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## CONTRIBUTIONS TO THE PLEISTOCENE GEOLOGY OF THE NILE VALLEY

K. W. BUTZER

with 7 figures and 5 photos

*Zusammenfassung.* Die pleistozänen Terrassen des Niltals deren Studium von K. S. SANDFORD in grundlegender, langjähriger Arbeit 1926—1933 eingeleitet worden ist, wurden 1958 v. Verf. neu untersucht zwecks einer Unterscheidung lokalklimatischer (in Ägypten sowie südlich der Sahara) und eustatisch bedingter Aufschotterung. Es wurde zuerst eine quartär-geologische Kartierung in Mittelägypten durchgeführt. Dabei stellte sich heraus: 1) Nilablagerungen in erkennbaren morphologischen Niveaus fehlen zwischen Beni Adi und Mallawi vollkommen. 2) Nördlich Mallawi können Niveaus in 78 und 90—98 m über dem Flußniveau (Sicilien) zum Meer verfolgt werden; südlich Mallawi fehlen diese auf 300 km Entfernung bis Gebelein, wo zwar ähnliche Niveaus, die aber wahrscheinlich nicht gleichzeitig sind, zu erkennen sind. Nördlich Gebelein gibt es keine 46-m-Terrassenstufe. 3) Eine 25—30-m-Terrasse ist durch ganz Ägypten verbreitet, mit Ausnahme der 140-km-Strecke Beni Adi—Beni Mazar. Nördlich hiervon handelt es sich um eine eustatisch bedingte Terrasse mit Acheul (Tyrrhenien), südlich um eine ältere Pluvialterrasse mit Abbeville. 4) Eine 10—15-m-Terrasse ist in Unterägypten ebenfalls interpluvial und

eustatisch bedingt (Monastirien), in Oberägypten klimatisch (mit Acheul). Diese Unterscheidung wurde auf Grund der Terrassenzusammensetzung, der Bodenbildungen und der bekannten Industrien vorgenommen. An Hand von Bodenprofilen hat sich folgender Ablauf mehrmals vollzogen: a) Sandablagerungen durch Nil und Wadis. b) Schlußakkumulation von Schottern (in Oberägypten). c) Braunerdebildung mit mächtigen Kalkanreicherungshorizonten. d) Lokalaridität mit Aussetzen der chemischen Verwitterung sowie der Bodenbildung. Gleichzeitig eustatisch bedingte Aufschotterung in Unterägypten. c) Roterdebildung mit Entkalkung. Die Wadiprofile Oberägyptens deuten auch auf eine komplizierte Talentwicklung im Verlauf des Jungpleistozäns (3—4- und 1—2-m-Waditerrassen) hin.

The investigation of the complex system of Pleistocene river and wadi terraces in the Nile Valley was successfully begun some 60 years ago when M. BLANCKENHORN (1901) geologically mapped the eastern bank of the Nile between

Cairo and Maghagha. However the sum total of geological knowledge concerning this great exotic river flowing from the equator across half of Africa remained fragmentary and incoherent until K. S. SANDFORD began his fundamental and notable survey of the post-Miocene deposits below Wadi Halfa. Working in good part with W. J. ARKELL, SANDFORD's thorough investigation lasted from 1925 to 1933, since 1926 under the auspices of the Oriental Institute of the University of Chicago. The material was published in four volumes 1929—1939, a preliminary report on the unfortunately discontinued work in the Sudan appearing in 1949. Excepting the contributions of G. KNETSCH (1953, 1954, 1955) no Pleistocene field work of importance has been carried out in the Egyptian Nile Valley since 1933, although the classical work of E. J. WAYLAND, E. NILSSON and others in East Africa and the valuable contributions of A. J. ARKELL (1949) from the Sudan have greatly added to our knowledge of the Quaternary history of the Nile south of the Sahara.

During the last 20 years Pleistocene geomorphology and stratigraphy have received great impetus, and complemented by notable advances in palaeopedology, have been subjected to considerable revisions in concept and principle. Above all doubt has arisen whether the Nile terrace sequence is altimetrically uniform and contemporary between Wadi Half and the sea, a stretch of some 1500 km. It is not feasible that glacial eustasy should be appreciable so far upstream, something implicit from SANDFORD's work which postulates a continuous Pleistocene pluvial phase. Neither can aggradation or degradation proceed so fast upstream as to keep pace with the fairly rapid fluctuations of Mediterranean sea-level. An interplay of essentially independent eustatic and local climatic factors (both in Egypt and East Africa) must be allowed for. Many of the difficulties inherent in the monumental work of Sandford have already been pointed out in an earlier publication (BUTZER 1958b, p. 60 seq.), but it remained for further field surveys to help clarify the problem.

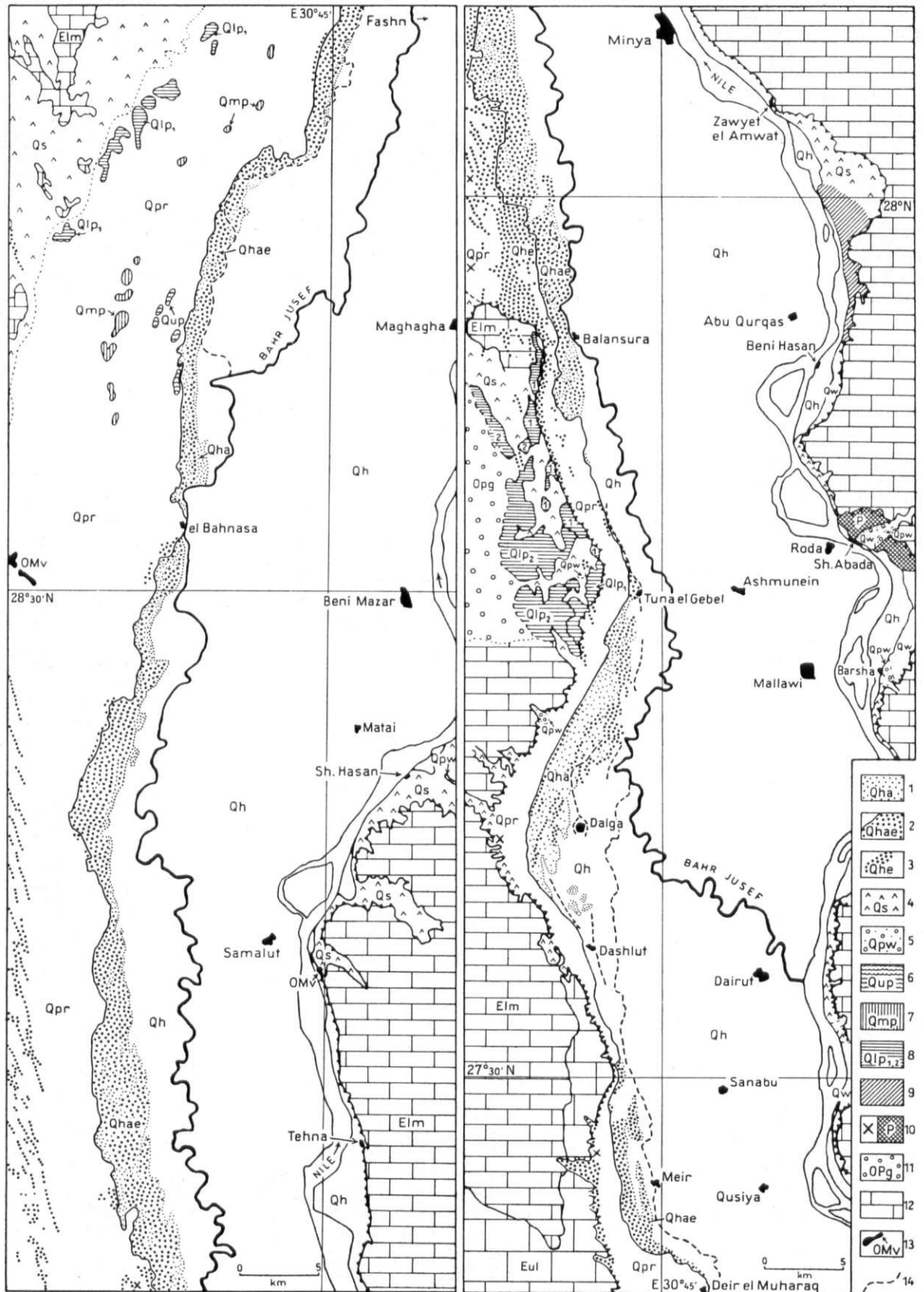
During the winter and spring of 1958 it was at last possible for the writer to carry out a first season of work with the support of the Deutsche Forschungsgemeinschaft. Based upon the results of a field reconnaissance in 1956 it was originally intended to study the extensive wadi terraces of the Eastern Desert between Qena and Luxor and in Lower Nubia. This was rendered impossible by the military closure of the Eastern Desert routes in February 1958. Consequently the investigation was transferred to the Nile Valley in Middle Egypt after initial work had been carried out between Edfu and Qena. It was essential to carry out a preliminary mapping of the deposits between el Fashn and Manfalut and only a lack of time

prevented the completion of a similar mapping of the Asyut area between Manfalut and Badari. Geological mapping in Egypt until 1929 was limited to the 1:1,000,000 map of W. F. HUME in King Fuad's Atlas of Egypt (1928). A year later SANDFORD and ARKELL published their 1:150,000 map of the Nile-Fayum divide, and their map of the desert between Cairo and Wadi el Natrun appeared a decade later on the same scale. Apart from these no further contributions other than the Oriental Institute Publications (OIP) 1:1,000,000 sheets for the Nile Valley between Wadi Halfa and the Fayum have appeared. The preliminary map attached here (Fig. 1) is meant to continue the work of SANDFORD and ARKELL to the south after a brief interruption between Biba and el Fashn. A second season would be required to bring this material to sufficient detail on a 1:150,000 level and complete the sections in the Wadi Asyuti delta and around Beni Adi for the 1:100,000 topographic series to Badari. It is hoped that this preliminary and tentative study will indicate a means whereby a full solution of the inherent problems can eventually be gained on the basis of further detailed field work.

The writer's appreciation is particularly due to the Deutsche Forschungsgemeinschaft for financial assistance and to the German Archaeological Institute in Cairo for permitting the benefit of jeep and driver during the period of work carried out together with one of their Egyptologists. Prof. A. MOUSSA of the Egyptian Mission in Bonn and Dr. R. HIGAZY, Director of the Geological Survey of Egypt, were further of kind assistance. The hospitality of the American College in Asyut is also appreciated.

#### A. The Pleistocene Terraces of the Nile

The areal denudation and erosion of the Cretaceous and Eocene marine beds covering the greater part of Egypt west of the Red Sea Hills began at latest during the Oligocene, when large gravel spreads were deposited in the Libyan Desert between the latitude of Minya and the Fayum. These cobble gravels, predominantly hornstein, were derived from the limestone beds and the Nubian Sandstone and possibly deposited by a predecessor of the modern Nile. Certain is that at the close of the Lower Pliocene (Pontic) the Nile Valley already existed in its present position north of Aswan and with more or less similar areal dimensions. During the Upper Pliocene a marine transgression in the form of a gulf flooded the Nile Valley and deposited brack and freshwater sediments in Upper Egypt to north of Aswan. This implies that the river must have gone over to linear erosion at latest during the Upper Miocene period, and have completed the incision of the present valley to a depth of 200 to 600 m in the limestone plateau during the Lower Pliocene. Similarly the location and fundamental geomorphological character of the present desert valleys is due to vertical erosion during the Miocene and Pliocene. Subsequent erosion and deposition have only remodelled them. At the close of the Pliocene the Nile began the removal of the Astian and Plaisancian filling, a tendency only periodically interrupted in favour of renewed



deposition during the Quaternary. Once the Nile had shifted back upon its ancient bed, fairly immediately in Upper Egypt and during the Middle Pleistocene in Middle Egypt, lateral erosion accounted for most earlier gravel deposits within a fairly short time. In Upper Egypt north of Gebelein Nile deposits are only preserved in deeply indented bays in the Lower Tertiary beds, while in southern Middle Egypt the former Nile beds can be traced with remarkable certainty upon the limestone of the Western Desert. Unfortunately the widespread clayey facies of the Mokattam stage, subjected to severe erosion by water, has not been too favourable for the preservation of the Pleistocene deposits either. The greater part of such areas is covered by undifferentiated Nile gravels. All in all the Nile terraces cannot be compared in development or preservation with those of any larger river in temperate latitudes. It is therefore all the more to the credit of K. S. SANDFORD that so much has already been done with this deficient geological material.

The Plio-Pleistocene limit was implicitly accepted by SANDFORD (1934, p. 51—52) as the changeover from subaqueous to fluvial deposits.

Fig. 1: Map of Quaternary Deposits in Nile Valley between el Fashn and Deir el Muharaq (Markaz Qusiya).

