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Study of ground water potentialities of the Nubian formation in the Western Desert of Egypt using gravity data

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ABSTRACT

The Nubian Sandstone Formation, which has a regional extension in Egypt and the neighbouring countries, is regarded as including the most promising ground water reservoir in the area. It is deposited on the surface of the basement rocks. The basement relief map, which is constructed on the basis of gravity data for the northeastern portion of the Western Desert, is analysed together with the drill holes information for determining the configuration of the sub-Nubian surface and its effect on the thickness distribution of the Nubian Formation as well as on the occurrence, movement and quality of ground water. It is of interest to indicate that (1) the Nubian stratigraphic interval varies in thickness from less than 250 m to about 2110 m, being greater towards the north, (2) the aggregate thickness of the Nubian Sandstone section varies approximately from 100 to 1000 m, (3) the depth to the top of the Nubian Sandstones varies from about 250 to 3500 m, (4) the northward movement of ground water is restrained by El Bahariya–El Khatatba basement ridge as well as several fault systems associated with the ridges, and (5) ground water of good potentialities is expected in the southwestern portions of the area.

INTRODUCTION

The study area is located in the Western Desert of Egypt between Latitudes 28° 30′ and 30° 30′ N and Longitudes 29° 00′ and 31° 30′ E (Fig. 1).

The importance of the Nubian Sandstones as a ground water reservoir lies in the following facts:

(1) They have great thickness ranging between 500 and 1600 m as recorded in some parts of the Western Desert. They are found in successive strata separated by thin layers of shale and shaley limestone. They are known to be deposited on and along the surface of the Pre-Cambrian basement rocks and continue upward to underlie the younger members of the Cretaceous deposits (Farag 1959).

(2) They have an enormous water storage capacity as has been proved by the discharge of many of the flowing wells present in some parts of the Western Desert, e.g. 103,300 m^3/day in Kharga Oasis, 187,000 m^3/day in Dakhla Oasis and 54,600 m^3/day in Bahariya Oasis (Borelli & Karanjac 1968).

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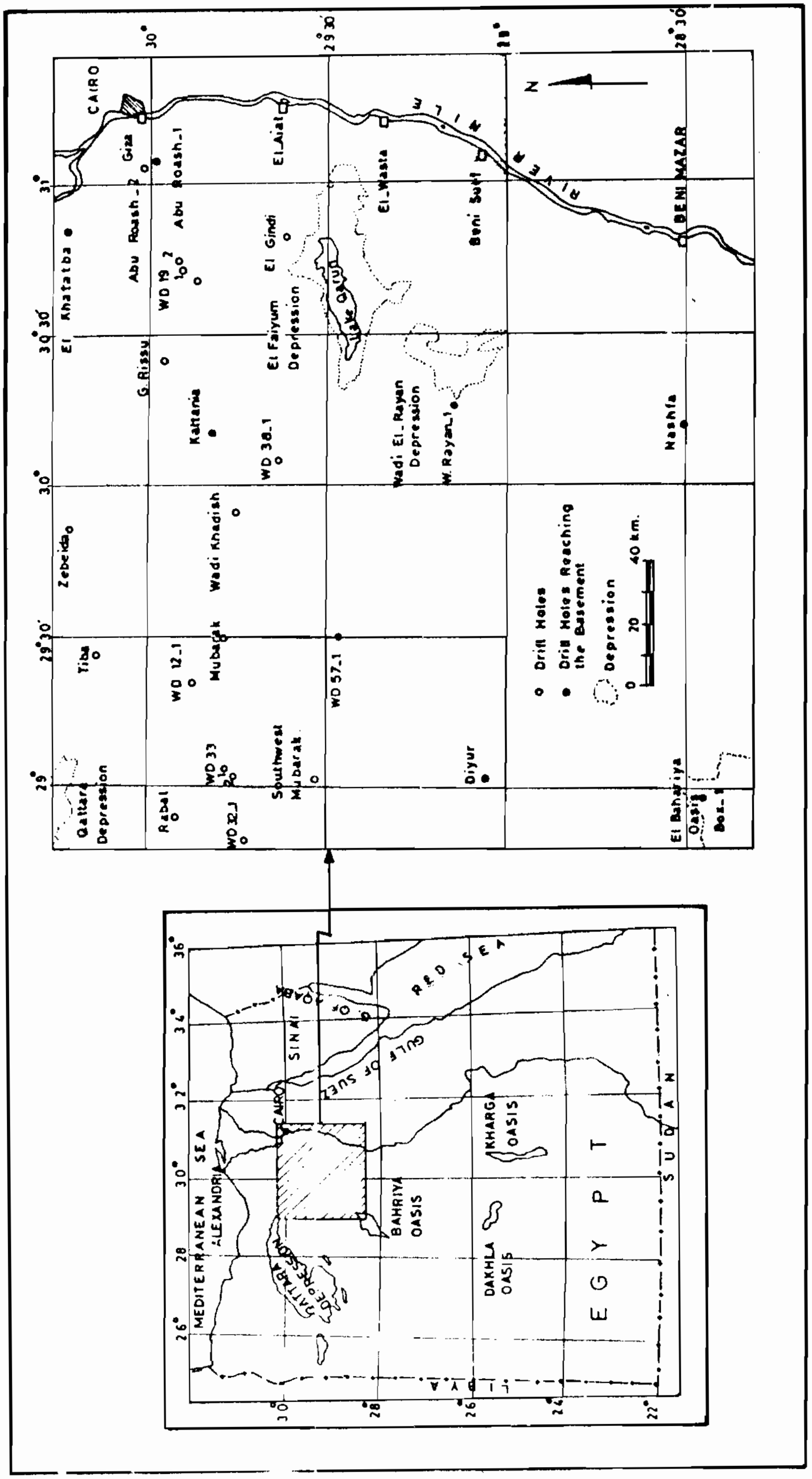

