# Geological aspects in Cairo subsoil development

## Aspects géologiques dans le développement du sous-sol du Caire

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SYNOPSIS By studying the geological development of Cairo subsoil through a worked out, assembled and analysed vast amount of boreholes, reports and detailed records, it has been possible to use the geological information and geological methods to obtain new information about soil condition in Cairo area. Therefore, on the geological time scale, soil deposits in Cairo area could be identified and classified on their origin and the environmental setting in which they have been formed.

INTRODUCTION

Cairo today presents primarily engineering problems of which soil and foundation problems have assumed greater importance. This is the result of increased construction activity within the city and the many plans put for establishing its accomodations, utilities and modern facilities required to permit the expanding metropolis to function efficiently.

As a result, geotechnical work, enormously augmented. Borings were made at many sites in almost every part of Cairo and the data generated has become enormous. However, most of this information has been used only to plan construction at sites from which it came and there has been a little exchange of information between these organizations. Thus no general corpus of knowledge has been established.

The primary aim of the present work is to find some order, rational form, or pattern in soil deposits in Cairo area through a synthesis of vast amount of information (1600 boring record).

In order to avoid the apparent complexity of detailed records and being blinded by the exactitude of involved tests, the approach considered here is from the point of view of geological development of Cairo subsoil. Therefore rather than direct simplification of boring records, the processes of formation of soil deposits in Cairo area are taken into account macroscopically. This could shape an idea by which they may be identified and classified however varied and complicated profiles may appear.

PHYSICAL SETTING

Cairo (Fig.1), the capital of Egypt, is situated 20 km. south of the apex of the Nile and occupies some 250 square kilometers of which the main part is on the east bank while extensive suburbs lies on the west bank. The city covers the entire flood plain which is bounded, immediately in the east, by the desert hills of Al-Muqattam and in the west by the Pyramids Plateau. The Nile River has two islands that form part of the city. The first, Zamalek Island, about 1.5 km wide, has its southern end opposite modern Cairo and extends northwards for almost 6 km. The second, Rowdah Island, farther south, opposite to Old Cairo, is not quite so large as Zamalek.

TOPOGRAPHY

The topography of Cairo may be divided into two areas of geohistorically different characteristics: the high land and the low land.

The high land borders Cairo and comprises two main parts with different elevations: the eastern high and sleep cliffs of the Muqattam Hills which rise to an elevation of 200m, and the western Pyramids Plateau which rise to a height of 90m (elevations are above ordnance datum related to mean sea level at Alexandria.

The low land, along which most of Cairo is built, comprises the entire flood plain or the Nile Valley. As it is controlled by the position of the bordering highland, it is shaped like a fan with the narrow end to the south where the Muqattam Hills and Pyramids Plateau converge on the river, and widening to the north where the Valley spreads into the Delta. Its height ranges between 18m and 21m above sea level gradually rising towards the margin of the high land. (see Fig.1 and 2).

GEOLOGICAL HISTORY

The geological history and evolution of the River Nile in Egypt was studied by many research workers (Hume, 1925; Lawson, 1927; Murray, 1949; Attia,1954; Said, 1962; Maldonado and Stanley, 1976; Abu El-Izz, 1971; Said, 1981).