Legend:

- Qh Nile Mud (Recent).
- Qha (1) Marginal Mud overlying aeolian sand at no great depth and lightly covered with drifting sand (Recent).
- Qhae (2) Same, covered with sand dunes, at present mostly fixed.
- Qhe (3) Recent sand dunes upon Pleistocene deposits.
- Qs (4) Superficial deposits (downwash, scree, detritus) Pleistocene to Recent.
- Qw Wadi fans (Upper Pleistocene to Recent).
- Qpw (5) Wadi gravel terraces (Middle and Upper Pleistocene).
- Qup (6) River gravels of Upper Pleistocene (Monastirian).
- Qmp (7) River gravels of Middle Pleistocene (Tyrrhenian).
- Qlp<sub>1,2</sub> (8) River gravels of Lower Pleistocene.
- Qpr Undifferentiated river gravels of general Pleistocene age, locally covered with superficial deposits.
- P (9) Well stratified local detritus of uncertain age.
- P (10) Pliocene deposits (travertines, conglomerates etc.).
- OPg (11) Tertiary gravels (Oligocene to Pliocene), Eocene limestone locally exposed.
- OMv (12) Tertiary igneous rocks: dolerite and basalt (Oligocene-Miocene).
- Elm (13) Eocene limestones of Lower Mokattam stage, widely covered by superficial Tertiary gravels in west.
- Eul (13) Eocene limestone of Upper Libyan stage.
- (14) Former courses of Bahr Jussef in historical times.

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This transition is recorded in four main exposures. At Qena Hill (*ibid.* p. 45—46) 10—30 m falsebedded subaqueous loose white sands overlie Pliocene marls disconformably, and are overlain by 12 m of igneous and quartz gravels from the Red Sea Hills basement complex and the Nubian Sandstone. East of Balyana SANDFORD (p. 24—25) noted up to 25 m of quartz-feldspar sandstone and crossbedded conglomerate discordant upon Pliocene marls. Similarly up to 12 m of subaqueous sand and sandy conglomerate are overlain by 15 m well-rolled conglomerate with some material of Red Sea origin in the Gebel abu Farwah, 8 km NNE of Matmar (*ibid.* p. 46—47). The upper levels of these earliest Pleistocene deposits are now at 42, 41 and 54 m above alluvium respectively. Lastly,

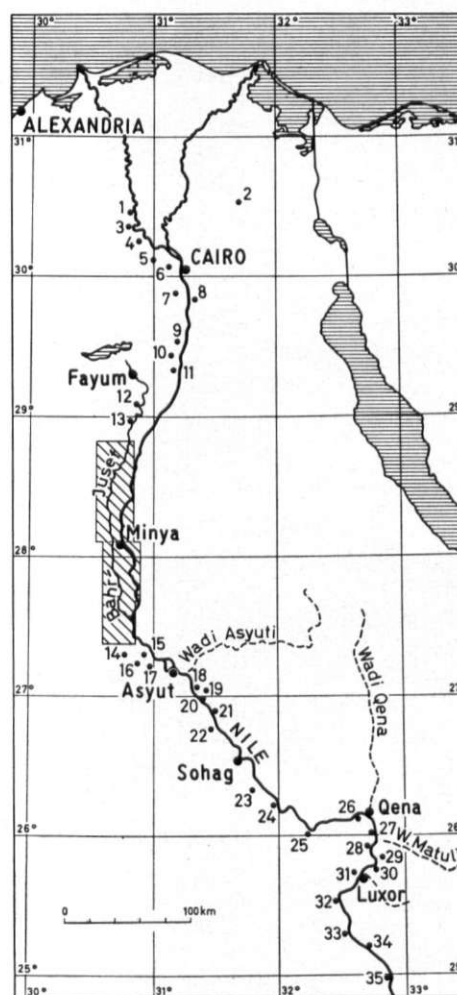


Fig. 2: Outline Keymap of the Nile Valley.

1 Kafr Dawud; 2 el Abbasa; 3 el Khataba; 4 Abu Ghalib; 5 el Mansuriya; 6 Abu Roash; 7 Abusir; 8 Helwan; 9 Tarkhan; 10 Gerzeh; 11 Wasta; 12 Sedment; 13 Deshasheh; 14 Beni Sharan; 15 Manfalut; 16 Beni Adi; 17 Gahdam-el Izziya; 18 Matmar; 19 Deir Tasa; 20 Badari; 21 Qau; 22 Tahta; 23 Mahasna; 24 Balyana; 25 Nag Hammadi; 26 Dandara; 27 Ballas; 28 Tukh; 29 Higaza; 30 Khuzam; 31 Qurna; 32 Gebelein; 33 Esna; 34 Sibaiya Sta.; 35 Edfu.



the Abassiya beds near Cairo (OIP 46, p. 20, 44, 51—2) expose some 15 m of crossbedded estuarine feldspar-bearing sands overlying a very coarse conglomerate resting on Pliocene clays and sands. Disconformably above the estuarine sands are two implementiferous gravel beds separated by Nilotic sands and overlain by silts. In P. BOVIER-LAPIERRE's (cf. OIP 46) section a pre-Chellian industry occurred from — 10 m to — 5 m, a Chellean and Chelleo-Acheulian in — 5 to — 2 m, above which Acheulian occurs to the surface. The oldest implements include circular pebbles reduced to a zigzag cutting edge on one side by alternate chipping (HUZAYYIN 1941, Pl. VI, no. 1—2), a technique recalling a pebble culture. These seemingly occur together<sup>1)</sup> with crude triangular hand axes with zigzag edge and enormously large, untouched butt (OIP 46, Pl. XVII, no. 2), suggesting an overall Abbevillian facies. In the higher level typical Lower and even Middle Acheulian specimens were found in situ. This extremely long palaeolithic development makes it all but likely that the various beds form a conformable series. The Upper Acheulian gravels in 32 m (OIP 46, p. 52) are probably contemporary to the 25—30 m gravels upstream, so that the Abassiya beds include a section from the Upper Pliocene to the Middle Pleistocene.

#### The 45—100 m Gravels in Lower and Middle Egypt

The highest Nile gravels (defined as quartz, igneous and cherty flint pebbles by SANDFORD 1934, p. 43—4) appearing as surface-features occur in Lower Egypt (cf. OIP 46, p. 42 seq.). They achieve a maximum at 233 m above alluvium west of Abu Roash. South of Helwan there are occurrences at 116 and 198 m. Along the Nile-Fayum divide there are patches of these gravels at 120 and 143 m.

A first general feature however, are the gravels to + 98 m alluvium reappearing continuously from near Abu Ghalib eastward along the Gebel el Mansuriya to el Wasta. Westward of Abu Ghalib it should be possible to establish the connection with the 103 m N.N. Sicilian level immediately southwest of Alexandria (cf. ZEUNER 1950, p. 233). These features of Lower Egypt are obviously eustatic, as only a few kilometers separate the fluvial and marine-lagoonal deposits in corresponding altitudes. Not noted by SANDFORD were similar deposits considerably further south. Well-rounded quartz, flint pebbles and water-borne sand occur from 78 m to at least 90 m above alluvium over a wide area on the limestone plateau between Tuna Resthouse and south of Balansura. As the 78 m gravels they contain redeposited cobble gravels while the finer materials have been subjected to similar rubification (cf. below). One or two downwash-covered, flat-topped hills at a similar level west of the 78 m gravels in the latitude of Maghagha may represent a link be-

tween the 98 m gravels of the Nile-Fayum divide and those of Tuna.

Whether some small patches of quartz pebbles in 95 m alluvium at Ballas and Dandara (OIP 18, p. 48) are associated with the 98 m gravels of Middle and Lower Egypt about 300 km further north seems rather questionable.

South of Abu Roash SANDFORD and ARKELL (OIP 46, p. 42 seq.; 10, p. 22 seq.; 18, p. 48 seq.) have already referred to very extensive gravels fields up to 76 m at Gizeh<sup>2)</sup>, at Idwit and Sedment on the Nile-Fayum divide, behind Deshasheh and between Fashn and Maghagha. These gravel patches are a very prominent morphological feature, often standing out many meters above the gradually descending plain between the Eocene remnants to the west and the edge of the alluvium. Between Bahnasa (Oxyrhynchos) and Fashn they constitute a string of small platforms up to one or two km<sup>2</sup> area running almost parallel to the desert edge (Fig. 1) some 10 km west of the alluvium. Summit levels attain 56—78 m between Bahnasa and Maghagha, 60—80 m between Maghagha and Fashn. South of the dolerite 'Black Hills' a stretch of longitudinal dunes obscures the former river bed until south of Balansura. Here there is not only a 61—76 m platform upon the Middle Eocene between Tuna Resthouse and west of the limestone headland of Balansura. This nummulitic limestone exposure is also thinly covered with Nile gravel suggesting the river may once also have passed behind the headland during an earlier period. Further south there are no traces of the 78 m gravels: the section Dalga — Tuna Resthouse was never part of the river bed as the limestone is deeply dissected and covered by erosional debris, merging into the Tertiary cobble flats further westward and northward. The river obviously occupied its present valley south of this point ever since the return to fluvial conditions. Like the 98 m gravels these 78 m Nile deposits are limited to Lower and Middle Egypt north of Mallawi, and most likely reflect the eustatic sea-levels of the Mediterranean. North of Abu Roash they disappear along the slope of the 98 m gravels, but the marine facies is probably to be found in the 80 or 85 m (Sicilian) shorelines southwest of Alexandria. A last but rather obscure 'Plio-Pleistocene' stage according to SANDFORD is the so-called 46 m terrace. So for example some gravels at 35 m near Nag Hammadi and at 46 west of Dashlut (OIP 18, p. 49 seq.). We can hardly consider the foot

<sup>1)</sup> Kind personal communication of C. B. M. McBURNEY.

<sup>2)</sup> It appears that C. ARAMBOURG (1947) identified the Villafranchian mastodon *ANANCUS OSIRIS* from these deposits, although no elevations are given.

of the 78 m gravel slope in about 50 m between Tuna and Balansura as valid evidence for such a stage. It is true that Nile gravels occur at the foot of the limestone cliffs and a little above 30 m, but it would be wrong to assign a definite value to these gravels as many meters of Eocene detritus and washed-down 78 m gravels occupy the first few hundred meters east of the cliffs. SANDFORD'S Fig. 12 (OIP 18) also indicates '46 m' rock terraces south of Samalut, et el Fashn and along the Nile-Fayum divide, data which remains to be verified. In the Delta the evidence is more convincing (OIP 46, p. 43—4): traces near Abusir and especially south of el Khatatba. This feature apparently goes over into a subaqueous facies at a somewhat lower level near Kafr Dawud. The latter is however in 35 m, and whether all these features are connected still requires a good deal of field confirmation. From our observations we tend to be sceptical of the 46 m stage in Middle and Lower Egypt.

A different problem is presented by the 'Plio-Pleistocene' terraces south of Gebelein. Disregarding the 75 and 100 m rock platforms south of Aswan, well-developed at Abu Simbel, Kasr Ibrim and Korosko<sup>3)</sup> (OIP 17, p. 16 seq.), a 45 m platform covers a wide area on the eroded surface of the Nubian Sandstone west of the Nile between Esna and Daraw. Over wide areas it attains a breadth of 20—25 km and more. This terrace is covered by a thin mantle of apparently sterile gravels attaining 7 m locally. The material is derived from the wadis Shait and Kharit from the Red Sea Hills. However this impressive terrace only extends to Gebelein and it would be advisable to regard it as a phase of aggradation and lateral erosion characteristic of the Upper Nile, and not connected with eustatic cycles in northern Egypt. Possibly the barrier of slipped limestone from the Gebel Rakhmaniya at Gebelein influenced the evolution of the southern Egyptian Nile until the close of the 46 m phase. West and northwest of the two exposed cliffs are a series of further slipped Eocene layers planed off by the river at 40—45 m — obstacles certainly constituting rapids at the time. The matter requires further investigation. Another complication as yet of not assessable value was kindly communicated to the writer by G. KNETSCH.

<sup>3)</sup> The wadi deposits ending as hanging valleys about 80 m over the Nile west of Dakka (G. KNETSCH 1954) indicate fluvial transport in the Western Desert during the Lower Pleistocene.

Borings south of Aswan have shown that the late Tertiary Nile incised its bed to 215 m below its present level and to 125 below sealevel. The bores revealed two fluvial phases of the local wadis, features bound to change our present picture of aggradation in southern Egypt considerably. Further our knowledge of the 'buried channels' of the Nile (e. g. OIP 18, 46; M. PFANNENSTIEL 1953; BUTZER 1958b) will certainly require some modification.

