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K. W. BUTZER and C. L. HANSEN

INTERRELATIONSHIPS OF SUBSAHARAN NILOTIC DEPOSITS AND LOCAL WADI ALLUVIA IN SOUTHERN EGYPT

Introduction.

During 1962-63 the Pleistocene sediments of the Nile Valley and the adjacent desert tributaries of the Kom Ombo Plain and Egyptian Nubia were studied in detail by the writers (BUTZER and HANSEN, 1967, 1968; HANSEN and BUTZER, 1966; BUTZER, 1967). Today the tributary *wadis* of Egypt contribute practically no sediments to the Nile floodplain: the rare rainstorms and local wadi floods, related to westerly frontal-cyclonic disturbances (November through March), perform little more than local redeposition of wadi bed materials. Sedimentation in the Nile Valley is essentially confined to flood silts and channel sands primarily derived from the summer monsoonal rains (June through September) over the catchment of the Atbara, the Blue Nile, and the Sobat Rivers.

This balance of geomorphic activity was not always so, and as recently as 5000 years ago the wadis of southern Egypt were considerably more active, their deposits interfingering with nilotic flood silts along the margins of the Nile Valley. Such interrelationships of nilotic and wadi sediments can be readily determined in southern Egypt, allowing systematic study of the comparative vicissitudes of summer Nile floods and winter wadi spates. This has considerable paleoclimatological implication since it can establish whether moister paleoclimates in Egypt (related to winter rains of the planetary westerlies) were or were not synchronous with periods of higher and more vigorous Nile floods (related to summer monsoonal rains over the Ethiopian highlands).

Late Pleistocene to mid-Holocene History of the Nile Valley in Southern Egypt.

The early and middle Pleistocene were characterized by net erosion and downcutting in Egypt and Nubia, with temporary aggradation of gravels of local origin: mainly quartz, together with igneous and metamorphic components or ferricrete sandstone at the mouths of larger wadis drainng the Red Sea Hills. There is no clear evidence of materials exotic to Egypt and the northern Sudan (see also de HEINZELIN, 1967). However, important hydrographic changes occurred in the Nile Basin during early Upper Pleistocene times, when true flood silts, derived from the Blue Nile and Atbara systems, made their first appearance in the sedimentary record of Nubia and Egypt. There is then some reason to believe that the annual, late summer floods, as we know them today, may be a comparatively recent phenomenon.

The subsequent history of events can be outlined as follows:

(a) *Wadi Floor Conglomerate.* — At the base of the late Pleistocene sequence, up to 5 m of ferricreted, well-rolled, cobble conglomerates overlie the bedrock and are graded to a floodplain level at least as low as that of today. They suggest major wadi activity and a pluvial climate, probably corroborated by gravels and calcareous tufas (Wadi Tufa III) at the Kurkur Oasis, dating "greater than 40,000 years" (BUTZER, 1964, 1965; BUTZER and HANSEN, 1968). Deposition of the Wadi Floor Conglomerate was followed by a period of erosion and consolidation.

(b) *Korosko Formation.* — Extensive spreads of coarse quartz sands and marls were deposited by a rapidly aggrading, braided Nile to + 34 m near the Sudanese border and to + 20 m at Kom Ombo. Local wadis injected great quantities of sand and gravel into temporary lacustrine environments along the valley margins, and coarse, well-rolled wadi conglomerates immediately underlie the Korosko Fm. in Egypt. Similar gravels are interdigitated in the middle of the sequence. These gravels record the terminal phase of late Pleistocene "pluvial" conditions in Egypt (1). Swift and turbulent summer floods of Ethiopian origin introduced silt, clay, and solubles, while local materials—made available by wadi discharge during the winter months—were reworked and redeposited in the Nile Valley. The heavy mineral and clay mineral spectra suggest a greater influx of Bahr el-Ghazal waters and sediments, relative to those of the modern Nile.

