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# Geology, sedimentology and mineralogy of the Tell el Farkha site, the Eastern Nile Delta – Egypt

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## Introduction

The present study is supposed to sum up the geological research in the Ghazālah region and on the Tell el Farkha archaeological site. It aims to reconstruct the environment, geological history and settlement condition(s) since the Pleistocene/Holocene transition through the Predynastic and Early Dynastic period.

The study of the Nile and as well as its Delta history and sediments have a long tradition. It was already discussed in the time of Herodotus, mainly on the basis of ancient Egyptian papyruses, historical relations (e.g. BELL, B. 1970) and geological, hydrological investigations (e.g. BUTZER, K.W. 1960; ADAMSON, D.A. *et al.* 1980). There are several important geological works concerning especially the northeastern Delta and its sediments e.g. COUTELLIER, V. & D.J. STANLEY. 1987, de WIT, H.E. 1993. However, the precise reconstruction of the Nile flood height, silt sediments layers and their attribution to the precise periods of time is still very difficult and quite often uncertain.

The very beginning of the Nile Valley and Delta can be situated in the Miocene/Pliocene (ZALAT, A.A. 1995), but the contemporary shape and structure of the Nile began to emerge in the Late Pliocene, when sediments of so-called Eonile were formed in the old sea bay. Since the end of Pliocene (1.85 billion B.P.) through the whole Pleistocene different sediments of marine

and lagoon as well as fluvial and eolian origin filled the Nile Delta up to 7-50 m (av. 30 m) below today's surface. The most interesting for us is fluvial in origin (the one fluvial one), the Pleistocene sand forming the hills, which are called "turtle-backs". Since the Holocene (up to now) several strata of silt and sand have been formed in the delta region. The depth of the Holocene formation varies from about 7 m in the North-West, 10-15 m in the central and northern part, up to 40-50 m in the North-East (in Manzala Lake). They generally tape towards the borders of delta. It is to be emphasize that in the Manzala Lake the thickness of the sediments is significantly bigger than in other parts of the Delta because of the simultaneous processes of the sea-level changes, the Nile sedimentation and subduction.

Usually the history of the Nile is divided into five stages called: Palaeonile – in Pliocene, Protonile between 1.85 billion and 700 000 years B.P., from 700 000 B.P. to 200 000 B.P. Prenile, Neonile (or Nile) up to today (SAID, R. 1982; ZALAT, A.A. 1995). The chronology presented above is based upon the sequence of fluvial-erosion intervals.

The most ancient archaeological artefacts (Acheulian) are connected with the Abbassia Formation with the age estimated at about 700 000 – 200 000 B.P. (SAID, R. 1982). During the Neonile phase three complexes of silts and clays were formed. They are called Bilqas Formation β, γ and δ (or I, II and III). β-silt was formed between 200 000 – 40 000 B.P. and is connected with the Middle Palaeolithic artefacts (Khormusan tradition); γ-silt (21 000 – 12 000 B.P.) carries the Late Palaeolithic artefacts. The third part of the complex δ-silt is dated to 9 000/8 500 B.P. It was formed in the Holocene, after an episode of very intense erosion. The beginnings of agriculture in the Nile Delta emerged about 8 000/7 500 B.P., on 500 years' old δ-silt formation (it could have been approximately 0.5-1.0 m of sediment) (RIZZINI, A. *et al.* 1978; STANLEY, D.J. & A.G. WARNE. 1993b; ZALAT, A.A. 1995). This δ-silt Holocene

sequence was described by de Wit in 1993 as having three phases Nile 1A, Nile 1B and Nile 2. The Nile 2 is dated to 9 000/8 500–6 500/6 000 B.P. The lower Nile 2 is most probably of the same age as the old pediment in the Upper Egypt Nile Valley and lower sediments of Paleo Moeris (lake marls of Old Birket Quarun, near Fayum). The upper part of this sediment is of younger pediment age in the Upper Egypt, and is well correlated with the Complex of White Sand and Silts form Birket Quarun (de WIT, H.E. & M. PAWLIKOWSKI. 1992; de WIT, H.E. 1993). The boundary between Nile 1A and 1B is defined by the different rates of sedimentation due to the different flood intensity (15.2 cm/century – 1A, 6.4 cm/century – 1B) and lies about 5 020 B.P. It is necessary to point out that the evaluation of silty sediments increase differs in various papers from 0.1 mm/year (SAID, R. 1982) to 5 mm/year (COUTELLIER, V. & D.J. STANLEY. 1987).

The very bottom of the Holocene formation (Nile 2 by de Wit) in the North part of the Delta consists mostly of the marine sand and lagoon mud and in the South of the fine gravel, terrestrial sand, silt and mud (STANLEY, D.J. & A.G. WARNE. 1993a; de WIT, H.E. 1993). The coarse terrestrial sand dated to 7 000 – 4 500 B.P. is usually linked to the wet climate. It was sedimented by ephemeral streams in floods' episodes much higher than today. The average level of flood started to decline from the beginnings of the Holocene through the Predynastic and Dynastic times onward. For example, during the period that is in the center of our interests, the average flood was about 0.7-1.0 m higher than during the 2$^{nd}$ Dynasty (BELL, B. 1970; BROWN, A.G. 2001). In the landwards part of Delta the sandy floodplain mud was also deposited (STANLEY, D.J. & A.G. WARNE. 1993a). The younger Holocene sediments (Nile 1 by de Wit) consist of the silt with eolian and sandy fluvial insertions (de WIT, H.E. 1993). The general sediment profile of the Nile Delta in the Holocene was presented by Stanley and Warne in *Science* in 1993.

They describe it as follow:

- 12 000 – 7 000 B.P. homogeneous marine sand;
- 7 000 – 4 000 B.P. coarse material (sand) with silt, mud and some eolian sediments;
- 4 000 – 2 000 B.P. silt interbedded with sand;
- 2 000 B.P. – today silt, eolian sand, wastes.

It seems that about 7 500 – 7 000 years B.P. the Nile Delta began to gain its present shape. The Holocene started with the recessional marine episode and around 8 000 B.P. the sea was 12 m below the contemporary position and it reached present level about 2 700 B.P. Since then it has been more or less stable (COUTELLIER, V. & D.J. STANLEY. 1987; STANLEY, D.J. & A.G. WARNE. 1993b). Especially important is the fact, that the Delta was built by the Nile approximately 10 m/year towards the sea (to the North) – much faster than sea-level grew (STANLEY, D.J. 1988). It means, that about 5 000 B.P. the sea shore could have been aproximately 30-50 km to the South from its present position (COUTELLIER, V. & D.J. STANLEY. 1987).

