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# Hydrology of deltas

*Proceedings of the Bucharest symposium*
*6-14 May 1969*

# Hydrologie des deltas

*Actes du colloque de Bucarest*
*6-14 mai 1969*

*Volume 1*

A contribution to the International Hydrological Decade
Une contribution à la Décennie hydrologique internationale

IASH/AIHS - Unesco
Gentbrugge-Paris 1970

documentation pour des travaux scientifiques futurs. On espère que ces volumes fourniront aux hydrologues et aux gouvernements qui participent à la DHI des matériaux d'un intérêt tant pratique que théorique et qu'ils répondront aux besoins des techniciens et des hommes de science qui s'occupent, dans tous les pays, des problèmes de l'eau.

L'Unesco et l'AIHS ont entrepris de réaliser conjointement plusieurs projets importants de la DHI qui les intéressent l'une et l'autre; dans cette perspective, elles ont prévu un certain nombre de publications Unesco-AIHS.

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# Foreword

The hydrology of deltaic areas was included in the scientific programme of the International Hydrological Decade from its very beginning. The first session of the IHD Co-ordinating Council, in 1965, retained this topic as one of the selected projects of the Decade.

The Bucharest symposium was organized by Unesco with the collaboration of the Romanian Government and with the support of IASH as a contribution to this IHD project; the aim was to bring together specialists from different countries for a broad exchange of views based on specific experience in various parts of the world.

This symposium was preceded by another on the deltas of the tropical zone (Dacca, 1964) which was not, however, limited to the hydrology of deltas. Although certain problems are common to deltas as a whole, it is certain that those of the temperate zones present aspects which justified the organization of a symposium dealing with their hydrology. Also, the latter have the advantage of having been known and studied over a long period of time and more thoroughly.

No country could be more fitting than Romania for the holding of such a symposium as the Danube Delta enables the participants to verify on the spot the principles and results as explained by the various specialists.

It may be said that most of the problems concerning deltas were dealt with during the fifty of so reports assembled in this work. The purely hydraulic question of the discharges and particularly of their distribution amongst the various arms was of course treated very thoroughly; but this problem, like so many others, is linked to that of the movement of the sediments, a question which was treated in depth, in its multiple aspects: hydraulic, mineralogical, geological, geographical, economic. It can be said that this question of sediments constitutes the basic problem with regard to deltas.

The geological and geographical aspects, which have just been mentioned, have been touched upon by a large proportion of the authors, but many of them have dealt at greater length with the hydrological problems of recent and old deltas. The questions of "salinity" are closely linked to these problems.

Another aspect of the problem is of special interest to engineers: this is the question of the effects of man's activities, and above all of the effects of the work which men carry out with a view to using the deltas for navigation, for agriculture or even for industrial purposes.

Should one conclude from this that the subject of deltas has been fully dealt with? This is not at all the case. Many questions remain unanswered. Moreover, due to financial

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## DISCUSSION

I. *Question* by Mr. COLEMAN

You mention only one type of rapid change; modification by man that will affect delta equilibrium.

What effect does natural catastrophic events such as earthquakes, abnormal floods, storms, tectonics, etc. have on deltas?

*Réponse* de M. BANU

Les échanges naturels catastrophiques ne peuvent se produire que dans le cas d'une tectonique violente ou d'autres facteurs naturels qui ont été mentionnés par M. Coleman. Dans le delta du Danube on ne connaît pas des telles situations.

II. *Questions* by Mr. P. SANTEMA

*a*) How much has the transgression been in historic times (cm/100 years); is a breakdown in land subsidence of the deltaic material and loaming by general geologic causes possible?

*b*) In view of the considerable difficulties which one meets in developing deltaic areas for agricultural purposes and in view of the unique value of the Danube delta for studying deltaic processes (geo-morphological, hydrological, biological), it seems to be reasonable to declare a large part of the delta a protected natural reservation. Has this been done or are there any plans on this direction?

