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The hydrogeologic connection between Lake Nasser and the Nubian Sandstone aquifer in Toshka area, South Western Desert, Egypt

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Abstract

The groundwater samples of the Nubian Sandstone aquifer were subjected to chemical and isotopic (Oxygen eighteen and Deuterium) analysis with respect to geological and hydrogeological parameters. The lithology of the concerned aquifer in most parts of the area has vertical and horizontal changes. This aspect is more represented towards the western and the northern parts where a rich content of clay and calcareous materials is encountered in the aquifer sediments. The obtained results from pumping and recovery tests recorded high potential and good quality aquifer in the eastern and southern parts and low potential to moderate quality aquifer in the western and northern parts. The isotopic content of the Nubian aquifer shows a general enrichment of δ O-18 (from -11‰ to -1.3 ‰) and δ D (from -84.8 ‰ to -23.2‰). These percentages indicate the contribution of recent Lake Nasser recharge to the groundwater aquifer.

Keywords: Nubian Sandstone aquifer; transmissivity; hydraulic conductivity; chemical and isotopic analysis; Lake Nasser recharge.

1- Introduction

In developing countries, increasing population constitutes a big problem because of its great effect on the national growth leading to increase of poverty and social problems. The acquisition of new land for agriculture still remains as one of the major solutions to minimize such harmful effects. In Egypt, some governmental and investmental agricultural programs are now under execution while some others are planned to be started in the near future. Surface water from Lake Nasser is used in addition to the Nubian Sandstone groundwater for this purpose. This Lake is considered one of the greatest artificial lakes in the world where it has an area of 6276 km^2. The area in concern lies on the western side of Lake Nasser between Abu Simbel and Toshka where it occupies a surface area of about 11000 km^2 between latitudes 22º 15- 00 and 23º 15- 00 N and longitudes 31º 00- 00 and 32º 00- 00 E (Figure 1).

Toshka project aims to reclaim 540,000 feddans using Nile water using 3×10^9 m^3/year taken from Lake Nasser and transported to the area by El Sheikh Zayed Canal and its tributaries (Figure 2). El sheikh Zayed Canal includes a main channel and four subsidiary branches numbered 1, 2, 3 and 4. The main channel is about 50 km from the intake area to Toshka where it bifurcates near the intersection of Abu Simbel road and Wadi Halfa road. The water stands at level varying between + 147 m and + 201 m near the huge Mubarak lifting station constructed at Lake Nasser. Moreover, another reclamation process is under execution in the area depending on groundwater of the Nubian Sandstone aquifer which represents the main aquifer in the area. About 155 wells were already drilled for this purpose (Figure 3) besides 210 wells will be drilled by the end of the year 2017. All these activities are expected to have its effect on groundwater in the area. The main recharge of this aquifer depends up on the leakage from the Lake Nasser and/or the underground flow from the southwestern parts.

Due to the importance of groundwater source to the area adjacent to the Lake Nasser for reclamation projects this paper aims to demonstrate the connection between the Lake and the Nubian Sandstone aquifer using isotopical and hydrological evidence.

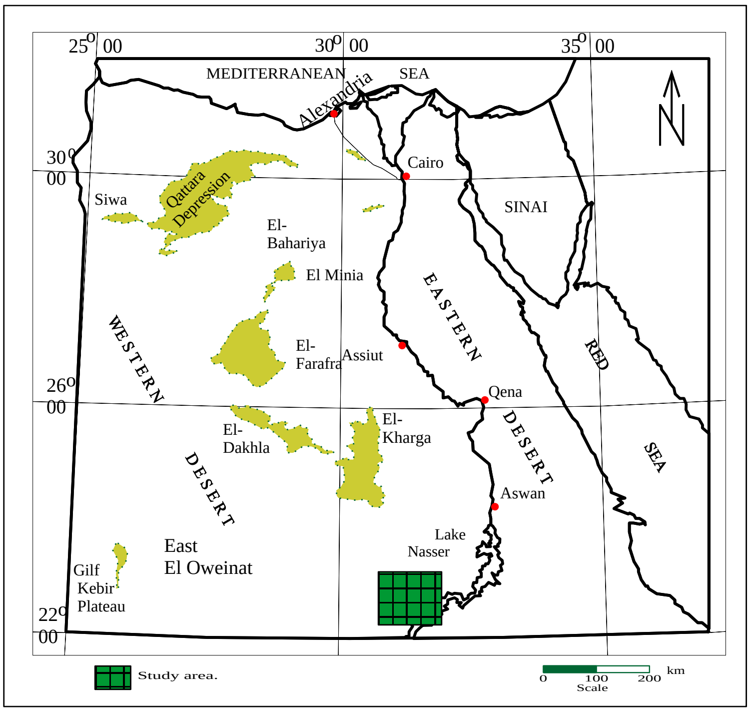

Figure 1: Location map of the area.

2- Geomorphologic and Geologic aspects

The study area is a part of the western desert of Egypt which has subjected to alternative arid and wet periods that left their effect on the present land feature. Prevalence of present aridity is manifested in the formation of sand dunes accumulation and sand sheets, scarcity of natural vegetation and lack of inland surface water. Referring to the geomorphologic map prepared by El Shazly, *et al.*, 1980, and CONOCO, 1987, five geomorphologic units are distinguished in the study area (Figure 4): Aswan High Dam Lake, The Nile Valley, Wadi Kurkur pediplain, Toshka depression and West Dungul plain. Wadi Kurkur pediplain represents most parts of the area. The pediplain surface is covered mainly by nearly horizontal beds of Nubian sandstone, with outcrops of igneous and metamorphic rocks as well as several volcanic exposures. Few conspicuous hills in this part are also formed of relatively higher masses and ridges of Nubian sandstone capped by limestone beds representing remnants of younger sediments.

From the geological point of view, the area is distinguished by sedimentary cover ranging in age from Upper Jurassic to Quaternary (CONOCO, 1987). The main geological units are arranged from older to younger as follows (Figure 5):

- Upper Jurassic-Lower Cretaceous rocks (Abu Simbel Formation), developed into sandstone with intercalations of mudstone and weakly developed paleosoil related to Abu Simbel Formation.
- Lower Cretaceous rocks; differentiated into Lake Nasser Formation and Sabaya Formation, both mainly developed into coarse grained sandstone with shale and clayey siltstone intercalations.
- Upper Cretaceous rocks, represented by Kiseiba Formation, developed into fine sandstone with shale, silt and sandstone intercalations, bone and phosphate beds.
- Paleocene rocks; made up of a succession of clastics and reefal limestone intercalations rich in fossils related to Kurkur Formation.
- Lower Eocene rocks; differentiated into Garra Formation and Dungul Formation and are composed mainly of thick limestone beds, partly chalky and occasionally siliceous and dolomitic.
- Oligocene rocks; developed into dark low hills.
- Quaternary rocks; developed into alluvial, lake and playa deposits, as well as aeolian deposits.

The Nubian sandstone rocks in the area represented rocks ranging from Upper Jurassic-Lower Cretaceous rocks to Upper Cretaceous rocks.

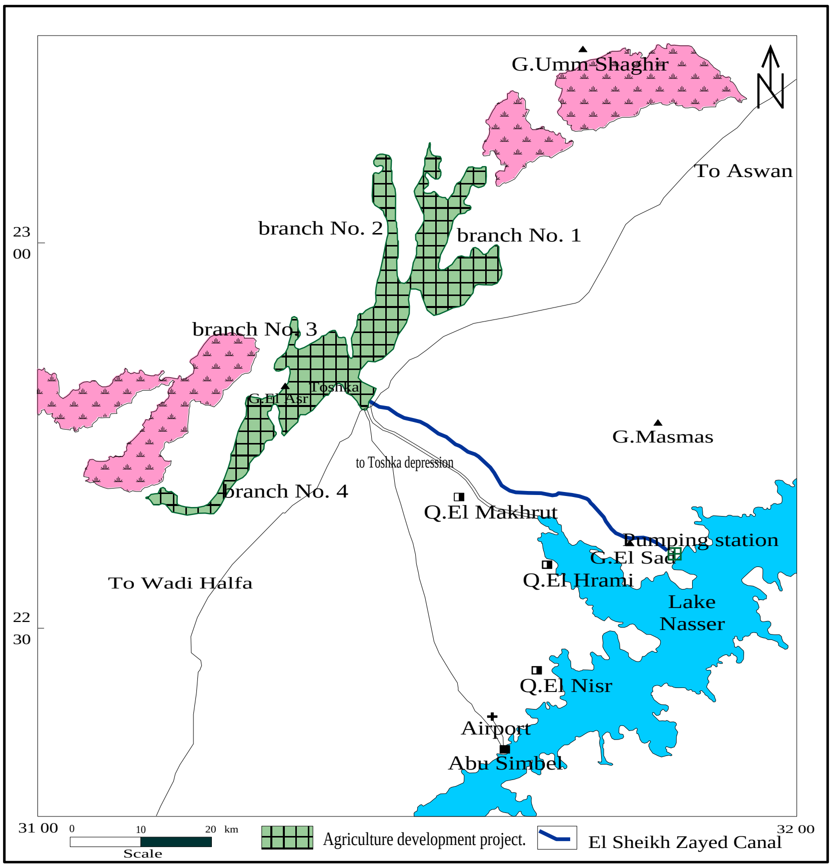

Figure 2: El Sheikh Zayed Canal project.