Most authors state that between 12 000 – 5 000 B.P. the Delta climate was wetter than today and warmer than in the Pleistocene, with optimum phase in 8 000 – 6 000 B.P. (STANLEY, D.J. & A. MALDONADO. 1977; ADAMSON, D.A. *et al.* 1980; SAID, R. 1982). More arid phases, however, appeared several times during the whole 7 000 – 5 000 B.P. period and from 5000 B.P. the aridity increases significantly (de WIT, H.E. & M. PAWLIKOWSKI. 1992). There is the opinion, that this temporary aridity caused the emergence of the Predynastic and Early Dynastic settlement and the development of civilization (BUTZER, K.W. 1976; STANLEY, D.J. & A.G. WARNE. 1993a).

The character of the Nile in Delta and importance of its branches as well as Delta subsidence were the main factors in forming the Delta geomorphology

(STANLEY, D.J. 1988). In the Early and Middle Holocene until 4500 years B.P. the Nile Delta was dominated by several main Nile branches (fig. 1) of so called braided river. In this humid period central – Sebennitic Canal became dominant, but Mendesian and Pelusian channels were also important especially in the Eastern Delta. The Damietta and Tanitic branches existed only from 3 000-2 000 B.P. in the Eastern Delta. All the early settlements were localized along the water flows especially on the sandy-silty hills called *gezira*. Such places had not only refugial significance, but also offered quite easy access to agricultural and grazing fields, fishing resources etc. Geziras are much more common in the Eastern Delta than in others Delta regions (STANLEY, D.J. & A.G. WARNE. 1993b).

**Fieldworks and methods**

As it was mentioned (this volume) the Tell el Farkha, site lies in the Eastern Nile Delta on three koms near Ghazālah village (fig. 4). The area of the site covers about 4.5 ha. All three koms of the site are on the northern edge of Ghazālah village. The site is bordered by a big canal branch (Masraf Ghazālah) on the North, a small canal and fields on the West, the village buildings on the South and the East.

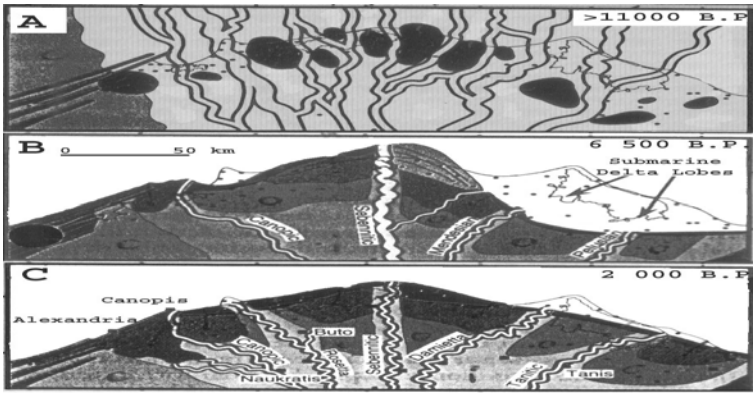



Fig. 1. Development of the Nile Delta during the last 11 000 years (adapted from STANLEY, D.J. & A.G. WARNE. 1993a).

We executed 43 boreholes and several geological trenches (fig. 2). 23 boreholes in line 1-10-23 were done during preliminary works in the years 1998-2000 by J. Kabaciński. The remaining boreholes were done with hand auger, during excavation seasons 2002-2004. We have reached maximum depth of about 8.5 m beneath the terrain surface.

The aim of our work was, first of all, to estimate the vertical distribution of sediments rich in artefact. The second purpose was to reconstruct the surface of sandy hills – gezira. Our drilling net covers, not only the site itself, but extends to the South, East and North (fig. 2). It is supposed to give a better understanding of geological context of the site's sediments. To determine the mineral assemblage and to describe the sand-grain, surface core, samples of sand were examined by binocular magnifying glass with ten power. The samples of silts were tested by X-ray diffraction. The results of fieldworks were worked out by the means of topographic maps, GPS data and computer mapping programmes.

**Observations**

We have distinguished two general complexes of sediments (fig. 3): the gezira sand and the Nile silt. There is also a thin (0-10 cm) transitional silty-sand layer between them. It is possible to distinguish a grey-green silty layer on the NW-N slope of koms, and a layer of greenish sand in the South part of the site. The water table is about 2-2.5 m above the present sea-level.