*Réponse* de M. BANU

L'oscillation du niveau de l'époque historique a enregistré des valeurs comprises entre +5 m et −4 m par rapport au niveau actuel. Le niveau le plus haut (+5 m) correspond à l'époque de « l'optimum climatique » postglaciaire que nous appelons « transgression néolithique ». Le niveau le plus bas (−4 m) correspond à l'époque « pessimum climatique »; nous l'appelons « régression dacique ». Aujourd'hui nous assistons à une transgression « transgression valaque » qui a élevé le niveau avec 4 m en 2000. ans. Sur le delta danubien on ne peut faire une distinction claire entre la transgression provoquée par les oscillations du niveau glacio-eustatique et la subsidence.

Au sujet de la dernière partie de l'intervention de M. Santema, nous considérons que le delta entier est un monument naturel et nous plaidons pour une exploitation rationnelle qui pourra conserver entièrement les qualités actuelles du biotope deltaïque.

A l'heure actuelle 10 % seulement de la superficie du delta constituent une réserve.





# Remarks on the regional geological structure of the Nile Delta

A. Shata and I. El Fayoumy,
Desert Institute, El Mataria, Cairo.

RÉSUMÉ : La structure géologique régionale du delta du Nil (22.000 km²) fait partie d'une zone de dépôts alluvionnaires majeure, caractéristique pour la région instable de la plateforme continentale du Nord de l'UAR.

Cette zone de dépôts alluvionnaires est sujette à des failles, particulièrement dans la partie sud. On y soupçconne deux catégories de failles : une, orientée nord-ouest, qui expliquerait la formation locale d'une structure semblable au graben et une deuxième catégorie orientée nord-est. A l'extrémité nord de cette zone de dépôts alluvionnaires on s'attend à une faille due aux pressions latérales orientée nord-est.

SUMMARY: The regional geological structure of the Nile Delta (22,000 km²) is a portion of a major downwarp zone characterizing the unstable shelf region of Northern UAR. This downwarp zone is affected by faulting which is felt particularly in the southern portion. Within that portion two sets of faults are suspected; the NW set of faults which account for the local development of a graben-like structure and the NE set of faults. Towards the northern edge of this downwarp zone, thrust faulting with a NE strike, is expected.

## REGIONAL STRUCTURE

Certain facts must be pointed out when discussing the regional geological structure of the Nile Delta :

1. The delta region is bounded on the eastern side by a major upwarp zone which occupies most of North Central Sinai. This zone extends westward into the "Cairo-Suez Anticlinal Horst", and is followed, in the northward direction, by a major downwarp zone which occupies most of the delta region and its extension into northwest Sinai (fig. 1).

2. The downwarp zone is affected by faulting. At least two sets of faults are suspected; faults with a NW-SE strike (Clysmic or Erythrean or African) which are particularly felt in the southern portion of the delta and give it the shape of a "graben-like structure". Another set of faults, having a NE-SW strike (Aualitic), affect the delta as well as its fringes and account for the subdivision of the delta, presumably, into two structural zones (fig. 2).

3. The sedimentary section in the delta, has an anticipated thickness of more than 10,000 metres of which about 5,000 metres belong to the Neogene (fig. 3). The occurrence of such a thick section allows the development of some mobility in the earth crust, and accounts for the possible development of strong thrust faults particularly in the northern portion of the delta. The occurrence of such fault may mark the start of another structural zone.

In the literature, little information about the geological structure of the Nile Delta can be found. Such information if principally contained in the works of Yallouse and Knetsch (1954), Sigaeiv (1962) and Shata (1965). Information of general importance, bearing upon the geological structure of the delta, is found in other sources, most important of which are :

1. Picard (1943); who placed the Nile Delta within the "folding autochtonous zone" and showed a major rift zone bounding it on the eastern side (fig. 4).

