Gebel Silsila is 0.94 per 10,000, those of the BSM and OFS, 1.33 and 1.28, respectively.

The YCS are more complex. The higher substage in +28 m is only recorded with certainty at Ballana. The more ubiquitous +20–22-m stage in Egyptian Nubia can probably be correlated with the +10–12-m silts of identical facies at Kom Ombo, although the radiocarbon and archaeological correlation must await publication of the different expedition reports. The +13–15-m and +6-m stages of southern Nubia were not identified downstream of Amada and Masmas, respectively. As a matter of convenience the YCS substages of southernmost Egypt can be designated as follows: 0 (+28 m), I (+22 m), II (+15 m), and III (+6 m). This classification can only be applied upstream of Dakka, and Substage 0 is of uncertain stratigraphic position with respect to Substages I–III.

## *LATE PLEISTOCENE FILL OF WADI OR (NORTH BRANCH)*

Wadi Or, one of the larger Nubian tributaries of the east bank, reaches the Nile opposite Ballana. At 1.2 km from the valley edge the wadi bifurcates, with a minor, northern branch terminating after a total length of only 4.1 km. This north branch preserves a remarkably complex record of Upper Pleistocene fill. A complete longitudinal section was surveyed, with seventeen detailed cross-sections and subsequent laboratory analysis of twenty-five sediment samples. This fundamental sequence will be discussed from the youngest stratigraphic unit downward, on the basis of Figure 6. A selection of sedimentological data is presented in Table 1.

*Unit 1.*—Unconsolidated, stratified and current-bedded, coarse quartz sands with dispersed quartz granules and beds of subangular ironstone detritus. Munsell colors are reddish-yellow (5–7.5 YR 7/6). This completely sterile fill is 50–100 cm thick and forms a terrace between Km 2.1 and 3.7, rising from a relative elevation of + 3.2 to + 3.5 m upstream. It is represented by extensive colluvial wash and sheetflood detritus away from the wadi channel.

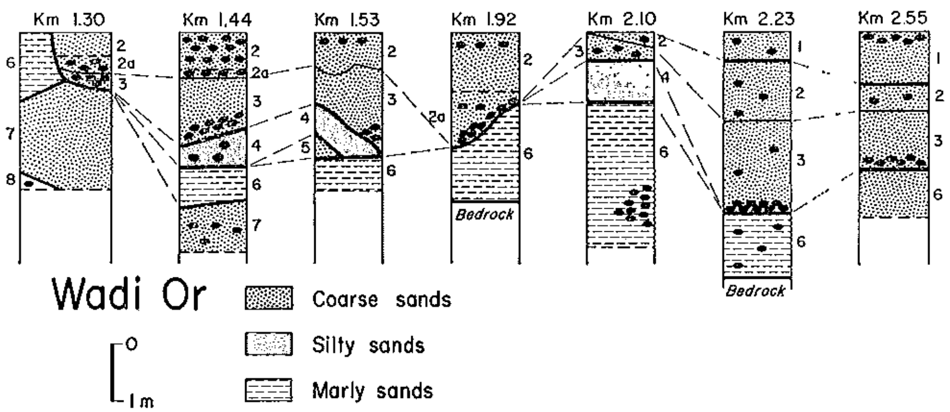


Fig. 6.—Stratigraphic sequence in Wadi Or (north branch)

TABLE 1

WADI OR SEDIMENT ANALYSES

(Fines under 60 μ are not differentiated in samples not treated by hydrometer method)

| Unit | Locality (Km) | Non-carbonate Fraction (Per Cent) | | | | | | Carbonates (Per Cent) |
|---|---|---|---|---|---|---|---|---|
| | | Over 2,000 μ | 200–2,000 μ | 60–200 μ | 20–60 μ | 2–20 μ | Under 2μ | |
| 1 | 2.55 | 2.8 | 55.8 | 31.8 | 8.4 | ........ | ........ | 1.2 |
| 2 | 2.55 | 6.7 | 74.4 | 7.2 | 11.7 | ........ | ........ | 0.0 |
| 2 | 1.53 | 0.4 | 83.9 | 10.8 | 4.9 | ........ | ........ | 0.0 |
| 2a | 1.53 | 22.3 | 63.0 | 12.1 | 2.6 | ........ | ........ | 0.0 |
| 3 | 2.55 | 0.8 | 52.3 | 29.6 | 13.1 | ........ | ........ | 4.2 |
| 3 | 2.23 | 6.0 | 49.7 | 20.0 | 20.8 | ........ | ........ | 3.5 |
| 3 | 1.53 | 0.2 | 40.9 | 35.1 | 19.0 | ........ | ........ | 4.8 |
| 4 | 2.10 | 0.2 | 36.0 | 15.4 | 8.1 | 21.0 | 13.5 | 5.8 |
| 4 | 1.53 | 1.0 | 25.4 | 15.3 | 13.0 | 18.0 | 15.5 | 13.8 |
| 5 | 1.53 | 0.0 | 79.3 | 20.1 | 0.6 | ........ | ........ | 0.0 |
| 6 | 2.55 | 1.6 | 61.7 | 28.4 | 0.5 | ........ | ........ | 8.8 |
| 6 | 2.23 | 16.7 | 40.7 | 12.7 | 16.6 | ........ | ........ | 13.6 |
| 6 | 2.13 | 4.3 | 44.3 | 22.9 | 17.5 | ........ | ........ | 10.6 |
| 6 | 1.53 | 0.0 | 1.4 | 19.2 | 17.5 | 11.0 | 10.5 | 40.4 |
| 7 (upper) | 1.30 | 0.2 | 71.9 | 17.5 | 9.3 | ........ | ........ | 1.1 |
| 7 (lower) | 1.30 | 5.7 | 76.7 | 12.7 | 4.9 | ........ | ........ | 0.0 |

A radiocarbon determination of 27,200 ± 1000 B.P. (I-2061) was obtained from a laminated marl at Km 1.53.

*Unit 2.*—Semiconsolidated beds of identical grade and bedding as unit 1, but with few gravel lenses. Munsell colors reddish-yellow (5 YR 6–7/4–6), paler near base (7.5 YR hues). Averaging 50–200 cm thick, this fill can be traced from Km 1.2, where it forms a + 2.5-m terrace, to Km 2.2 and beyond, where it is disconformably overlain by unit 1, attaining relative elevations of + 3–5 m. Fairly abundant snails of the species *Zootecus insularis* (identified by C. A. Reed) are locally confined to this unit and form a useful stratigraphic aid.

Well-patinated, Middle Palaeolithic flakes, scrapers, flake-blades, and cores, manufactured in ironstone, were found *in situ* at Km 1.20, 1.53, and 2.55. Since these artifacts were patinated during a period of subaerial weathering, they are clearly derived. Similar, patinated flakes are common on nearby bedrock surfaces today. A single diminutive flake of patinated flint and Late Palaeolithic type was found on the surface or in the upper part of unit 2 at Km 1.44. A radiocarbon determination of 8890 ± 160 B.P. (Y-1377) (Stuiver, in press) was obtained from *Zootecus* shells in unit 2 at Km 1.92.

As indicated by decalcification and superficial rubefaction to depths of 30 cm or so, a reddish-yellow palaeosol developed following sedimentation and a minor phase of erosion.

