Development of geotechnical map using a geographic information system

Dévelopement du plan geotechnique en utilisant le systeme d'information geographique

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ABSTRACT: This research is directed to provide geological, and geotechnical maps of Fayoum Oasis, using the Geographic Information Systems GIS techniques. The chosen area is located 80 km south west of Cairo between " 30° 21′ 15" and 31° 5′ 00" longitude, 29° 5′ 27" and 29° 34′ 54" latitude". The work is based on 450 borings distributed allover the study area of 1700 km^2. Evaluation of the GIS output information is checked.

RESUME: Cette recherche est menée Pour fournir une carte topographique, geologique et geotechnique, de la oasis de Fayoum située a 80 km sud-ouset du Caire, en utilisant le systéme d' informations geographique (SIG). La région est située entre longitude " 30° 21′ 15" et 31° 5′ 00" et entre latidue 29° 5′ 27" et 29° 34′ 54". Létude est basée sur les renseignements obtnues de 450 sondages excutés et distribués sur 1700 km^2 de la région choisie . Critique du renseignement du SIG est aussi examiné.

1 INTRODUCTION

Geographic Information Systems (GIS) allows preserving and utilizing any data. Also it provides the facilities to capture, manipulate and analyze the results in graphical and statistical form. GIS started to be heavily used in the last 25 years. According to the rapid development of the computer technology, GIS have been applied on many fields such as geology, earthquakes and floods, by Clifford (1993), Nickolas & Maowen (1993), and Fletcher (1997), respectively. It is believed that applying GIS to the geotechnical field is greatly needed. The results provide engineers with enough information for taking the right decision in environmental and development aspects. In addition GIS allows continuous updating the collected data and adding more design parameters whenever needed.

This work is accomplished through three stages, namely forming the database, running the GIS program, and producing the information maps in layers. Each layer can be obtained separately or combined with any other one. The application of the GIS for El-Fayoum Oasis including the geotechnical field is chosen for two reasons. Firstly soil at this district belongs to "desert" formations, including problematic soils,and varies widely from the Nile Valley formations. Secondly, the available input information data were abundant from 450 boreholes. Figure 1shows Fayoum location and streams distribution, Figure 2 illustrates sites of boreholes.