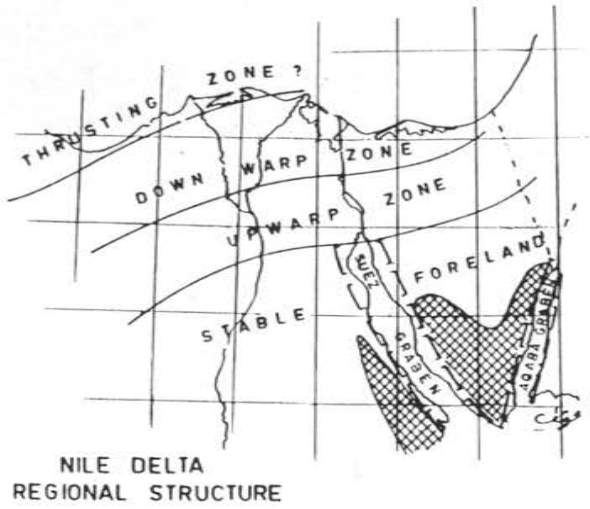



FIGURE 1.

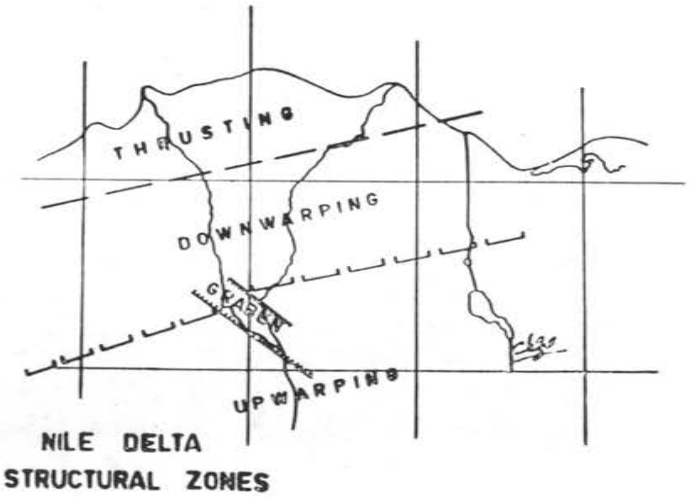
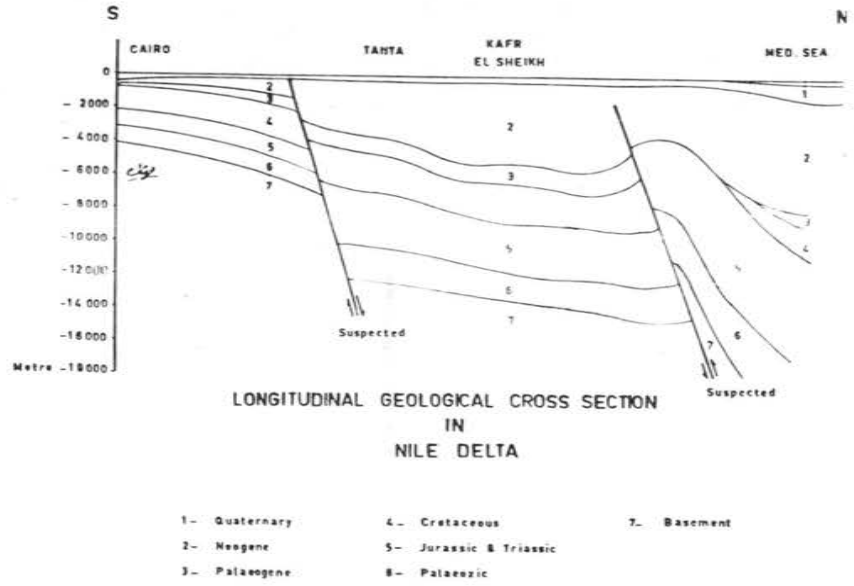



FIGURE 2.





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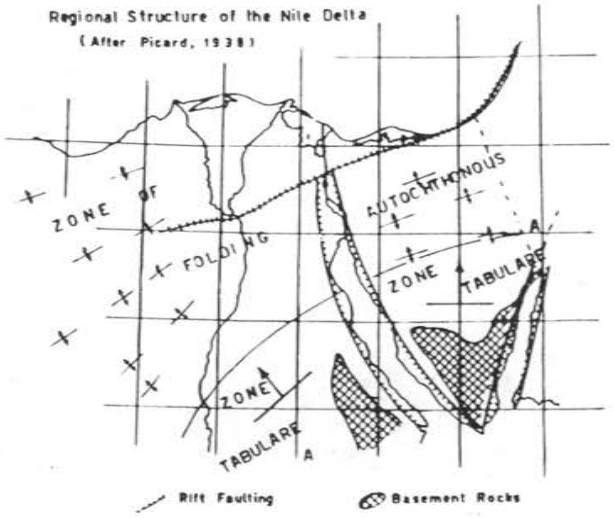



FIGURE 4.