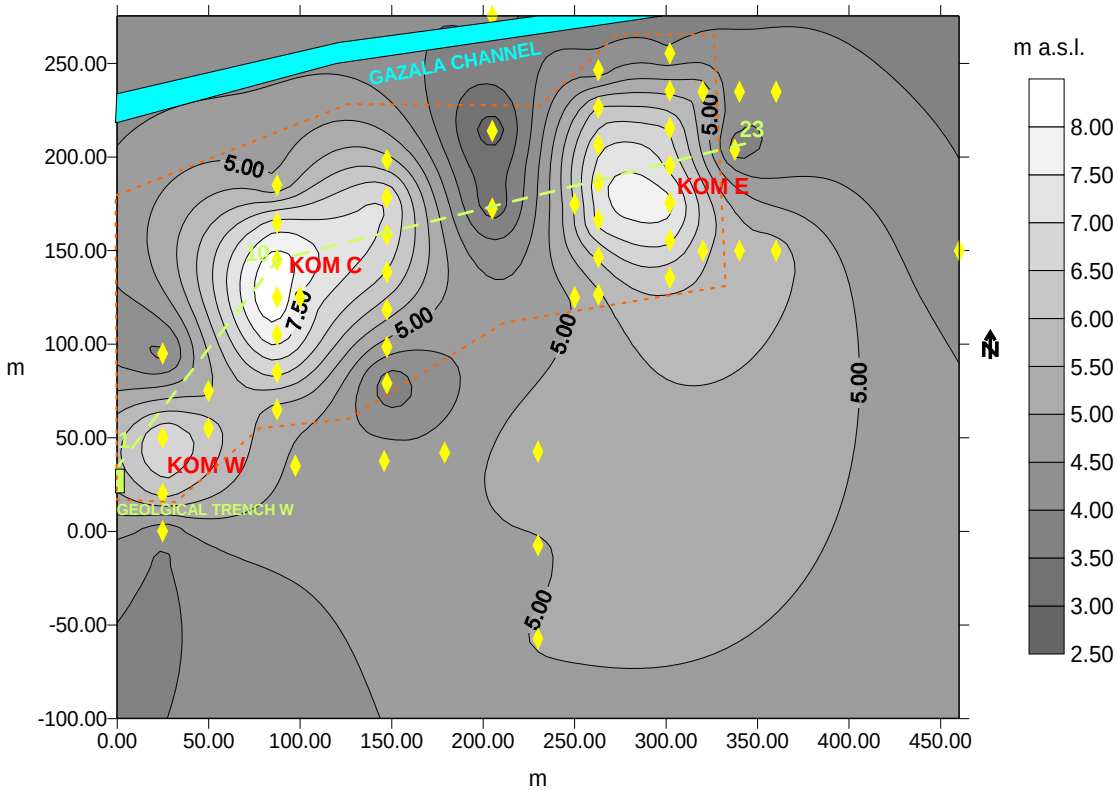



Fig. 2. The map of the Tell el Farkha area (□ - bore-holes, - - - 1 10 23 – Kabaciński drillings line, --- - excavation area).

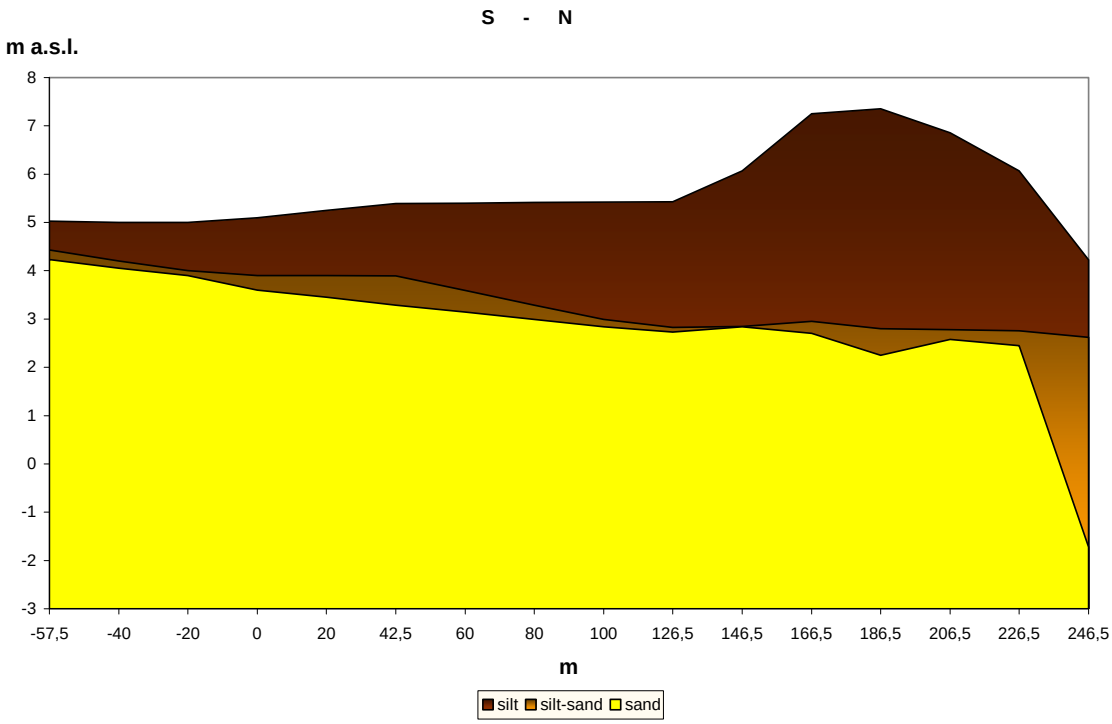
The gezira is built of the yellow-brownish friable sand. The sand is composed mainly of quartz grains, with addition of small amounts of plagioclases, K-feldspar and heavy minerals (i.e. amphiboles, pyroxenes and others). The size of grains varies between 2-0.1 mm, with majority of 2-1 mm grains. Quartz grains are coated with iron oxides and sometimes with carbonates. These coverings give colours raging from white and yellow to red and brown. The surface of grains is characteristic for the fluvial sediment previously rolled by the wind. The material comes most probably from the Eastern desert and the Abyssinian Plateau (KHOLIEF, M.M. *et al.* 1969) and was redeposited in the Delta by the Nile. It is possible that the layer contains some eolian sand. This sediment could be classified as coarse to fine sand of the fluvial origin and the Pleistocene age (COUTELLIER, V. & D.J. STANLEY. 1987). This is the lowermost sediment in our drilling core. It lies about 2.30 to 3.50 m above the contemporary sea level (fig. 5). We have not reached the

bottom of gezira in Tell el Farkha. It was also impossible to determine the lamination of this sediment. The gezira surface lowers abruptly towards the North, where present canal branch (Masraf Ghazālah) is situated. The mollusks shells discovered at the top of sands prove relatively dry climate at the final phase of sedimentation (fig. 6 A).

Fig. 3. Generalized profile of the Tell el Farkha site sediments.

On the south-western part of gezira there is a layer of greenish sand. This sediment is identical with the previous one in every feature but the colour. The difference may have resulted from various (i.e. reductive) sedimentation regime or post-sedimentation conditions. Usually the greenish sand is linked to the elder Nile channels, oxbow lakes or swamps (ANDRES, W. & J. WUNDERLICH. 1992).

The gezira is covered with a layer of mixed sand-silt sediment, which is 5-50 cm thick. It is thinner on the slopes and top of gezira, while on the base



of the hills it becomes thicker (fig. 6 B). The silt component of this sediment is the same that  the brown-greyish silt described just below.