*Unit 2a.*—The previous unit is conformably underlain by 20–70 cm of moderately limonite-stained materials of identical facies and fauna in the lower half of the wadi. This evidence of modest seasonal groundwater logging can be found in the lower third or half of bed 2 to a maximum elevation of 133 m (13 m above floodplain). The inference is seasonal flooding by the Nile to about that level during the earlier part of the sedimentation. Although turbulent local alluviation was dominant, presumably during the winter, Nile floodwaters must have seeped into the wadi fill during the summer.

*Unit 3.*—A period of channel cutting separates units 2 and 3. The older facies consists of semiconsolidated, stratified, coarse sands with dispersed granules and beds of ironstone gravel. Characteristically, 20–40 cm of subangular to subrounded basal gravels are overlain by up to 150 cm of sands. At Km 1.44 the beds are deltaic in character, inclined 8–17 per cent Nileward at an elevation of 125 m (5 m over floodplain). Up to absolute elevations of 133 m this unit is consistently charged with limonite, giving a multicolored appearance averaging about 7.5–10 YR 5–6/6, a strong brown. At higher elevations the oxidation staining decreases, colors change to reddish-yellow (5–7.5 YR 7/6), and calcareous concretions about 1.5 cm in diameter are common. Oxidation phenomena disappear between Km 2.3 and Km 2.4 at an elevation of about 140 m (20 m above floodplain). Colors then remain reddish-yellow (5 YR 6–7/6).

The limonitic fill is a classical oxidation horizon pertaining to a pseudo-gley or gley soil in the sense of Kubiena (1953) and Franz (1960). Considering the increasing calcification and decreasing oxidation with elevation, there can be no doubt about wadi alluviation contemporary with a high Nile stage. The local deltaic beds in 125 m corroborate this interpretation. Nile floods appear to have attained 140 m, whereas the mean low-water stage was between 125 and 133 m. The suggested flood amplitude of 7–15 m compares with a nineteenth-century level of 7.5–9 m at Aswan. The resulting seepage and seasonal fluctuations of the groundwater table explain the phenomena satisfactorily.

The calcareous concretions and local root drip found within unit 3 in the central and upper wadi are noticeably concentrated in the uppermost horizons. They suggest secondary calcification *per ascensum* during or shortly after the terminal stages of sedimentation.

The fill of unit 3 suggests a period of greater stream competence and more frequent rainfall. A relative elevation of 3.5 m is common in the upper wadi. Corroded, partly waterworn, ironstone flakes of Middle Palaeolithic type are numerous and frequently found *in situ*. These are badly oxidized when found in the Fe- horizon, but patination is entirely absent, even where no groundwater oxidation is evident. More or less freshly struck artifacts were obviously imbedded in unit 3, and their abundance suggests that Middle Palaeolithic occupation of the wadi may have shortly preceded alluviation.

*Unit 4.*—OFS. Separated from unit 3 by a major interval of channel cutting, unit 4 is only fragmentarily preserved to an elevation of about 135 m (15 m above modern Nile floodplain). This is a poorly stratified, unconsolidated, silty, coarse sand of grayish-brown color (10 YR 5–6/2). The heavy minerals contain a proportion of pyroxenes. A nilotic flood silt with wadi admixture, unit 4 is devoid of artifacts and mollusks. There is some evidence of oxidation staining, and the sediments are broken up by networks of fine cracks, filled with later sands. The dehydration fissures may only reflect on the fine grain size of the sediment.

*Unit 5.*—Some 125 cm of unconsolidated, stratified, coarse quartz sands at Km 1.53 suggest that some form of wadi deposition interrupted the period of major erosion separating units 4 and 6.

*Unit 6.*—BSM. Through much of the lower wadi a marly stratum is preserved near the base of the late Pleistocene fill, attaining a maximum elevation of about 139 m (19 m above floodplain). The most common facies is a white to pale yellow (2.5 Y 8/2, 5 Y 8/3), marly, coarse sand with pockets and lenses of quartz granules and coarse, subrounded, ironstone gravel. The marly sands *per se* are subaqueous deposits of mixed wadi and nilotic provenance, and seasonal groundwater-logging is recorded by limonitic flecks and stains as well as pyrolusite dendrites and microconcretions. Mollusca are absent but fine rootlet impressions and, less common, horizontal root casts are present. Corroded, partly waterworn, but unpatinated ironstone flakes of Middle Palaeolithic type were found *in situ* at Km 1.92 and Km 2.13.

Near the mouth of the wadi over 12 m of these marls are exposed, revealing complex changes of facies. At Km 1.28, within the south branch, two major facies are exposed in a 5-m section attaining 134 m. The upper, consolidated marl lacks coarse detrital inclusions but otherwise parallels the marly sands of the north branch exposures. The lower 2.5 m of light brown (7.5 YR 6/4), medium, sandy silts are more typically nilotic. Both sediments contain pyroxenes as well as significant quantities of clay minerals, almost certainly derived from Ethiopian flood waters.

Upstream at Km 2.55 and 142 m elevation, the marly sands grade over into coarse alluvial sands, with dispersed quartz granules and a high carbonate content (9.0 per cent). The lack of stratification of structure suggests deposition may still have been made into standing water or into a transitional environment.

The marly strata of unit 6 imply a long period of seasonal lacustrine situations in the wadi embouchures, culminating with a flood level of at least 142 m.

*Unit 7.*—In the lower wadi (Km 1.30 and 1.44) some 160 cm of typical, coarse alluvial sands with dispersed granules and pebble bands underlie the marls of unit 6. These sands are well stratified and often current-bedded, and mollusks and tools are absent. At Km 1.30 the upper 40 cm are a 5 YR 7/6 reddish-yellow, compared with 5 YR 8/6 in the lower horizons. In addition, the upper horizon is calcified, with root drip and concretions. A slight rubefaction and secondary calcification are indicated for the hiatus between units 6 and 7. This alluvium may be identical with similar deposits constituting a +7-m terrace in the upper wadi.

*Unit 8.*—The base of the late Pleistocene fill is given by a 3–5 m of semicemented, cobble conglomerate of rounded sandstone and ironstone. The matrix is a coarse sand, with ferruginous cement. Although exposed under unit 7 near Km 1.28, this conglomerate was transported by the south branch only and rests on the bedrock floor of the wadi. It has been potholed and at the same time fills in older bedrock potholes, indicating considerable prior and subsequent erosion. The relative level drops from +2.7 m at Km 1.38 to +2.2 m at Km 0.63, +2.0 m at Km 0.31, and +1.3 m at Km 0.21. In other words, the gradient is oversteepened so that the contemporary base level of the Nile Valley must have been at least as low as that of the present time. This wadi floor conglomerate is morphologically and sedimentologically distinct from older terrace spurs of ferricreted conglomerates in the south branch, at relative elevations of +9, +21, and +36 m.

The Wadi Or (north branch) sequence can be summarized in chronological order:

*a*) *Wadi floor conglomerate.* Period of major wadi activity in the south branch, suggesting considerable stream competence and transport distance, with a pluvial climate. Floodplain level 119 m or lower.

*b*) Extended period of erosion in wadis.

*c*) *Wadi Alluvium I.* Wadi alluviation, probably suggesting more frequent rains than today. Base level rising?

*d*) Minor rubefaction. A 40-cm (B)-horizon of rudimentary kind and secondary calcification record a period of subaerial weathering, with some vegetation.