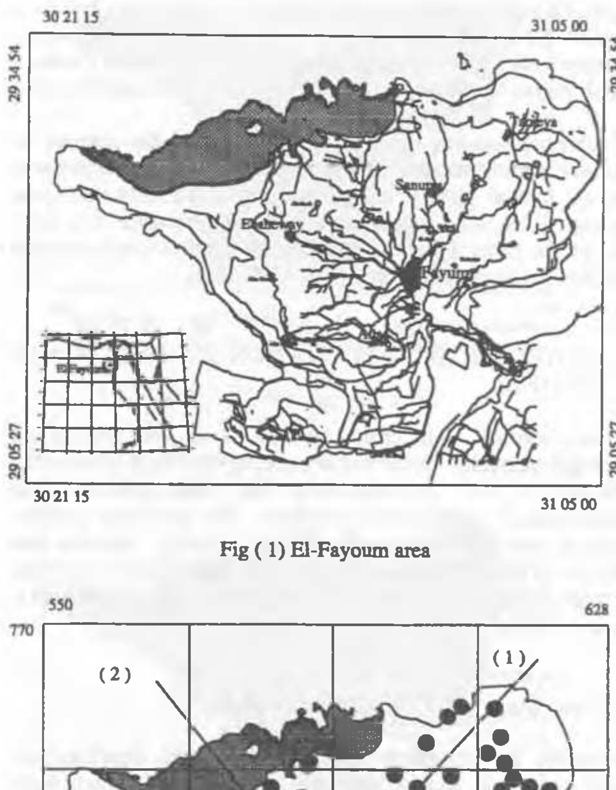

Fig (1) El-Fayoum area

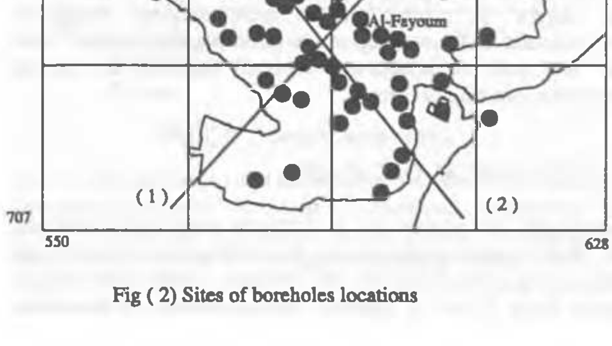

Fig (2) Sites of boreholes locations

2 GEOLOGY OF FAYOUM

El-Fayoum is a circular depression situated in the western desert of Egypt, adjacent to the west of the Nile Valley and at about 80 km south west of Cairo, Figure 1. The depression has an area of approximately 1700 Km^2. It is closely connected with the River Nile by a narrow channel (Bahr Yousef) through the desert hills. The entire district of El-Fayoum drains into a shallow brackish lake called Qarun lake which occupies the northern and lowest parts of the depression. Qarun lake has an area of less than 200 km^2. It has an elongated shape, with the long axis lying east - west; and it has an elevation of 45 m below sea level. Figure 3 shows the geological map of Fayoum. Beadnell (1905) described in detail the succession of rocks of El-Fayoum, as follows:

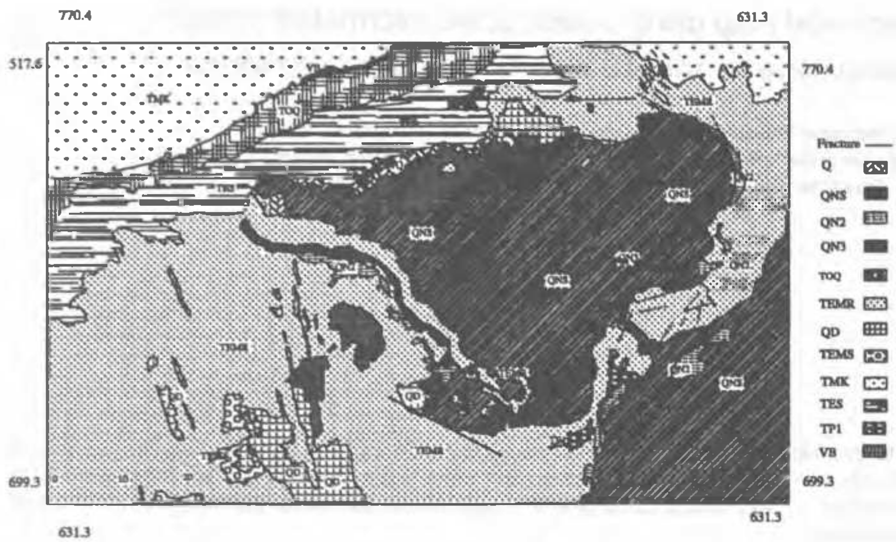

Figure 3. Geology of El-Fayoum

- Pleistocene lacustrine deposits
- Pliocene
- Gebel Khashab red beds (Lower Miocene)
-Basalt (Oligocene)
-Gebel Qatrani formation (Fluvio-marine sries) (Oligocene)
- Qasr El-Sagha formation (Upper Eocene)
-Berket Qarun formation (Upper Eocene)
-Ravine beds Gehannam formation (Middle Eocene)
-Wadi Rayan formation (Middle Eocene)

Geological studies by Said (1962) revealed the absence of Pliocene sediments and indicated that the Fayoum depression was an upland plateau during this period. The depression was excavated by wind action during Upper Pliocence and early Pleistocene times. Later on, the depression had access to the Nile sediments (alluvium) covered most of this area.

3 GEOTECHNICAL INFORMATION BY TRADITIONAL METHOD.

Twenty vertical soil cross sections from 450 borings are prepared manually. Nine sections are constructed parallel to the direction of the soil deposition. The other eight are taken perpendicular to the former sections. The last three sections cover a new developing area. Figure 2 show direction and position of two of these sections. Figures 4 and 5 show these two vertical sections, the first is perpendicular, and the second is parallel, to the soil deposition, respectively.