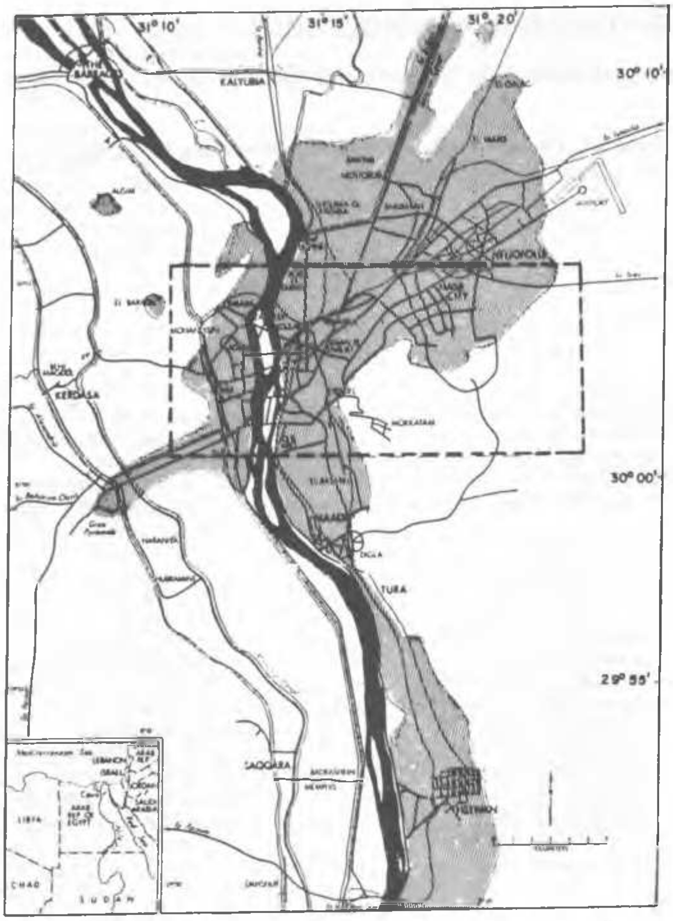


Fig.1 Cairo - Location Map and Area of Study.

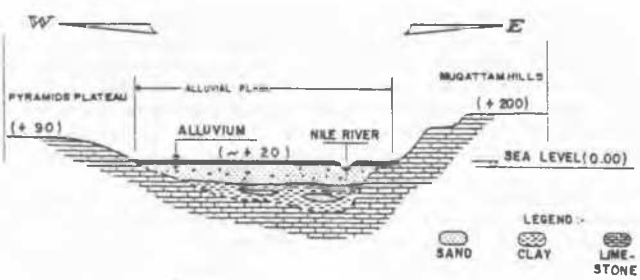


Fig.2 Section across the Nile Valley at Cairo.

At the end of Miocene, a general movement of uplift took place which produced the northwest recession of the sea and the present River Nile originated. The newly borne river started cutting a deep course for itself in the older geologic formations of Eocene limestone which now form the cliffs on both sides of the Nile.

In Middle Pliocene times, the Valley flooded by waters from the Mediterranean which converted a long stretch of the Valley into a marine gulf. This caused Marine Pliocene sediments to be deposited all along the Valley. In Cairo, these Marine Pliocene sediments are exposed on both sides of the Valley and lie with a depositional dip abutting against the Eocene limestone cliffs.

In Plio-Pliestocene, the sea water receded from the Pliocene bay. During this regression of the sea, sediments were transported northwards to the bay mouth and shore line advanced gradually towards the sea with the development of an estuary deposition. After the Pliocene deposits has completely filled the mouth of the estuary, the Plio-Pleistocene sand was laid on them.

During Pleistocene, sea level fluctuated. By flooding and retreating, the sea left patches of sediments of different periods of Pleistocene.

In recent times, alluvial deposits were formed by overbank deposition when flood waters were spilling, in period of spate, beyond the River Nile channel.

GEOLOGICAL FORMATIONS OF THE HIGH LAND

The gological formations of the highland, bordering Cairo have been investigated within the study of research workers of the geology of Egypt, (Fourteau, 1897; Beadnell, 1900; Baron, 1907; Cuvilier, 1924; Hume, 1925; Shukri, 1953; Said, 1962; Youssef, 1968; Abu Al-Izz, 1971). These formations are indicated in Fig.3 where the western side of the highland is outside the area of study. The types of formations that outcrop on the eastern side are: Upper Eocene, Middle Eocene, Oligocene, Pliocene and Pleistocene.

Eocene Formations

It is a wall like ridge of bedded limestone with a marked topographical and lithological separation. The upper unit is a series of easily identified well developed beds of a red-brown sandy limestone, shale and marl, it is dated to upper Eocene and designated as the Maadi formation. The lower unit consists of a series of massive grey to white limestones dated to Middle to Upper Eocene and designated as the Muqattam formation. At the Muqattam Cliff, the Maadi formation reaches a thickness of 66m and the underlying Muqattam formation has a thickness of 130m.