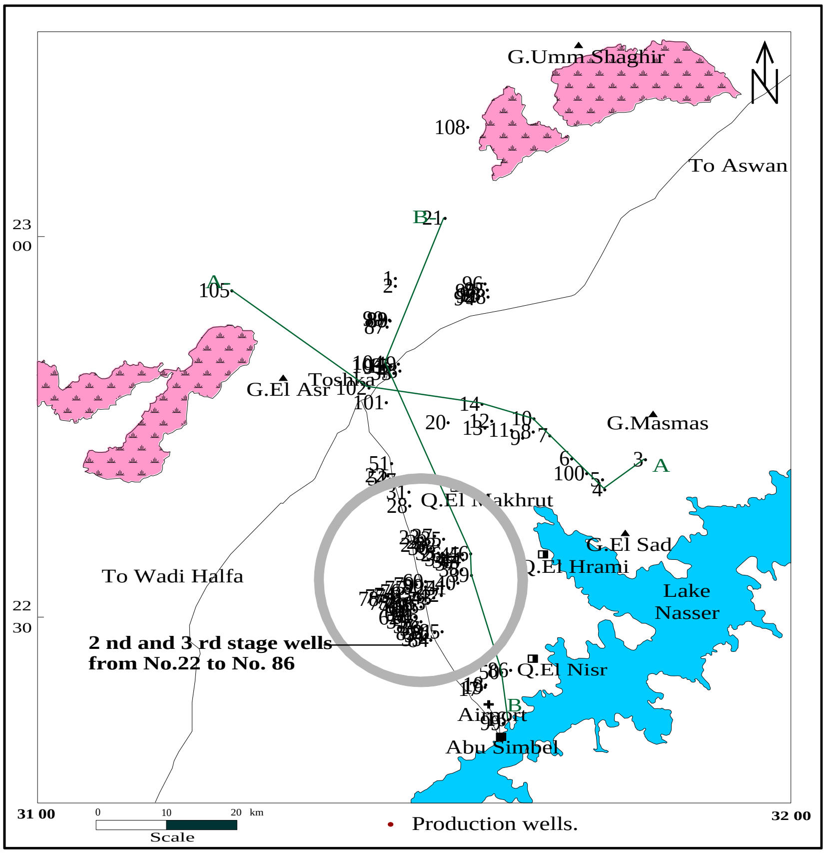

Figure 3: Well location map showing directions of geologic profiles and hydrogeologic sections A-A- and B-B-.

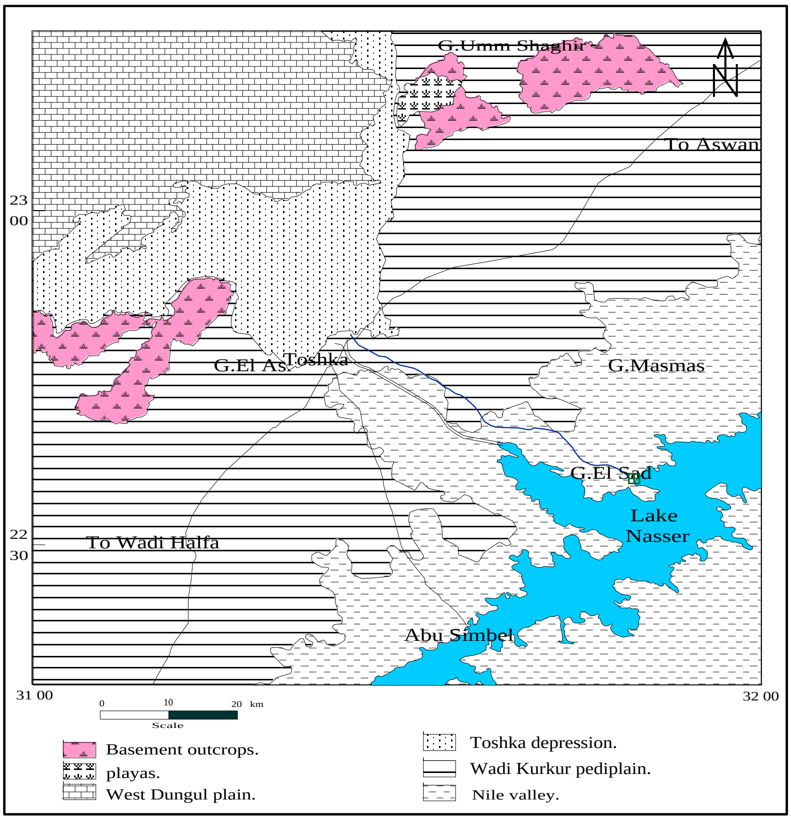

Figure 4: Main geomorphologic units (Compiled after El Shazly, *et al.*, 1980 and CONOCO, 1987).

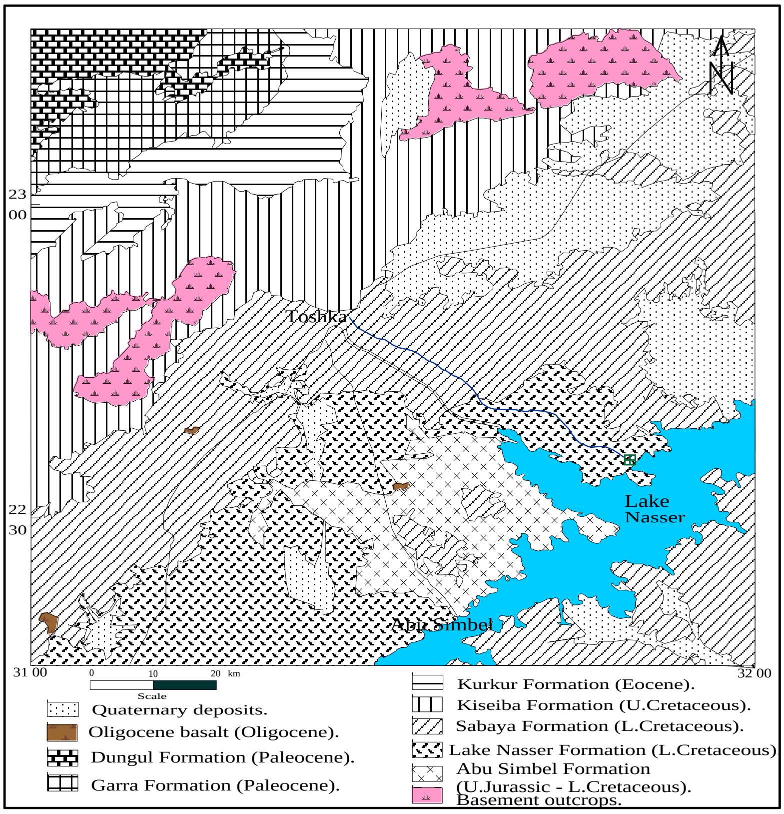

Figure 5: Geological map (After CONOCO, 1987).

Structurally, the area is very complicated represented by major uplift and faulting which are originated through the action of deep seated earth forces (Figure 6). However local folds are due to the compaction of igneous injection in the Lake region. On the other hand faulting is represented by four sets trending in N-S, E-W, NW-SE and NE-SW directions (G.S.E., 1981 and CONOCO, 1987).