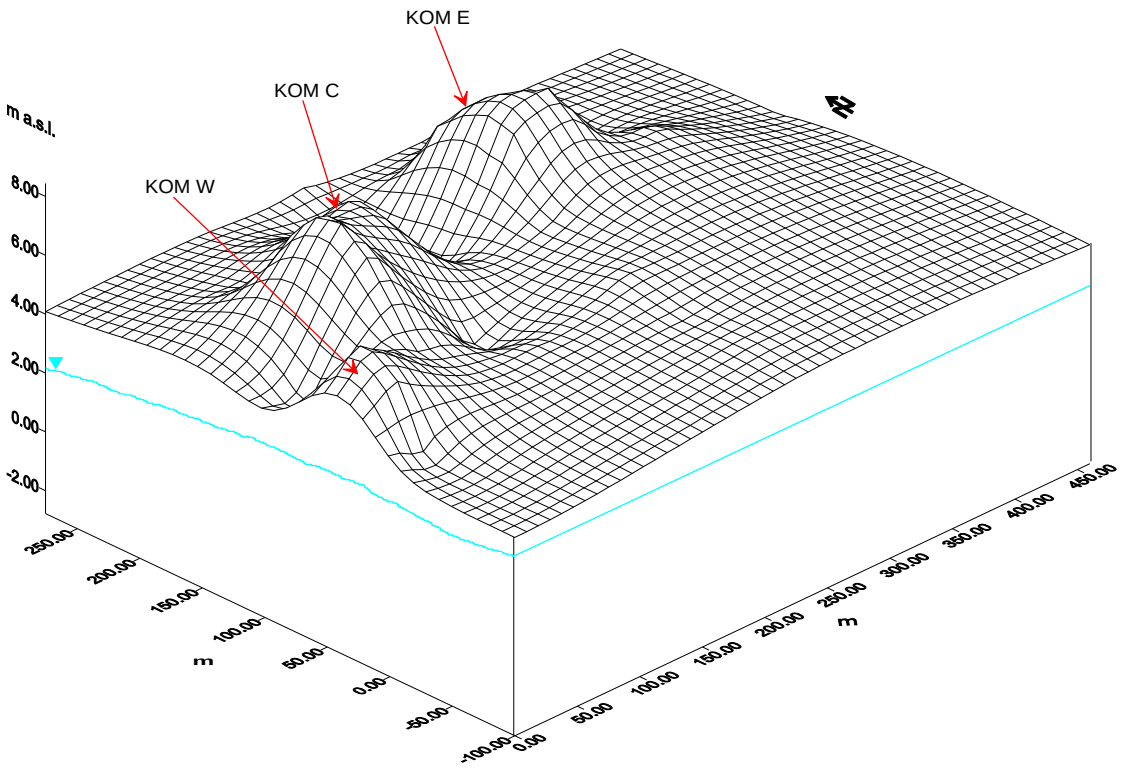



Fig. 4. 3-D map of the Tell el Farkha site (□ - water table).

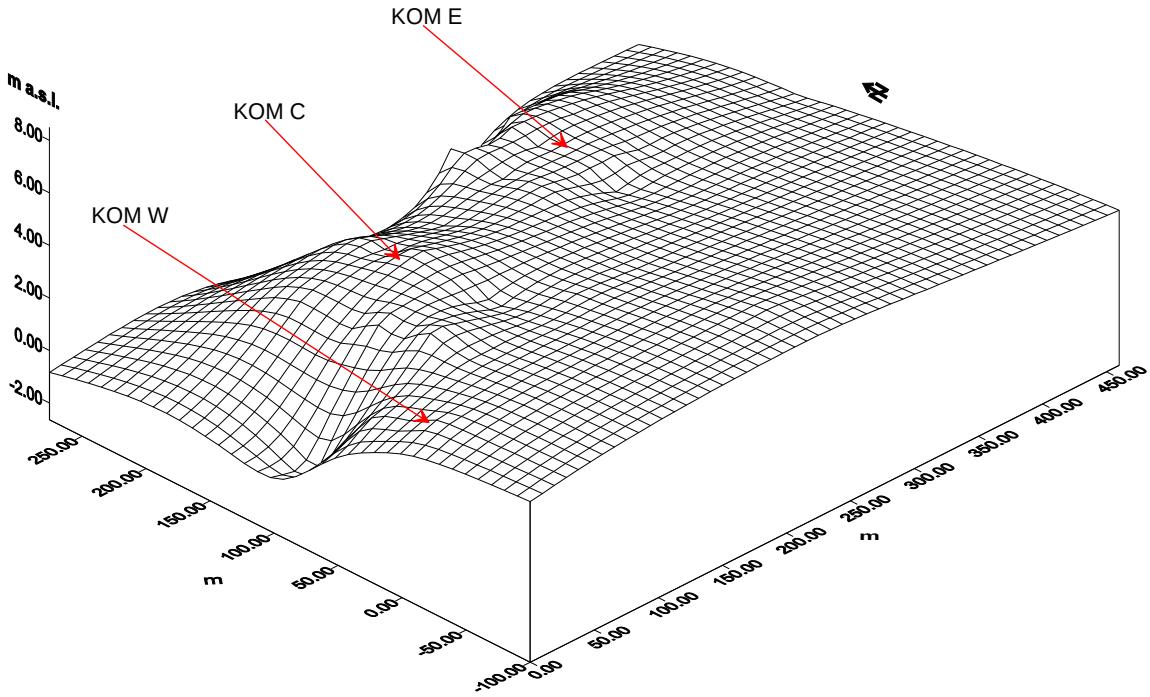



Fig. 5. 3-D reconstruction of the Pleistocene sand surface in the Tell el Farkha site.

The brown-grey silt covers all contemporary surface of the site and its neighborhood. The thickness of this unit is about 1-6 m. X-ray analyses revealed that the Nile silt of this region is composed mostly (95 %) of smectite and illite. These minerals are accompanied with small amounts of kaolinite and some organic substance. The admixtures of other components are very small. The uppermost unit of this silty layer contains admixture of contemporary waste, rubbish and some sand. Further research proved that this material was used to produce clay bricks (sun-dried or burned) and it was also used for pottery production (…).

The green-greyish silt forms the stratum on the North and North-western margin of the koms. It has 20 cm to more than 1.5 m of thickness. This silty layer consist similarly as the brown-greyish silt of smectite, illite and kaolinite but it contains up to 5-7 % of quartz, rutile, calcite and feldspars grains. The colour is certainly due to sedimentary conditions.

The archeological artefacts appear, first of all, in the brown-greyish silt. This artefacts-rich zone continues down in sand-silt sediment (to about 2.50 m a.s.l.). There are also some artefacts in green-greyish silt on the depth 2.10-2.20 m a.s.l. The maximum depth on which some artefacts were found (1.50 m a.s.l.) is linked to the northern part of the site, where present and ancient canal bed lies. The artefacts have been flooded from more elevated parts of Tell el Farkha gezira. The yellow-brownish and greenish sands are completely deprived of any archaeological remains. The sediments with artefacts contain charcoal, bone fragments, pottery and honey flint implements (of the Near East provenance).