Oligocene Formations

Oligocene formations are massive fluviatile deposits which form rounded low hills of sands and gravels. They form the land between the Eocene formations in the south and Marine Miocene in the north. Their thickness vary between 70 and 100m.

Pliocene Formations

Estuarine Pliocene exposures occur as a pink limestone between Abbassia and Heliopolis. Marine Pliocene exposures occur as a strip of yellow sands and brown sandstones at the foot of the Muqattam Hills.

Pleistocene Formations

Pleistocene exposures in Cairo are represented

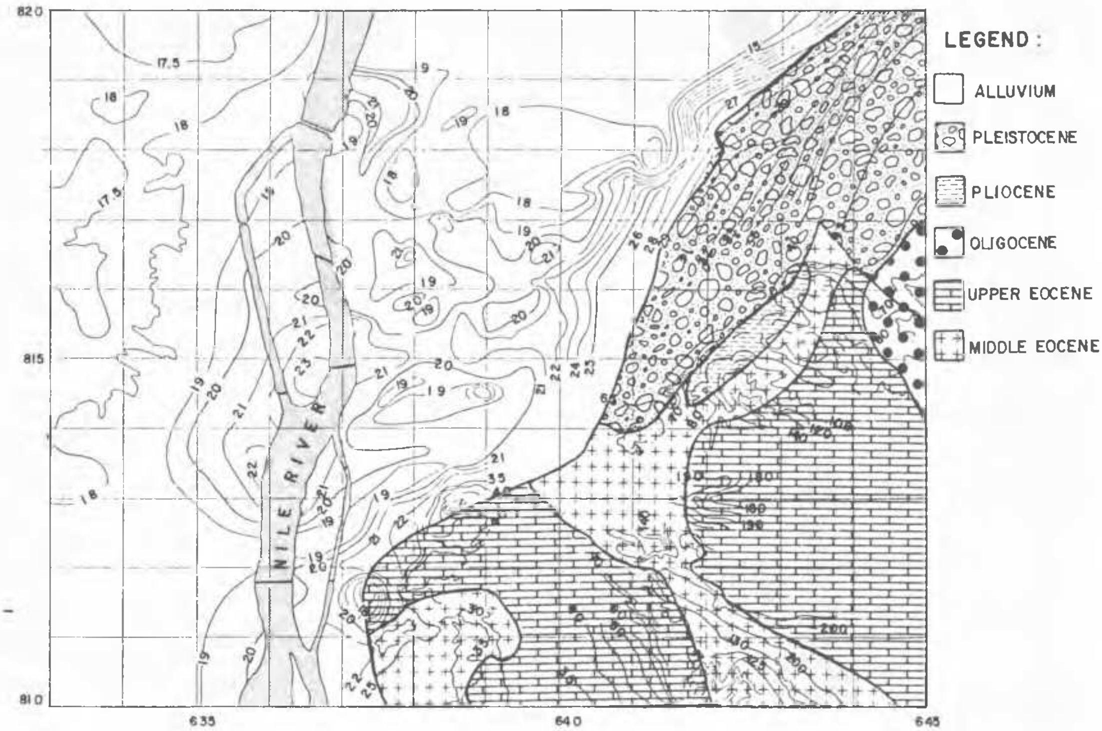


Fig.3 Cairo Area - Topography and Geological Map

by river terraces which are gravelly in appearance. On the east, they occur as a conspicuous terrace at an elevation of 45m between the Citadel and Heliopolis.

GEOLOGICAL FORMATIONS OF THE LOW LAND

The study of the sedimentary history of the fluviatile deposits of the Nile Valley show that the valley has been filled with deposits ranging from Pliocene to recent sediments. These sediments, which constitute the valley fill are river borne deposits. However, they may be classified on their node of formation into alluvial and diluvial deposits. Alluvial deposits are formed by flood water in recent times, whereas diluvial deposits are soil deposits at delta formed in earlier stages of river developments.

Characteristics of Alluvial and Diluvial Deposits in the Low Land

The process of formation of flood plains (alluvial deposits) and of estuary deposition (diluvial deposits) as well as their characteristics were studied by various research workers (Twenhofel, 1950; Attia, 1954; Krumbein and Sloss, 1963; Holmes, 1975; Abu Al-Izz, 1977).