*e*) *Basal sands and marls.* Semi-lacustrine sedimentation in wadi embouchures, contemporary with alluviation. Subrounded gravels suggest greater stream competence than today. Floodplain level attains 142 m or more. Some Middle Palaeolithic artifacts *in situ*.

*f*) Extended period of erosion in wadis with base level of Nile floodplain lower than 120 m. Possibly interrupted by temporary phases of alluviation.

*g*) *Older floodplain silts.* Flood silt accumulation in the wadi embouchures, with some admixture of fine wadi wash but no evidence of accelerated wadi activity.

TABLE 2

KHOR ADINDAN SEDIMENT ANALYSES

(Fines under 60 μ are not differentiated in samples not treated by hydrometer method)

| UNIT | LOCALITY (KM) | NON-CARBONATE FRACTION (PER CENT) | | | | | | CARBONATES (PER CENT) |
|---|---|---|---|---|---|---|---|---|
| | | Over 2,000 μ | 200–2,000 μ | 60–200 μ | 20–60 μ | 2–20 μ | Under 2 μ | |
| 1a | 0.91 | 0.0 | 0.8 | 43.9 | 38.0 | 6.5 | 10.0 | 0.8 |
| 1b | 0.94 | 17.0 | 75.6 | 4.8 | 2.6 | ... | ... | 0.0 |
| 2a (?) | 1.65 | 0.4 | 4.6 | 14.2 | 22.0 | 29.0 | 17.0 | 12.8 |
| 2b | 1.12 | 3.3 | 87.2 | 4.6 | 4.7 | ... | ... | 0.0 |
| 3 | 1.12 | 0.1 | 18.8 | 12.7 | 28.0 | 35.0 | 15.0 | 0.4 |
| 3 | 1.13 | 0.0 | 4.0 | 17.3 | 17.5 | 33.5 | 21.0 | 6.7 |
| 4 | 2.83 | 6.0 | 46.3 | 22.4 | 6.9 | ... | ... | 18.4 |

*h*) Period of wadi erosion.

*i*) *Wadi Alluvium II.* Aggradation of wadi alluvium with stream competence slightly greater than today, with rising base level and floodplain level culminating in about 140 m. Flood amplitudes may have been as much as 15 m. Profusion of coarse Middle Palaeolithic flakes *in situ*.

*j*) Period of wadi erosion.

*k*) *Wadi Alluvium III.* Aggradation of wadi fill to +2.5–5 m similar to (*i*), but with flood level at about 133 m, possibly falling later during this stage. Profusion of terrestrial snails (*Zootecus insularis*) suggests improved ecological conditions. Derived Middle Palaeolithic (and possibly also Late Palaeolithic).

*l*) Minor rubefaction. Development of a 30-cm (B)-horizon with decalcification. Chemical weathering and some vegetation implied.

*m*) Period of wadi erosion.

*n*) *Wadi Alluvium IV.* Colluvial wash and minor wadi aggradation to +3.5 m, base level unknown. Essentially a period of redeposition of older alluvium and detritus by sheetflood activity. Sterile.

*o*) Recent wadi erosion with redeposition of coarse sands with dispersed pebbles.

## *LATE PLEISTOCENE DEPOSITS OF KHOR ADINDAN*

The spectrum of Upper Pleistocene wadi and nilotic beds in Egyptian Nubia is complemented by the sequence exposed in Khor Adindan, an east-bank wadi. Whereas Wadi Or records the BSM and OFS, and their interdigitation with the local fills, Khor Adindan illustrates the complexity of the YCS and the associated wadi activity. The Khor Adindan sequence can be outlined as follows, once more beginning with the youngest unit. Table 2 summarizes some of the more pertinent sedimentological data.

*Unit 1a.*—Unconsolidated, well-stratified, backset or topset, micaceous, medium-sandy silts of light brownish-gray (2.5 Y 5–6/2) color. These levee-type sediments of nilotic origin are sterile and attain 127 m (5.5 m over local floodplain level of 120.5 m). They clearly record YCS III, and over a longitudinal distance of 30 m are interdigited with typical wadi deposits (unit 1*b*).

*Unit 1b.*—Unconsolidated to consolidated, well-stratified and sometimes current-bedded, coarse quartz sands with dispersed ironstone pebbles. This reddish-yellow (5 YR 7/8) alluvium forms a +2.5-m wadi terrace inclined 3 per cent downstream, except at the silt contact, where foresets inclined to 8 per cent alternate with backsets of 0.5 per cent dip. Intact laminae (2 mm) of the wadi sands penetrate into the nilotic silt complex, while redeposited silts occur within the sands as lenses some 5 cm thick. The two facies are contemporary but out of phase seasonally. During the summer, nilotic alluviation was uninterrupted by any wadi activity. In winter, however, wadi aggradation took place in a ponded area near the wadi mouth, with very localized fill and scour of nilotic silts on the floodplain periphery. These exposures at the mouth of Khor Adindan (Km 0.91–0.94 from terrace (Fig. 7) of unknown external correlation. The 8-m terrace proper suggests vigorous wadi alluviation, competing successfully with nilotic aggradation. A flint flake and an ironstone micro-flake with faceted platform found at the base of unit 2*b* are both patinated but not waterworn, whereas a coarse, Levalloisian flake-blade is waterworn. Concentrations of diminutive flakes, some with faceted platforms, but lacking blades and geometric forms, may be found on the surface of the +5-m terrace. This suggests a Late Palaeolithic cultural identification with the +8-m terrace.

At Km 1.65 a patch of sandy nilotic silt in 136 m (+15.5 m) rests on a spur of reddish-yellow, coarse wadi sands, forming a local terrace in 9.5 m. This silt may be identical with or older than that of the Km 1.12 section.

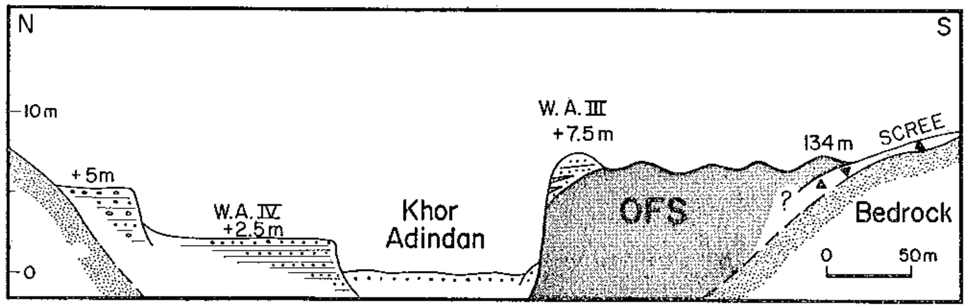


FIG. 7.—Cross-section of Khor Adindan at Km 1.12

Nile) emphasize the dualism of exotic summer floods and local rains. The wadi fill seems sterile except for a patinated and waterworn Late Palaeolithic flake.

*Unit 2a.*—Unconsolidated, stratified, calcareous, medium-sandy silt of brown (10 YR 5/3) color and nilotic facies. Long wedges 10–15 cm in thickness are intercalated with wadi alluvia in an exposure at Km 1.12 (Fig. 7). Inclined Nileward at 1.5 per cent, the eroded upper ends attain 131 m (+9.5 m) and presumably record remnants of YCS II.