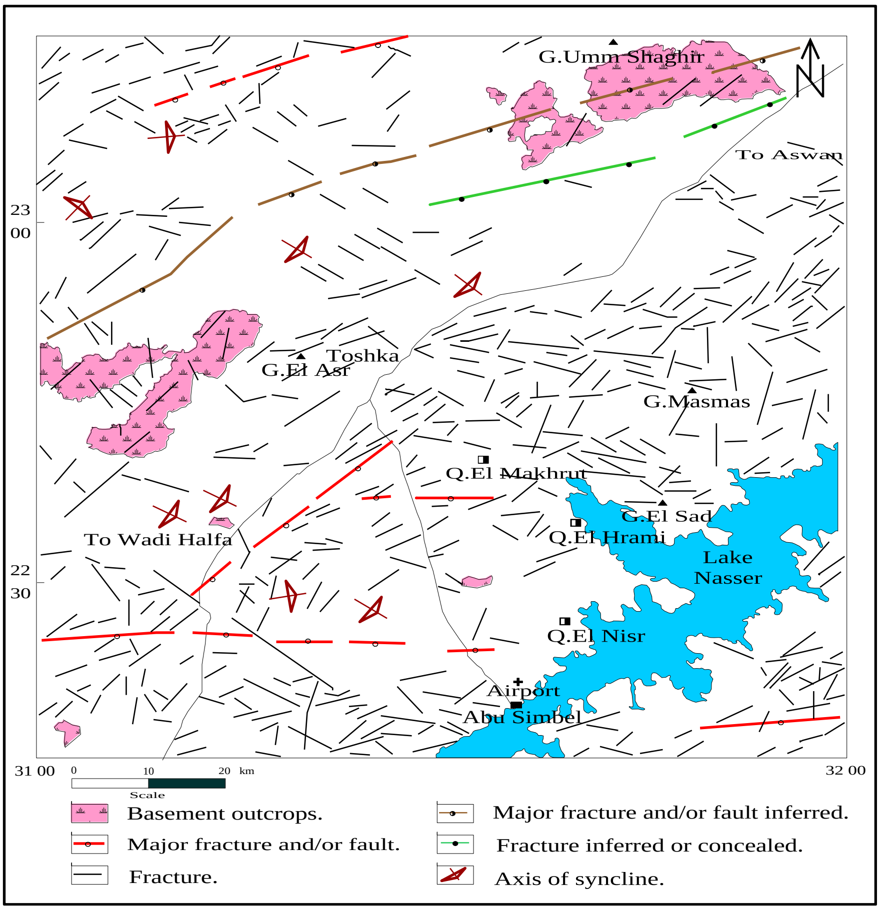

Figure 6: Structural lineation map (After EGS, 1981 and CONOCO, 1987).

3- Lithological changes

The lateral and vertical facies changes of the Nubian sediments affected greatly the movement rate of groundwater from Lake Nasser to the adjacent aquifer. So the detailed lithofacies changes in the area were studied through two stratigraphic correlation profiles in SE – NW and N – S directions as follows (Figure 3):

1. Profile A-A$^-$ (Figure 7) includes six wells and extends sixty kilometers. The depth of these wells varies from 78 m (well No. 105) to 313 m (well No. 3). The ground surface is gently sloping towards the northwest. Intercalations of sandy clay and shale are well noticed allover the section and at different depths. Layers of highly compacted clay in this section can be classified into two main types; the first type of clay dominating the upper horizon is of pale greyish green colour, highly massive (Mokhtar, 1988). The second type of clay prevailing in the lower horizon is of deep black colour and of highly compacted elastic type. The basement rocks are recorded in the well No. 105 at a depth ranges from 72 to 78 m (towards Gebel El Asr and Umm Shaghir granite exposure). They are represented by fragments of massive pink granite.
2. The second profile B-B$^-$ (Figure 8) takes the S-N direction. It passes through six wells and extends about sixty five kilometers. The depth of wells varies from 187 m (well No. 104) to 250 m (well No. 16). The succession is characterized by significant amounts of fine grained sandstone deposits (well No. 21). Claystone in the upper part suggests shallow marine environment.

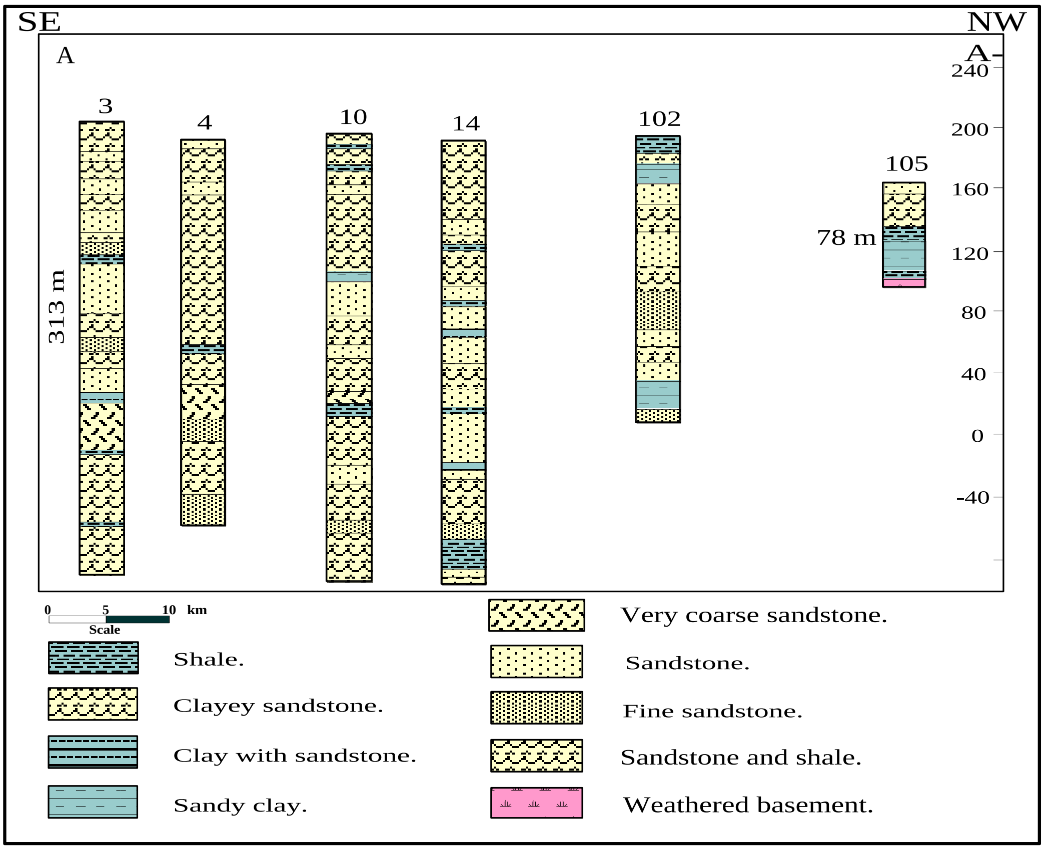

Figure 7: Geological correlation section A-A⁻.

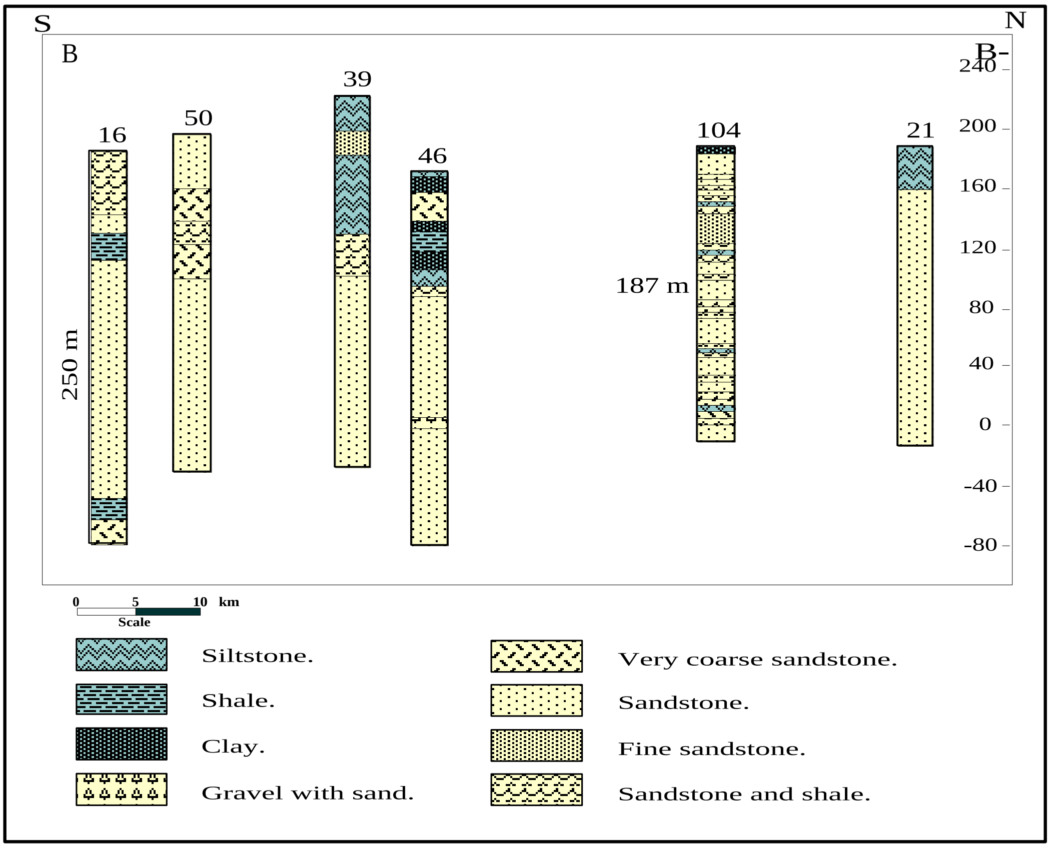

Figure 8: Geological correlation section B-B⁻.