Fig. 1. Location map of the study area.

(3) They have been proved to have water of good quality in many localities where water salinity is as low as 150 ppm (Ezzat 1974).

(4) They are known to have a regional extension in North Africa and follow—in the present area—the general trend of the sedimentary succession which dips gently towards the north.

(5) They are believed to be continuously replenished by the rainfall on the Abyssinian Plateau and on the area between the Sahara and the Lybian Desert; replenishment from rainfall on the high mountains of Equatorial Africa is another possibility.

Previous geophysical work was conducted in the study area in the form of local surveys, mostly by oil companies. No attempts were made to interpret quantitatively any of the observed geophysical fields in relation to the deep ground water reservoir of the Nubian Sandstone.

GENERAL GEOLOGIC SETTING

The study area is about 250 km in length and 215 km in width and is characterised by an almost featureless plain cut by the occasional depression of El Faiyum–Wadi El Rayan, as well as the local folded and faulted complexes of Abu Roash and El Bahariya. The surface is covered mainly by the northerly gentle-dipping Tertiary strata (Fig. 2). In the northern and northeastern portions of the area, Pliocene, Miocene and Oligocene sediments are the dominant surface outcrops, while in the east, south and southwest, the surface is covered mainly by the Eocene rocks. Recent and Nile alluvial deposits are restricted to the Nile Valley and El Faiyum Depression. The continental sands and sandstones covering the area make it difficult to get any useful information on the subsurface geology or structures. However, such subsurface information, particularly on the basement complex, can be obtained from the basement relief map (Fig. 3) as well as the information obtained from holes drilled in the area (Table 1). Such a study reveals that the sedimentary section increases in thickness from about 550 m in the south (Nashfa well) to about 4000 m in the north. The northward increase in thickness is not regular due to the presence of either basement structural highs or deep depositional centres where the sedimentary section reaches a thickness of more than 3500 m.

CONFIGURATION OF THE SUB-NUBIAN SURFACE IN RELATION TO GROUND WATER POTENTIALITIES

The study of the two N–S profiles shown in Fig. 4 derived from the basement relief map, as well as the major structural elements present on the basement (Fig. 5), indicate that:

(1) Several depositional centres are present in the form of closed troughs, e.g. at Mubarak, southwest Mubarak, El Gindi, Kattania, north of Lake Qarun, northwest of El Bahariya, north of Diyur and south and southwest of Wadi El Rayan. In such localities thick Nubian sections are expected and may thus be regarded as centres of ground water accumulation. Following the same line of reasoning, relatively thin Nubian sections are expected on basement high areas as at El Khatatba, Abu Roash, Rabat, east of Diyur, east of Wadi El Rayan and north of Beni Mazar.

(2) Along the steep slopes of the basement surface, fault systems are expected to restrain the ground water movement. Particularly important is the regional NE–SW fault system that brought about the central uplifted zone extending from El Bahariya to El Khatatba. This regional fault system, together with the basement ridge extending in the same direction, form a barrier which limits the recharge of fresh ground water believed to be coming from the south. This allows, in turn, the Nubian aquifer in the northern and northwestern portions of the area to be enriched in salt content more than that in the southern portions as a result of sea water intrusion from the