*Unit 2b.*—Two facies of wadi alluvium are interdigited with unit 2*a*: reddish-yellow (7.5 YR 8/6) coarse sands and, less commonly, brown sandy and detrital beds, but a definite, derived nilotic component. Unit 2*b* is part of a +7.5–8-m wadi terrace, fragmentarily preserved in the lower wadi, and separated from unit 1*b* by a period of downcutting to below modern floodplain. Vertical incision was interrupted by deposition of a +5-m coarse fill

*Unit 3.*—OFS. Semiconsolidated, unstratified, non-calcareous, brown (10 YR 4.5/3), coarse, sandy silt to calcareous, light olive-gray (5 Y 6/2), clayey silt. These are typical nilotic flood silts, containing abundant hornblende as well as pyroxenes, with a variable admixture of local wadi sands. Slickensides, prismatic structure, polygonal crack networks, 1–2-cm calcareous concretions, and pyrolusite flecks are all common. The cracks occur as a major network at intervals of 50–100 cm, and minor networks at 15-cm intervals. These dehydration cracks are 5–10 and 1–2 cm wide, respectively, over 130 cm deep, and filled with coarse wadi sands. Crack networks are best developed at the base of a shallow channel filled in by unit 2 at Km 1.12. Each of these phenomena indicates development of a vertisol, under obscure conditions, probably after the period of major downcutting between units 2 and 3.

The highest fragment of these nilotic silts is preserved to 138 m (+17.5 m) near Km 1.61. They are sterile, although Late Palaeolithic artifacts occur on the surface or in the epigenetic crack fillings.

*Unit 4.*—BSM. Semiconsolidated, stratified, very pale brown (10 YR 8/3–4), marly, coarse sands with intensive yellow, limonitic-staining bands of subrounded local gravels, and root drip or root casts. Considerable colloidal silica is present. These marly sands form a terrace on the north bank of Khor Adindan between Km 2.7 and 3.0, attaining some 148.5 m (+28 m). Resting on potholed and fluted bedrock, the sands are overlain by younger, reddish-yellow wash, recalling unit 2*b*. Similar wash penetrates a crack network in the upper parts of unit 4. The facies suggests a subaqueous deposit, primarily of local origin, with occasional addition of coarse detritus, and pronounced groundwater oxidation.

Some basal conglomerates are probably an integral part of unit 4.

Summarizing the Khor Adindan sequence, the following Upper Pleistocene sedimentary and erosional phases can be identified:

*a*) *Basal sands and marls.* Coarse wadi sands and coarse, subrounded gravel, deposited in a semi-lacustrine nilotic environment (to 148.5 m or more) at a time of accelerated wadi activity.

*b*) Period of wadi erosion.

*c*) *Older floodplain silts.* Deposition of flood silts in the lower wadi to at least 138 m, with wadi activity no greater than that of today.

*d*) Period of major wadi erosion.

*e*) Major vertisol development on the OFS as a result of periodic wetting, either by local wadi flow or inundation.

*f*) *Wadi Alluvium III.* Aggradation of wadi alluvium to +8 m, with slightly improved stream competence, in response to nilotic aggradation to 131 m or more. Late Palaeolithic *in situ.* There may have been an earlier complex of wadi alluvium and nilotic silts, graded to a floodplain level of 136 m or more. This may also have been a later alluvial substage. In any case the +8-m wadi terrace represents WA III and is directly correlated with YCS II.

*g*) Period of wadi erosion to below modern floodplain level.

*h*) *Wadi Alluvium IV.* A +2.5-m fill terrace as *f*, contemporary with nilotic aggradation (YCS III) to 127 m.

*i*) Recent erosion and redeposition of fill.

Although there are many lacunae in the Khor Adindan sequence and the palaeosol record is poor, correlations with Wadi Or are evident and the direct correlations between WA III and YCS II, WA IV and YCS III, are clear.

## *LATE PLEISTOCENE DEPOSITS OF THE LOWER WADIS KOROSKO AND ABU SUREIH*

The lower courses of Wadi Korosko (floodplain level at Korosko 113 m) and Khor Abu Sureih (floodplain level at Nag Ibeidalla 109 m) both expose interesting although fragmentary Upper Pleistocene deposits. Korosko lies 35 km upstream of Khor Abu Sureih, but sediments are remarkably similar in both wadis. The major stratigraphic units can be briefly outlined, assuming duplication of features unless indicated.

*Unit 1.*—Unconsolidated, stratified, subrounded ironstone gravel of coarse to cobble grade with a matrix of light brown (7.5 YR 6/4), coarse sand. This wadi fill forms a +2–5-m terrace in Abu Sureih only and is sterile but for very rare specimens of *Zootecus insularis.*

*Unit 2.*—Semiconsolidated to semicemented, stratified, light reddish-brown (5 YR 6/4), coarse sands with dispersed coarse, subrounded ironstone pebbles. A basal gravel sub-unit is present in Wadi Korosko and forms a universal +2–5.5-m terrace with proliferations of *Zootecus insularis.* In Wadi Korosko a dozen small flakes, many with faceted platforms, were found *in situ* in the north branch, just beyond the first confluence. The facies of unit 2 is identical to that of Wadi Alluvium IV in Wadi Or. Some channel cutting followed its deposition, major erosion preceded it. The surface of unit 2 appears to be rubefied in many sections.

*Unit 3.*—Alternating stratified beds of (*a*) unconsolidated, pink (7.5 YR 7/4), marly medium sand; (*b*) unconsolidated, brown (10 YR 5/3), medium-sandy silt; and (*c*) unconsolidated, pink (5 YR 7/3) marl. Confined to Korosko Station, these nilotic beds attain 12 m over floodplain. They probably correspond to semi-consolidated light gray (10 YR 7/2) to pink (7.5 YR 7/4) marly medium sands forming a long terrace remnant about 1 km upstream at an identical elevation. A similar fragment occurs in Abu Sureih at 24.5 m above floodplain, also separated from unit 4 by an interval of downcutting. Despite certain difficulties of internal correlation, the Korosko Station strata clearly belong to the OFS. The marly sands upstream form a logical mixed nilotic-wadi deposit in the same progress of facies. All these beds are sterile.

*Unit 4*.—Semiconsolidated, stratified, white (10 YR-5Y 8/1–2) marls or silty medium sands, attaining +24.5 m in Wadi Korosko, +28 m in Abu Sureih. The carbonates have been leached out in the latter wadi and replaced by secondary, diffuse limonite or ferruginous concretions. Upstream in Khor Abu Sureih the nilotic facies grades over into light brown (7.5–10 YR 6/4), coarse sands with delta bedding. Lenses of subangular to subrounded, coarse to cobble ironstone gravel are concentrated in the lower part of the unit. Sterile except for rather common root impressions, mainly vertical and under 3–5 mm in diameter. BSM.

*Unit 5*.—Semicemented, stratified, coarse to cobble conglomerate of subrounded ironstone, forming a wadi terrace in +3–6 m but most commonly preserved in the wadi sole. The matrix of coarse sands is usually rubefied to a pink (5 YR 7/4) color, although the core color in deep sections is a very pale brown (10 YR 7–8/3). The stratigraphic position of this palaeosol is uncertain. Limonitic staining is also common. This unit closely parallels the wadi floor conglomerate of Wadi Or. It is separated from unit 4 by a period of erosion, although similar but younger gravels are intercalated with the base of unit 4.