Our present overall picture of the Lower Pleistocene before the aggradation of the 30 m gravels can be summed up. An eustatically-controlled Nile deposited extensive gravel fields to 78 and 98 m north of Mallawi. Higher levels are also indicated in the proximity of the Delta. A not too considerable time lapse separates the two Sicilian levels as the younger 78 m gravels rest on the limestone just a little lower and east of the 98 m gravels. Both gravels lie upon an uneven and strongly eroded surface of Eocene rocks. This characteristic is very striking between Tuna Resthouse and Balansura where hollows of 10 m and more are filled with the Lower Pleistocene gravels. These filled-in valleys are often exposed inside the weakly developed wadis suggesting a former local drainage towards the east, whose main lines of erosion were followed by the younger wadis in Middle Pleistocene and later times. The abandonment of the 78 m bed of the northerly Nile was followed by vertical incision coupled with a further eastward shift of the Nile onto the softer Pliocene filling of the Neogene valley. No definite interruption of the incision into the latter deposits can be verified until the renewed aggradation of Lower Acheulian times. It is noteworthy that the Nile north of Mallawi only found its way back into the deep Lower Pliocene channel after the 78 m stage. Even though no human implements have yet been found in situ in these Lower Pleistocene gravels, the precedent established by the Oriental Institute Publications, by which human habitation in the Nile Valley begins with the 30 m 'primitive Chellian, Chellian and Chelleo-Acheulian' gravels, may be misleading. The Abbevillian of the lower gravel beds at Abassiya suggests that human occupation of the valley had taken place long before the deposition of the 30 m gravels. This is further substantiated by numerous Abbevillian surface finds in the Sahara. A prehistoric investigation of the extensive Lower Pleistocene gravels in western Lower and Middle Egypt may probably confirm older habitation in the valley.

In Upper Egypt — between Asyut and Gebel-ein — one can say little more than that some Nile aggradation took place during this long period, accompanied by local transport of Red Sea Hills material towards the river on a large scale. Erosion and removal of the Pliocene filling seems to have been of greatest regional importance however. Only in the far south did the Nile meander over a wide plain, depositing gravels up to the barrier of Gebelein, which probably long determined the gradient of the Upper Nile just as the cataracts do to-day. Somewhere between the local 45 and 30 m gravel phases the Nile changed its course to the east side of the two cliffs, directly at the foot of the Gebel Rakhmaniya.

#### The 25—30 m Gravels of the Egyptian Nile

For the entire Egyptian Nile Valley SANDFORD and ARKELL have set up a 30 m gravel stage characterized by the first Lower Palaeolithic industries established stratigraphically in situ so far. It is physiographically not feasible however that a river controlled by eustatic fluctuations in its lowermost course should conform to a general, contemporary level at 30 m over a 1500 km stretch to the Sudanese border. The question then is are these gravels everywhere contemporary and genetically identical? We must begin by a survey of the occurrences of the 30 m gravels with some complementary remarks on their significance in Middle Egypt.

As its predecessor during the 98 and 78 m stages, the 30 m Nile followed a very straight course along the edge of the Western Desert in Lower and Middle Egypt. This old river bed is also an important morphological feature between Bah-nasa and the Delta. A smooth surface attaining some 30 m above alluvium runs between el Mansuriya and Abu Ghalib (OIP 46, p. 51) while a 35 m Mediterranean shoreline is well developed in the Sanakra Habbub bar (cf. ZEUNER 1950) further north west. Apart from the questionable Abassiya beds the Nile channel is met again south of the pyramid of Lisht. From here to Deshasheh the excellent 1 : 150,000 geological map of SANDFORD and ARKELL (1929) shows the course of the ancient Nile and the great extension of its deposits which achieve 21—26 m above alluvium and an average breadth of 1—6 km.

A series of small gravel ridges reappears often about 5 km west of the alluvium at levels of 22—32 m between Fashn and Bahnsa. These levels need not be regarded as a measure of the true height of the gravels as they were subjected to erosion and are covered by downwash. South of Bahnsa the traces are few and far between, and although Nile gravels do occur between the great longitu-

dinal and barchan dune fields it is fallacious to speak of a 30 m stage there. Neither can we accept the isolated Nile pebbles at Gezirat Shai-bah (SE of Abu Qurqas) and near Bawit as evidence of a 30 m Nile stage. Between Beni Sharan and Gahdam gravels are once more preserved as a chain of small hillocks up to 2 or 3 km west of the alluvium, achieving some 25 m elevation. These do not rest upon Pliocene marls (*viz.* OIP 18, p. 60) but upon fluvial sands of the same stage subject to subsequent soil developments (cf. below). This series of small hills represents a Nile terrace strongly dissected by lateral wadis of two subsequent stages. In other words the 30 m stage is not distinctly recognizable between Beni Sharan and Bahnsa, a stretch of 140 km.

In Upper Egypt the 25—30 m stage is represented by local deposits in Wadi Matmar, Wadi Qena and Wadi Khuzam, Nile gravels in meander sweeps in Qau Bay, west of Tahta, west of Mahasna and at es Sibaiya Station (OIP 17, p. 27—28). In Nubia (*ibid.* p. 25 seq.) platforms at about 30 m with occasional thin patches of gravel occur repeatedly.

In short the 25—30 m stage is geologically confirmed throughout most of Egypt. However one striking feature deserves note; north of Asyut its traces are preserved singly on the western margins of the valley, following an almost straight course, while south of Asyut Nile gravels alternate continuously on both sides of the valley indicating very wide meanders entered even the deepest bays. To help clarify this problem we propose to reexamine the implements known in the 30 m Nile gravels according to the material presented in the Oriental Institute Publications. Progressing upstream from Lower Egypt to Nubia:

Abassiya upper beds. 1. Hand axe of Acheulian character with straight edges and finely retouched. Smooth surface retained at butt. (HUZAYYIN 1941, Pl. VIII, 1).

Abassiya upper beds. 2. Same. OIP 46, no. 3.

Near mouth of Wadi Hof (Helwan). 3. Same, although not so highly developed. Acheulian. OIP 46, 4.

Kom Tim a (Nile-Fayum). 4. Chellian hand axe with large unworked butt and without retouching. Rolled<sup>4)</sup>. OIP 10, Fig. 8.

Kom Tim a (Nile-Fayum). 5. Symmetrical Acheulian hand-axe with straight sharp edge, well worked. OIP 10, Fig. 9.

Beni Adi. 6. Sharply triangular early Chellian hand axe with heavy butt and fairly straight edges. OIP 18, no. 1.

Beni Adi. 7. Chelleo-Acheulian hand axe with primary flaking that almost removed entire outer surface. Straight carefully retouched edges. Point broken off. OIP 18, 5.

<sup>4)</sup> SANDFORD and ARKELL (1929, p. 29—32) clearly state that the Rus Channel gravels contain "rolled Chellean implements" and "slightly rolled Acheulian implements" which justifies the assumption that the gravels are Acheulian, the older implements being derived.



SW of Sohag. 8. Chellian hand axe showing skillful primary flaking and some retouching of point. Full bilateral symmetry. OIP 18, 4.

SW of Sohag. 9. Picklike implement of Chelleo-Acheulian character flaked on all three sides and butt, with special attention to point. Rolled. OIP 18, 6.

SW of Sohag. 10. Plano-convex Chelleo-Acheulian hand axe with almond-shaped point, barely retouched. Very straight edge. OIP 18, 10.

Qena Hill. 11. Bifaced Chellian hand axe showing skillful primary flaking. Edge fairly straight, butt untouched. OIP 18, 2.

es Sibaia. 12. Early Chellian hand axe with zigzag edge due to primary flaking from alternating sides in three edges. Butt untouched. OIP 17, no. 1.

es Sibaia. 13. Same, but bifaced. Early Chellian. OIP 17, 2.

es Sibaia. 14. Same, with broad, chisel-shaped edge. OIP 17, 3.

es Sibaia. 15. Bifaced Chellian hand axe with zigzag edge but without butt. OIP 17, 4.

es Sibaia. 16. Core with coarse zigzag edge. Waterworn. Chellian. OIP 17, 5.

es Sibaia. 17. Coarse thick Chellian flake with strong median ridge. Unprepared striking platform making strongly obtuse angle with ventral side. OIP 17, 6.

es Sibaia. 18. Bifaced Chellian hand axe with moderately zigzag edge without butt. OIP 17, 8.

es Sibaia. 19. Bifaced Chellian hand axe as no. 18. OIP 17, 7.

es Sibaia. 20. Bifaced Chellian hand axe with almost straight edge. OIP 17, 9.

To this assemblage may be added the Chellian surface implements on 30 m gravels near Ballas (OIP 18, p. 57) and a Chellian hand axe found in situ in 30 m gravels near Tumas, Nubia (OIP 17, p. 26).

As far as this small output of prehistoric finds allows we believe the regional differentiation is rather striking: Delta to Fayum = Lower or Middle Acheul ('Acheul'); Beni Adi to Wadi Halfa = Abbeville to Lower Acheul ('primitive Chelles, Chelles, Chelleo-Acheul'). The 25—30 m gravels are in other words somewhat older in Upper than in Lower Egypt. In Morocco P. BIBERSON (1955) established a sequence of industries from raised shorelines and regressional dunes whereby the transitional Clacto-Abbevillian is dated in the post-Milazzian regression (Mindel), the Middle Acheulian I in the 30 m Tyrrhenian transgression (Mindel/Riss). This is more or less contemporary with the Somme sequence where the Abbevillian was already characteristic for the Günz/Mindel. In view of these facts we suggest that a phase of climatic aggradation to 30 m in Upper Egypt (Mindel Pluvial?) preceded a phase of eustatic aggradation to a very similar altitude in Lower Egypt (Tyrrhenian = Mindel/Riss). The former is represented by Nile gravels with some Abbevillian to Lower Acheulian implements occurring repeatedly from Beni Adi to Nubia. The latter is

represented by the Rus Channel evident north of Bahnasa to the Delta, and containing no older industries than later Lower Acheulian of an undetermined nature. The meandering Nile of Upper Egypt was the result of overloading due to great masses of wadi gravels issuing into the Nile. Subsequently vertical incision began to remove these gravels which were redeposited in an eustatically rising Nile bed in northern Egypt. Probably the gradual diminution of Nile volume following this Lower Pleistocene pluvial did not permit the lower Nile to meander to any large measure.

In support of this we can state that the constituents of the Nile gravels in Upper and Lower Egypt are identical but the relative composition is different. In sections examined between Gahdam and Beni Adi the 25 (30) m Nile pluvial gravels are composed of flint pebbles averaging 5–10 cm in major axis and containing small flint boulders of 15 cm and more. The gravel beds are compact and only the intervening hollows are occupied by sand. Gravel beds alternate distinctly with or more often lie upon earlier sands (Ill. 3). On the hand sections examined on the Nile Fayum divide and on the Gebel Abusir 'island' showed that the 26 (30) m Nile interglacial gravels were smaller on the average (4–8 cm) and that specimens over 10 cm occurred only seldom. The beds are predominantly sandy with interspersed pebbles and pure gravel beds are very seldom. The closest approximation to a gravel bed still contains great quantities of finer material (Ill. 4). This feature of the north Egypt facies can only be accounted for by redeposition of older gravels from further upstream with a lack of local wadi activity and inflow of fresh material in northern Egypt. True pluvial gravels in Lower Egypt can be expected to be buried well below present alluvium. Stratigraphical and pedological examination of the gravels seem to confirm the above distinction in that calcareous horizons of great depth occur only in the terrace profiles south of Beni Adi; there are no lime horizons in the gravel-sand beds of northern Egypt (cf. below). This applies to the younger gravels as well. In the Upper Egypt terraces brown soils with lime concentration were followed by rubification; in northern Egypt the red weathering succeeded upon aggradation without an intervening brown earth development. Climatic phases with pedological importance are not local so that one may assume the gravels were neither



contemporary nor in phase with each other. A third method of approach has been the detailed mapping of the deposits themselves. Thanks to SANDFORD's long years of work there are now practically no larger deposits that have escaped notice, but a detailed 1 : 25,000 mapping of the whole valley remains indispensable. Nile gravels are missing at any certain altitude between Beni Adi and Bahnasa. North of this gap the gravels rise from 21—26 m in the Fayum area to 30—32 m in the Delta while southward they rise from 25 m at Beni Adi to good 30 m in Nubia. The sag towards the middle seems to indicate that two genetically different terraces cross somewhere in southern Middle Egypt.

#### The 10—15 m Nile Gravels.

The problem of the 15 m terrace is very similar to that of the 30 m gravels, only that the very fragmentary gravels and Fayum lake deposits of this stage in northern Egypt contain no industries in situ. Local gravels are developed in a good number of wadis between Cairo and Sheikh Hassan while Nile terraces occur on both sides of the Delta west of el Khataba at 13 m, and at el Abbasa in Wadi Tumilat (OIP 46, p. 53) in 11 m. A last line of more indefinite parallel gravel ridges accompanies those of the older Nile beds some 3 km west of the alluvium in northern Middle Egypt. Altimetric values are of little use as the downwash of Tertiary gravels obscures them. Nile gravels of recognizable 10—15 m altitude are lacking between Beni Mazar and Qau. It may not be wrong to assign an eustatic character to the old river level at 10—13 m north of about Beni Mazar or Minya. ZEUNER (1950, p. 233) notes shorelines at 15—20 and 5—10 m near Alexandria. In the area formerly traversed by the writer south of el Alamein-Sidi Abdel Rahman the 15—20 m stage is not distinct but a definite 10 m fossil lagoon floor with abundant marine shells occurs.