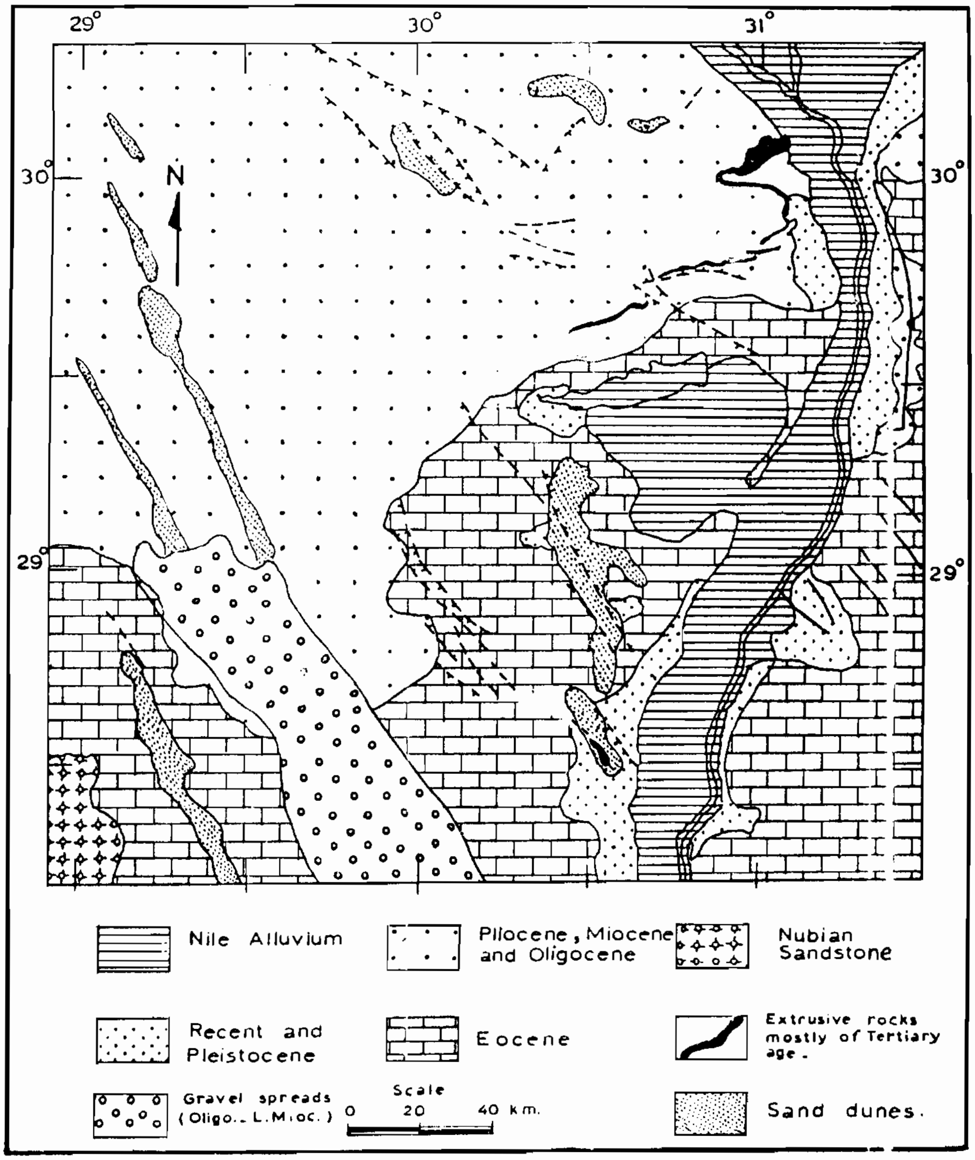

Fig. 2. Geological map of the study area (simplified from the geological map of Egypt, 1971).