2. Weeks (1952); who placed the delta region within the "Hinge Belt Zone" (fig. 5).

3. Said (1962); who revealed the complicated structural pattern of the regions around the Nile Delta (fig. 6).

Referring to the main article of Yallouse and Knetsch (1954), the Nile Delta is a "Graben-like" feature which was fractured in Late Oligocene times or Early Miocene times i.e. contemporaneous with the Gulf of Suez (fig. 7). According to these authors, the delta collapse "in all probability took place below sea level" (prior to this work, Lawson-1927, suggested that the formation of the Tectonic Delta Triangle took place in post-Pliocene times).

According to Sigaeiv (1959), the Nile Delta occupies a "large trough of the marginal part of the Mediterranean Sea" (fig. 8). This trough is bounded on the northern side by a deep rupture thrust fault with a latitudinal strike. On the southern side, the delta trough is affected by a series of "step sub-parallel faults" as well as by a series "of transverse faults" (all such faults are not definitely present, but presumably they are there). Again, according to the same author, the delta displays a sort of structural independence and took on much of its shape in pre-Eocene times as a result of subsidence or downwarping.

The first author (Shata 1966), described the greater portion of the area now occupied by the delta as a "major structural basin or synclinorium" which is affected by faulting (proven in the southern portion) and which made this basin develop a "graben-like structure" (initiated at the end of Eocene times and developed in Oligocene times i.e. contemporaneous with the Gulf of Suez). The same writer adds that the basalt eruptions, noted around the delta (20 m exposed and about 350 m drilled), were presumably associated with the strong rift faulting affecting that basin.

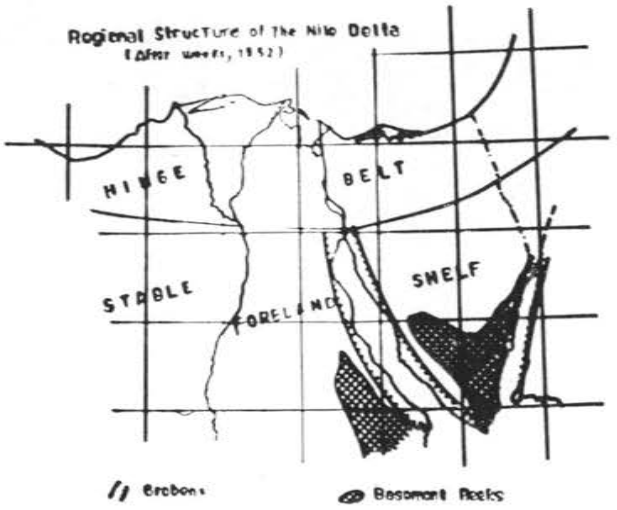
That the delta, has a genetic structural background is undoubted, but whether this structure is essentially associated with a strong fracture zone as asserted by Yalluse and Knetsch (1954) or associated with a major downwarp zone or synclinorium, is uncertain due to lack of information. Our knowledge may be in a state of immaturity and it is certain that much of what has been written about the subject, is in part hypothetical. Although we are fairly well informed about the subsurface geology of the areas adjacent to the delta (Wadi El Natrun, Burg El Arab along the Mediterranean Coast, Cairo-Suez, Cairo-Alexandria and North Central Sinai) much information is still lacking about the subsurface geology of the delta prior to the Neogene (all new gas wells terminate in the Miocene strata and few water wells reach below the Pliocene). Notwithstanding this fact, the writers wish to emphasise the major role of the down-warping phenomenon in the evolution of the Nile Delta. The delta downwarp zone balances the upward zone of the North Central Sinai (and its westward extension), which had been formed in pre-Cretaceous times and which became morphologically developed in Late Miocene times and in Plio-Pleistocene times.