As far as present knowledge goes locally re-deposited gravels near Beni Adi first contain implements in situ, Nile gravels first at Sohag. Further southward this Acheulian industry is slightly more abundant. From the illustrated material an evolved or later Middle Acheulian, but definitely pre-Micoquian designation seems most suitable. The good numbers of Lower Acheulian hand axes found were all waterworn and rolled "in varying degree" (OIP 17, p. 30 seq.; 75 seq., 18, p. 112 seq.). From BIBERSON's study in Morocco (1955) the Middle Acheul II—III, evolved Acheul and Lower Levallois belong in the post-Tyrrhenian regression, the Micoque in the Monastirian transgression, while the Upper Acheulian (stages

IV—V) and Micoque (Acheul VI—VII) occupy similar positions respectively in the Somme Valley sequence. In view of this palaeolithic chronology an association of the Upper Egyptian 15 m stage with the (earlier) Riss, the Lower Egyptian 10—13 m deposits to the subsequent Riss/Würm or Monastirian seems possible.

The different character of the deposits in Upper and Lower Egypt again confirms this distinction. Characteristic is once more that the Nile gravels of northern Egypt are not developed as pure facies of gravel and of sandy beds. Gravels are interspersed throughout most of the sands whereas gravel beds merely mean a relative concentration. At exposures near Bahnasa (cf. below) a coarse quartz sand without any admixture of local debris means the load was entirely derived from the Nubian Sandstone of Upper Egypt, excluding notable local water activity. The same applies to what appears to be material of similar age on top of the Rus Channel gravels near Gerzeh (cf. Fig. 7). Where encountered pebbles are again of very resistant rock and small, never exceeding 8 cm. In the Fayum the lake deposits distinctly indicate a lack of running water on the surrounding land (see BUTZER 1958b, p. 69). In contrast the 15 m gravels at the mouth of Wadi Qena (quarries at Nag el Gazriya) or the 12 m gravels south of Deir Tasa are composed of flint boulders averaging 15 cm at the first cut, 8 cm at the second — the difference reflecting the strength of the two wadis. Once again the calcareous horizons present in various 12—15 m gravels of Upper Egypt do not exist in the 10—13 m gravels of northern Middle Egypt. Whether the local '15 m' gravels of the east bank there are contemporary with the 10—13 m Nile is not at all certain according to SANDFORD (1934, p. 54—5). That area was not visited by the writer. A distinction of 12—15 m pluvial gravels (rising from north to south) in Upper Egypt in early Riss(?) times and 10—13 m eustatic gravels (rising from south to north) in northern Egypt during the Riss/Würm interglacial at least seems probable on both geological and archaeological grounds.

#### The 9 m, 3—4 m and 1—2 m Gravels of Upper Egypt

The problem of the 9 m terrace is essentially that of the 15 m gravels. Recognizable only as such in Upper Egypt Nile gravels at this level are not known north of Sohag, certain wadi gravels not north of the Wadi Asyuti. The so-called local gravels of the west bank between Beni Adi

and Tuna el Gebel are rather doubtful in our opinion. The physiography is more that of vertical incision in older Nile deposits followed by lateral downwash which smoothed the slopes so that floor, slope and former, now terrace surface are of identical composition. Aggradation is at best an insignificant local redeposition. The systematic treatment and revision of the contained industries (in Upper Egypt) by Miss G. CATON-THOMPSON (1946) classifies the material *in situ* as Acheulio-Levallois, and together with the realization that a considerable time interval must separate the 9 m from the certain Upper Pleistocene 4 m deposits, a later Riss pluvial age (Riss II??) is rather arbitrarily suggested<sup>5</sup>).

The 3—4 m gravels are more or less confined to a similar area, and with exception of a bank of sterile Nile gravels in 4 m north of Qau at Hemamiah, are entirely composed of wadi deposits. Together with the 1—2 m local gravels they may be considered of Würm pluvial age. The wadi terraces of Upper Egypt are discussed in detail below.

#### Upper Pleistocene Aggradation in Northern Egypt

The so-called 8 m aggradation gravels of the lower Nile are better termed silts. Already west of Wasta they are such and barely contain gravels as seem to occur just south of the Fayum entrance. SANDFORD (1934, p. 79—80) mentions the southernmost deposits of these "fine gravels" (OIP 46, p. 56) north of Sedment in 8 m. The Middle Palaeolithic Fayum level of +28 m belongs to this period. Further north the silts still attain 8 m near Cairo, west of Khatatba they have fallen to 5 m (OIP 46, p. 55) while on the east bank they achieve 6 m at el Abbasa, 8 km further north at el Kurain only 4 m (OIP 46, p. 56—7). Obviously they drop surprisingly fast in the Delta. The industries contained have been described as Upper Levallois by Miss CATON-THOMPSON (1946) and are very similar to those of the base of the Lower Sebilian silts in Upper Egypt (OIP 18, p. 124 ff.). This is probably the clue to the problem.

These silt phases, to-day continuing in the form of mud deposition, begin only with the Upper Levalloisian. They are alien to Egypt prior to this date. They must be assigned to the establishment of the modern hydrography of the Nile, most probably the full connection of the Blue Nile and Atbara with

the older Nile system. Augite, the characteristic heavy mineral of these two rivers is first found in Nile sediments of the 30 m terrace in Lower Egypt but modern proportions first occur in the Upper Levalloisian. SHUKRI and AZER (1952) have given mineral analyses for the Fayum and elsewhere. Relative frequencies of the pyroxenes for different deposits are as follows: Pliocene 0.5%, Lower Pleistocene 0.4%, 30 m eustatic gravels and +42 m Fayum lake deposits (Monastirian) 5.7%, +34 m Fayum terrace 15.1%, +28 m Fayum terrace 14.9%, +22 m Fayum terrace 9.1%, modern Nile sediments 12.3%. Obviously the 34 m terrace corresponds to a great 'surge' of Ethiopian silts and water. Silt aggradation is different from gravel accumulation — as the Nile mud today, silts will have been deposited by summer floods, although of considerably greater magnitude and reaching higher levels. In the Delta region this flood-level dropped rapidly from 8 to 4 m above alluvium over 50 km as the waters spread out. This rapid drop speaks for an earlier suggestion (BUTZER 1958 b, p. 65) that eustatic sea-level fluctuations played no measurable positive part; indeed the gradient was steeper than now, possibly indicative of a falling sea-level.

During Epi-Levalloisian times the Nile floods in all Egypt reached progressively lower levels in the falling Fayum lake levels downstream, in falling Nile levels upstream (OIP 17, p. 48—52). The heavy mineral statistics imply a decrease in Ethiopian influx as the answer — reaching a minimum in late Epi-Levallois times. The suballuvial gravels of Middle Egypt (OIP 18, p. 87—91) still require much clarification, but are not necessarily of any great importance in the present discussion.

#### B. The Pleistocene Tributaries of the Nile

Over wide areas, particularly in Upper Egypt, the local deposits of wadis emptying into the Nile Valley are better developed or preserved than corresponding Nile gravels. Their morphology and stratigraphy provide considerable auxiliary information on the Pleistocene evolution of the Nile Valley. In general a striking contrast can be noted in the topography and relief of the Upper Cretaceous and Lower Tertiary limestone plateau on both sides of the valley. With exception of the limestone massif deflecting the Nile in the great bend of Qena, the wadis of the Western Desert are shallow channels reaching only a few kilometers back onto the relatively level plateau. The Thebaid and the Eastern Desert on the other hand are deeply dissected by tributaries cutting

<sup>5</sup> In East Africa the Acheulio-Levallois industry belongs in the last part of the penultimate, Kanjeran pluvial (SONIA COLE 1954, p. 156—58).

deep gorges or eroding large estuaries in the limestone beds. That this contrast reflects local distribution of the episodic rainfall can be shown by present day vegetation and other traces of waterflow in the wadi channels. Between Nag Hammadi and the Fayum no trace of vegetation was observed in any of the countless wadis traversed. On the Nile-Fayum divide a few wadis harbour some thorn bushes and succulents in their sole, north of which the wadis are generally bare until the northerly slopes of the Gebel el Qatrani and Abu Roash are reached. Here a semi-desert vegetation gradually passes over into the dry steppe of the Mediterranean littoral. The shallow wadi channels from the Fayum to Nag Hammadi show no traces of subrecent water action such as erosional rills, waterlaid sand or other torrential deposits. In contrast every wadi large or small issuing from the Eastern Desert has a few acacia bushes and perhaps *leptadenia*, *artemisia*, *calligonum* and *capparis spinosa* as well as recognizable water channels often filled with masses of poorly assorted and little stratified material deposited by wadi floods in more recent times. The same applies to the wadis of the Thebaid although vegetation is much more scarce. The reason for the markedly differentiated distribution of the occasional rains is given in the local topography: wherever the surface is elevated or exposed to the westerly or northerly winds a dissected relief is noticeable, particularly so on the flanks of the Red Sea Hills (to 2184 m); where the plateau is level or falling towards the south or east surface relief is at a minimum. An exception to the latter is the abrupt scarp of the narrow Theban mountains. Interesting is that the Luxor-Qena area also witnessed the greatest fluvial erosion of the eastern Sahara in Lower Pliocene times. Local topography was also most probably responsible and one must suspect a second source of moisture from northward surges of the monsoon low up the Red Sea graben, a feature still responsible for occasional catastrophic storms in the Red Sea Hills and Suez-Cairo area.

Before commencing a more detailed study of the local deposits it should be mentioned that wadi gravels are almost limited to the low desert between the alluvium and the point of emergence from the limestone scarp. Exceptions to this are only the wadis Qena and Matuli. In the limestone plateau of the Eastern Desert north of Qena the wadis have cut deep, narrow canyons from which all fill has been subsequently removed by erosion. In the Western Desert waterflow never sufficed for full-scale aggradation in Quaternary times, deposits being limited to favourable localities at confluences or in front of the plateau scarp. Exceptions are again the wadis of the Thebaid.

### The Western Margins of the Nile Valley in Upper Egypt

Between Dandara and Thebes the scarp of the Lower Eocene limestone and the later Pliocene deposits are deeply dissected by short steep wadis (with gradients from 1—2‰). Their valleys are narrow and the strong torrential character of the last pluvial waterflow has removed practically all traces of Lower Pleistocene stream deposits, preventing the preservation of any Nile deposits on the low desert. Accordingly younger deposits are all the better represented and deserving of closer attention. Two particularly instructive wadi profiles will be described here.

A 5 km long wadi, known by the name of Ibeidalla embouches on the plain halfway between el Zawayda and Tukh. Fig. 3 gives a profile of

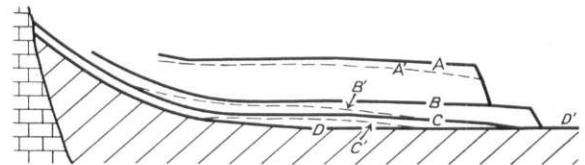


Fig. 3: Wadi Ibeidalla Profile (Thebaid, NW of Tukh).

A = Acheulio-Levallois terrace in 10 m; B = Late Lower Levallois terrace in 4 m; C = Epi-Levallois II terrace in 1.5—2 m; A', B', C' = Pliocene base of same gravels; D = modern wadi bed; D' = Alluvium. Terraces 30 x exaggerated in vertical scale.

the southern branch. The uppermost 1—2 km display terraces at 1.5 and 4 m consisting of angular, coarse local limestone rubble, occasionally with blocks up to 50 cm in diameter. The subsequent 2 km stretch downstream has terraces at 4 and 10 m (Ill. 2), a little later also again in 1.5 m. Here flint gravels lie disconformably on yellow Pliocene marls, to a depth of 1—2 m in the 4 and 10 m terraces, to 30—100 cm in the 1.5 m gravels. In the lowermost stretches of the wadi the same terrace sequence continues while the gravels thicken and the Pliocene base is no longer visible under the 4 m gravels. This wadi displays the transition from angular gravels to "well-rolled" material passing downstream, a feature so often noted from arid lands. In fact the observation is of little importance as the angular gravels consist of limestone rubble and debris while only a remnant of flint concretions can withstand the chemical and mechanical wear and tear of transport downstream. The latter gravels are however already "wellrounded" in their source of origin, the Libyan limestone. Subsequent mechanical weathering has so broken and split up the eroded surface of the 10 m gravels that the fluvial nature of the deposits can only be recognized 20—30 cm below the surface. Interesting is the different



gradient of the surface and base of the 4 m gravels. Upstream these are over 4 m thick, midstream 1–2 m, downstream over 3 m. The material was apparently collected from greater erosion upstream and was carried across the middle section to be deposited in great fans downstream. The 10 m terrace, as far as it is preserved, shows a similar tendency. The gradient of the younger 1.5 m gravels is better displayed in another wadi. Interesting is that the modern wadi bed narrows very strongly as it approaches the edge of the alluvium, indicating how few spates ever reach the mouth.

The area is relatively rich in palaeolithic implements. Late Lower Levallois flakes and cores occur frequently in situ in the 4 m gravels downstream, and Epi-Levallois flakes were found on the surface of the 1.5 m gravels, together with Neolithic blades.