The typical process of formation of Alluvium is by overbank deposition; While the river is flowing through a flood plain, a natural levee and a backmarch are developed. These are related to the period of spate, when flood waters spilling beyond the river channel suffer a sudden decrease in their rate of flow. Settling of the load of suspended sediment takes place in the slack water covering the flood plain. Coarse sand and gravel are concentrated at the levee during an overflow and, as a result, only fine grained materials (clay and silt) stagnate and are deposited at the backmarch.

As a result of the sedimentary history of the Nile delta, the process of deposition of diluvium at sea shore in Cairo area may be described as follows: With the decrease of water velocity, coarse sand and gravel are first dropped during the fluvial transportation and, in the vicinity of a mouth of river finer sand is deposited. Then towards offshore, silt and clay are deposited in this sequence. As a rule, the shore line tends to advance gradually towards the sea with the development of an estuary deposition. This is the process of a delta deposits formation and in this case the downward sequence of soil layers is coarse grained cohesionless soils and fine grained cohessive soils, respectively.

MAPPING

The present study is based on 1600 boreholes and detailed records gathered from several government bodies, firms, organizations, consultants and contractors who have been engaged in site investigation in Cairo. The knowledge obtained was then expressed in maps (see Fig.3,4 & 5).

Topographic Mapping

Survey map of Cairo show the configuration of the land outside the bourdaries of Cairo in terms of contours lines. Therefore, by the use of Survey Department book of description and elevation of standard points in Cairo