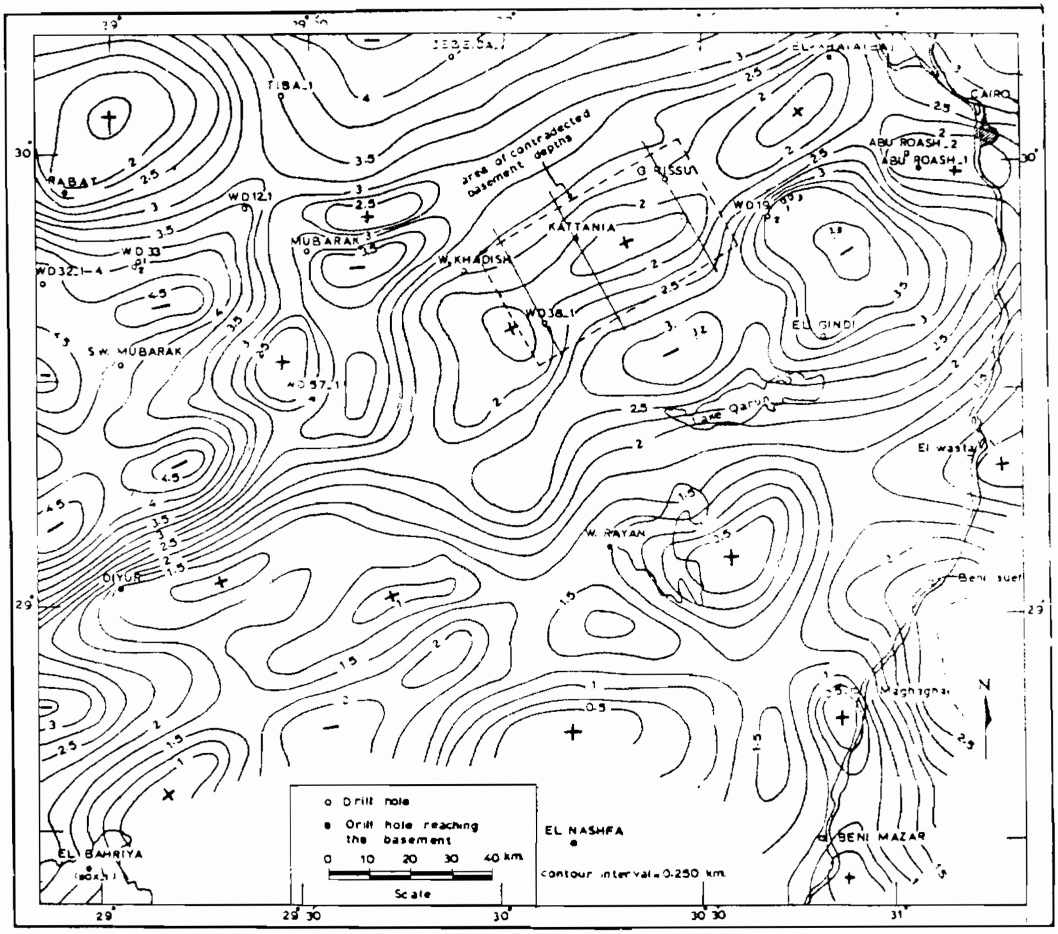

Fig. 3. Basement relief map of the study area, calculated from the residual gravity field (after Sayed 1977).

Mediterranean sea. Consequently, an approximate boundary line between zones of poor ground water quality and others of good quality is assumed along the southern slopes of El Bahariya–El Khatatba basement ridge. This 'structural' boundary explains the already recorded high salinity of ground water in the northern portions (120,000 ppm chloride salinity (Ezzat 1974)) in contrast to that recorded at El Bahariya in the south (150 to 1150 ppm), Kharga and Dakhla Oases (200–600 ppm) and at Diyur. Local increase in salinity, however, is to be expected due to some palaeotectonic effects that might lead to the presence of some isolated aquifers which have water of high 'remnant' salinity as is the case at El Nashfa and Wadi El Rayan.

THICKNESS AND EXTENSION OF THE NUBIAN AQUIFER

The basement relief map of the area is further utilised to map the stratigraphic interval, extending from the top of the basement to the top of the lower Cretaceous. This is very important in anticipating the depth and thickness variations of the Nubian aquifer in

Table 1. Summary of drill hole data

Drill hole	G.L. (m)	Total depth sub-Sea (m)	Ended in
Abu Roash–1	95·40	1,810	Basement
Abu Roash–2	193·00	1,517	Permo-Carboniferous
El Gindi	50·00	3,081	Lower Cenomanian
Gebel Rissu	97·00	3,374	Lower Jurassic
Kattania	222·00	3,831	Basement
WD* 19-1	128·60	3,306	Neocomian–Barramian
WD 19-2	153·00	2,897	Albian
WD 19-3	132·00	2,674	Albian
WD 38-1	284·00	2,672	Permo-Jurassic
Wadi Rayan	8·00	1,278	Basement
Nashfa	177·00	552	Basement
Khatatba	70·10	1,815	Basement
Wadi Khadish	201·00	1,775	Upper Jurassic
WD 32-1	140·00	3,102	Albian
WD 33-1	128·00	3,742	Albian
WD 33-2	125·88	3,253	Coniacian–Turonian
Mubarak	171·60	2,607	Aptian
Southwest Mubarak	174·00	3,716	Upper Jurassic
Zebeida–1	114·60	3,710	Middle Jurassic
Tiba–1	75·00	3,012	Palaeozoic
WD 57-1	242·00	2,740	Basement
WD 12-1	170·00	3,482	Middle Jurassic
Rabat	109·70	2,088	Basement
Diyur	210·00	1,400	Basement
Bahariya (Box-1)	30·50	1,720	Basement

* WD = Western Desert.

this part of the Western Desert, although this interval does not indicate—by itself—the net thickness of the Nubian Sandstones.

The isopach contour map for this interval is shown in Fig. 6. It is constructed by making use of the basement depths in the basement relief map as well as the information obtained from 24 holes drilled in the study area. Sometimes the Cenomanian is added to this interval as an upper time limit for the Nubian Sandstone. In the present study this is not followed because of two reasons. First, it is doubted as an upper limit. Second, it is noticed on most of the composite logs of the area that the sandstone section almost diminishes or thins out by the end of the lower Cretaceous.