However, in most cases the succession starts with thin sandy-loam deposits near the surface where sandstone, siltstone and clay are dominating together with multicolour clay intercalation of brownish fossiliferous limestone formation (Kurkur Formation) at the upper horizon, or fine sands in the lower horizon. Sometimes clays are banded or include iron minerals such as pyrite crystals and hematite ores.

4- Aquifer characteristics

Referring to the hydrogeological cross sections shown in Figures (9 and 10) as well as the hydrological investigations the following points can be mentioned:

i- The sedimentary section is mainly composed of water bearing sand and sandstone of the Nubian type with considerable content of intercalations of clay and shale or sandy clay which is encountered at different depths. Most of these water confining interbeds increase in the wells towards the middle and northern parts, while they decrease in the southern and southeastern wells. Therefore, groundwater is mostly present under either unconfined or semi-confined conditions depending on the occurrence, thickness, and continuity extent of these interbeds. The groundwater is shallow at the south and southeast close to Lake Nasser (depth to water is about 14 m) (Figure 11). The aquifer thickness decreases locally towards north and northwest due to the presence of basement complex at shallow depth (e.g. well No. 105). Hence, the increase and decrease of the aquifer thickness are controlled by the depth to basement (Figure 12).

ii- The recorded variation in transmissivity and hydraulic conductivity of the aquifer is highly reflecting the remarkable changes of lithology in both the horizontal and vertical levels. This phenomenon is well illustrated by estimating the values of such parameters in some wells (based on analysis of pumping and recovery test using Theis recovery mthod, 1935 and Jacob straight line method, 1958). Taking well No.42 and 47 as examples for the middle part of the aquifer. The determined values of transmissivity ranges between 588.6 m^2/day and 2802 m^2/day respectively, El Sabri, 2006. In the north and northwestern parts represented by well No. 1, the determined transmissivity value is 134 m^2/day which is very low (Figure 14). While in the south and southeast near Lake Nasser the transmissivity is very high as determined in well No. 3, 4, 5, 6 and 16 where it amounts to 1032, 1372, 1592 1248 and 1212 m^2/day respectively (Figure 15). On the other hand the hydraulic conductivity value varies generally from 2.6 m/day in well No. 1 to 44.3 m/day in well No. 47 (Fig. 14). It is obvious from the above calculations that the transmissivity shows generally low values in the north and northwest part and in some wells of the middle part. This is more likely attributed to the rich content of the clay and shale interbeds besides the relative decrease of aquifer thickness which affected by the presence of the basement compared to the southern and the southeastern wells (Figures 9 and 10). However, the higher value of transmissivity in the south and south east can be interpreted by the thick sandy nature of the water bearing formation and the less content of clay and shale interbeds (Figures 9 and 10). This indicates the high groundwater potentiality of the aquifer near Lake Nasser at south and southeast.

iii- The constructed water table contour map for "November, 2008" (Figure 16) indicats that: 1) The water level decreases regionally from south to north, 2) The main groundwater flow is from the direction of Lake Nasser at the southeast towards the middle part of the study aquifer surrounding Toshka depression, and 3) The hydraulic gradient becomes locally steep near Lake Nasser while it becomes moderate towards north. The groundwater flow rate was estimated as 0.054 m/day near Lake Nasser and decreases to 0.044 m/day towards northwestern and middle parts of the area.

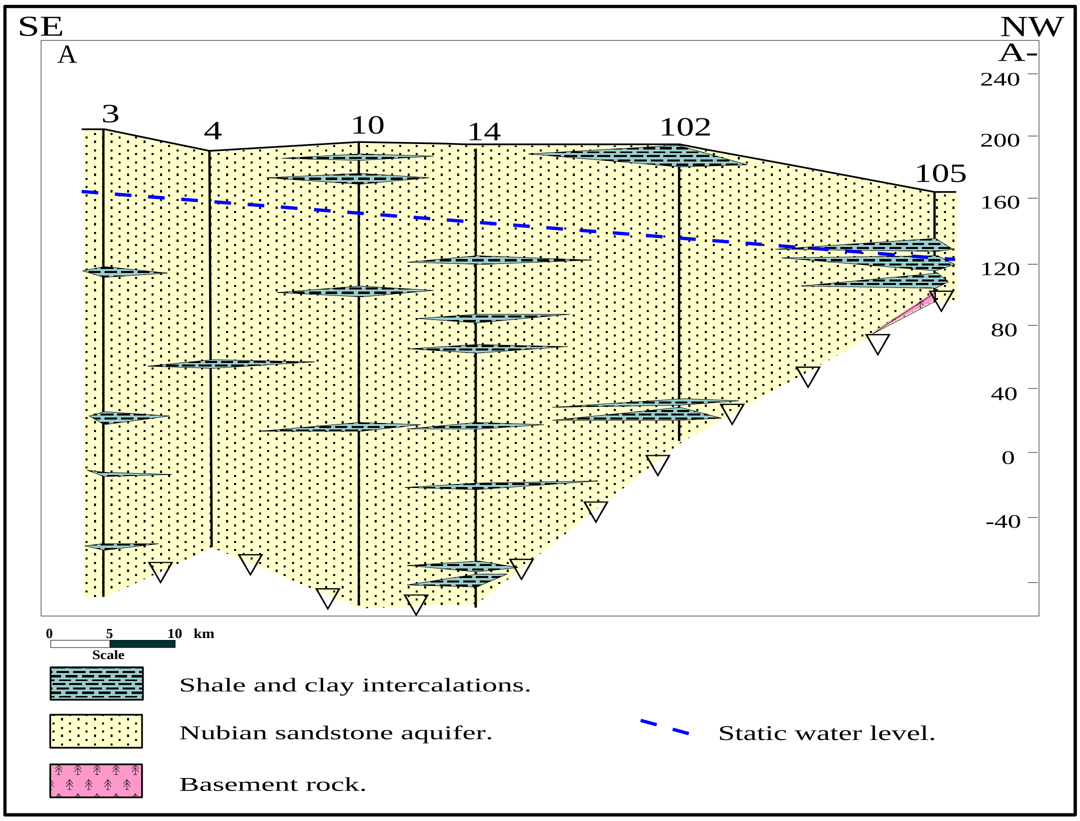

Figure 9: Hydrogeological cross section A- A-.

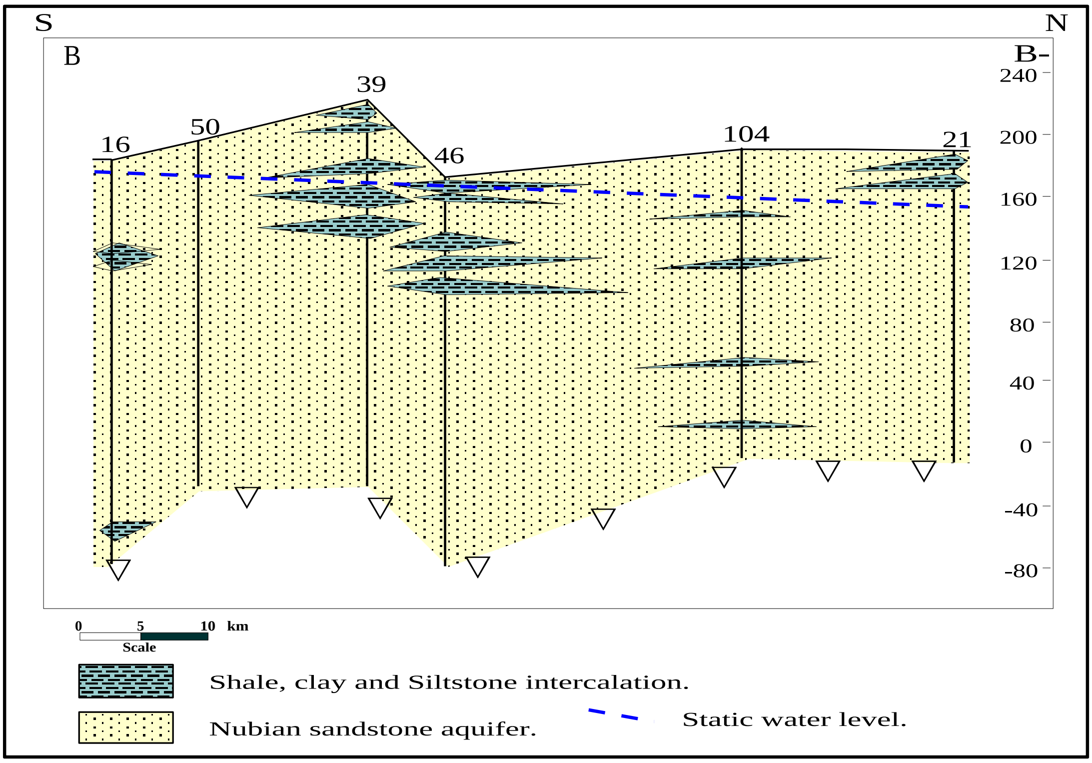

Figure 10: Hydrogeological cross section B- B-.