The Wadiyein near Qurna likewise bifurcates upstream into a north and a south valley, the latter being described and shown in profile earlier (BUTZER 1958 b, Profile 2) when the question of 1.5–2 m gravels was first discussed. The relation of these younger deposits to wadi gradients to-day and during the 4 m stage is highly

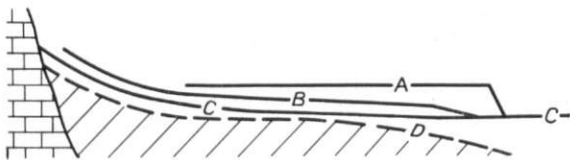


Fig. 4: Profile of Wadiyein (North Valley), Thebaid.

A = Late Lower Levallois terrace in 4 m; B = Epi-Levallois II terrace in 1.5–2 m; C = modern wadi bed; C' = Alluvium; D = Pliocene surface under wadi fill. Terraces 125 x exaggerated in vertical.

instructive in the north valley (Fig. 4). Older terraces have been removed from above the confluence at Elwa el Dibban by repeated erosion and redeposition in the narrow but 7 km long gorge. In the upper 2 km a 1.5 m terrace of angular rubble occurs, followed by terraces in 1.5 and 2.5 m in the next 1.5 km downstream, where flint gravels already predominate. Midstream these gravels lie in 2 and 3 m respectively, while further downstream the upper terrace approaches 4 m, the lower continuing in 2 m and then gradually approaching wadi sole. It disappears beneath the floor some 500 m from the mouth. The behaviour of these gravels can be summed up as 1.5 m elevation upstream, 2 m midstream, gradually falling below wadi sole downstream. The 1.5–2 m stage signifies a short phase of aggradation with 20–50 cm of

newly deposited gravels while the Nile was flowing at a level below that of to-day. This gradual drop is 2 m in 3 km. The redeposited material thins out, not thickens, downstream. Either the base level was falling or the responsible torrents were not able to transport their materials to the mouth of the 4 m gravels estuary. In either case it is significant that the 1.5–2 m gravels, frequently represented in the smaller wadis of Upper Egypt, were not deposited in response to an aggrading Nile but on account of local climatic factors, a greater and more abundant waterflow than to-day. A number of implements were found in situ near the north valley confluence.

These artefacts contain a blade-like piece with moderately good, steep trimming and a short faceted platform of 'Sebilian' character (Ill. 1 b); a similar blade-like piece with faceted platform but considerably less characteristic (Ill. 1 c); a scraper probably made from a core, with flaking only in one direction and a small striking platform. Minute retouching from both sides on two edges (1 a). Lastly a flaking product reworked to a scraper. One corner is broken off due to the rough retouching or through use (1 d). The array seems to show all the characteristic 'Sebilian' innovations, evolving from the true Levalloisian, as described by G. CATON-THOMPSON (1946). Striking parallels in workmanship and forms can be found among the Sébil Niveau 2 (Epi-Levallois II) implements illustrated by E. VIGNARD (1923) from the type locality at Kom Ombo. So for example our 1a compares well with VIGNARD'S Pl. 14, no. 13; or 1b with Pl. 9, no. 8. It seems reasonable to designate these artefacts from Wadiyein as fairly typical Epi-Levallois II material.

A little above the confluence 10 m gravels are developed north of the wadi. The older gravels are however described by SANDFORD (1934) and previous authors.

#### The Eastern Margins of the Nile Valley in Upper Egypt

Between Luxor and Qena the low desert forms a flat undulating surface composed of Pleistocene gravels of local origin thinly covering beds of Upper Pliocene age. Miocene and Lower Pliocene erosion removed the greater part of the Eocene, Upper Cretaceous and Nubian Sandstone to 5–20 km east of the cultivated land, an area now occupied by the post-Pontic filling. In the southern part of this great bay the Pleistocene terraces are weakly developed on Pliocene marls, limy sands and sandstones. Only the great fans of the wadis represent a sizeable extent of Quaternary deposits. From Amba Bakum monastery to well south of Luxor Aerodrome the small wadis have deposited no materials of note, and consist of shallow valleys in Pliocene deposits with a veneer of angular limestone or flint gravels and wind-blown sand.



The over 60 km long Wadi el Madamud forms one of the three great wadis of the Luxor-Qena segment, but its somewhat poorly developed or preserved terraces have almost escaped mention even in the OIP. In the lower part of the wadi terraces are well developed in 10 and 15 m on the south bank while the inflow of numerous smaller wadis has led to the removal of most older gravels downstream of the Cretaceous relict on the north bank (Fig. 6). Again the gravels thicken towards the mouth where the 10 m terrace achieves over 5 m of flint gravel disconformable on dark sands, calcareous sandstone and marls of the Pliocene. There is no sign of a 4 m terrace, a feature probably lost in the 2—3 km broad wadi bed of coarse flint boulders still showing considerable water activity in more recent times. Three to six channels cut this great fan, braiding in various patterns. Below each channel confluence new fans have been deposited inside the wadi, recognizable by the lighter, unweathered gravels exposed. Water torrents apparently diverge into several shallow channels and then converge on deeper ones, then suddenly going over from incision to deposition of their load in wide fans. The process is then repeated again a little further downstream. Possibly these base gravels represent the 4 m gravels of the west bank. Apparently this strong wadi did not go over to vertical incision upstream while the Nile cut its bed to below alluvium in Upper Palaeolithic times, possibly on account of the coarse character of the deposits or the lack of a well-defined channel. It is however also possible that the 4 m gravels have been removed. The matter can only be decided by artefacts in situ in both the base and 10 m gravels. In more recent times channels of 1—2 m have been cut into the base gravels (Fig. 5).

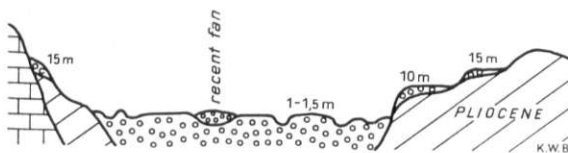


Fig. 5: Cross section of Wadi Madamud (8 km upstream). Vertical scale = 50 x horizontal scale.

The map Fig. 6 shows how the gravel spreads of the wadi bed about up to 2 km into the alluvium at a maximum elevation of 4—5 m. This feature was explained in a parallel occurrence further north in Wadi Banat Beirri at Khuzam. This wadi is similar to Madamud but much smaller. Terraces are developed in 8 and about 20 m with a 15 m Nile terrace remnant behind the southern part of the

village. 8 m remnants are preserved in the wadi mouth which likewise extends 1 km into the fields. This fan is cut by the Saiyalet Makram

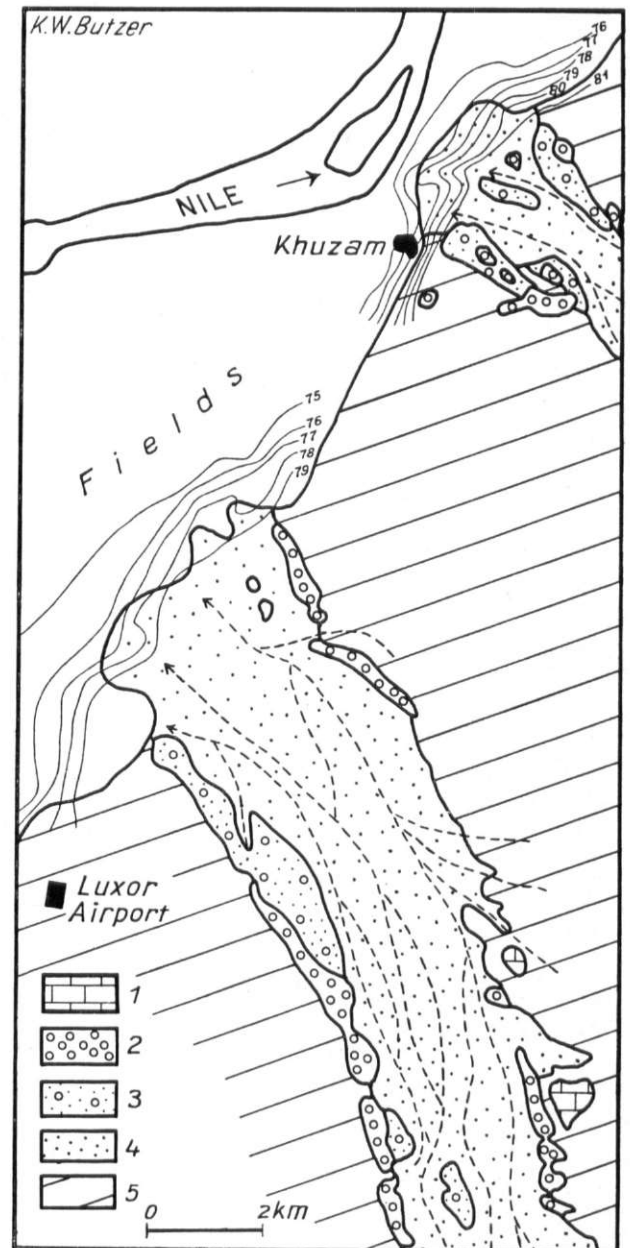


Fig. 6: Geological Map of Wadis Madamud (Luxor) and Banat Beirri (Khuzam), showing meter contours at mouths of wadis.

1 = sporadic outcrops of Upper Cretaceous; 2 = 15 m gravels (with 20 m local gravels of wadi Banat Beirri); 3 = 10 m gravels; 4 = base gravels; 5 = Pliocene and superficial deposits.

canal exposing 2 m of crossbedded gravels upon at least 2 m of sandy silt, identical in composition to the Sebilian silts further south. The upper level of the buried mud is in 77 m, 1 m above the present Nile plain. Upper Pleistocene gravel deposition was apparently interrupted by the silt phase and resumed thereafter. Subsequently a certain erosion indented the mouths of the main wadi channels of Madamud and Banat Beirri. From better developed features of even stronger wadis further north these indented mouths seem to be contemporary to the later Epi-Levallois degradation of the Nile. Palaeolithic artefacts were not found in situ in either of these wadis, although Levallois flakes occur in number on the surface of the 10 m Madamud terrace.

Both Wadi Matuli and particularly Wadi Qena have been described in detail by SANDFORD (1929, 1934) and already M. BLANCKENHORN (1921) gave a crossprofile of the latter. From the limited observations possible around Qena one should note that the lower wadi bed is excavated so deeply that the alluvium juts 3.5 km up the wadi mouth. The 4 m gravels which are apparently developed (together with terraces in 9, 15 and 30 m) at least as far as el Haita 50 km upstream are missing in the estuary, suggesting considerable vertical and lateral erosion in Upper Palaeolithic times. The surface of the older terraces does not however follow the steep gradient of the wadi floor. The mouth of Wadi Matuli (Qarn) occupies an intermediate position between Wadis Madamud and Qena.

The reason for protruding gravel fans near Luxor going over into drowned wadi mouths near Qena is probably manifold: waterflow was greater and persisted until a later period in the north, Nile degradation was likewise more pronounced and a little earlier at Qena than at Luxor, and lastly the gradient of Wadi Madamud is 0.6‰ compared to that of 0.2‰ in Wadi Qena. The absence of a 1.5 m terrace on the east bank here seems certain, not surprising in view of the independent climatic character of this feature. With greater erosive force and waterflow the eastern tributaries must have behaved other than the small Theban wadis. In smaller wadis further north a post-4 m aggradational phase occurs once more, so for example immediately south of Deir Tasa (Markaz Badari) where some 30 cm of gravel were deposited on sands to 1 m above present wadi sole. No implements were found. The assumption of SANDFORD that the 4 m stage was followed by gradual vertical incision until the close of the Old Stone Age

should be modified. Following a relatively brief erosional phase in Upper Levallois or Epi-Levallois I times, deposition was briefly renewed during the Epi-Levallois II as witnessed by the 1.5 m gravels of the smaller wadis and the protruding gravel fans of the Wadis Madamud and Banat Beirri — overlying Sebilian (?) silts. Only after this did fullscale vertical erosion set in. The cutting of the lower wadis to below normal gradients is hardly noticeable anywhere except in Wadi Qena, and here only in the lower 5 km. Further upstream the gradients of terrace surface and wadi sole are parallel it seems. Either the Epi-Levallois III phase of vertical incision was very much shorter in this latitude than SANDFORD supposes, or the rainfall had failed entirely. Nile degradation may really have been less appreciable so far south.

#### Wadi and local Deposits in Middle Egypt

The wadi gravels of the valleys embouching from the eastern limestone plateau north of Nag Hammadi are limited to between the alluvium margins and the edge of the scarp. Only where the wadis emerge from the narrow, steep-sided gorges have gravel deposits been preserved from full subsequent erosion. North of Wadi Qena few wadis are suited for investigations upstream, and all references are necessarily to the mouths of the watercourses.