**Archaeological implications**

The surface of the Tell el Farkha gezira (fig. 5) resembles to great extend the situation described by M. M. el-Gamili et al. in 1992. The geoelectrical research proves the existence of so-called "turtle-backs" in the Eastern Nile Delta. These are the Pleistocene sandy hills usually containing archaeological remains (el-GAMILI, M.M. *et al.* 1992).

The observation of the site profiles proves that whole gezira was partly formed of blurred anthropogenic constructions. The drillings executed in the streets of the Ghazālah village gave the results confirming this hypothesis. The drillings reveal, either a very thin layer of silt, or prove it does not exist at all (fig. 3). Floods episodes are quite well visible in the profiles as well as in the plans. Thanks to detailed observation of silt layers, bricks walls and sedimentary structures we have reconstructed several stages of site existence.

The oldest settlement came to existence on the lower parts of gezira on a thin, (0.5 m) silt sediment. This settlement sediment were discovered at geological trench W and archaeological trench W. Today this archaeological stratum forms severely damaged and sometimes completely washed out anthropogenic-natural remains. The layer of the grey Nile silt appears on them.

It has variable thickness and documents high oscillations of the Nile level (fig. 6 B, fig. 8).

Bricks of brewery were found directly on these two layers (fig. 6 C, fig. 9). High flood episodes of the Nile destroyed them in several places. This is also the time, when sediments of the Nile 1B were deposited in the Delta (de WIT, H.E. 1993). They are recorded in Tell el Farkha as well. These stages of the higher Nile level are simultaneous with interruption in the site occupation at the time between use of the brewery and the next phase of settlement around 5600 and 5300 B.P. The walls build of sun-dried bricks, which contain relatively high admixture of gezira sand (fig. 6 D), belong to this "after brewery" period. These constructions were also destroyed by the water. It can be noticed in the profiles as the sequence of layers with typical water-current structures, composed of natural silt and blurred bricks (fig. 6 E, fig. 10). The sediments are slightly lighter in colour than natural silt and contain organic detritus coming from bricks.

Subsequent remains of human origin are well visible on morphological elevations. These are fireplaces as well as next beds of sun-dried bricks walls (fig. 6 F). The bricks differ in mineral composition from the previous ones. … These edifices just like other ones were destroyed by the Nile flood or floods. There are some factors supporting the hypothesis, that this phase was not so short. The Nile constantly fluctuated up and down (fig. 7 A) maintaining quite high level all the time. Then the topmost parts of gezira were dry and suitable for human occupation.

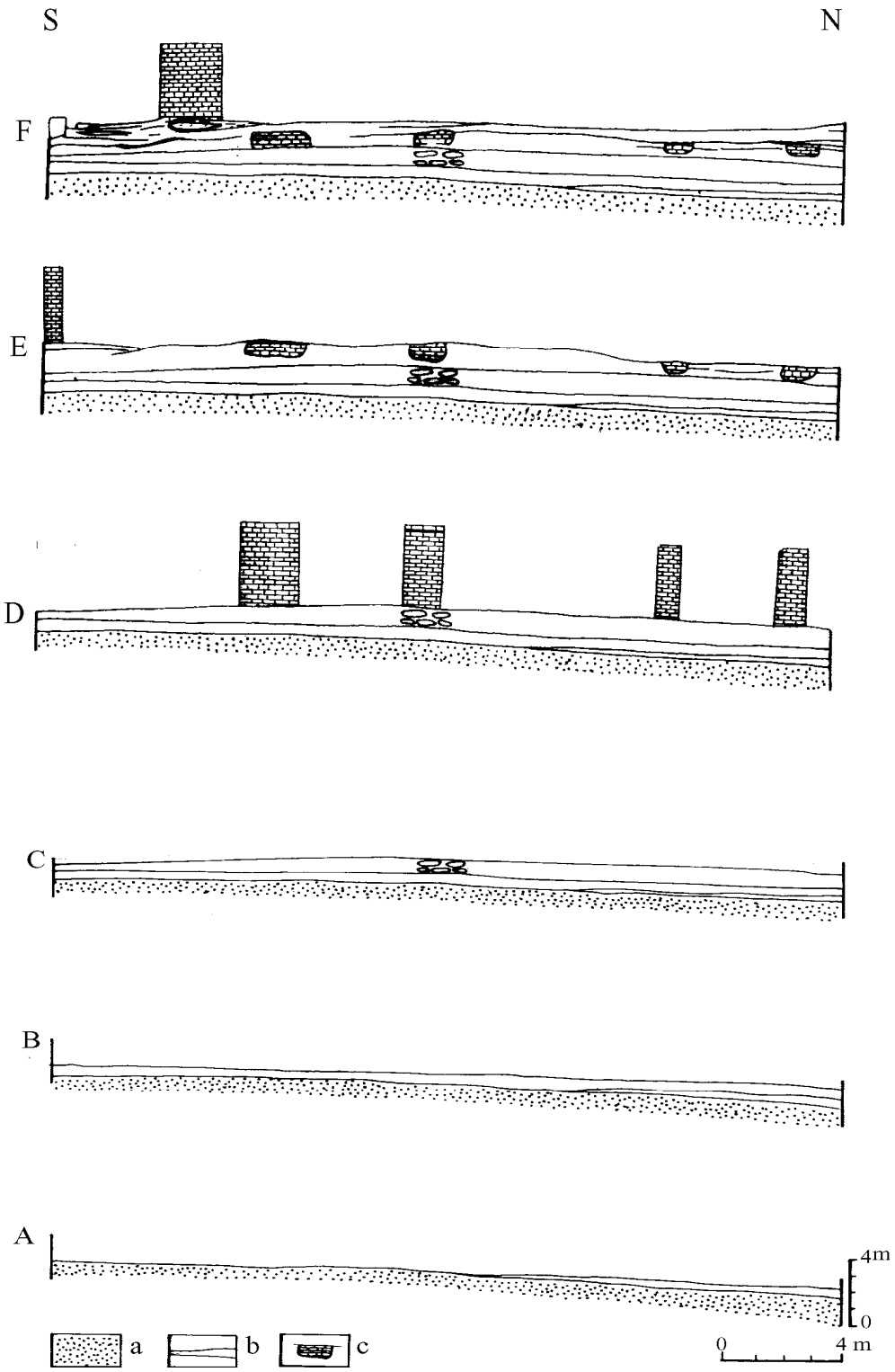



Fig. 6 A-F. Reconstruction of Tell el Farkha site sedimentation sequences (detailes in the text); a – gezira sand, b – Nile silt, c – bricks and walls.