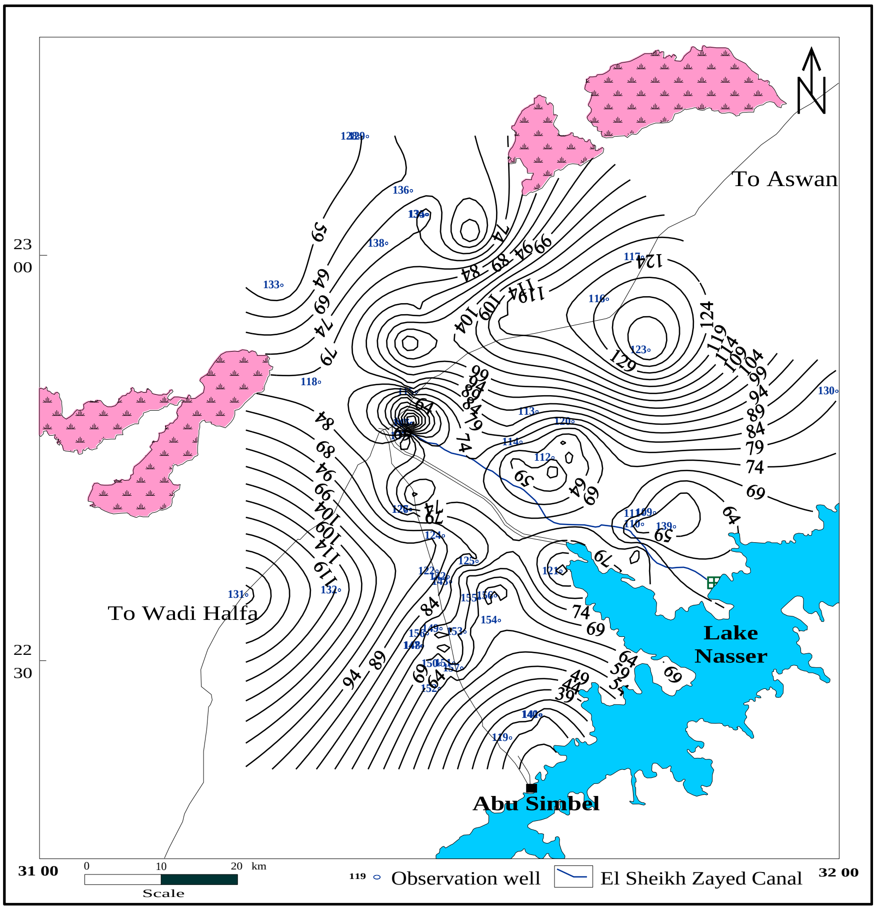

Figure 11: Depth to water contour map of the Nubian aquifer (November, 2008).

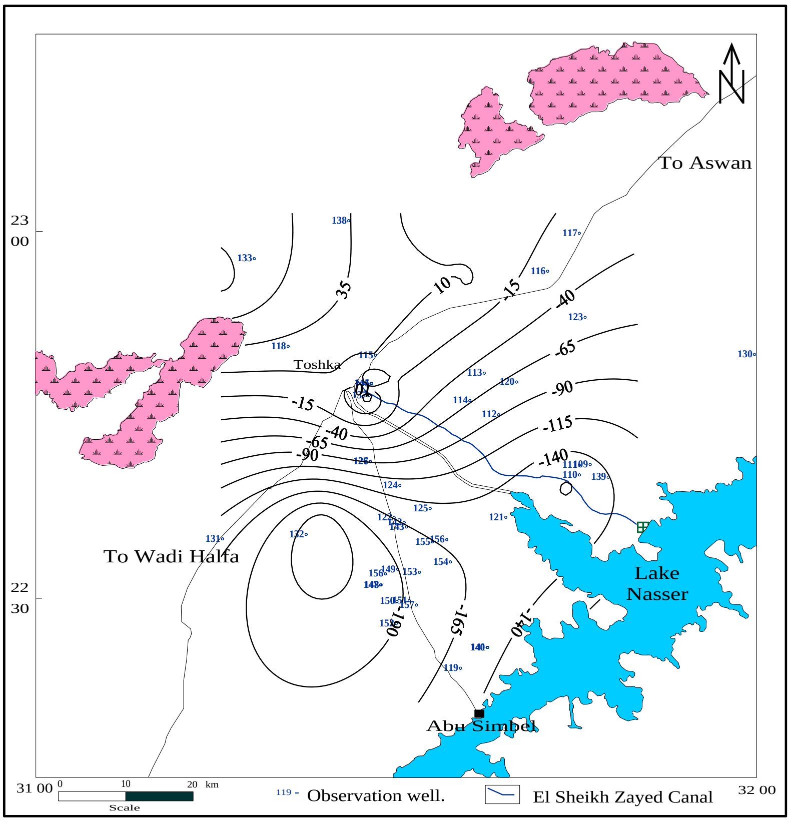

Figure 12: Basement relief (level) contour map (After El Sabri, 2006).

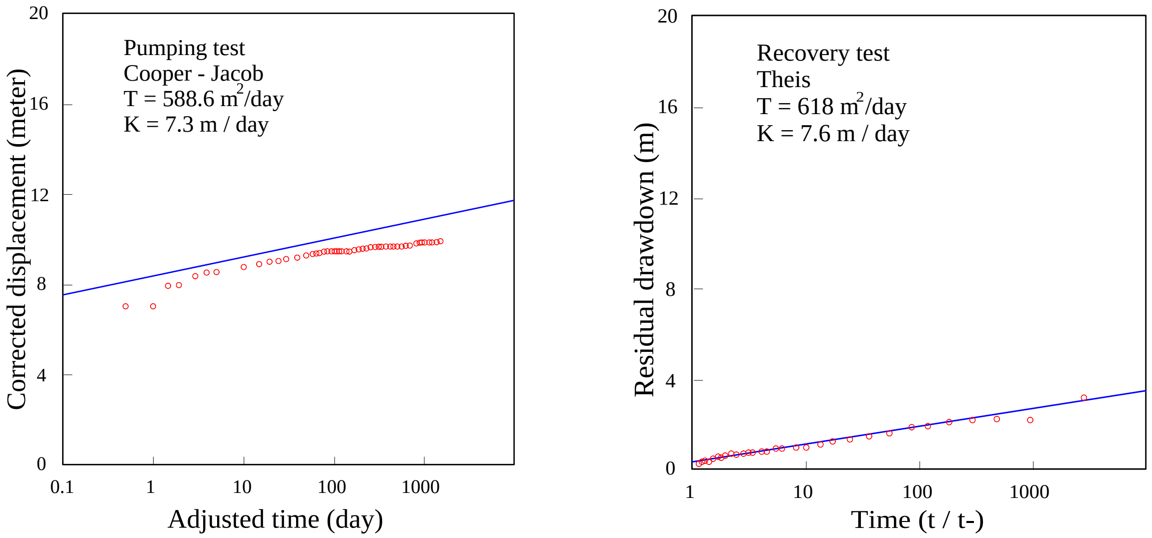

Figure 13: Constant discharge and recovery tests for middle part (well No.42 for example).

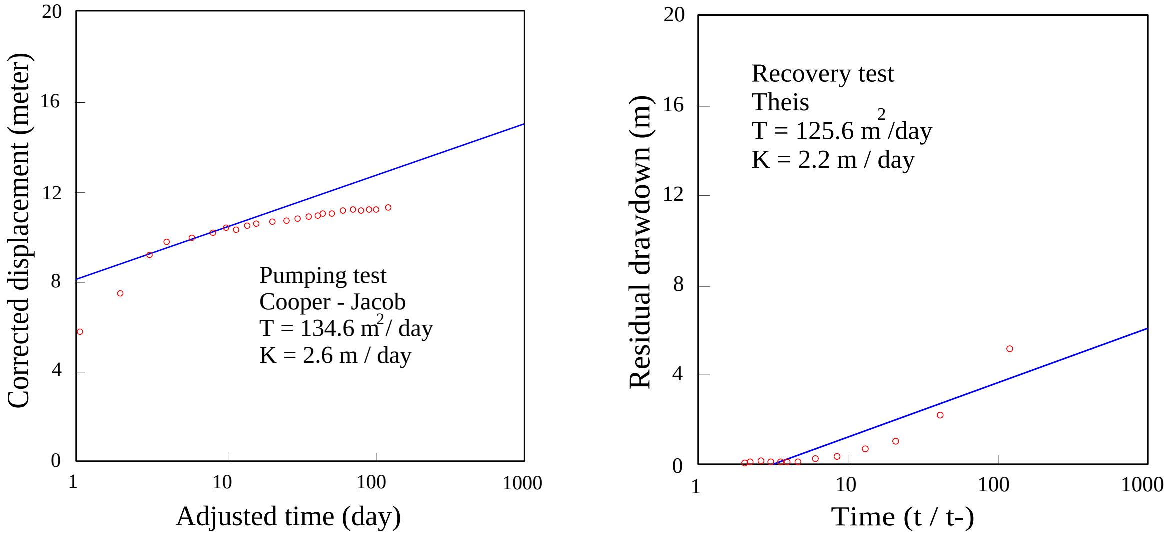

Figure 14: Constant discharge and recovery tests for north and northwestern parts (well No.1 for example).