Local deposits are well developed on the east bank between Badari and Deir el Gabrawi. In Badari bay local deposits of small angular rubble and sand rest upon a limestone basement, partly buried in scree. These sands accompany the short wadis in 10 m at the edge of the scarp, falling rapidly to 5 m at the edge of the alluvium about 500 m away where the terrace is cut off. In the bay south of Deir Tasa a sequence of local terraces in 1, 4, 6—7 and 12 m is preserved. The terraces of Wadis Matmar (Emu) and Asyuti have already been referred to by SANDFORD (1929, 1934). Noteworthy is that the well-developed but seemingly sterile terrace of the latter wadi in 10 m also shows a gradient to well below alluvium at its lower end, a characteristic for the whole area. The wadi sole with a slope of 0.4‰ is drowned in alluvium to 2.5 km, achieving some 5 m depth at the edge of the cultivated land where the 10 m terrace tapers out and disappears under the fields. Both wadi sole and 10 m terrace follow more or less the same gradient, suggesting a Nile level 5—7 m lower than to-day at the time of last important vertical incision, and a degrading Nile at the time of last wadi aggradation.

A 3—4 m terrace is not distinctly recognizable. Many characteristics of these 10 m gravels suggest contemporaneity with the 12—15 m gravels of upper Egypt, something that would make a longer period of work in Wadi Asyuti more than worth the while.

North of Arab Miteir large wadi fans with hillocks of 4 m gravels go over into the alluvium until the area of Deir el Gabrawi is reached. In Wadi el Gabrawi an 8 m terrace of flint boulders is preserved on the northwest bank, while a 4 m terrace of compact, gritty sand and fine angular rubble is developed on Pliocene sands, clays and sandstone. Further north on the east bank SANDFORD refers to some local gravels near Amarna (1934, p. 64), while 3 and 8 m deposits occur along Wadi el Barshawi and Wadi Ibada at Antinopolis. The latter deposits are so massive that SANDFORD (1934, p. 75—6) already expressed doubts about the true age which he suspected to be older than that of the true 9 m gravels. Wadi terraces are very poorly developed north of this point as either the scarp borders immediately at the alluvium or the eroded clay beds of the Mokattam stage have preserved no traces. Exception to this is a patch of 18 m gravels on a limestone hill at the mouth of Wadi Bustan opposite Matai. SANDFORD (1934, p. 54—5) has misgivings about the validity of altimetric values in northern Middle Egypt as a shifting Nile seems to have changed wadi gradients abruptly.

Local terraces are not properly developed on the west bank as already mentioned. Between Dalga and Tuna 3 m gravels are developed where the Raqabet Umm el Bab opens in the Eocene scarp. South of Bawit sand rivers issue from the breaches in the Libyan stage limestone and all gravels are obscured by a veneer of sand. Of limited interest is the wadi ending a little NW of Tuna el Gebel, where gravels are developed to 4 m above bedrock at the confluence of two branches. Further up no accumulation could be recognized while sand dunes drown parts of the lower valley. SANDFORD (1934, p. 78—9) apparently collected some Levallois from these gravels. However we could find no unequivocal 8 m gravels in the lower wadi.

There is reason to believe that the east bank gravels of Wadis Ibada, Gabrawi, Asyuti and Tasa represent the 15 m stage north of Sohag (where Nile pluvial gravels of this stage are last met), deposited in 8—12 m (N.-S.) to the base level of a Nile eustatically degrading north of the great Asyut bend. In this sense levels north of Asyut lose their value through the interplay of several elements in Middle and Lo-

wer Egypt. Without incorporated implements or other dating means it is better to defer an opinion on them.

A number of local features in Middle Egypt are of further interest to the question of Pleistocene morphological processes. The 1000 km<sup>2</sup> area of eroded clay and gypsum-bearing beds east of Matai — Fashn have been levelled off to about Nile alluvium, reduced to a thin sheet of fine, angular detritus strongly charged with gypsum and other salts. The lack of a 4 m terrace in Wadi Bustan, a comparatively large wadi, points to the persistence of fluvial denudation at least to the close of the Pleistocene. Only crossbedded coarse sands over 8 m deep and over 2 km<sup>2</sup> lying below alluvium in the wadi mouth convincingly document the Pleistocene waterflow of this dreary shallow wadi. A section of softer rocks southeast of Minya shows an identical morphology.

A depositional counterpart to the denuded Mokattam beds is met in the local detritus beds possibly deposited by sheetfloods along the Nile margins from Beni Hassan to el Matahra el Sharqiya. These consist of well-stratified clayey sands and local material, particularly *Nummulites gizehensis* foraminifers. They gradually rise from the latitudinal margins to attain 8—10 m above alluvium. The surface is remarkably plane and partly occupied by Roman and Arab remains, although all traces of older occupation are curiously missing from this favourable location. Small wadis issuing from the limestone scarp have cut deep channels to the level of the alluvium, channels deepened or enlarged since the construction of the old Arab village Beni Hassan. Similarly the Nile front has been undermined somewhat since this time. The curious morphology of these beds is difficult to account for, but we find it difficult to agree with SANDFORD (1934, p. 29) that they are of Pliocene age. Firstly they are too little resistant to have maintained themselves in this exposed position in front of the cliffs throughout Quaternary times. Gullying has only recently taken hold of the Nileward edge, and the wadis that have cut through the deposits have never gone over to accumulation. Even a large wadi like the Hishaggig has only shot a fan of wadi wash out into the Nile at its mouth. The erosion in historical times emphasizes the difficulty for these beds to have withstood the vicissitudes of a million years<sup>6)</sup>. For that matter SANDFORD'S

<sup>6)</sup> That considerable deposition of local material still could take place in fairly recent times was observed from well stratified clayey sand and fine local detritus, resembling the 4 m deposits of Wadi el Gabrawi or the questionable Beni Hassan beds, found at Tahna (Acoris) and Zawyet el Amwat (Hebenu) and which can be archaeologically dated as post-Roman.

red marl at el Barsha (OIP 18, p. 28) is not Pliocene but rubification of the surface of an 8 m wadi deposit. Only the tough conglomerates encountered under beds of fine local detritus at Antinopolis convince the observer of their antiquity. Amarna bay was not visited by the writer but SANDFORD (1934, p. 28, 78) speaks of both many meters of red marl under 3 m conglomerate (Pliocene) and of banks of "general surface debris".

Aeolian deposits are of considerable areal extent in western Middle Egypt but it was possible to show that their present expansion and position is of historical age. The geological map (Fig. 1) gives an accurate picture of their occurrence and classification, but a discussion, along with that of other deposits of historical times is deferred to a subsequent paper on the Recent geology of the Nile Valley (BUTZER 1959).

The Nile and local deposits of Middle Egypt between el Fashn and el Qusiya are depicted in Fig. 1 based upon the topographic series 1:100,000 (1931—33). The Tertiary gravels are actually more extensive than shown as they overlie the neighbouring limestone and mix with the Lower Pleistocene gravels to a large extent. The latter are probably a bit exaggerated as far as the 98 m gravels go. The Pliocene travertines of the Western Desert are given after Sandford (1934). Also the area northwest of Maghagha which was not covered has been extrapolated from the detailed description of SANDFORD (1934) and the topographic detail of the 1:100,000 series sheet. The former courses of the Bahr Jusef are reconstructed on the basis of abandoned canals, fluvial sands of recent date and other morphological characteristics. Many of these are substantiated by the 1:100,000 topographic maps of the French Expedition 1799—1800. Details must again be deferred to a further article (BUTZER 1959).

### C. Fossil Soil Profiles of the Pleistocene Terraces in Egypt

In this third section it shall be attempted to complement the history of Pleistocene sedimentation and weathering in the Nile Valley. Fossil soil profiles can be frequently observed in sections of river or wadi deposits in most parts of Egypt, and it is all the more remarkable that no systematic observations have ever been made in this regard. The soil samples collected by S. PASSARGE in 1914 and analyzed by E. BLANCK (1925) contribute valuably to our knowledge of weathering and soil formation in arid zones but come from sites without specific relation to Quaternary deposits. M. BLANCKENHORN (1901, p. 479—84) describes modern calcareous crusts, occurring

partly on Pleistocene deposits; and in a later contribution (1921, p. 178) he refers to a red calcareous cement in the gravel beds of his main pluvial terrace at Thebes. BLANCKENHORN obviously recognized the individuality of these phenomena without fully realizing their significance or paying any great attention to them. It remained for SANDFORD and ARKELL to bring the relative stratigraphy of the Pleistocene deposits of the Nile Valley on a respectable basis, replacing the fragmentary and sometimes erroneous remarks of previous writers. But surprisingly SANDFORD and ARKELL ignore mention to fossil weathering, perhaps confusing such features with Pliocene deposits. It is hoped that the following profiles, representing almost the whole sequence of Pleistocene gravels in its different regional forms, will inaugurate a systematic study of fossil soils datable on a geological basis<sup>7)</sup>.

Some 2.5 km NW of Tuna el Gebel (Markaz Mallawi) good sections of the 78 m gravels of Middle Egypt are exposed about 500 m south of a larger wadi opening in the limestone scarp:

0—40 cm Light yellow-brown scree.

160 cm Flint and hornstein gravels (up to 15 cm major axis) with quartz sand bound by a calcareous and gypseous cement. The finer material is weathered brick red due to a veneer of iron compounds on the carbonate and gypsum aggregate, not however effecting the quartz grains. Where finer materials dominate, flecks of white calcareous gypsum precipitate in columnar shape to 2—3 cm long occur within the clayey sands, giving a mottled appearance.

5+ m Limestone of the Lower Mokattam series marked with numerous 3—4 m long vertical clefts suggesting an embryonal karstification.

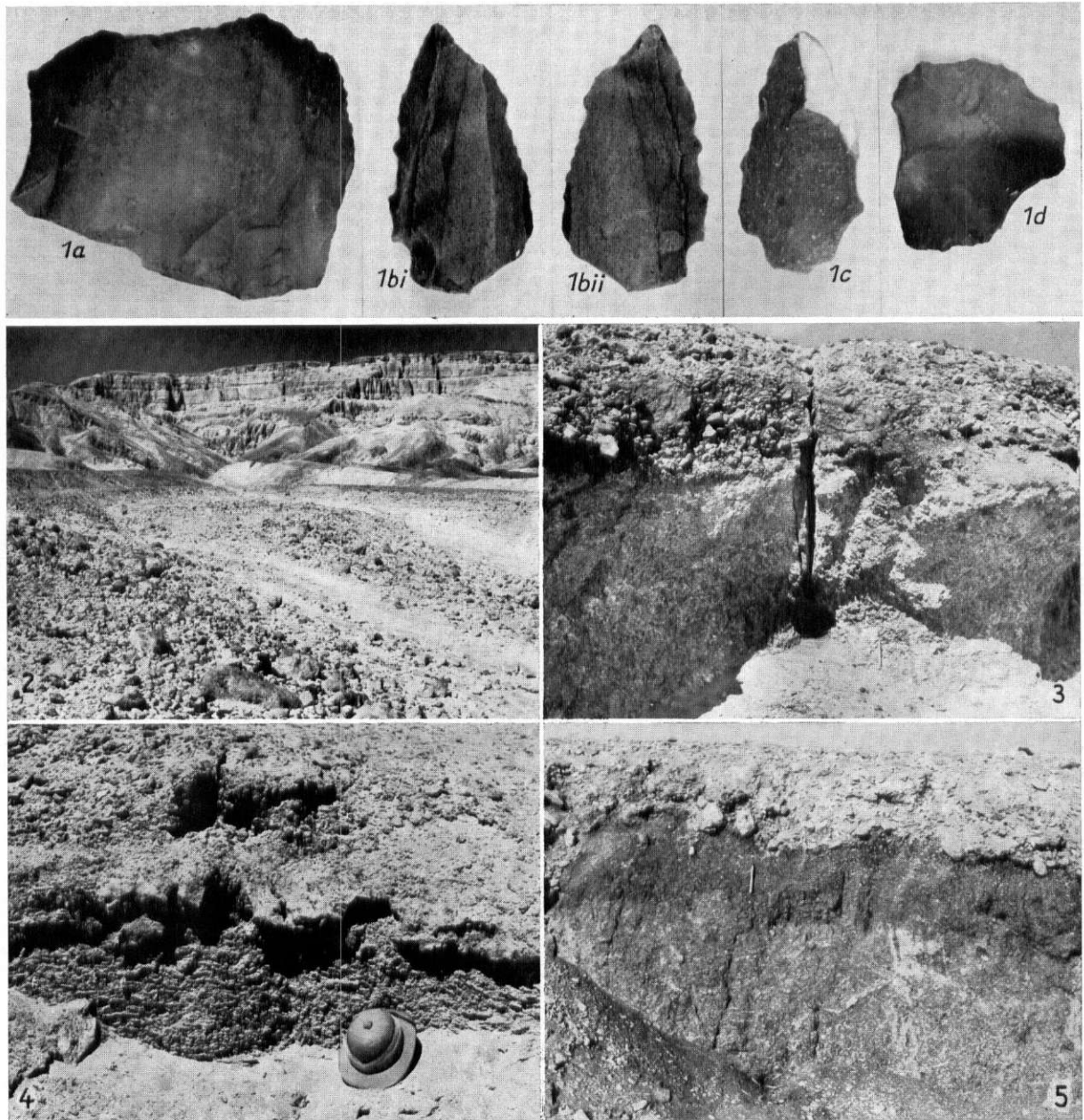
A microchemical analysis of the sandy red earth was kindly carried out by the Bodenkundliches Institut, Bonn. As a basis of comparison a similar sandy soil from the Mediterranean littoral developing from oolithic limestone to-day with about 100 mm precipitation was also analyzed. The results gave

		SiO <sub>2</sub> (%)	Fe <sub>2</sub> O <sub>3</sub> (%)	Al <sub>2</sub> O <sub>3</sub> (%)
Modern soil (El Alamein)	I.	33.3	1.59	5.6
	II.	33.7	1.63	5.8
Fossil soil (Tuna el Gebel)	I.	51.3	1.10	2.2
	II.	50.9	0.97	2.2

The Lower Pleistocene red earth apparently developed under a moister climate in order to account for the very considerably larger SiO<sub>2</sub> con-

<sup>7)</sup> On account of the impracticable customs regulations controlling the export of geological samples from Egypt, it was not possible to bring back soil samples in sufficient number and quantity for systematic laboratory analyses. That material which was retained has been kindly examined by the Pedological Institute and by the X-ray Laboratory of the Mineralogical Institute, both of the University of Bonn.