The isopach map (Fig. 6) also shows that the maximum thickness of the Nubian interval exists at Gabal Rissue (2,770 m) while its minimum thickness is at the southeastern portion of the area (less than 250 m). Other thick sections are also present near Abu Roash (1,500 m), Tiba-l (more than 2,500 m), southwest Mubarak (more than 2,000 m) and El Bahariya (1,110 m) wells. Most of these localities lie to the north and northwest of El Bahariya–El Khatatba basement ridge where the water quality is supposed to be poor. Consequently, it is only the southwestern portions of the area that are recommended for the exploration and exploitation of ground water of the

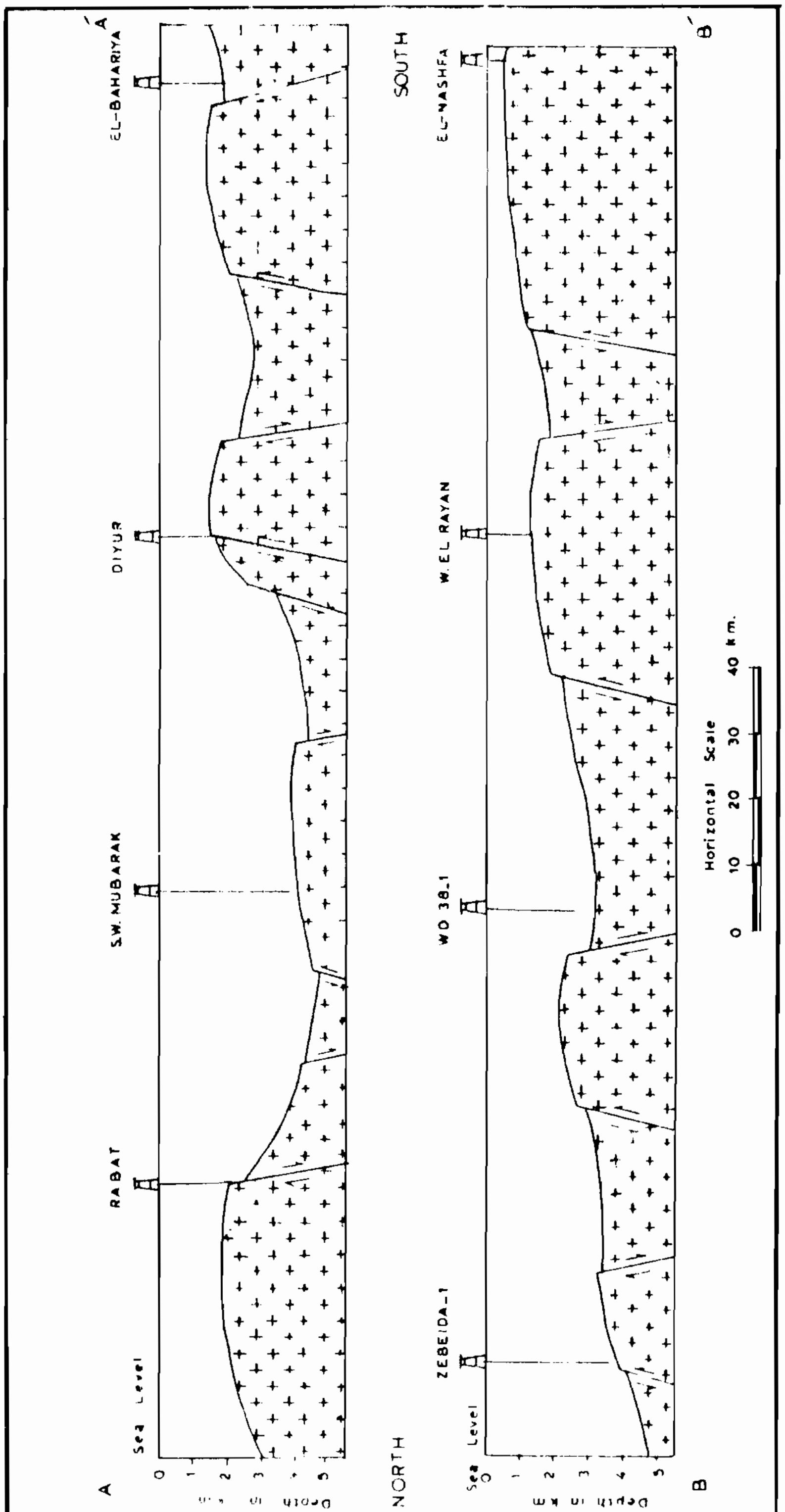

Fig. 4. Basement depth and structure along profiles (A–A′) and (B–B′).