In overview, the Upper Pleistocene sequence of Wadis Korosko and Abu Sureih can be summarized briefly.

*a*) *Wadi floor conglomerate*. Subrounded ironstone cobbles, attaining relative elevations of as much as +6 m, following an interval of wadi bedrock incision. Suggests major pluvial activity prior to nilotic sedimentation. A similar conglomerate has been described from Wadi Abu Uruq, some 10 km downstream of Korosko Station, by Sandford and Arkell (1933, p. 42).

*b*) Period of major wadi erosion.

*c*) *Basal sands and marls*. Marls and fine sands attaining 28 m over floodplain and grading upstream into coarse wadi sands with some deltaic bedding. Gravel intercalations are common, particularly near the base suggesting accelerated wadi activity. Abundant lower vegetation is suggested by root impressions.

*d*) Period of major wadi erosion.

*e*) *Older floodplain silts*. Silts and marly beds to 12 m above floodplain, possibly with semi-lacustrine marls farther upstream to +24.5 m. Limited wadi activity.

*f*) Period of major wadi erosion.

*g*) *Wadi Alluvium III*. Aggradation of coarse wadi sands to +3–6 m, with proliferations of *Zootecus* and a Late Palaeolithic flake industry. Accelerated wadi activity recorded by subrounded gravel strata.

*h*) Minor rubefaction.

*i*) Period of wadi erosion.

*j*) *Wadi Alluvium IV*. Wadi aggradation to +2–5 m. Sterile.

*k*) Recent erosion and redeposition of fill.

The Wadi Korosko–Khor Abu Sureih sequence closely parallels that of Wadis Or and Adindan and provides an important link with Wadis Kharit and Shait over 200 km farther north. Unfortunately, the relationship of fill gradients to former Nile base levels is not clear.

### *LATE PLEISTOCENE DEPOSITS OF WADIS SHAIT AND KHARIT*

The great wadis emptying onto the Kom Ombo Plain derive their waters from an extended drainage basin in the Red Sea Hills. Shait, to the north, and Kharit, to the south, aggraded their lower courses several times during the late Pleistocene. These alluvial beds are interdigited with nilotic deposits about 15 km east of the Nile. Typical sections, selected from about 150 exposures studied in detail, have been described from each wadi in an earlier publication (Butzer, 1967). The following sequence of depositional units summarizes the data collected in these two valleys at distances of 15–30 km from the Nile.

*Unit 1.*—Unconsolidated, stratified, light brown to yellowish-brown (7.5–10 YR 6/4), coarse sand with a variable admixture of subangular to subrounded gravel (ironstone, sandstone, igneous rocks derived from older terraces). Forms a 30–200-cm deep fill in the wadis, grades upslope into a coarse colluvial wash, generally 30–40 cm thick. Archaeologically sterile, there are milling stones, chert flakes, and blades, as well as potsherds of black-topped ware on the surface. These materials may imply that late Predynastic occupation followed deposition of unit 1. Fine, vertical root drip or root casts are common in many of the more compacted beds. Locally there may be some *Zootecus insularis* shells.

*Unit 2.*—Unconsolidated, stratified or current-bedded, light reddish-brown (5–7.5 YR 5–6/4), silty medium sand to coarse sands. In the ponded embayments of minor tributaries, particularly where weathered Pleistocene gravels provide residual clays, the facies may be that of a light brown (7.5 YR 6/4), medium-sandy silt or clayey silt. Human industries appear to be absent. Coarse, horizontal root drip or root cast systems occur in the sandy facies, fine vertical root drip in the clayey vegetation. Proliferations of *Zootecus insularis* and an unidentified associate gastropod are common in some areas. Forming a wadi terrace in +1.5 to +4.0 m, this alluvium attains a maximum thickness of at least 9 m. It appears to be graded to a Nile base level of 95–100 m (modern floodplain 88.5–90 m). The finer facies of unit 2 shows development of an epigenetic crack network to depths of at least 140 cm, the individual fissures up to 4 cm wide. These dehydration cracks were subsequently filled with unit 1 materials, after a period of major dissection. A fossil vertisol is implied. On the other hand, a reddish soil horizon seems to have developed simultaneously on the sandy facies of unit 2.

A radiocarbon age of 17,400 ± 300 B.P. (I-2179) was obtained from a wadi marl near New Korosko. Together with the stratigraphic position of the later red palaeosol and the $C^{14}$ determination from Wadi Or this suggests that unit 2 includes both WA II and III of Wadi Or. Thus unit 2 would include the time span covered by the YCS, extending into the early Holocene.

*Unit 3.*—Semiconsolidated, unstratified, brown (10 YR 5/2–3), medium-sandy silt to clayey silt with pyroxenes, some prismatic structure, well-developed crack networks, and occasional pseudo-gley phenomena such as limonitic staining and pyrolusite veneers. Secondary carbonates or salts commonly occur in the form of concretions. Mollusca include *Planorbis* sp., *Valvata nilotica* (Olivier), *Bulinus truncatus* (Audouin), *Radix (Lymnaea) lagotis* (Müller), and *Corbicula fluminalis* (Müller) (probably ssp. *vara*) (identified by E. G. Leigh). This association is dominated by species preferring muddy or stagnant waters. Abundant *Corbiculae* are never found in association with the pulmonate gastropods. This typical OFS facies may occur with several variants. These include (*a*) grayish-brown (10 YR–2.5 Y 5–6/2), marly beds, often rich in organic matter or gypsum, and (*b*) gravelly basal strata. The marls are rather localized in their distribution and, with their concentrations of planorbids, suggest stagnant ponds or semi-lacustrine environments. The basal gravels are uncommon and restricted to tributary wadi valleys invaded by nilotic silts. The general facies suggests little wadi activity. Maximum elevations in Wadi Shait are about 105 m, in Wadi Kharit, about 111 m. Total thickness within the wadis exceeds 3 m locally, and may attain well over 10 m.

Deposition of unit 3 was followed by development of a conspicuous vertisol and by an extended period of dissection.

*Unit 4.*—Semiconsolidated, unstratified, light brownish-gray (2.5 Y 6–7/2), medium-sandy marl with a similar fauna as unit 3, and a massive basal sub-unit of coarse gravel. A single fresh Middle Palaeolithic artifact found *in situ* may be contemporary. Not recorded in Wadi Kharit, these BSM attain 107.5 m or more in Wadi Shait, with a vertical thickness of at least 6 m, base not seen. Major dissection separates units 3 and 4.

Although only four Upper Pleistocene units can be identified in Wadis Shait and Kharit, the respective deposits are better exposed or better developed than in Nubia. Detailed publication of the wealth of information gathered here must await a comprehensive monograph. In summary form the sequence of events can be outlined as follows.

a) *Basal sands and marls.* Semi-lacustrine sandy marls attaining 19 m or so above modern floodplain, with considerable evidence of local wadi activity; e.g., at least 85 cm of coarse basal gravel and a general preponderance of local sands over nilotic silts.

b) Period of major wadi erosion.

c) *Older floodplain silts.* Nilotic silts and some local semi-lacustrine beds to 21 m above modern floodplain. Limited wadi activity only.

d) Major vertisol development on the OFS.

e) Period of major wadi erosion.

f) *Wadi Alluvium III* (local designation: Lower Wadi Alluvium). Aggradation by both the major and local tributary wadis of relatively homogeneous alluvium to +2–4 m, with snail proliferations and frequent root impressions, but lacking coarse lateral intercalations. Suggests more frequent rains but an absence of sheetflooding. Contemporary with but presumably also lasting longer than deposition of YCS at Kom Ombo.

g) Period of major wadi erosion.

h) *Wadi Alluvium IV* (local designation: Upper Wadi Alluvium). Aggradation of torrential wash with considerable local sheetflooding.

i) Modern wadi erosion, minor local redeposition and clay alluviation.