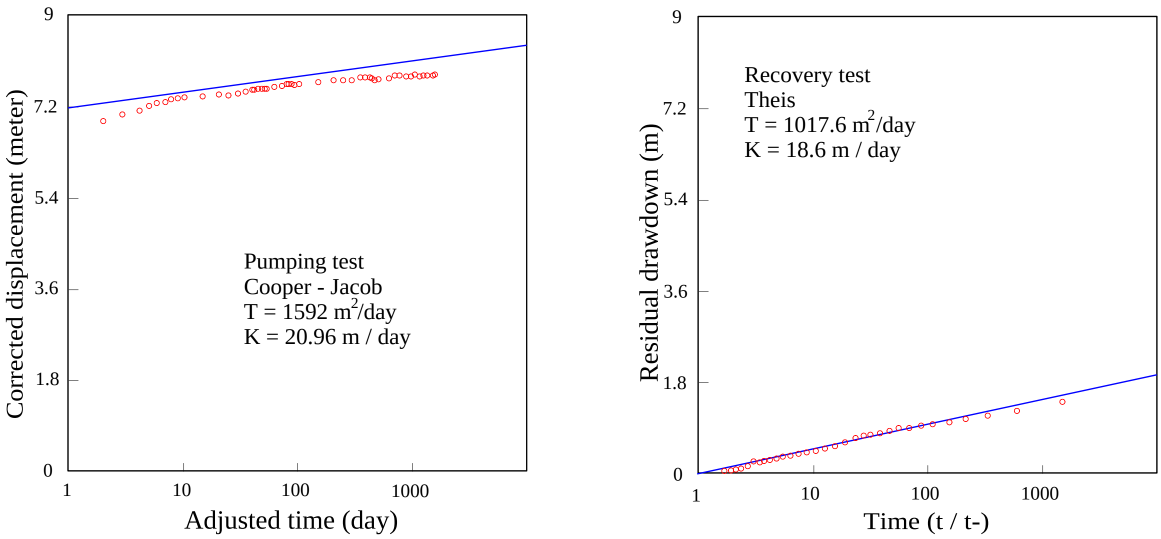

Figure 15: Constant discharge recovery and tests for south and southeast parts (well No.5 for example).

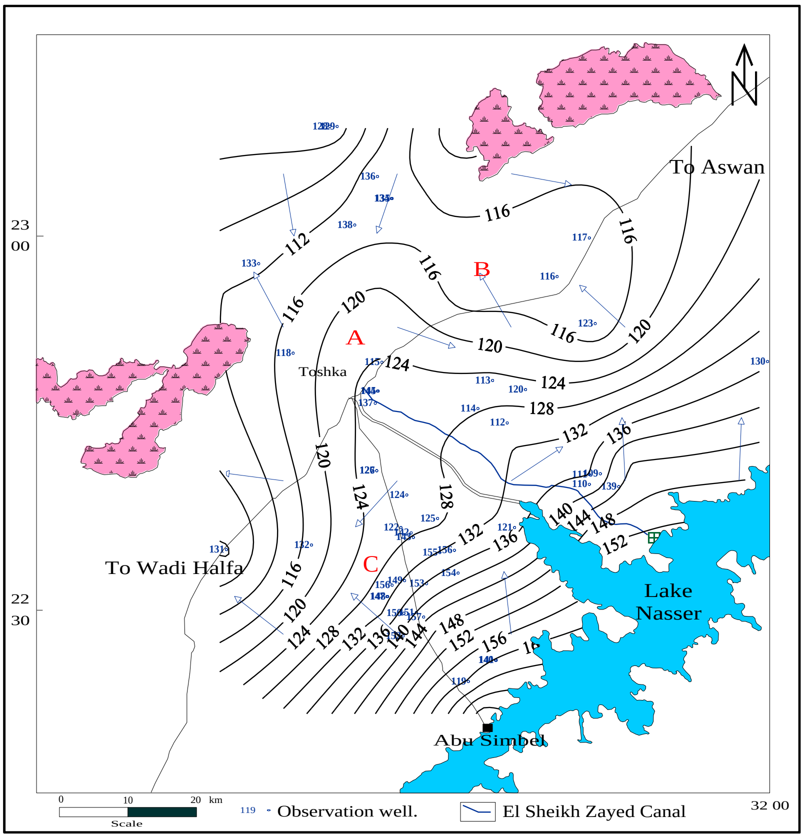

Figure 16: Water table contour map and flow directions (November, 2008).

5- Hydrochemistry and isotopic characteristic

Laboratory analyses (major ions and stable isotopes, Oxygen eighteen and Deuterium were conducted. Stable isotopes concentration were measured using isotopes ratio Mass Spectrometer, Delta-S after converting the water samples into suitable gases, CO_2 in case of Oxygen eighteen and H_2 in case of Deuterium, Epstein's. and Mayeda, T. K. (1953) and Craig, H. (1961). These are expressed as per mil deviation from Vienna Standard Mean Ocean Water (VSMOW).

$$\delta = \{(R_{Sample} - R_{Reference}) / R_{Reference}\} * 1000$$

where R = $^{18}O / ^{16}O$ or D / H

The chemical analyses results of representative groundwater and surface water samples (Table 1) have led to the following results:

1. The groundwater salinity distribution map (Figure 17) shows a general increase from the southeast direction towards the northwest (i.e. from the direction of Lake Nasser towards Toshka depression and Nakhlie - Aswan uplift). This result supports locally recharge from Lake Nasser.
2. The correlation of the groundwater chemical type zonation map (Figure 18) with salinity map (Figure 17) indicates that the distribution of chemical types of water follows the same trend of salinity distribution with regard to the location of Lake Nasser as a fresh recharge source. This obvious from the occurrence of HCO_3 - Ca and HCO_3 - Na chemical type in the southeast which is mainly occupied by good fresh to fairly fresh groundwater (500- 1500 ppm).
3. The dominance of the Cl - Na and SO_4 - Na chemical types and sometimes the SO_4-Ca within Toshka depression (Figure. 18) indicate the effect of dissolution and ion exchange Processes for sediments rich in clay or shale interbeds during the slow movement of groundwater.
4. The detection of two major hypothetical salt groups in groundwater: 1- NaCl, Na_2SO_4, $MgSO_4$, $CaSO_4$, $Ca(HCO_3)_2$ and 2- NaCl, $MgCl_2$, $MgSO_4$, $CaSO_4$, $Ca(HCO_3)_2$ is considered as a good indication for both surface water contamination and possible changeable environment of deposition.
5. From Durov's diagram (1958) representation (Figure 19), the trend of metasomatic changes runs from the fresh water $Mg(HCO_3)_2$ subquadrant (surface water) to the fairly fresh Na_2SO_4 and $MgSO_4$ subquadrants and ending by the most advanced stage $MgCl_2$ and NaCl subquadrant.

On the Other hand, the content of Oxygen eighteen and Deuterium in water samples ranges from -11 to -1.3 and from -84.8 to -23.2 respectively (Table 2). The obtained results reflect variability in recharge conditions from Lake Nasser. The relationship between O-18 and D (Figure 20) declare that the water points distribute into three groups (A, B and C) along the line of mix between paleowater of the aquifer and the recent water from Lake Nasser affected by recent recharge from the lake respectively.

The relationship between TDS and O-18 shows the effect of mixing between the isotopicaly enriched lees saline water (Lake water) and isotopicaly depleted higher saline water (Paleowater of Nubian aquifer) (Figure 21). This figure clear that, O-18 content responds only to mixing while TDS responds to leaching and dissolution of salts of Nubian Sandstone.