Approaching the subject from another angle, we learn from the literature that the delta area is situated within the "unstable belt". Within that belt, local troughs or active zones of subsidence are witnessed at the Gulf of Suez and probably also at the Nile Delta. The characteristics of such troughs, have presumably been inherited from pre-Cambrian Basement Rocks. The delta trough received great thicknesses of sediments (exceeding 10,000 m)-figure 9, and in this respect it can be compared with the Gulf of Suez trough in which practically all the stages from pre-Jurassic to the Quaternary, are represented (Said, 1962).

With the formation of the "Upward Zone" referred to above, a major fault (or a series of major faults arranged in echelon) became developed on its northern side. This fault, having a vertical displacement of about 1,000 m (downthrow side to the north), is represented on the western side of the delta by "Ruzza Fault" and on the eastern side by "Abu Hammad Fault", and cuts the delta area approximately at Benha. It accounts for





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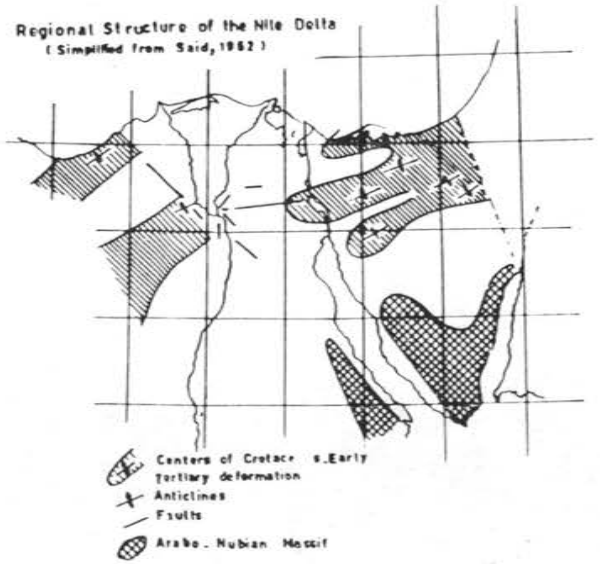


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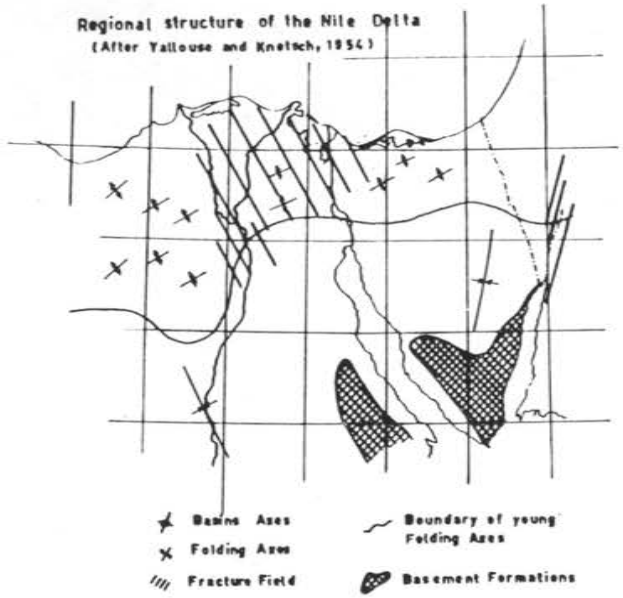