None of these units contains significant archaeological materials, but Predynastic and later remains rest on WA IV. Despite certain local differences, however, the sedimentary and geomorphological parallels with the Nubian wadis studied are unmistakable.

## *COMPOSITE LATE PLEISTOCENE STRATIGRAPHY OF SOUTHERN EGYPT*

The local stratigraphic sequences established for different parts of the Nile Valley (Fig. 8) and its tributary wadis in southern Egypt can be synthesized in composite form (Table 3). The results are of a complexity never envisaged by Sandford and Arkell (1933). The correlations of nilotic and wadi phenomena are based on substantial field evidence, and the basic sedimentary units themselves must be considered as established. Nonetheless, there are several uncertainties that require emphasis or discussion.

1. The exact age of the vertisol developed on the OFS cannot be determined on the basis of the exposures studied. This palaeosol postdates major sedimen-

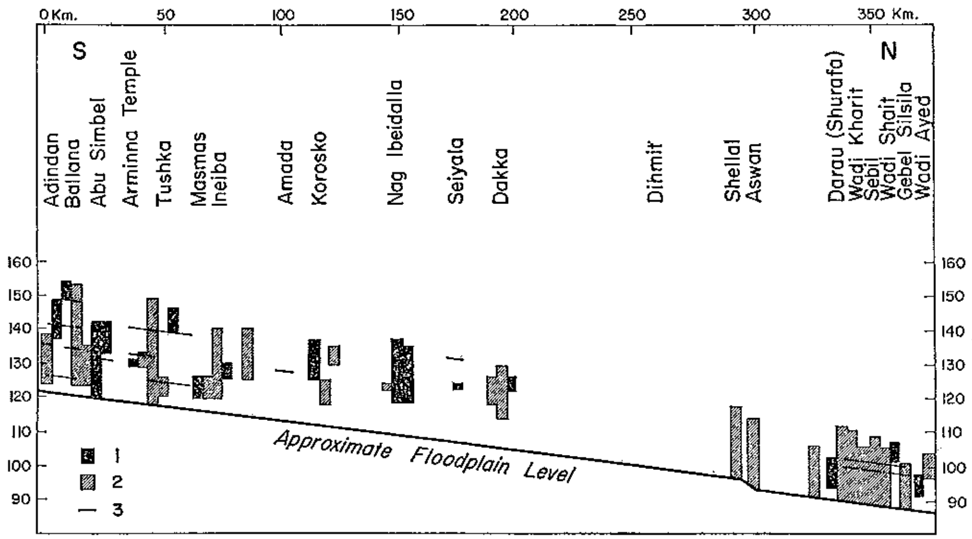


FIG. 8.—Late Pleistocene nilotic series in southern Egypt. *1*, Basal sands and marls. *2*, Older floodplain silt. *3*, Younger channel silts. Whereas *1* and *2* indicate the vertical range of sediments recorded, *3* shows the elevation of distinct substages only.

tation of the OFS and predates WA III. The stratigraphy of the other late Pleistocene palaeosols, mainly a matter of minor rubefaction, is also unsatisfactory. Although several red palaeosols appear to be rather striking in the late Pleistocene record of the northern Sudan (J. de Heinzelin, W. Chmielewski, H. Irwin, personal communications; Hewes *et al.* 1964), their record is less impressive north of the border and they appear to be absent at Kurkur or on the Red Sea coast. In Egyptian Nubia and to a lesser degree at Kom Ombo, superficial rubefaction with kaolinite formation is generally noticeable on coarser-grained WA III sediments. The period of chemical weathering indicated predates WA IV, but its exact relationship to the intervening period of dissection could not be locally determined.

2. The relationship of the OFS to YCS Substage 0 can hardly be resolved in Egyptian Nubia where development of this earliest YCS stage is poor. Even at Ballana, deflation and washing have largely obscured these strata so that ex-

TABLE 3

UPPER PLEISTOCENE AND HOLOCENE STRATIGRAPHY IN SOUTHERN EGYPT

| NILOTIC STAGE | LOCAL PHENOMENA | SUGGESTED CORRELATION AND RADIOCARBON DATES |
|---|---|---|
| Downcutting followed by late Predynastic to modern siltation | Dissection and redeposition of fill interrupted by minor alluviation | Late Holocene |
| YCS III (to +6 m, in Nubia only) | Wadi Alluvium IV, wadi and nilotic facies interdigited | Middle Holocene |
| Downcutting (to below modern floodplain) | Dissection and deflation | Early to Middle Holocene |
| YCS II (to +13–15 m in Nubia, Kom Ombo Plain?). Late Palaeolithic | Wadi Alluvium III, wadi and nilotic facies interdigited. Followed by minor rubefaction in Nubia, minor vertisol formation at Kom Ombo. Late Palaeolithic | Upper Dryas to Early Holocene |
| Downcutting | Dissection | Allerød |
| YCS I (to +20–22 in Nubia, +10–12 m on the Kom Ombo Plain). Late Palaeolithic industries of Kom Ombo: Sebilian, Menchian, Silsilian, Sebekian | Wadi Alluvium II | Late Würm (ca. 15,000–11,000 B.C.) |
| Downcutting | | |
| Older floodplain silts (to +33 m in Nubia, +22 m on the Kom Ombo Plain) followed by significant vertisol development | Limited wadi activity only | Middle Würm |
| Downcutting (to below modern floodplain) | Dissection, possibly interrupted by temporary alluviation | |
| Basal sands and marls (to +34 m, in Nubia, +20 on the Kom Ombo Plain) | Accelerated wadi activity, wadi and nilotic facies interdigited. Middle Palaeolithic? | Early to Middle Würm |
| Nile floodplain aggrading | Wadi Alluvium I, followed by minor rubefaction and calcification | |
| ? | Erosion | |
| ? | Wadi floor conglomerate | |
| Downcutting (to below modern floodplain) | One or more phases of dissection and general rubefaction, sequence unknown | Eem |

cavations would be necessary to obtain representative sediments for study. YCS 0 may only be a terminal degradation stage of the OFS, associated with minimal alluviation. On the other hand, if the YCS 0 are indeed distinct, the time interval represented must have been brief, and the deposits so shallow that deflation has destroyed them in most of southern Egypt. Another possibility is that the questionable deposits at Ballana date from the very temporary high Nile flood phase to +30 m, clearly recorded at the Colorado excavations with radiocarbon dates in the time range of 10,000 to 8,000 B.C. (H. Irwin, personal communication). Because of these uncertainties, YCS 0 has been omitted from Table 3.