The Dipole Mixing Model of O-18 {δ 18 O = a X + b (1 - X)}, was used to calculate the percent of Lake water reaches to each well (Table 2). It was found that the percentage of Lake water in the groundwater have a quite variable, it ranges between 0% and 68% with an average 34%. The areal distribution of percentage Lake water in groundwater samples (Figure 22) does not show a well defined pattern but proves the connection between Lake Nasser and the adjacent groundwater aquifer. The distribution of Lake water could be related to structure complex and lithofacies heterogeneity. The distance beyond which contribution of Lake water disappear is about 40 km. In contrast, a distance of 50 km was mentioned by Sonntag, 1983.

Table 1: The results of groundwater chemical analyses in Toshka area (2008).

Well No.	PH	Ec µmohs	TDS	Units	Cations				Anions			
					Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	SO_4^{--}	Cl^{-}
P10	7.08	3430	1992	ppm	90.2	36.5	547.7	15.6	00.00	280.6	259.2	762.4
				epm	4.5	3.00	23.81	0.40	00.00	4.6	5.4	21.5
3	8.22	860	545	ppm	75.2	6.1	91.75	2.82	00.00	170.8	38.4	159.6
				epm	3.75	0.5	3.99	0.07	00.00	2.8	0.8	4.5
4	7.75	920	533	ppm	40.1	18.3	100.1	2.31	00.00	170.8	76.8	124.1
				epm	2.00	1.5	4.35	0.06	00.00	2.8	1.6	3.5
5	7.8	900	532	ppm	55.1	9.12	100.1	3.36	00.00	183	57.6	124.1
				epm	2.75	0.75	4.35	0.09	00.00	3.00	1.2	3.5
7	7.45	1190	707	ppm	70.1	21.3	126	4.49	00.00	183	124.8	177.3
				epm	3.5	1.75	5.48	0.12	00.00	3.00	2.6	5.00
8	7.65	1010	623	ppm	40	30.4	112.8	3.36	00.00	170.8	105.6	159.6
				epm	2.00	2.5	4.90	0.09	00.00	2.8	2.2	4.5
9	7.77	913	591.1	ppm	50.12	21.3	176.4	3.91	00.00	146.4	153.6	248.2
				epm	3.00	1.75	7.67	0.10	00.00	2.4	3.2	7.00
10	7.7	1430	944	ppm	75.2	45.6	189	3.91	00.00	134.2	230.4	2.66
				epm	3.75	3.75	8.22	0.10	00.00	2.2	4.8	7.5
11	7.79	1460	948	ppm	70.1	39.5	182.7	3.91	00.00	158.6	244.8	248.2
				epm	3.5	3.25	7.94	0.10	00.00	2.6	5.1	7.00
12	7.72	1910	1312	ppm	70.1	66.9	270	4.49	00.00	146.4	346	407.8
				epm	3.5	5.5	11.74	0.12	00.00	2.4	7.2	11.5
15	7.47	1830	1203	ppm	90.1	30.4	240.3	2.82	00.00	207.4	259.2	372.3
				epm	4.5	2.5	10.45	0.07	00.00	3.4	5.4	10.5
16	7.3	1340	892	ppm	80.2	42.6	164.0	3.36	00.00	134.2	201.6	266
				epm	4.00	3.5	7.15	0.09	00.00	2.2	4.2	7.5
19	7.47	880	600	ppm	50.1	26.8	83.7	3.91	00.00	170.8	158.4	106.4
				epm	2.5	2.2	3.64	0.10	00.00	2.8	3.3	3.00
20	7.95	260	194	ppm	35.1	3.00	15.94	2.31	00.00	97.6	4.8	35.5
				epm	1.75	0.25	0.69	0.06	00.00	1.6	0.10	1.00
21	7.78	910	655	ppm	60.1	34.1	91.75	2.31	00.00	158.6	148.8	159.6
				epm	3.00	2.8	3.99	0.06	00.00	2.6	3.1	4.5
25	7.83	320	232	ppm	30.1	12.00	9.33	2.31	00.00	146.4	14.4	17.7
				epm	1.5	1.00	0.41	0.06	00.00	2.4	0.30	0.50
43A	7.47	770	601	ppm	40	30.4	83.76	2.31	00.00	207.4	148.8	88.7
				epm	2.00	2.5	3.6	0.06	00.00	3.4	3.1	2.5
43B	7.65	760	634	ppm	45.1	45.6	83.76	2.31	00.00	195.2	172.8	88.7
				epm	2.25	3.75	3.6	0.06	00.00	3.2	3.6	2.5
43C	7.69	770	615	ppm	40	48.7	83.76	2.31	00.00	183	168	88.7
				epm	2.00	4.00	3.6	0.06	00.00	3.00	3.5	2.5
60	7.73	1110	765	ppm	70.1	36.5	121.6	3.91	00.00	158.6	196.8	177
				epm	3.5	3.00	5.29	0.10	00.00	2.6	4.1	5.00
80A	7.72	800	599	ppm	55.1	27.4	70.29	2.82	00.00	170.8	139.2	106.4
				epm	2.75	2.25	3.06	0.07	00.00	2.8	2.9	3.00
80B	7.67	850	704.0	ppm	50.1	57.8	55.1	2.82	00.00	146.4	163.2	124
				epm	2.5	4.75	2.4	0.07	00.00	2.4	3.4	3.5
80C	7.75	810	525	ppm	40.1	51.7	70.3	2.31	00.00	158.6	158.4	124
				epm	2.00	4.25	3.06	0.06	00.00	2.6	3.3	3.5
85A	7.37	700	522.0	ppm	55.1	39.5	62.6	2.82	00.00	146.4	129.6	88.7
				epm	2.75	3.25	2.72	0.07	00.00	2.4	2.7	2.5
85B	8.07	730	573	ppm	40.1	51.7	65.13	2.31	00.00	158.6	148.8	106.4
				epm	2.00	4.25	2.83	0.06	00.00	2.6	3.1	3.00

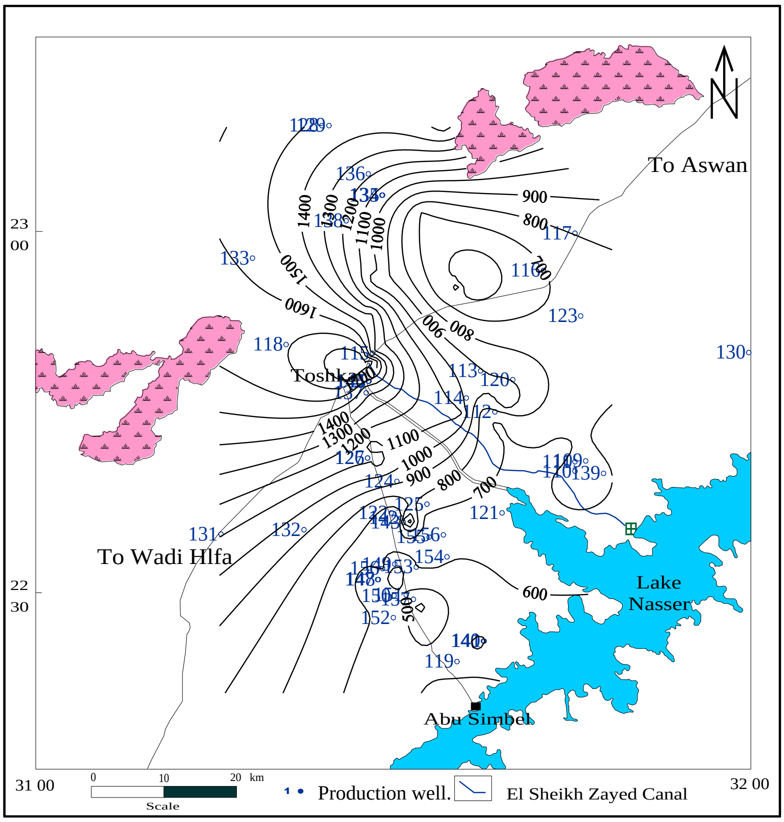

Figure 17: Iso-Salinity contour map (November, 2008).