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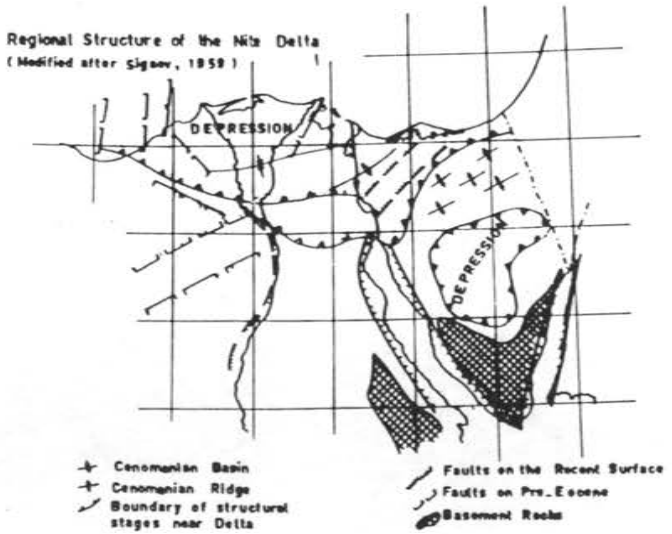



FIGURE 8.





the northward thickneing of the sedimentary column (fig. 3). The characteristics of this fault (or faults) are also presumably inherited from the pre-Cambrian Basement Rocks and movements were consequently re-initiated along its strike throughout the geological history (possibly even today).

During Oligocene times, the delta trough (downwarp) as well as the Gulf of Suez were strongly affected by a taphrogenetic phase which was accentuated by Miocene and post Miocene faulting phases. All the faults have a NW strike (Erythrean), have typical antithetical characteristics and are presumably arranged in echelon. In the southern portion of the delta, such faults are evident from more than one locality in the subsurface (figs. 10, 11, 12). Such faults account presumably, for the horizontal dislocation of the NE fault (or faults). With regard to the occurrence of the NW faults in the northern portion of the delta trough, no evidence, is, so far, available (faults are suspected and are presumably deep seated).

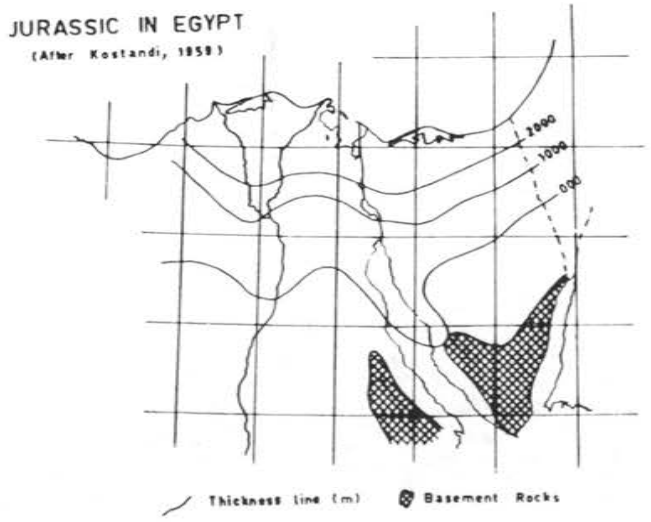
At this stage of our knowledge, the delta region can be subdivided into three structural provinces each having its own geological history (fig. 2):

1. The southern province, which constitutes a portion of the "upwarp zone" and which is characterized by a relatively thin sedimentary cover and by the development of a "graben-like structure". This province is bounded on the northern side by the NE fault.

2. The central province, which coincides with the central portion of the main downwarp zone and which is more of a synclinorium feature. This zone is bounded on the northern side by a major thrust fault oriented in the NE direction (hypothetical assumption).

3. The northern province, which marks the edge of another upwarp zone and which is typified by major folds (simply a nappe zone). We expect that such folds were truncated prior to the deposition of the Neogene.

With all such complexities, the authors may be allowed to adopt the terminology of Said (1962) for the Gulf of Suez (a taphrogeosyncline) for the region occupied by the

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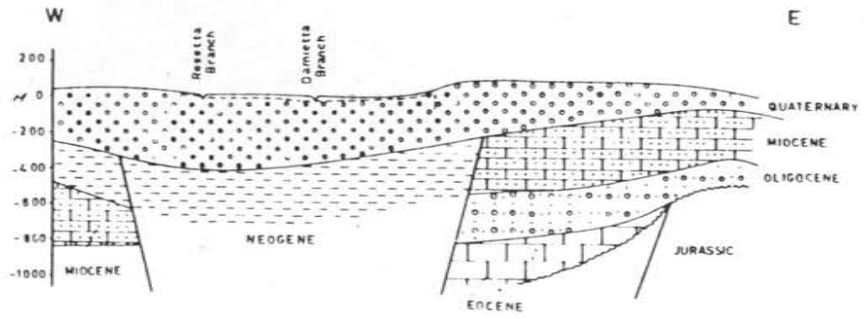