*Photos*

Ill. 1. Epi-Levallois II (Middle Sebilian) flakes from 1.5—2 m terrace of Wadiyein (Thebaid). 10/11 natural size.

Ill. 2. Terraces of Wadi Ibeidalla (Thebaid) midstream. 3—4 and 10 m terrace on right, 1.5 and 3—4 m gravels left center with shoulder of higher terrace from tributary on left. Confluence in foreground, Lower Eocene cliffs on horizon.

Ill. 3. 25 m pluvial gravels and sands at el Izziya (Manfalut) showing red earth development upon older brown

earth with massive calcareous accumulation. Red earth washed down in crevice. (Pencil 14 cm long.)

Ill. 4. 25 m eustatically aggraded gravels at Kafr Tarkhan (el Wasta) upon decomposing Eocene beds showing 'convulsed' (gewürgte) gypsum crust.

Ill. 5. 7 m gravels and sand at Deir Tasa (Badari) with red earth beneath leached gravels distinctly darker than underlying, older brown soil with calcareous precipitate. White spots in red earth due to concentrations of soft calcareous gypsum.

Photos by the writer.

tent, which presupposes greater amounts of humic acid at the time of formation and implicitly more vegetation than the dry steppe belt of the Mediterranean coast. Similarly the sesquioxides appear to have been leached to a greater extent.

For the initiation of the karstic phenomena perennial water infiltration will have undoubtedly been provided for by the Nile before the deposition of the gravels. These clefts are filled with cemented sand and gravel, to a good part stratified. The rubification with iron compounds has penetrated in most to the base. Where this has not been the case a hard gray conglomerate stands in contrast to the compact but soft, decalcified zone of rubification. Little or no gypsum occurs in the conglomerate. The weathering must represent a long period, having penetrated through gravels originally at the very least 2 m thick to the base of some 3 m deep clefts, there superficially discolouring the limestone.

Lower Pleistocene gravels of an intermediate age between el Khatatba and el Katta west of the Delta expose 2 m sections of identical terra rossa, base not seen. Innumerable sections can also be picked out on the 21—26 m Rus Channel gravels of Lower Egypt on the Nile-Fayum divide e. g. Kafr Tarkhan (Markaz el Wasta), due west of village at desert margin (Ill. 4):

130 cm Gravels (flint and some quartz) and brown clayey sand firmly cemented with calcareous gypsum.

15 cm Dark red crystalline gypsum bands with vertical columnar structure alternating in horizontal layers with loose dirty to brown calcareous or gypseous earth decomposed from Eocene rocks. Red colouring of gypsum due to hydro-hematite.

20—30 cm Hard crust of formerly plastic, convulsed calcareous gypsum, alternatingly white and red. Lies irregularly upon convulsed brown soil as above. This feature in an arid zone soil is similar to cryoturbational features of higher latitudes.

50+ cm White gypsum bands alternating with brown soil as above, rich in gypsum debris in form of small horizontal flakes.

Locally the dark red bands of gypsum are to be seen as the upper part of the exposed Eocene limestone, directly underlying sand and gravels. The convulsed („gewürgte“) crust is of considerable interest and apparently a novelty. Most probably a gypsum crust absorbed ground moisture after formation, exerting strong pressure under hydrostatic expansion between bedrock below and the gravel load above. Elsewhere large pieces of gypsum breccia occur in this horizon, white on the outside, orange or red inside. Apparently the red weathering effected these gypsum beds rather differently than the usual sandy terrace deposits.

Further to the center of the Rus Channel a cut is exposed a few kilometers further south, 500 m west of the alluvium, 100 m south of the asphalt road Gerzeh-Philadelphia:

4 cm Light brown, slightly clayey, fine sand with small pebbles which also lie free on the surface.

3 cm Soft, calcareous gypsum crust, often cementing pebbles.

40 cm Coarse quartz sand, weathered reddish in upper 15 cm, lower 25 cm unweathered yellow.

Disconformity.

60+ cm Finer, brick red sand with small and moderate sized gravel. Iron compounds mainly confined to calcareous and gypsum crystals.

The sequence here (Fig. 7) can be described as 1) deposition of the 26 m Rus (Tyrrhenian I) gravels, 2) intense weathering and decalcification, 3) erosion of surface, 4) fluvial deposition of coarse sands, 5) moderate rubification of sands, 6) reversal of weathering process to gypsum deposition under surface by capillary action. The

top of the section is a little over 10 m above alluvium, so that the coarse fluvial sands, which contain no local material, seem to belong to the 10—13 m Nile stage apparently superimposed upon the margins of the Rus Channel. Significant is that the initial weathering was reddish, i. e. red earth formation followed upon eustatic aggradation.

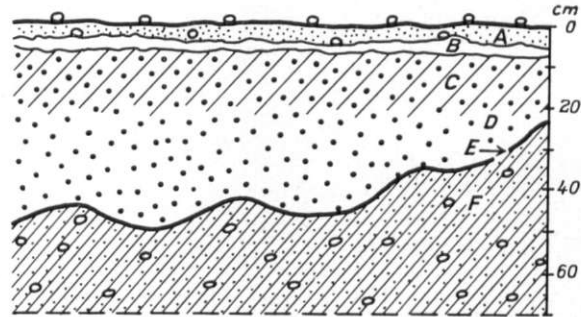


Fig. 7: Soil Profile on Nile-Fayum Divide; south of Darb Gerzeh.

A = sandy surface wash with pebbles; B = gypsum horizon; C = coarse fluvial quartz sand, weathered red; D = same, unweathered and yellow; E = disconformity; F = sand and gravel of 0—28 m Rus Channel (eustatic = Tyrrhenian), weathered to a sandy red earth.

The 25—30 m Nile gravels of Middle Egypt present a rather different aspect. One kilometer behind el Izziya (Markaz Manfalut), hills of 25 m gravels stand out prominently on the low desert exposing type sections such as the following.

45 cm Flint and quartz gravel with dark brown red clayey sand in crevices. On slopes these gravels attain 130 cm showing further differentiation into light reddish brown material over dark brown red. Overlying modern scree is unweathered.

8 cm Dark brown red clayey sand with small spots of calcareous gypsum concentrate.

120+ cm Calcareous horizon forming a net-like structure describable as a cavernous calcareous marl, the hollows of which are filled with light-brown, earthy sand. This sand is cemented in the lime throughout the remainder of the complex.

The brown soil embedded in a cavernous calcareous marl occurs at the base of all pluvial gravel profiles and is the calcium horizon of a former, semiarid brown soil, later subjected to rubification under somewhat differing climatic conditions. Thus the fossil brown soil, now represented only by its own lime horizon, is preserved as the unweathered C-horizon of a subsequently developed red earth. In its turn the latter is now also a palaeosol.

Similar cuts as this can be met frequently between el Izziya and Beni Sharan. At a similar location behind Gahdam, a little southeast of Izziya, it was possible to find proof of the uninterrupted sedimentation of these terraces in the form of intercalated sand and gravel beds.

Apart from the upper marginal 12 m deposits from the Rus Channel, sections of 15 m gravels were recorded in a quarry 400 m west of the Muslim cemetery of el Bahnsa (Markaz Beni Mazar). The quarry exposes a gently inclined desert surface representing the Nileward slope of

the 10 m gravels a few kilometers further north. Top of cut 5 m above alluvium:

- 5 cm Fine to medium-grained, light coloured sand.
- 140 cm Coarse quartz sand with flint gravels, weathered red but of decreasing rubification towards surface. Iron compounds concentrated in lower 70 cm.
- 40 cm Coarse whitish sand with irregular gravels beds, weathered red towards top.
- 150<sup>+</sup> cm Moderately coarse white sand to below ground-water table.

Again the red weathering was quite intense, leading to an eluviation from the uppermost whitish horizon. The latter is common to most of the red earth profiles in Egypt, but generally limited to the uppermost gravel beds which are most susceptible to leaching. The coarse sands, remarkably identical with those of the Acheulian Wadi Qena gravels are derived from the Nubian Sandstone of Upper Egypt and are not of local origin, again indicating a lack of contemporary local wadi activity.

Further upstream in Upper Egypt 12 m gravels are exposed on the south bank of a wadi emptying south of Deir Tasa (Markaz Badari), 500 m from alluvium:

- 30 cm Flint gravels with light reddish brown sand and gypsum precipitate spots.
- 35 cm Dark brown red sand.
- 15 cm Light brown sand.
- 90<sup>+</sup> cm Calcareous horizon with middle brown clayey sand. The sands are fine to coarse-grained, probably redeposited Nile material in part.

The profile character is more or less identical with that of the 25—30 m pluvial gravels from el Izziya, although the calcareous horizon is not quite so well developed.

The base of the central wadi channels eroded to 8 m in the 25—30 m gravels behind Izziya exposed some 10—15 cm light reddish brown clayey sand over at least 40 cm gypsum breccia with pebbles. Red weathering and calcium horizons occur in the estuary gravels of Wadi Asyuti, but the morphology is not sufficiently clear there. Elsewhere 7 m local gravels are strikingly developed on the north side of the already mentioned wadi at Deir Tasa (Ill. 5):

- 20—30 cm Gravels with light yellow brown clayey sand and spots of calcareous gypsum precipitate.
- 20 cm Dark brown red clayey sand with some spots of gypsum.
- 80<sup>+</sup> cm Dark brown red clayey sand with rich calcareous precipitation, but insufficiently developed to be described as a lime horizon in the sense used above.

An identical profile occurs in the 8 m gravels on the north side of Wadi Higaza (Markas Qus), some 2.5 km east of the town:

- 40 cm Light reddish brown clayey sand with gravel.
- 20 cm Gravel with light brown, clayey sand.
- 50 cm Brown red clayey sand with concentrations of calcareous gypsum.
- 90<sup>+</sup> cm Brown coarse to middle-grained clayey sand with incipient development of a calcareous horizon as at Deir Tasa.

Particularly in these two profiles the removal of the carbonates from the red earth zone is striking. The gypsum precipitate, considerably more soluble, must have taken place at a later date than the red earth formation.

Soil profiles are hardly developed in the Upper Pleistocene terraces. The 4 m gravels can be most interestingly observed at Deir Tasa, a little downstream of the 7 m gravels described above:

- 2 cm Fine, light brown sand.
- 5 cm Loose, sandy gypsum, weathered brown red.
- 60 cm Gravels with light brown clayey sand; calcareous gypsum concentrations in upper 25 cm. Immediately below the overlying horizon the latter become reddish.

90<sup>+</sup> cm Dark brown clayey sand with calcareous gypsum precipitate.

Although the tendency for the development of brown soils with calcareous precipitation still existed, the lime horizon is already fully replaced by more soluble gypsum. Similarly the subsequent rubification was very superficial, never coming to full realization.

The 1.5—2 m gravels of southern Upper Egypt contain no traces of weathering, possibly due to their lack of finer materials. At Deir Tasa 1—1.5 m gravels, presumably also of Upper Palaeolithic age are exposed in a section very similar to the 4 m gravels:

- 6 cm Light brown sand with gravel, reddish towards base.
- 30 cm Gravels with light brown sand and calcareous gypsum.
- 110<sup>+</sup> cm Light brown clayey sand, partly with gypsum concentrate.

The reddish zone and the precipitates of the lower horizon are even distinctly weaker than in the 4 m gravels. The soil profiles of both these Upper Pleistocene gravels strongly confirm their youthfulness in comparison to the 7—9 m gravels, whose character is much closer related to that of the 12—15 or 25—30 m gravels of Upper Egypt.