3.1 *Description of the Soil Vertical Sections*

Generally, the topography and soil deposition direction have great impact on soil formations. As illustrated in Figures 4 and 5, thirty meters difference is found between the highest and lowest elevations through these cross sections. Interference of soil layers is noticed in the eight sections which are perpendicular to the soil deposition direction. On the other hand, the nine soil vertical cross sections, parallel to the soil deposition, are simply formed.

4 GEOTECHNICAL DATABASE

Two stages are carried out to form the geotechnical database. The first stage is collection of the information related to the geotechnical data from the 450 borings. Depth of the borings ranged from 15 to 20 meters. The second stage is directed to

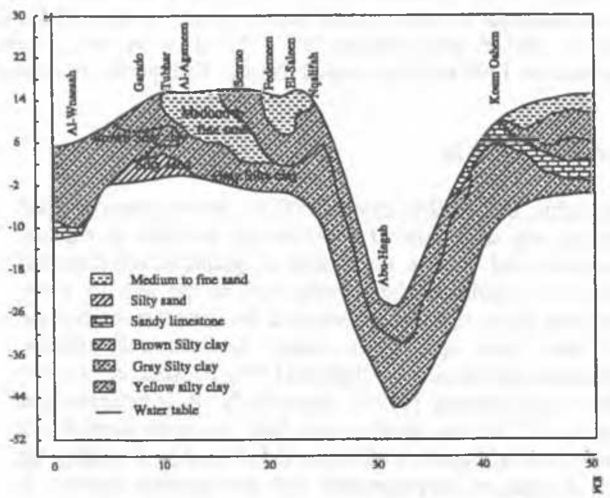

Figure 4. Section (1-1) perpendicular to soil deposition

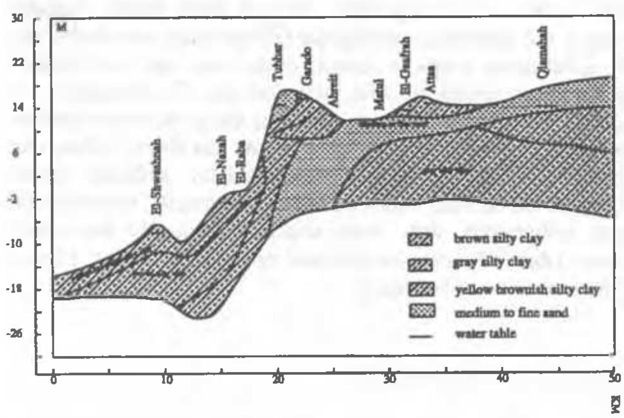

Figure 5. Section (2-2)parallel to soil deposition

transforming the collected data to a suitable form for the use of the GIS program (ARCINFO). Also administrative data are recorded to produce maps covering this field of knowledge.

Surveying information of the locations of the accepted boreholes are recorded by using the Global Position System (GPS-Sokkia). Geotechnical information stored in data base for each boring contains soil layers formation, ground surface and water table levels. Numeric and alphabetic codes are usually used to transform soil information data into digital form, the latter code was preferable to be used because of the difficulty for

Table 1 Verification of GIS at Site (4)

Item	GIS	Boring data
Coordinate	579.2,743	579.8,742.9
Level	+18	+14
Layers :		
Number	3	3
Sequences		
Silty clay (brown)	2 m	3 m
Silty clay (gray)	2 m	---
Silty sand (grayish green)	---	3 m
Sand	6 m	4 m

Table 2 Verification of GIS at Site (8)

Item	GIS	Boring data
Coordinate	599.25,727	600,728
Level	+20	+25
Layers:		
Number	2	3
Sequences		
Sand	---	1.5 m
Silty clay (brown)	6 m	5.5 m
Silty clay (gray)	4 m	3 m

the user to understand the numeric code without the key of its number. The used code was divided into seven parts as follows:

First	Position of boreholes.
Second	Type of soil or rock.
Third	Sand particle size and its adjective.
Fourth	Color of soil or rock.
Fifth	Consistency and the strength of soil.
Sixth	Stratification of the soil layer.
Seventh	Type of problematic soil.

4.1 *Geographic Database*

Geographic database for this study consisted of 14 Layers, each expressing certain information. All coverages and their features were tabulated. The application of the GIS in the geotechnical engineering for the studied area provides complete descriptions of the soil, geology and topography information. These information are presented in maps, as shown in Figures 6 to 11, which could be recalled separately or all together.