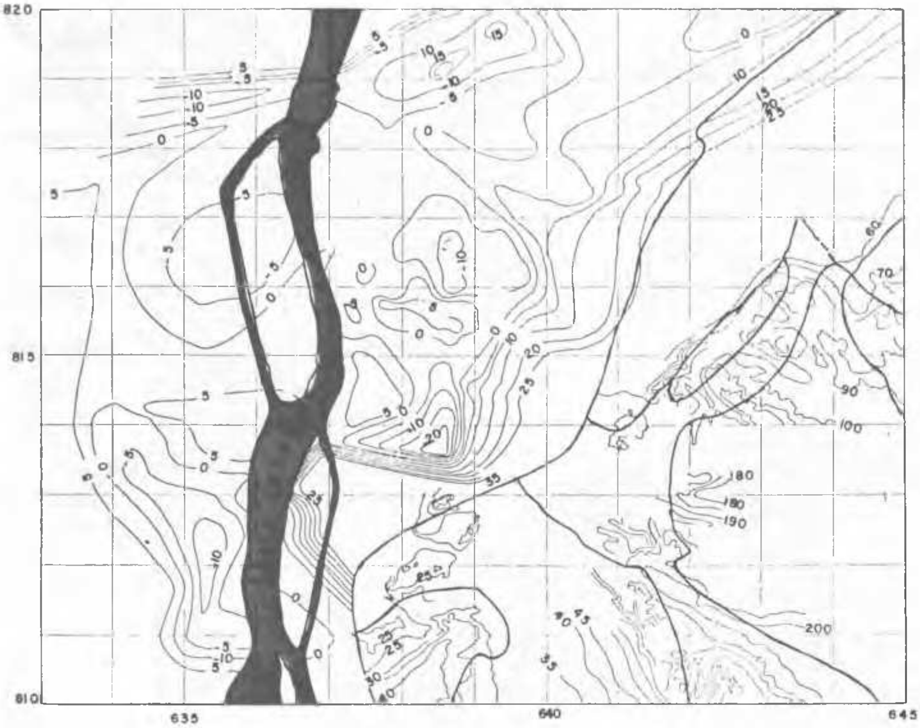


Fig.4 Cairo Area - Contour Map showing Top of Dilluvium

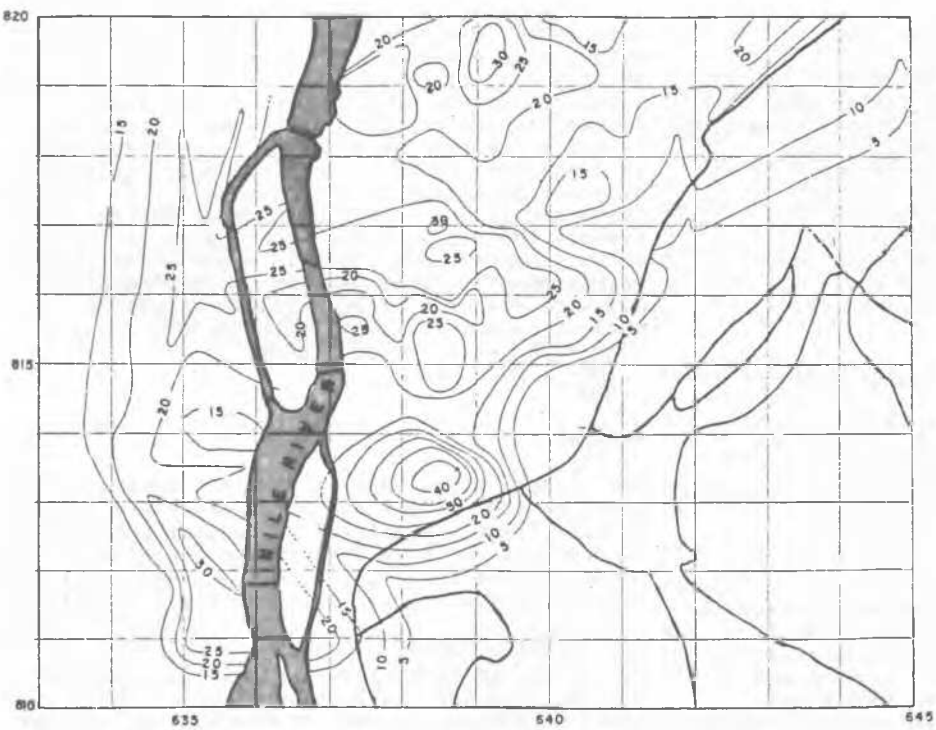


Fig.5 Cairo Area - Isopach Map of Alluvial Deposits

and elevations at boreholes locations indicated on some of the sources, it could be possible to trace the contour lines within Cairo area. These contours were connected to the corresponding contour lines of ground elevation outside Cairo boundaries to produce a topographic map of the area of study (see Fig.3).

Top of Diluvium Contours and Total Thickness of Aluvium

With the previously mentioned sedimentary aspects in consideration, alluvium could be sharply marked off from the underlying diluvium.

Alluvial deposits, formed by flood water are fine grained, dark in color, and with pronounced stratification. Diluvial deposits, being soil deposits at delta, are light in color, with more complex nature and their downward sequence is coarse grained cohesionless soils and fine grained cohesive soils respectively.

Therefore, for each borehole, the top of diluvium had been identified and its elevation with respect to sea level could be determined. This was presented by contour lines which represent reduced level of bed and strata boundaries with respect to sea level (see Fig.4). Then isopach map of the thickness of alluvial deposits in Cairo was produced (Fig.5).

## CONCLUSIONS

1- The topography of Cairo can be divided into two areas of geohistorically different characteristics: The high land and the low land.

2- Types of formations that outcrop on the high land are: Eocene, Oligocene, Pliocene, and Pleistocene.

3- Considering the mode of formation of the low land, they could be classified into alluvial and diluvial deposits. The first are soil deposits by flood water laid down in recent times, whereas the second are soil deposits at delta and formed in earlier stages of river developments.

4- Based on the above mentioned characteristics, the alluvial deposits could be easily identified from of the underlying diluvium in the 1600 boreholes in Cairo area. As a result two maps could be produced: The first shows the levels of top of diluvium with respect to sea level presented by contours (Fig.4), and the second is an isopach map of the thickness of alluvial deposits in Cairo (Fig.5).

5- The above two maps indicates that average thickness of alluvium in Cairo area is about 20m. which decreases gradually towards the boundary cliffs.

6- The minimum value of 5 meters of alluvium overlying the eastern cliff (see Fig.5) indicates that the river must have flooded in prehistoric times at a relatively high level.

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