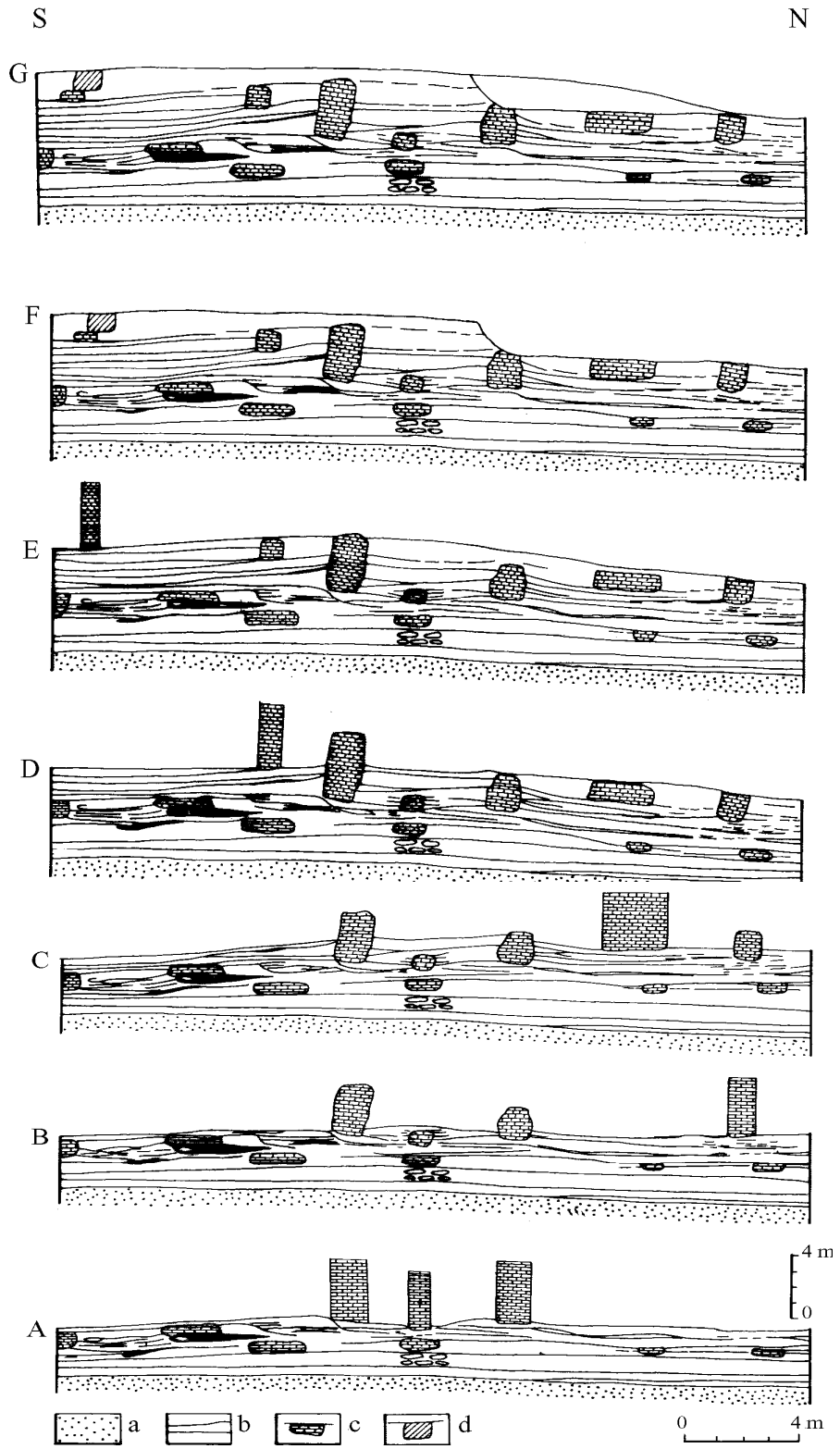



Fig. 7 A-G. Reconstruction of Tell el Farkha site sedimentation sequences (details in the text); a – gezira sand, b – Nile silt, c – bricks and walls, d – contemporary trench.