Middle Palaeolithic flakes and scrapers appear to be contemporary with these deposits. An approximate age of 50,000 to 25,000 years ago can be extrapolated from terminal radiocarbon dates. The subsequent period of Nile and wadi incision lowered the local base level to below modern floodplain, prior to renewed aggradation.

(c) *Masmas Formation.* — Extensive horizontal flood silts, rich in Ethiopian heavy minerals, filled the Nile Valley to + 33 m in Nubia and to + 22 m on the Kom Ombo Plain. The sedimentary environment indicated pertains to a floodplain (alluvial flats or backswamps), and only rarely to channel or levee beds. A broader floodplain was regularly inundated and levee-breaching by crevasses was common, indicating somewhat greater discharge. The clay mineral composition again suggests more Bahr el-Ghazal waters. However, in Egypt, wadi activity was minimal throughout this period. The Masmas beds represent the classical "high-silts" of SANDFORD and ARKELL (1933), and they attain a thickness of over 40 m at Kom Ombo, extending from Upper Nubia into Lower Egypt. They suggest an intensified summer flood regime. Meaningful archaeological associations are unavailable, but a time range from 22,000 to 16,000 B.C. can be inferred from radiocarbon dates. The Masmas Formation is equivalent to the Dibeira-Jer (Khor Musa) Formation identified in Sudanese Nubia by de HEINZELIN (1967).

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

(d) *Gabel Silsila Formation.* — The third and final episode of nilotic alluviation includes a sequence of fine gravels, silts and sands related to channel and levee environments of a rather more vigorous and competent Nile. Horizontal flood silts are rare; instead, former shoals of bed gravels or sands interfinger with laterally embanked topset and backset strata. Relative proportions of clay minerals and heavy minerals are, for the first time, almost identical to those of today. However, the gravels are marked by an influx of exotic flint, chert, chalcedony, agate, jasper, and carnelian—most of which are totally absent from all earlier deposits.

The Gebel Silsila Formation includes three major periods of nilotic aggradation, separated by periods of downcutting:

Darau Member: 15,000-10,500 B.C. (+ 22.5 m in Egyptian Nubia, + 13 m on the Kom Ombo Plain). The deposits exceed 18 m in thickness and include geologically stratified Sebilian and other Late Palaeolithic sites, formerly located along the banks of the Nile. Contemporary with accelerated fluvial activity in the local wadis, leading to accumulation of as much as 9 m of fill (lower member of Ineiba Formation). The stratigraphic interdigitation indicates that more vigorous Nile floods (summer) alternated with fairly frequent local rains of moderate intensity (winter). Equivalent ot the Sahaba Formation of de HEINZELIN (1967).

Arminna Member: 9,200-8,000 B.C. (+ 15 m in Egyptian Nubia, absent at Kom Ombo). Accelerated fluvial activity, with accumulation of at least 12 m of fill (upper member of Ineiba Formation). Wadi aggradation continued until ca. 6000 B.C., and was followed by development of a minor red paleosol with a 30 to 50 cm—deep B-horizon. Oxidation and decalcification were accompanied by formation of kaolinitic clays, indicating biochemical weathering, some form of vegetative mat, and more frequent, gentle rains. The age of this almost ubiquitous paleosol in southern Egypt may be about 5000 B.C.

Kibdi Member: ca. 4000-3000 B.C. (+ 6-7 m in Egyptian Nubia). Accelerated fluvial activity in wadis (over 6 m of fill), accompanied by extensive sheetwashing of surface, as a result of sporadic, but protracted, torrential rains (Shaturma Formation).

Discussion.

The nilotic deposits of southern Egypt were derived from the subsaharan drainage basin of the Nile, and indicate that flood amplitudes and velocities were significantly greater than today for most of the period between ca. 50,000 and 5000 years age. This can only be explained by greater precipitation and discharge over Ethiopia and the southern Sudan, a matter of interpretation corroborated by de HEINZELIN'S (1967) study of similar deposits in Sudanese Nubia. From this we can infer there, complex pluvial periods for the summer monsoonal belt of the Nile Basin. An almost identical sequence of events is evident in the lower Omo Valley of East Africa (BUTZER and BROWN, *n.d.*).