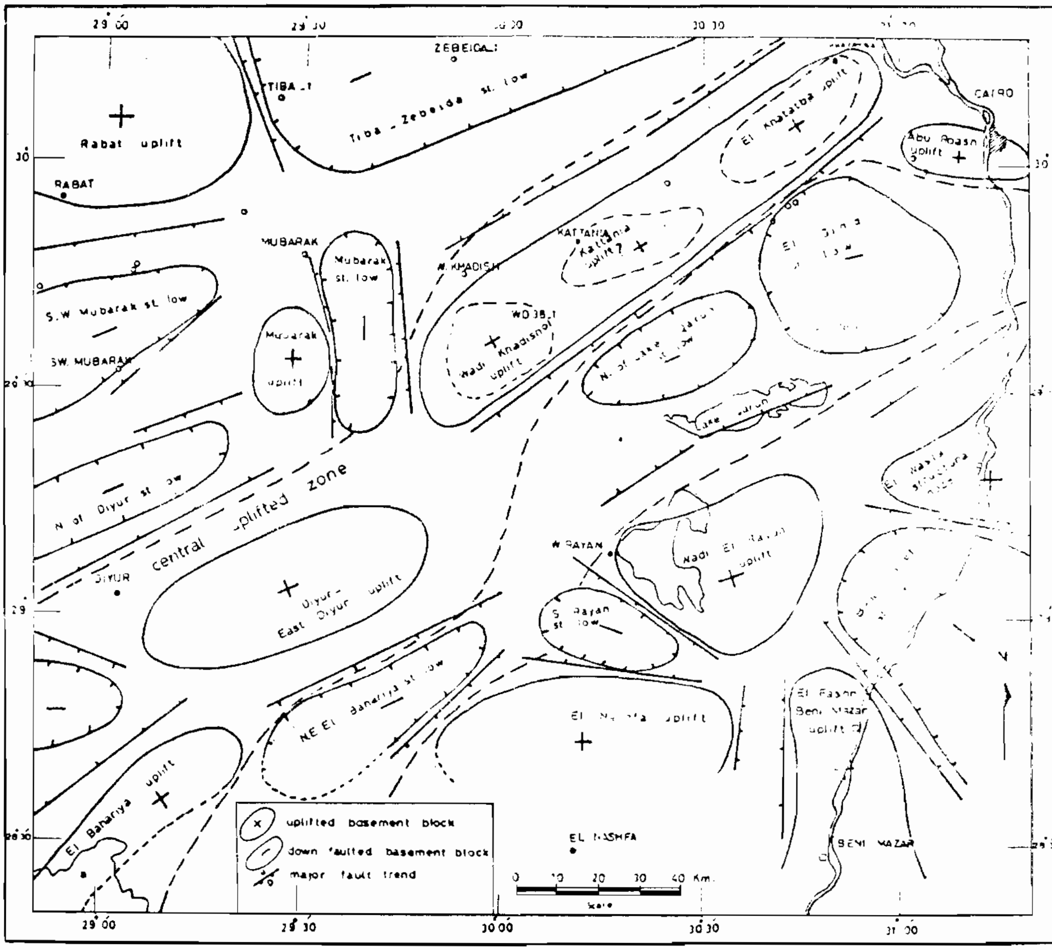

Fig. 5. Major structural features of the basement complex (delineated from the basement relief map).

Nubian reservoir. The average thickness of the Nubian interval in these portions is about 1,000 m.

The net thickness of the Nubian Sandstone could, however, be calculated from composite logs reaching the basement. This net or aggregate thickness is illustrated along the profiles shown in Fig. 7 in relation to the total thickness of the Nubian interval. It was not possible, however, to illustrate the thickness variation of the Nubian Sandstone all over the area in the form of maps as the deep holes are few in number and are widely spaced from each other; besides, the other holes do not reach the basement top.

Profile A–A′ illustrates how far the Nubian Formation is affected by the structural set-up present in the form of successive uplifts at Rabat, southwest Mubarak, Diyur and El Bahariya which would, definitely, affect the accumulation and movement of ground water. In Rabat high, most of the Palaeozoic as well as the Mesozoic sections are absent and the thin section of Palaeozoic shale and limestone is directly underlain by the Silurian sandstone, shale and gravel. Along this profile the depth to the top of