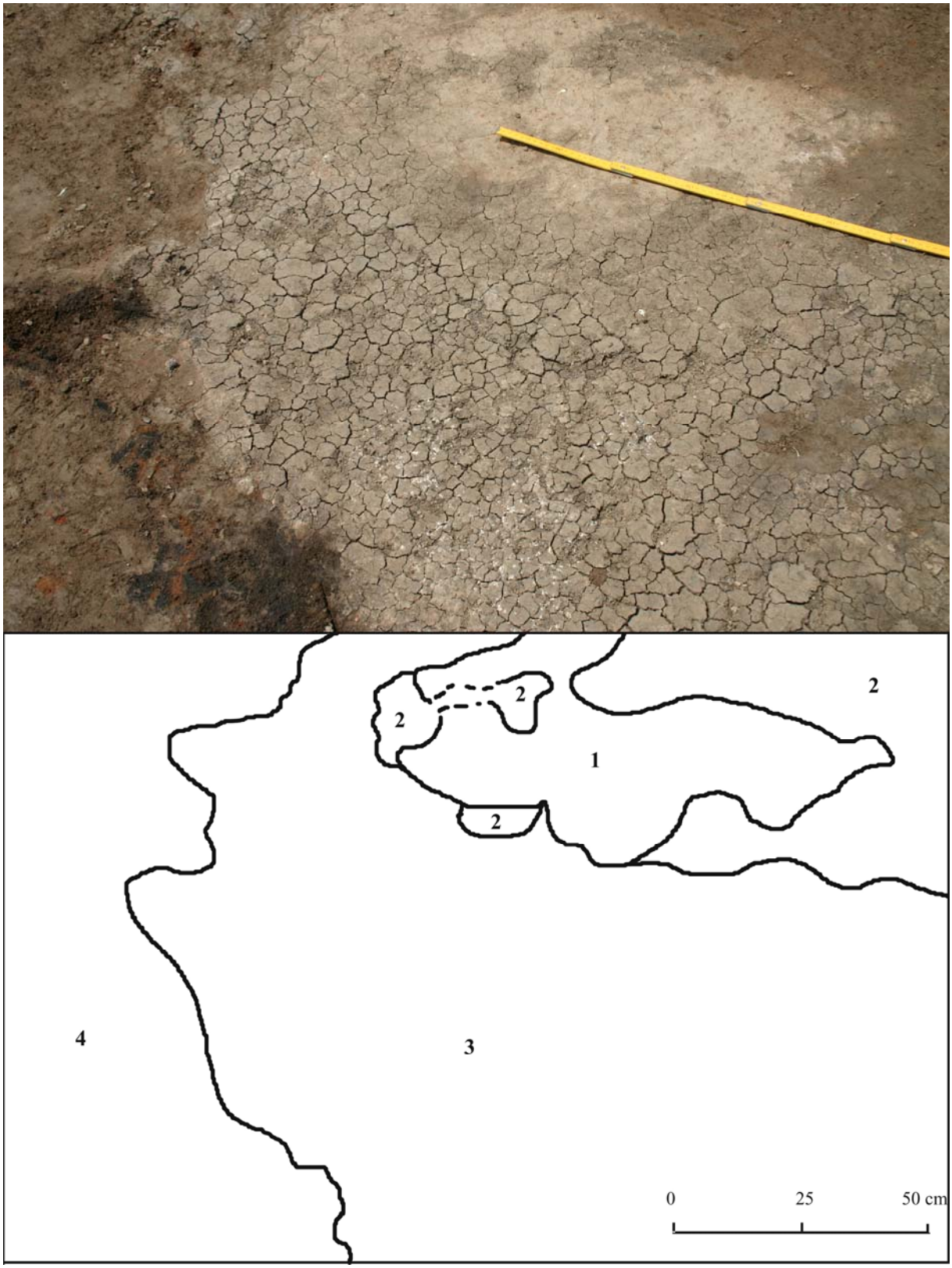



Fig. 8. Kom W, bottom of the trench W (2004), part N;

1 – gezira sand, 2 -

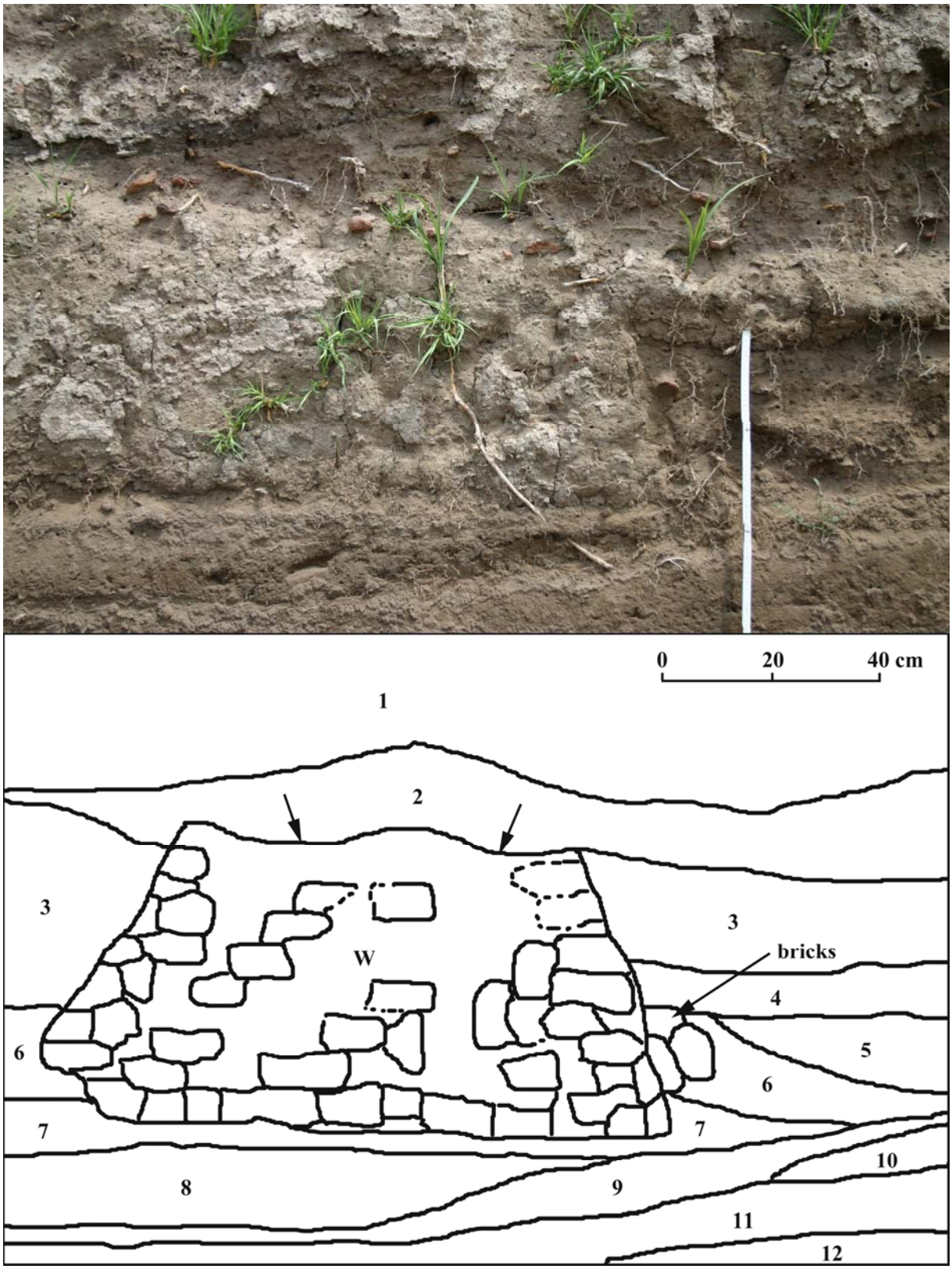


Fig. 9. Kom W, trench W (2004), profile E.