3. The internal stratigraphy of the YCS Substages I–III cannot be fully delineated on the basis of the present study alone. The extensive excavations of the Columbia–New Mexico and the Colorado expeditions in the northern Sudan promise to yield a wealth of microdata that can seldom be obtained by normal geological field study. A mass of radiocarbon dates is also pending from the same excavations. When the interim reports of the different expeditions to lower Nubia and the Kom Ombo Plain become available, detailed and reliable cultural and $C^{14}$ correlation should be possible from Gebel Silsila to Wadi Halfa.

4. It is not clear whether the substage YCS II is represented at Kom Ombo. P. E. L. Smith (personal communication; also Smith, 1964*a, b*) has collected sites near Sebil that have yielded radiocarbon determinations several millennia younger than those of the Gebel Silsila area. Their geology has been studied by R. J. Fulton. Further information in this regard is necessary before the stratigraphic position of WA III in Wadis Shait and Kharit can be defined more precisely.

5. The transition from YCS III to the siltation of the contemporary Nile floodplain is still obscure. The "modern" silts are considerably finer on the whole, with less fine sand than the YCS beds, and a quasi-total absence of sediments coarser than 0.6 mm. There also appear to be shifts in the relative importance of the different heavy minerals, with micas less abundant in modern floodplain materials. Through most of the Nile Valley (see Attia 1954), the late Holocene muds rest disconformably on fine micaceous sands with abundant heavy minerals presumably representing the YCS.[1]

External correlations of the Upper Pleistocene sequence described here with that of northern Egypt, the Libyan Desert oases, and the Red Sea littoral are beyond the scope of this paper. Certain stratigraphic correlations appear possible but, until $C^{14}$ determinations are available, discussion will serve little purpose. An exception to this are the fossil groundwaters tapped at the modern Kharga Oasis (see Knetsch *et al.* 1963). Three Heidelberg radiocarbon dates (25,400, 24,700, and 19,400 B.P.; H-1267, 1269, 1270) confirm their late Pleistocene age, while $C^{14}/C^{13}$ ratios of the waters suggest a surface accumulation environment moister than the contemporary Mediterranean littoral of Egypt. Furthermore, an isotopic temperature determination of shells in the fossil mound springs at Kharga suggests a former mean annual temperature of 16.5° C, which is 6.5° colder than the modern mean. This evidence from the Libyan Desert generally corroborates the Nile Valley sequence in southern Egypt.

[1] The general thickness of the Late Holocene mud in the Edfu-Esna area, downstream of Gebel Silsila, is 5–11 m (estimate based on 15 bores selected from the compendium by Attia 1954). Of a total thickness of 5 m at Hierakonpolis, midway between Edfu and Esna, some 3 m had already been deposited by 2250 B.C. (see Butzer 1959*b*, pp. 67–68). Assuming deposition of 10 or even 20 cm per century, late Holocene siltation at Hierakonpolis certainly began well before the Predynastic period. Radiocarbon dating of the YCS III sediments and related archaeological materials in the northern Sudan should help close this chronological gap.

*PALAEOCLIMATIC INTERPRETATIONS*

A picture of the geographical and ecological setting of the Nubian Nile in late Pleistocene times must await study and publication of the pollen and the mammalian and molluscan faunas. Geomorphological interpretation of the sedimentary record can be attempted (see Butzer 1964*a*) but remains limited in scope until completion of the laboratory analyses.

THE NILOTIC DEPOSITS

The existence of three distinct nilotic sedimentary units in the late Pleistocene record of southern Nubia can be shown on a number of lithological as well as stratigraphic grounds. In addition to the sections and facies characteristics already described in detail, the X-ray diffractograms show very distinctive and internally consistent clay fractions for each sedimentary unit. The YCS show a very intense montmorillonite peak and a very minor secondary peak for kaolinite. In the BSM the kaolinite peak is more prominent and almost as intense as the montmorillonite peak. The situation is intermediate in the case of the OFS, with the montmorillonite peak most prominent and intense, but the kaolinite peak still is significant. Heavy mineral analyses, although incomplete, seem inconclusive as to whether significantly different heavy mineral suites can be assigned to each sedimentary unit. Pyroxenes are clearly present in each, and mineralogic analyses of modern nilotic sediments by Shukri (1950) suggest that this group of heavy minerals is indicative of Ethiopian drainage influx.

In any case, the presence of exotic silt and clay and the presence of pyroxenes suggests strongly that each of the three nilotic units (BSM, OFS, YCS) can be ascribed to summer floods of sub-Saharan origin. In each case fairly rapid aggradation of an expanded floodplain, to elevations substantially higher than today, suggests greater and more persistent floods than are usual today. The dominant coarse sands of the BSM and the gravel lenses of the YCS further suggest greater stream competence during those stages. The quartz sands of the BSM are almost entirely of local origin, and an increasing detrital component of quartz grit, sandstone, or ironstone pebbles is evident near the mouths of larger wadis. The OFS contain some coarse quartz sands and, locally, quartz grit or medium pebbles. These again are of local origin, but are not as important as the detritus of either the BSM or YCS. The pebbles of the YCS are mainly medium to coarse quartz, but with an appreciable exotic component of flint, chert, chalcedony, jasper, agate, and carnelian. Many or most of these foreign elements are derived from the Hudi Chert of the central Sudan (Andrew and Karkanis 1945; de Heinzelin and Paepe 1965). They probably imply accelerated wadi activity in upper Nubia as well as increased competence of the summer floods in general.

Each of the three Upper Pleistocene nilotic alluvia implies a period of pluvial erosion in the summer rainfall belt of either Ethiopia and/or the southern Sudan. In particular, the YCS impressively record the existence of two or three pluvial substages during the late Würm and another in mid-Holocene times. Nile flow was probably most vigorous during the BSM, least vigorous during the OFS stage.

THE WADI DEPOSITS

Despite the almost total lack of rainfall, sporadic waterflow has been observed in the wadis of southern Egypt in recent decades. The resulting activity amounts to slow linear erosion and local redeposition of older fill. Bed load deposits are very shallow, suggesting a rather limited capacity. And in all cases the competence for gravel transport is less than that of the local late Pleistocene wadi fills. Although Wadi Alluvia I–IV do not imply anything but alluviation under arid conditions, occasional organic vestiges such as root drip or snail proliferations strengthen the argument that local rainfall must have been more frequent as well as of greater duration. The last two such subpluvial phases can be attributed to the last millennium of the Pleistocene and to the mid-Holocene.

The wadi floor conglomerate can only be explained by somewhat moister, subarid, or even semiarid conditions. The capacity and competence required to transport moderately well-sorted and rounded cobble gravels far exceeds that of modern wadi spates, perhaps even in the greatest wadis of the eastern hill country.

### THE PALAEOSOLS

The shallow red soil zones evident on coarse-grained late Pleistocene fill in much of Nubia are associated with kaolinite clays and can only be understood with some form of biochemical weathering. This implies more abundant moisture and vegetation. In Egypt, similar rubefaction apparently goes on at the Mediterranean littoral with an annual precipitation of 100 mm (Butzer 1959*a*). Whether the climate of southern Egypt has ever been this wet since deposition of the wadi floor conglomerate is open to question. Such moderately rubefied horizons are strikingly absent on fine-grained sediments of equivalent age.