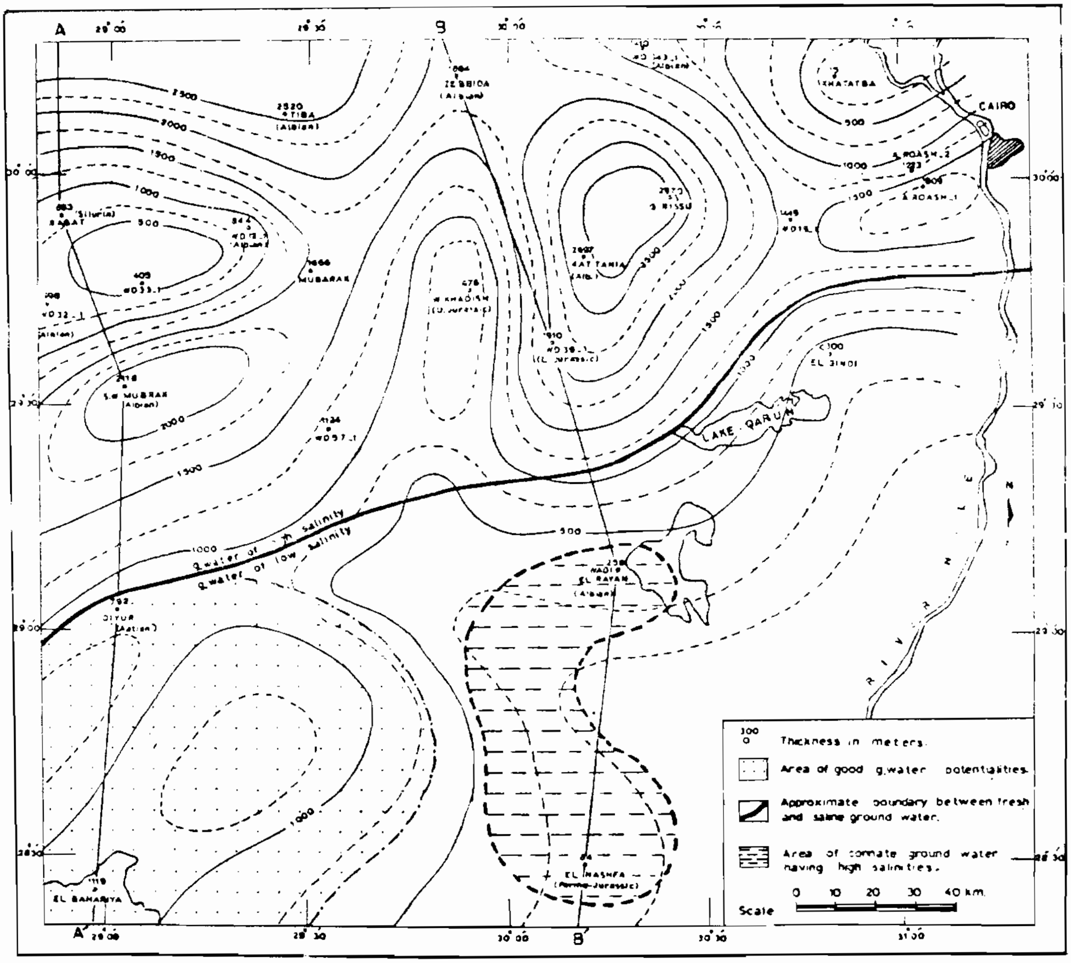

Fig. 6. Isopach contour map of the Nubian Sandstone Formation (including the interval extending from the top of the pre-Cambrian up to the top of the Lower Cretaceous).

the sandstone section varies from about 500 m to 3,500 m while its thickness varies from about 200 m to 1,000 m.

Profile B–B′ is less complicated structurally, since the basement surface varies in depth almost gradually from 500 m in the south to about 4,500 m in the north. It shows also that the Nubian section becomes thinner towards the south and almost diminishes near El Nashfa well. At El Nashfa well itself, the sedimentary section consists of 80 m of Tertiary limestone, 380 m of Upper Cretaceous sandstone and shale, 83 m presumably of Lower Cretaceous sandstone and finally the Pre-Cambrian basement complex. Along this profile, the depth to the top of the Nubian section varies from about 250 m in the south to 3,700 m in the north. Its thickness varies from less than 100 m to about 750 m.