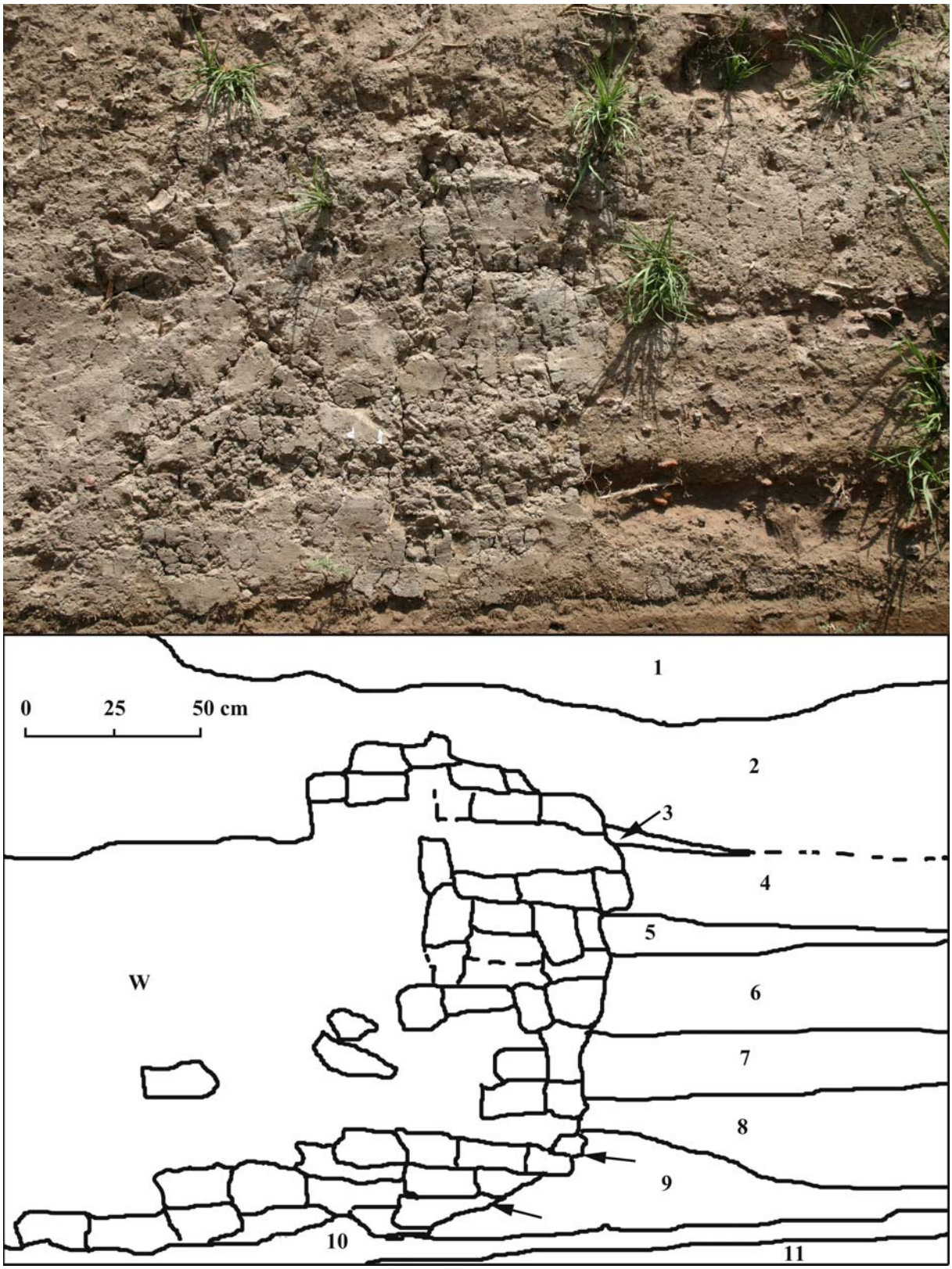



Fig. 10. Kom W, trench W (2004), profile W.

The fifth generation of walls was probably weakened and collapsed undermined by the Nile water (fig. 7 B – arrow, fig. 10). The water-current structures in the North and Northwestern part of the site well visible in the profile are in most cases typical and contain natural silt and anthropogenic materials.

The following sequence of buildings was constructed of very thick sun-dried bricks (fig. 7 B, C). The geological trench W clearly indicates, that this phase was replaced by another (fig. 7 D, E) one devoid of flood inter-phase. The construction of the walls differs form the previous one. This last stage of construction carries the traces of eolian and rain activity. The destruction of the top parts of the walls is the clear evidence of the process. The youngest human settlement is noticeable in the South (fig. 7 F) part of the site and consist of several walls. The North part (fig. 7 G) was partially taken by the water and later filled up with anthropogenic sediments.

**Conclusions**

The Tell el Farkha site was founded on gezira and was probably located near one of the Nile branches, surrounded by levees and floodplain flats (in the Predynastic time they were already maximum 2 m thick). The water streams were probably alternate with marshy grounds, swamps and waterpools. The fields suitable for agriculture were naturally watered. There was probably no artificial irrigation system around the site till the late Predynastic time.

The gezira “turtle-back” extended towards south (where contemporary village of Ghazālah is located) and was probably considered as a refugium area, since it has not been flooded in the Holocene yet. In spite of the factwe have not found any archaeological remains there. The kom situated far to the East was used as a cemantary (up to modern times), the elevations of central and western koms were settled to their North edge (steep slope). It is important to remember, that gezira was larger than today and settlement began to exist on its lower parts

on thin (0.5 m) silt sediment. Today it forms archaeological bed strongly destroyed and sometimes completely washed out. These sediments were discovered at geological trench W and archaeological trench W. The gezira was limited by the Nile channel from the North, but extended in other directions. The channel known today as Masraf Ghazālah has existed in this place since the late Pleistocene/early Holocene at least. Nile floods, their sediments and blurred anthropogenic material (sun-dried bricks) evened ancient morphology. They reduced sandy area and finally buried sandy hills. The silt sediments could be divided to at least eight settlement episodes.

The water table is about 2.30-3.00 m a.s.l. In some locations it is 0.3-0.5 m above the lowermost sediment containing archaeological artefacts. This fact, in some cases, makes the continuation of archaeological exploration to the barren subsoil impossible.

The Predynastic/Early Dynastic situation of the site resemble the general mode of settlement in the East Delta region, with the exception of terrain elevation (which was significantly i.e. 4.5-5.5 m lower), floods hight (about 1 m higher than in Dynastic time) and geomorphology, which was later (i.e. from Early Dynastic time) substantially transformed by artificial drainage and irrigation.

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**Figures**

Fig. 1. Development of the Nile Delta during the last 11 000 years (adapted from STANLEY, D.J. & A.G. WARNE. 1993a).

Fig. 2. The map of the Tell el Farkha area (□ - bore-holes, - - - 1 10 23 – Kabaciński drillings line, --- - excavation area).

Fig. 3. Generalized profile of the Tell el Farkha site sediments.

Fig. 4. 3-D map of the Tell el Farkha site (□ - water table).

Fig. 5. 3-D reconstruction of the Pleistocene sand surface in Tell el Farkha site.

Fig. 6 A-F. Reconstruction of Tell el Farkha site sedimentation sequences (detailes in the text); a – gezira sand, b – Nile silt, c – bricks and walls.

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