5 RESULTS AND ANALYSIS

5.1 *GIS and Traditional Methods*

Both GIS and traditional methods depend mainly on the quality of the collected data. Soil layers information obtained from vertical cross sections, prepared manually in this study, indicate vertical view of soil layer for an average width of 5 km around the section, while GIS method provides maps reflecting soil information in layer. Therefore, a combination of GIS and traditional methods could be very useful for a full picture of soil formation.

5.2 *Verification Method*

Ten new borings were executed randomly in ten sites in the studied area. GIS data at the nearest place to the position of the newly executed borings was recalled. Examining the GIS output data with the results of ten borings was focused on : 1) Soil formations, 2) Sequences of the soil layers, 3) Thicknesses of soil layer. Tables 1 and 2 show differences between GIS results and soil profile of the verification executed borings in two sites.

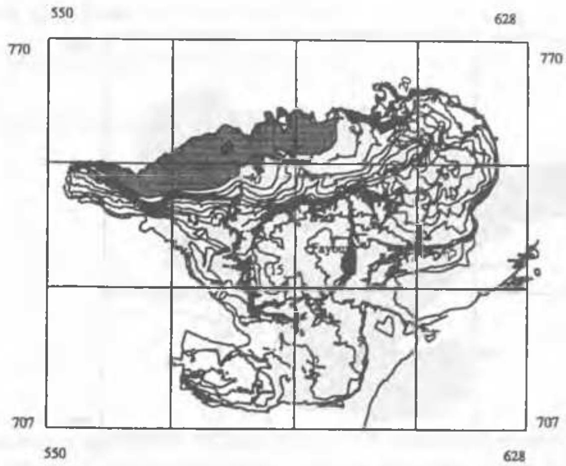

Fig. (6) Topography feature of the Fayoum Oasis

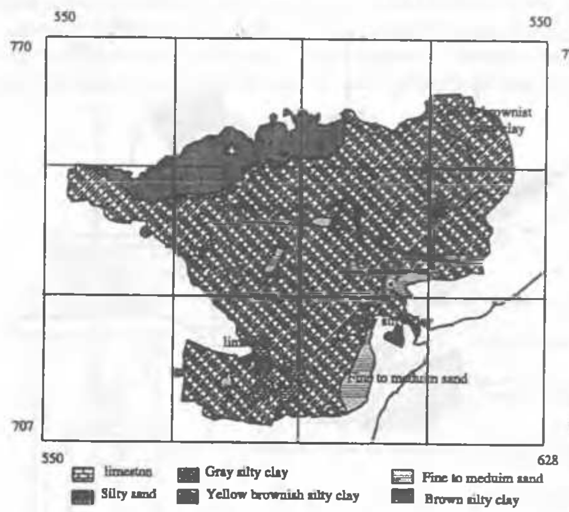

Fig. (7) First layer of soil

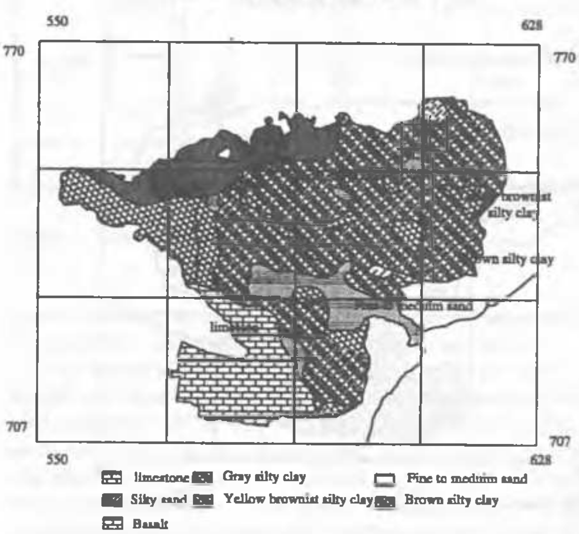

Fig. (8) Second layer of soil

As for soil formations and sequence of soil layers, no significant variations in results were noticed. However, thickness of soil layers were found to vary and even sometimes disappear. This could be attributed to the change of topography at the site.