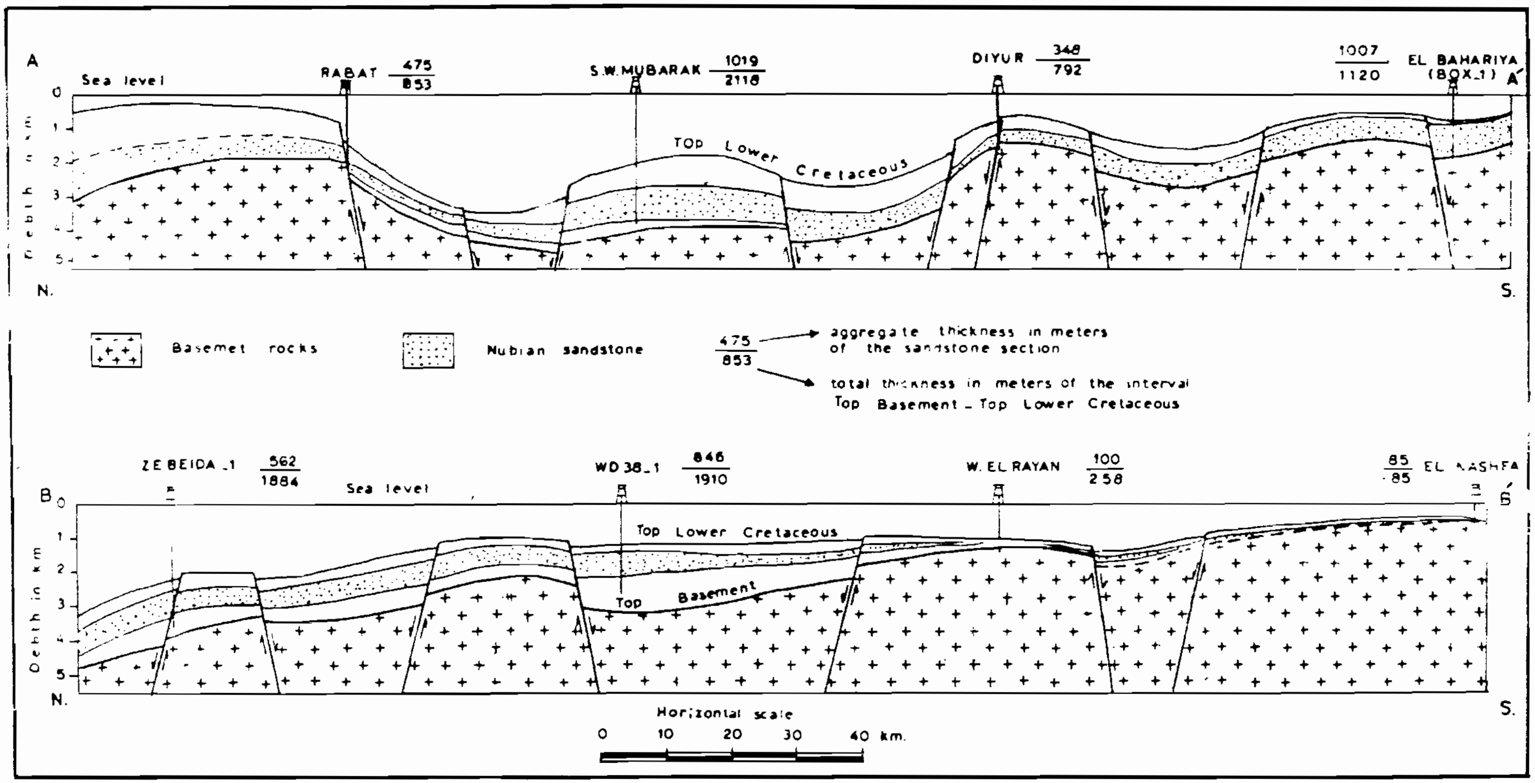

Fig. 7. Two profiles showing the aggregate thickness of the Nubian Sandstones in relation to the total thickness of the basement up to the Lower Cretaceous rocks.

CONCLUSIONS

From the present study, conclusions concerning the ground water potentialities of the Nubian Sandstone reservoir can be drawn as follows:

(1) The thickness of the Nubian stratigraphic interval varies from less than 250 m to about 2,770 m, being generally greater towards the north.

(2) Along two selected N–S directions the aggregate thickness of the Nubian Sandstone section is found to vary from 200 m to 1,000 m and from 100 m to 750 m respectively, while the depth to the top part of the section varies from 500 m to 3,500 m and from 250 m to 3,700 m respectively.

(3) Ground water movement towards the north is restrained by the regional El Bahariya–El Khatatba basement ridge as well as by several local fault systems.

(4) Ground water accumulation centres are expected at Mubarak, southwest Mubarak, El Gindi, Kattania, north of Lake Qarun, northwest of El Bahariya, north of Diyur and south and southwest of Wadi El Rayan well localities.

(5) Zones of favourable ground water quality and potentiality are restricted to the southwestern portions of the study area where further exploration and exploitation of ground water are recommended.

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REFERENCES

Borelli, M. & Karanjac, J. 1968. Kharga and Dakhla Oases, determination of hydrological and hydraulic parameters. Report presented to the Egyptian General Desert Development Organisation by Industro-Project, Zaghreb, Yugoslavia.

Ezzat, M.A. 1974. Exploitation of ground water in El Wadi El Gedid Project Area, Parts I & II. Ministry of Agriculture and Land Reclamation, Cairo, Egypt.

Farag, I.A.M. 1959. Stratigraphy of Egypt, Part I. Faculty of Science, Cairo University.

Sayed, M.A.A. 1977. Geophysical study on the area between Cairo and Beni Mazar in relation to ground water and oil possibilities. Ph.D. Thesis, Faculty of Science, Ain Shams University, Cairo.

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دراسة احتمالات المياه الجوفية للحجر الرملي النوبي
في الصحراء الغربية بمصر باستخدام الطرق التثاقلية

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خلاصة

يعتبر الحجر الرملي النوبي الذى يمتد في الصحراء الغربية بمصر من اهم الخزانات المائية المحتملة ، وهو يقع مباشرة فوق سطح الاساس الصخري . وقد تم اعداد خريطة سطح الاساس الصخري باستخدام البيانات التثاقلية والمعلومات المتوفرة عن الآبار المحفورة بالمنطقة وذلك بهدف دراسة تأثير سطح الاساس الصخري على سمك الحجر الرملي النوبي وتوزيعه ، وكذلك على تواجد المياه الجوفية به وحركتها ونوعيتها . وقد دلت الدراسات على ما يلي :

١ ـ يتراوح سمك العمود الطباقي للحجر الرملي النوبي بين ٢٥٠ و ٢١١٠ متر تقريبا .

٢ ـ يتراوح عمق سطح الحجر الرملي النوبي بين ٢٥٠ و ٣٥٠٠ متر .

٣ ـ حركة المياه الجوفية في اتجاه الشمال يحدها وجود مرتفع البحرية ـ الخطاطبة على سطح الاساس الصخري وكذلك وجود فوالق مختلفة .

٤ ـ يتوقع وجود مياه جوفية ذات نوعية جيدة في الجزء الجنوبي الغربي من المنطقة .

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