The significance of these soil profiles can be discussed briefly. The eustatically controlled Nile terraces of Middle and Lower Egypt each bear traces of red weathering, the development of sandy red earths from generally calcareous sand. The climate must be assumed considerably moister since a 5 mm mean annual rainfall will never suffice for the chemical reactions inherent in this process. From the high SiO<sub>2</sub> content of the 78 m terrace the humic acid present must have been considerably greater than that of the modern sandy red earth of the Mediterranean coast with 100 mm rainfall. This red earth formation must have occurred after the eustatic aggradation locally and before the deposition of the next pluvial gravels upstream, either during the later interglacial periods or the very early glacial phases. A probably similar case of warm-moist climate in the Mediterranean is illustrated at Sant Adrià del Besòs (VIRGILI & ZAMARRENO 1957, p. 8—16) where a succession of warm-dry, warm-moist and cold-dry periods is also known from soil profiles. It may be suggested that red earth development was characteristic in Egypt during late interglacial periods. The thin, relatively loose gypsum crusts found almost everywhere in the country may be recent or rather recent to Upper Pleistocene in age. BLANCKENHORN (1901) describes how gypsum precipitation or crystallization still takes place on the Cairo-Maghagha stretch of the east bank, whereas the writer noted similar distinctly fossil horizons of gypsum which had been cut through by Roman burials in western Middle Egypt. Near Hebenu on the other hand, a loose gypsum zone has developed since Roman times.



The stratigraphical examination of the climatic terraces of Upper Egypt suggests the following. Firstly to the sedimentary cycle of the wadis and the Nile: almost everywhere between Manfalut and Nag Hammadi a long period of sand deposition was followed by a final phase of gravel accumulation. So for example the wadi emptying south of Arab Miteir (near Abnub) deposited at least 10 m of almost pure sand before a cap of gravel (belonging to the Middle or Upper Pleistocene) was laid down on the top. Nowhere in the Asyut area were gravel beds greater than 2 m thick observed. Apparently the gravels only reached the Nile toward the close of the aggradation phases.

Secondly pluvial gravel deposition upstream was apparently immediately followed by the development of brown soils with massive calcareous horizons. The latter nowhere display remnants of true calcareous crusts so that it is difficult to obtain modern parallels in the Mediterranean area, excepting possibly terra fusca. However the wire-grass, brown prairie (Otero) soils of eastern Colorado or the basin lands of Wyoming in North America are comparable in our point of view. In these semiarid soils forming upon limestone with mean temperatures 5° C or more lower than in present-day Egypt and with a precipitation of 250—350 mm, the well-known lime horizon develops to close beneath the surface thanks to the absence of a high water-table. It may be justifiable to suggest a considerably moister and perhaps somewhat cooler climate for the development of the Egyptian counterparts, probably during the glacial phases. Significantly the gradual replacement of the carbonates by more soluble gypsum in the younger terraces indicates progressively weaker pluvials in the course of the Middle and Upper Pleistocene.

Thirdly it indicated that a red earth development followed the calcareous brown soil formation in the 25—30, the 12—15 and the 7—9 m pluvial deposits. We must assume the development of the two soils was separated by an arid phase without any soil formation as the rubification of the eustatic gravels succeeded upon a period without chemical weathering (e. g. Gerzeh) and a time of no local wadi activity, as described earlier. That there was not only one but rather several phases of rubification seems obvious from the two distinct periods of red earth development illustrated

at Gerzeh (Fig. 7). A terra rossa developing from limestone could not be expected to keep such a distinct, almost horizontal demarcation between fossil and developing soil. But in the Nile Valley case a sandy red earth was formed in a homogeneous sandy sediment, so that the border between the red and brown soils can be expected to remain as striking as it is. Possibly the decalcification of the upper soil horizon led to further carbonate precipitation in the older brown earth preserved below. Red earths are very stable and it is therefore not surprising that subsequent climates have not reversed the red soil profiles of Egypt.

The typical morphological and pedological sequence which has reoccurred several times can be summed up as follows:

1. Deposition of sand to great depth by wadis and Nile. Moist.
2. Final aggradation with fluvial gravels (in Upper Egypt). Moist.
3. Brown soil development with massive lime horizons in the form of a cavernous calcareous marl. Moist, cooler.
4. Eustatic aggradation downstream with cessation of chemical weathering and soil development. Arid.
5. Red earth formation with decalcification. Moist. This rubification has only in an incipient way (interstadial and Neolithic Subpluvial?) succeeded upon the last two Upper Pleistocene sedimentary phases.

None of the soil developments recorded here can be ascribed to a high groundwater table.

#### Summary

The evolution of the present Nile Valley below Gebelein can be tentatively summed up as follows. These suggestions are of a preliminary character and should be regarded as possible directives for future research, not as finished results.

**Miocene to Lower Pliocene.** Cutting of present Nile valley and tributaries to at least 125 m below m. s. l. probably in response to a very pronounced marine regression. Tributaries could apparently not keep pace with rapid incision of main valley.

**Upper Pliocene (Astian to Plaisancian).** Deposition of marine and freshwater beds in gulf flooding Nile valley to over 180 m m. s. l.

**Pleistocene. Calabrian.** Return to fluvial conditions. Various gravels between 115 and 230 m over alluvium in Lower Egypt, probably eustatic. Large-scale erosion in Red Sea Hills and transport of masses of gravel to Nile.



Sicilian. Nile course to +98 m on surface of Western Desert north of Mallowi in response to Mediterranean sea-level of 103 m.

Shorter period of vertical incision on lower Nile.

Nile course to +78 m on Western Desert from Mallowi to the sea in response to m.s.l. of +80—85 m.

Post-Sicilian, Pre-Mindel. Long period of intermittent vertical incision in entire valley. During part of this time longer phase of rubification of calcareous sands ('red earth') (with some precipitation).

Mindel (?). ('Abbevillian to Lower Acheulian'). Climatic aggradation on upper Nile and tributaries with gravels deposited to 25—30 m, gradually falling off towards the north.

Brown soil formation with strong calcareous precipitation below surface (strong precipitation and cooler).

Tyrrhenian I. Lower to Middle Acheulian. Vertical incision upstream, eustatic aggradation and redeposition of older material by Nile downstream following a course in 25—30 m on Western Desert north of Minya, bed rising towards north in response to sea-level of +35 m. Locally dry.

Longer period of red earth development (considerable precipitation).

Riss ('Middle and evolved Acheulian, pre-Micoquian') Climatic aggradation of Nile and wadis in Upper Egypt to 15 m, apparently falling off rapidly north of Sohag to 8 m at Mallowi. Vertical incision downstream.

Brown soil formation with calcareous horizon (strong precipitation and cooler). Vertical incision upstream.

Red earth formation (?).

('Acheulio-Levalloisian') Renewed aggradation of Nile and wadis in Upper Egypt to 9 m, falling off towards north. Vertical erosion downstream?

Period of brown soil formation with discontinuous calcareous horizon (considerable precipitation and cooler).

Tyrrhenian II (Monastirian). Aggradation of Lower Nile to 10—13 m rising towards north in response to sea-level of +15—20 m. Beds are merely redeposited older materials from further upstream showing no traces of local wadi activity. Pronounced local aridity.

Moderate period of red earth development (some precipitation).

Würm ('Late Lower Levallois'). Aggradation of 4 m torrential gravels in Upper Egyptian wadis.

Moderate period of brown soil formation with precipitation of calcareous gypsum (some precipitation and cooler).

('Upper Levallois to Epi-Levallois I') Inauguration of modern hydrographical regime with surge of exceptionally high, silt-bearing annual floods. Sea-level low or falling. Vertical erosion of wadis. Very short phase of slight reddish weathering with some moisture. Epi-Levallois I phase with little local wadi activity.

('Epi-Levallois II') Short period of wadi aggradation and wadi activity. Incision of Nile begins.

('Epi-Levallois III') Vertical incision of Nile with gradual cessation of all wadi activity. Some tendency to formation of arid, light brown soil (slightly moister, cooler?). Ultimately intense local aridity with greater aeolian activity.

Holocene. Resumption of silt deposition. Neolithic and early Islamic period locally moist, later dynastic period drier with greater aeolian activity.

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## BERICHTE UND KLEINE MITTEILUNGEN

### DAS NIEDERSCHLAGSDARGEBOT IN DEN DEUTSCHEN FLUSSGEBIETEN

Bemerkungen zu einem neuen hydrologischen Kartenwerk der Bundesrepublik Deutschland

REINER KELLER

Mit 1 Kartenbeilage

Auf dem Deutschen Geographentag in Frankfurt/Main 1951 berichtete ich erstmals über die Vorarbeiten zu einem hydrologischen Kartenwerk der Bundesrepublik Deutschland (R. KELLER, 1952) und veröffentlichte fast gleichzeitig die methodischen Grundlagen dieser gewässerkundlichen Arbeiten (1951). Inzwischen sind die gewässerkundliche Arbeitskarte der Bundesrepublik Deutschland, welche eine nach geographischen Gesichtspunkten erarbeitete hydrographische Gliederung enthält, und das Kartenwerk „Der mittlere Jahres- und Winterniederschlag 1891—1930 nach Flußgebieten“ vollständig erschienen, manche Blätter bereits als 2. Ausgabe. Jedes dieser Kartenwerke umfaßt 14 Blätter im Maßstab 1:500000 im Schnitt von VOGEL'S Karte des Deutschen Reiches. Dabei ist die Gewässerkundliche Arbeitskarte die kartographische Grundlage für die Niederschlagskarte der Flußgebiete. Die Niederschlagskarte nach Flußgebieten 1:500000 ist veröffentlicht als Beilage zur Hydrogeologischen Übersichtskarte 1:500000, die ebenfalls im gleichen Blattschnitt in 14 Blättern unter der Leitung von R. GRAHMANN im Hydrogeologischen Arbeitskreis beim Bundesministerium für Wirtschaft unter maßgeblicher Beteiligung der deutschen geologischen Landesämter bearbeitet wurde (Vgl. Besprechungen in ERDKUNDE XI, 3, 1955 u. a.).

Als Muster ist das Blatt Frankfurt der Karte der mittleren Jahres- und Winterniederschläge 1891—1930 nach Flußgebieten dieser Veröffentlichung beigegeben.

Der Niederschlag ist das am häufigsten dargestellte Klimaelement. Die Karten der mittleren Niederschlagshöhe sind um so zuverlässiger, je dichter das Stationsnetz und je länger der Zeitraum einer einwandfreien Beobachtung ist. Zwar gibt es dabei auch noch Probleme der Niederschlagsmessung sowie hier und da hinsichtlich der Führung der Linien gleichen Niederschlags verschiedene Auffassungen bei verschiedenen Bearbeitern (s. H. SCHIRMER 1951 u. R. KELLER, 1951, 1958), aber bei allen hydrologischen Bilanzen gilt trotzdem der Nieder-

schlag noch als das am sichersten faßbare Element. Zur Darstellung des Niederschlags wird heute allgemein die Methode der Isohyeten verwendet. Wenn der Jahresgang des Niederschlags hervorgehoben werden soll, ist die Methode der Niederschlagskartogramme üblich, wobei man für jede Beobachtungsstation ein Diagramm einträgt mit den Monaten auf der Abszisse und den mittleren monatlichen Niederschlagssummen auf der Ordinate.

Diese gebräuchlichen Niederschlagsdarstellungen sollen durch die hier vorgelegte Methode nicht verdrängt werden. Die ungewohnte Art der Niederschlagskarte nach Flußgebieten ist aber für hydrologische und manche wirtschaftsgeographische Fragestellungen zweckmäßig.

Aus dem Niederschlagskartogramm ersieht man das Niederschlagsregime, während die Isohyetenkarten es erlauben, für jeden Punkt eine mittlere Niederschlagshöhe abzulesen bzw. zu interpolieren. Man entnimmt daraus, wo es viel und wo es wenig regnet. Etwas schwieriger ist es schon, niederschlagsreiche und niederschlagsarme Flußgebiete aus einer Isohyetenkarte zu ermitteln, weil ein Abflußgebiet mit wechselnden Höhenverhältnissen in verschiedene Niederschlagszonen zerfällt. Vom hochgelegenen Quellgebiet nimmt bei kleineren Flüssen die Niederschlagshöhe zur Mündung hin in der Regel ab.

Man kann also aus den üblichen Niederschlagskarten nicht ohne weiteres entnehmen, wie groß die mittlere Wassereinnahme eines Flußgebietes aus dem Niederschlag ist. Das ist aber z. B. für gewässerkundliche Fragen entscheidend:

In die Wasserhaushaltgleichung wird nicht die Niederschlagshöhe einer Station, sondern die mittlere Niederschlagshöhe eines Einzugsgebiets bzw. einer Landschaft eingesetzt. Zu Talsperrenbauten, für den Bau von Wasserversorgungs- und Wasserkraftanlagen braucht man ebenfalls die gesamte Wassereinnahme eines Flußgebietes, um die vorbereiteten Berechnungen anzustellen. Die mittlere Niederschlagshöhe in einem Flußgebiet, d. h. die Wassereinnahme eines Flußgebietes aus dem Niederschlag wird aus Isohyetenkarten berechnet durch Planimetrieren oder durch die sogenannte Punktmethode