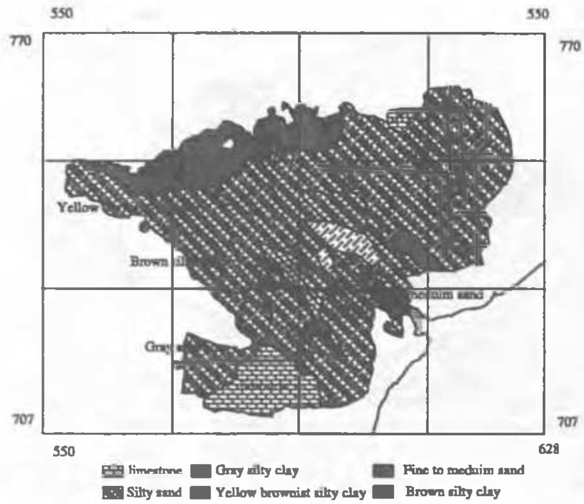

Fig. (9) Thrid layer of soil

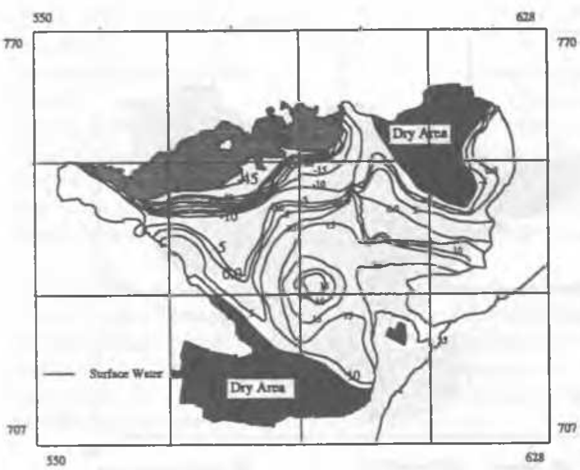

Fig (10) Subsurface water

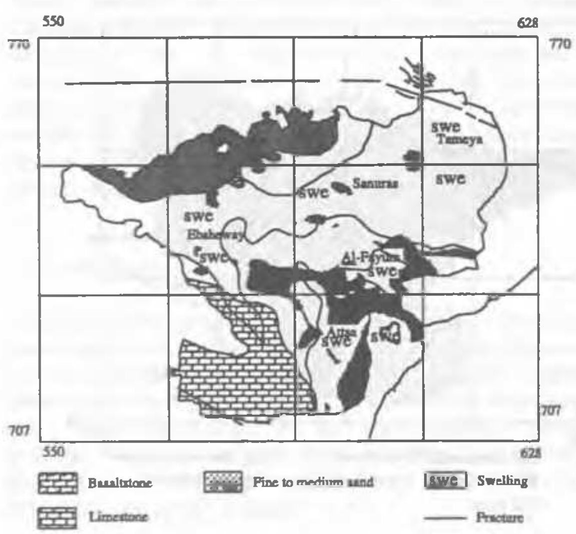

Fig. (11) Soil and rock zones

5.3 Analysis of Subsurface Water

Topography and contour lines of subsurface water in Figures 5 and 10 show that the level of the ground and the subsurface water are descending towards Qarun lake, the difference in elevation between the south and north is about 60 m. Therefore the direction of movement of surface and subsurface water in the area are directed to the north where Qarun lake exists.

6 CONCLUSIONS

a) Application of GIS on El-Fayoum was chosen because of the abundance of soil data available (450 boreholes).
b) El-Fayoum is a depression situated 80 km south west of Cairo. This depression is 45 m below sea level. It was excavated by wind action during Upper Pliocene and early Pleistocene.
c) Topography of the area shows that it descends from south towards Qarun lake . This explains the movement of subsurface water which is directed to Qarun lake.
d) The GIS data were interpreted into four maps, Figures 7 to 11. They reflect soil information at different layers.
e) Result of GIS were verified using 10 borings. Tables 1 and 2 indicated the likeness and the differences between results of GIS and borings data.
f) This work is made to assist for regional assessment of soil formations, and programming of soil investigation.

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