The vertisol developed on the OFS and, in Wadi Shait, on WA III, need not have any climatic implications. In each case the parent material is a fine-grained sediment, rich in montmorillonite and prone to swelling when wet, shrinking when dry. Dehydration crack networks and prismatic or slickenside structures are the only soil characteristics, however. Horizons of discoloration are almost entirely absent, and organic content is low. This rules out any very active soil dynamism. In the case of WA III and some of the OFS, the crack networks are epigenetic. In many cases, however, slickensides and polygonal cracks were observed in all clay strata of the OFS, regardless of vertical position. This leaves no doubt that these phenomena are at least partly syngenetic. In the writers' opinion none of the vertisols developed in OFS need imply a moister climate. They require no more than seasonal floodplain inundation. On the other hand, the vertisol developed on the WA III of Wadi Shait can probably only be explained by local rainfall. Stratigraphically this particular vertisol corresponds to the reddish soils developed in coarser-grained sediments.

### DISSECTION OF FILL

Implicitly, the intervals of Nile downcutting and wadi dissection were climatically more analogous to the present than to conditions prevailing during the different phases of active sedimentation. In the case of the wadis, this is only partially true. Erosional intervals were probably complex, interrupted by brief periods of renewed aggradation. Furthermore, erosion may have been most active during the waning phases of a pluvial, rather than at the maximum of a dry phase. Further, many of the local wadis responded at least in part to base-level changes of the Nile floodplain. Interpretation of these erosional phases is consequently not fully satisfactory.

In the case of the Nile itself, downcutting over 1,000 km from the coast can only be explained through variations of volume rather than movements of base level. Reduction of flood discharge would almost automatically lead to remodeling of the floodplain and regrading of the low-water channel. The details will be hard to reconstruct since the obviously changing longitudinal gradients in the Sudan and Egypt are barely understood as yet. But, with due reservations, the downcutting phases were probably times of comparatively low Nile floods with an Ethiopian summer monsoon certainly no stronger than at present.

In conclusion, the intercalations of local and sub-Saharan pluvial sediments can be reviewed. The wadi floor conglomerate had no apparent nilotic parallel. In the case of the BSM, pluviation was clearly contemporary in Egypt and in the Sudan or Ethiopia, and so again during WA substages II, III, and IV. The OFS are a significant exception, with increased rainfall confined to the sub-Saharan area. In four of six instances, however, the trend to greater moisture was simultaneous on both latitudinal margins of the Sahara.

The deposits at the mouth of Khor Adindan show further that local wadi alluviation in Egypt did not occur at the same season as nilotic aggradation. This juxtaposition of local winter rains and exotic summer floods in the late Pleistocene record confirms that no major changes have occurred in the rainfall regimes of Egypt and the sub-Saharan catchment area of the Nile.

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## *JOINT DISCUSSION OF PAPERS BY DRS. DE HEINZELIN AND BUTZER*

FLINT: In order to compare results, would it be possible to translate Butzer's findings into a chart comparable with the one prepared by de Heinzelin?

BUTZER: First it would be necessary to clarify some points. How does de Heinzelin compare the Khor Musa formation with the OFS?

DE HEINZELIN: The OFS are equivalent to the Khor Musa formation. There may be slight differences in facies, and in the extent of the vertisols, but on the whole they are the same. At Ballana, the OFS or Khor Musa is covered by the Ballana dune, at the top of which we find the first appearance of the Sebilian. Above this, the Sahaba is the equivalent of the YCS. The sequences match very well. The Arkin formation is less well expressed in Butzer's area. The basal sands and marls are less well expressed in our area, where they are patchy.

BUTZER: Can YCS III and IV be reıated with your younger stages, e.g., parts of the Arkin?

DE HEINZELIN: For the moment, I won't go further than the correlation I have just mentioned. There is one discrepancy: in your chart you show two Nile gravels at 180 m elevation, but we have no true Nile gravels above 157 m elevation (35 m above flood plain).

BUTZER: What do you mean by true Nile gravels? Those in question consist entirely of local materials derived from the Nubian Sandstone and Basement Complex in Egypt and the northernmost Sudan.

DE HEINZELIN: I define them on the evidence of elements of southern origin.

FLINT: It is apparent that, as a whole, the two contributors have no serious disagreements.

LEAKEY: What comparisons can be drawn between Butzer's evidence and the curve drawn up by Gardner and Caton Thompson for the Fayum?

BUTZER: From a superficial comparison of the sediments in 1958, it seemed to me that sediments exposed near the Fayum mouth were similar to the OFS material. But it will be necessary to reinvestigate the Pleistocene geology of the Fayum and the adjacent Nile Valley.

KLEINDIENST: Regarding the archaeology, it seems impossible to attach a date to the basal sands on the basis of the very few artifacts found in them by Butzer. Although of softer material—banded sandstone—and very fresh, many open sites in Nubia contain artifacts with a complete range of physical conditions. Owing to the scarcity of material, as well as the uncertainty of the physical condition, no undue importance should be attached to them as a basis for dating the basal sands. Artifacts such as these covered a wide range of time and it is not possible to say that these artifacts were made at a certain point. The Levallois technique is found at many surface sites, covering most of the Upper Pleistocene, and affords no sound basis for correlation.



BUTZER: It was frustrating that during the 1962–63 expedition, no material was collected by an archaeologist and that those materials collected *in situ* still remain unstudied two years later. I very much look forward to the possibility that they will now be studied.

HAY: The silts described by Fairbridge, with $C^{14}$ dates, seem to reverse the climatic interpretation.

BUTZER: Fairbridge's results were based on a short period of field work but derived largely from his earlier solar radiation curve.

DE HEINZELIN: Judging from the scanty field evidence published by Fairbridge, his curve must reflect theoretical assumptions only.

BAKKER: The Sebilian silts were said to represent a dry stage of the Nile, yet according to $C^{14}$ dates these deposits should be related to a maximum. The tree line should have been lower in Ethiopia then than now. Surely the situation was not as simple as Fairbridge supposed, and it is very important to get information for this area.

BRAIN: In de Heinzelin's Figure 2, the point at 22,000 years B.P. represents the highest level of the river, indicating the highest rainfall; is it possible to say where the rainfall occurred?

DE HEINZELIN: Very probably more water came from the Atbara and Blue Nile than from the White Nile, as indicated by the mineral content of the sediments.

BRAIN: In fact, it does not necessarily mean higher rainfall on this particular section?

DE HEINZELIN: The local climate can be interpreted to a certain extent by faunal assemblages and by the fact that soils were beginning to leach and there must have been some precipitation to account for the action of wadis that are now dry.

BAKKER: At the present time, 80 per

cent of the Nile water comes from Ethiopia; is it possible to tell what the difference may have been in the past?

DE HEINZELIN: The Dabarosa Formation, an extensive gravel Formation which the Nile now crosses, has a mineral content and gravels quite different from those of the present Nile system. The elevation is 80–40 m and it has been affected by block faulting. Clearly it belongs to a pre-Nile river system.

BAKKER: There seems to be a period of no information between the Dabarosa Formation and Butzer's basal sands and marls.

BUTZER: The BSM, which are some 40 m thick, can probably be correlated with the first half of the Last Glaciation. They contain Ethiopian pyroxenes, showing that at that time already a good part of the water came from Ethiopia; but what proportion of the water was Ethiopian and what was local is impossible to say. This was the first indication of a regime approximating but not yet identical to that of the present.