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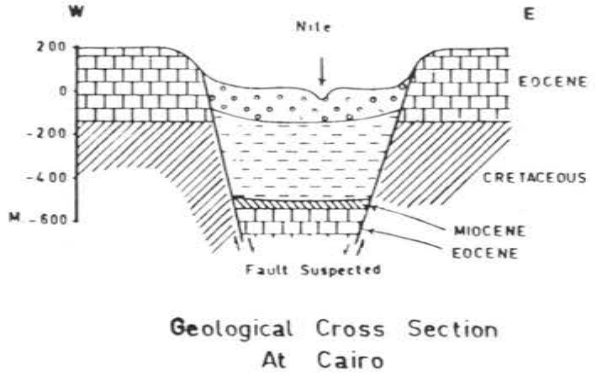


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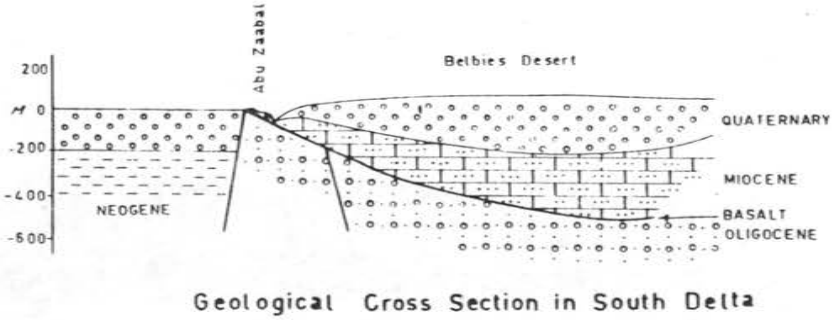


FIGURE 12.





Nile Delta. This taphrogeosyncline took much of its present shape prior to Miocene times and was a gulf in Pliocene times, but its limits cannot be easily defined. Scanty information from deep borings in the north delta region points to the occurrence of estuarine deposits followed by fluviomarine deposits (i.e. shales with interbedded sandstones) which have a thickness of about 5,000 m and which belongs to the Middle Miocene and to the Pliocene. The succession ends on top with marine shale beds (100 m) belonging to the Quaternary. The nature of this succession confirms the assumption of Yallouse and Knetsch (1954) according to which the ancient River Nile entered the delta region in post-Oligocene times. Prior to this period the Nile might have aggraded a course "following the axis of the lower Nile Basin and possibly discharged into the sea between Bahariya Oasis and El Fayoum" (fig. 13).

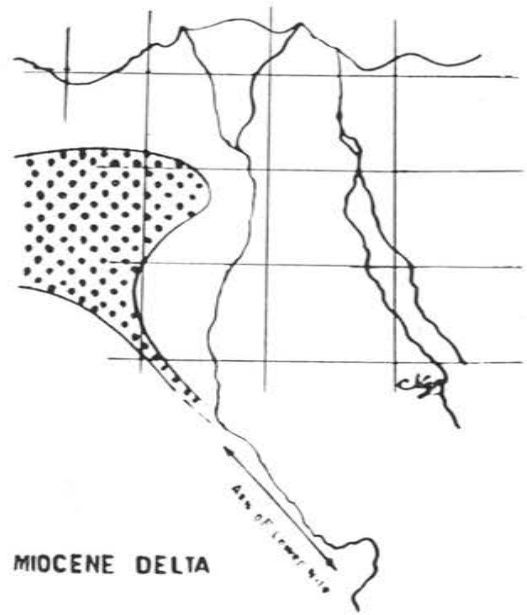


FIGURE 13.

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