If we compare these fluctuations of Nile discharge with the activity of local streams in southern Egypt we may note several facts:

(*a*) Maximum "pluvial" conditions in southern Egypt, as recorded by the Wadi Floor Conglomerate (ca. 60,000 B.C.), corresponded to the onset of the Würm Glacial in Europe. There is no evidence for higher Nile floods at the time. Egyptian climate was still "pluvial" although subarid in nature during the first half of the Korosko sedimentary hemi-cycle, in this case corresponding with much more vigorous Nils floods. But later during the Korosko stage, local wadi activity was limited. Consequently there was only a broad, incomplete correspondence between Egyptian and subsaharan pluvial oscillations during the time span of the Early Würm (ca. 60,000-25,000 B.P.).

(*b*) It is notable that the maximum of the Würm Glacial (ca. 24,000-18,000 B.P.) was dry in Egypt although comparatively moister in the subsaharan drainage basin of the Nile.

(*c*) Between 17,000 and 5000 B.P. greater Nile discharge of Ethiopian origin corresponded very closely with accelerated wadi activity in Egypt. It could be shown in the field that, despite the synchroneity of events, local winter spates and summer Nile floods were, in fact, seasonally out of phase. In other words, the evidence of late Pleistocene and Holocene wadi activity in northern Egypt can be largely, if not entirely attributed to winter rains, and not to an intensification and northward extension of the sporadic summer shower activity evident in Sudanese Nubia today.

(*d*) The accelerated activity of the Egyptian wadis ca. 9200-6000 B.C. and ca. 4000-3000 B.C. suggests very minor "subpluvial" episodes, which were contemporary with higher Nile floods. The intervening red paleosol (ca. 5000 B.C.) has no obvious nilotic counterparts. These three episodes account for most of the time represented by the Upper Dryas, Boreal, and Atlantic phases in Europe. Counterparts to these late alluvia in the northern Sudan are discussed along similar lines by de HEINZELIN (1967).

During the 3rd millenium B.C. Nile flood levels dropped, wadi activity was reduced to a minimum, while sand dunes were periodically activated around the margins of the Nile Valley (BUTZER, 1959, 1966; de HEINZELIN, 1964). The climate of Nubia and Egypt has remained hyperarid ever since.

Although the details of climatic fluctuations apparent from the geomophological record of southern Egypt should be susceptible to paleometeorological interpretation, a rationale for the curious, partial-coincidence of Ethiopian and Egyptian pluvial phases during the last 50 or 60 millenia must still be sought. Any interpretation would be premature until the dynamic climatology of the present summer circulations over Ethiopia and the southern Sudan are properly understood. In conclusion, further detailed studies in the Nile Basin promise to resolve many of the controversial problems of pluvial correlation on opposite margins of the Sahara. From this a better understanding of potential faunal and human movements across the Sahara is bound to emerge.

Note.

(1) Contemporary "pluvial" deposits in the Kurkur Oasis are recorded by Wadi Tufa IV (BUTZER and HANSEN, 1968).

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Interventions.

M. FAURE: Est-il possible de traduire les variations de niveau du Nil par une courbe (en fonction du temps) ?

Réponse: Oui, la courbe n'est pas différente dans l'essentiel de celle de DE HEINZELIN (1967).

Mr. VAN ZINDEREN BAKKER E.M.- I have made borings in Ethiopia and work on the hypothesis of dryness of the tropical African mountains during the glacial periods.

Mr. VAN ZINDEREN BAKKER E.M.- Does the speaker conclude that the Ethiopian highlands were dry prior to 21.000 B.C. ?

Mr. LIVINGSTONE- Can one really draw conclusions about pluvial and interpluvial climates in Abyssinia from the degradation or aggradation on the Lower Nile ? It seems to me that the matter is very complicated and that changes in the weathering regime, or the rate of change of discharge might be as important as the absolute amount of discharge.