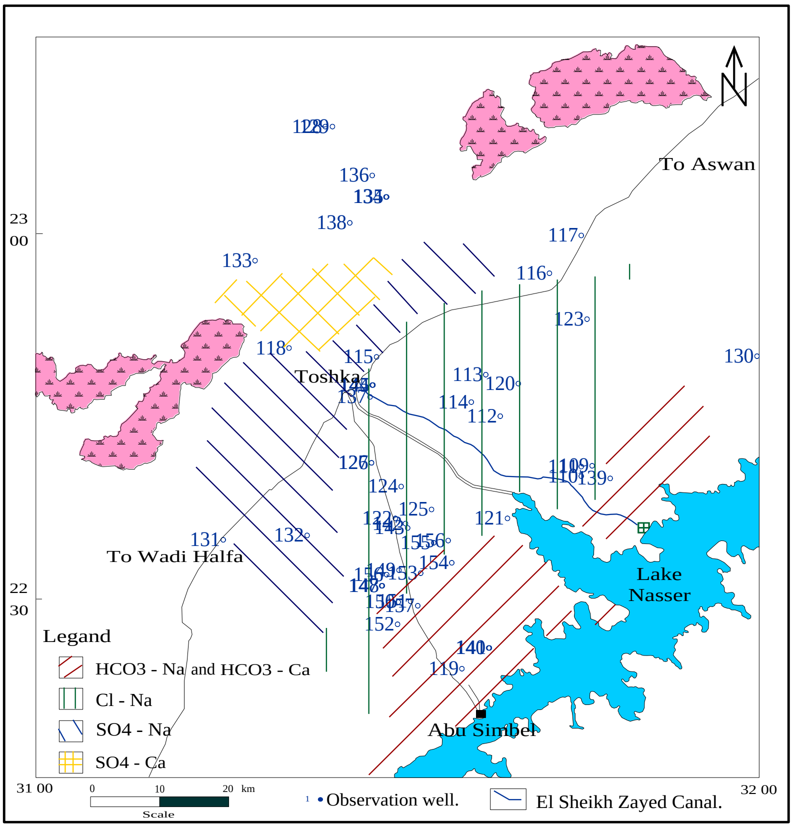

Figure 18: Water chemical type zonation map (After El Sabri, 2006).

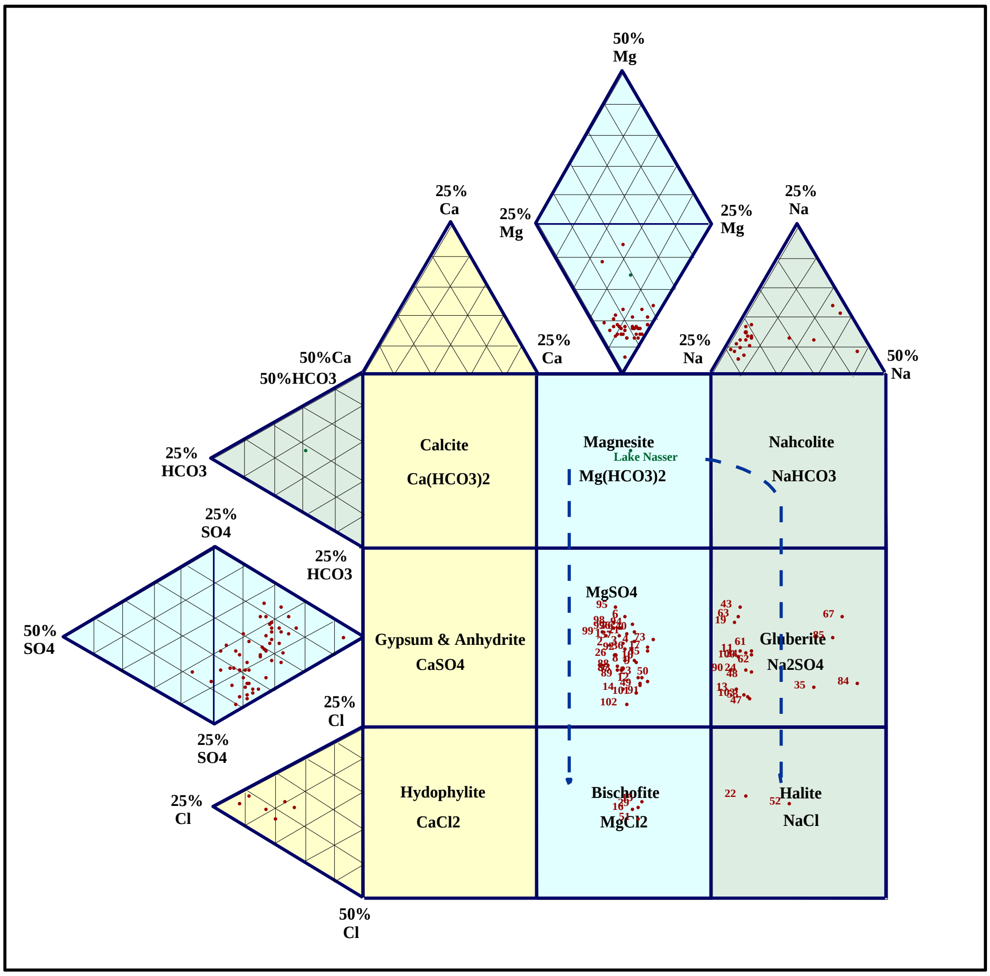

Figure 19: Durov's diagram (1958) of groundwater samples.

Table 2: Isotopic analysis and percentage of Lake water in groundwater samples.

Well No.	δ O-18 ‰	δ D ‰	% Lake Water	Well No.	δ O-18 ‰	δ D ‰	% Lake Water
1	-10.2	-81.3	0	34	-10.6	-83.7	0
2*	-7.9	-68.6	17	47	-10.3	-82.6	0
3	-10.8	-82.3	0	55	-10	-78.7	0
4*	-6.0	-60.4	32	61	-10.7	-85	0
6*	-8.7	-77.8	11	73	-10.7	-84.7	0
8	-824	-73.9	14	87	-9.9	-81.3	1
10*	-9.5	-80.8	3	92*	-7.2	-63.4	22
11*	-5.8	-53.4	33	93*	-10	-76.6	0
12*	-7.8	-71.9	17	94*	-6.4	-64.1	28
13*	-6.9	-59.6	0	95	-10.5	-84.8	0
14	-10.3	-81	0	99	-3.5	-23.2	51
15	-10.7	-83.7	0	100*	-9.0	-75.8	7
20*	-7.3	-70.6	20	101*	-5.5	-53.9	35
21	-10.5	-84.1	0	102*	-11	-81.3	0
24	-10.7	-84.2	0	103*	-8.0	-69.1	15
27*	-1.3	-27.7	68	106* (L N)	-0.2	+9.0	-

Where; * is wells after Aly et al, 2004 and LN is Lake Nasser water sample.

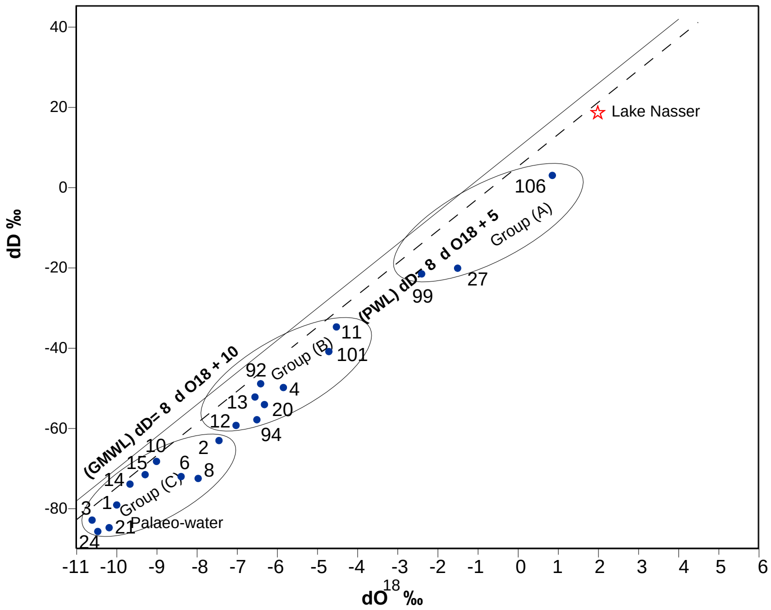

Figure 20: Relationship between O-18 and Deuterium.

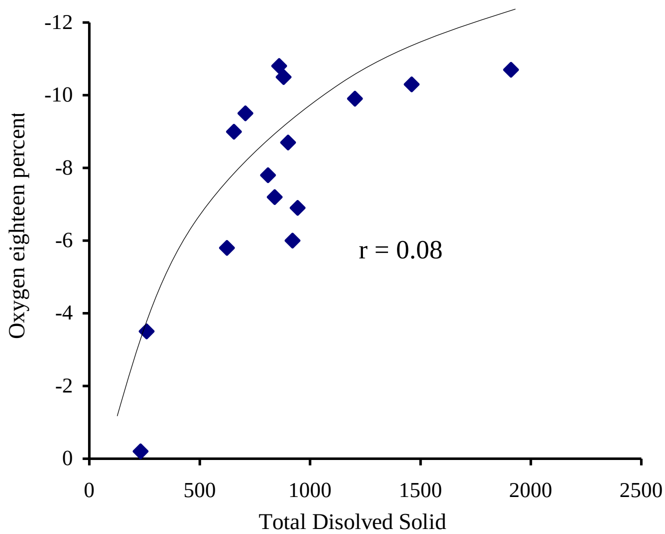

Figure 21: Relationship between O-18 and TDS.

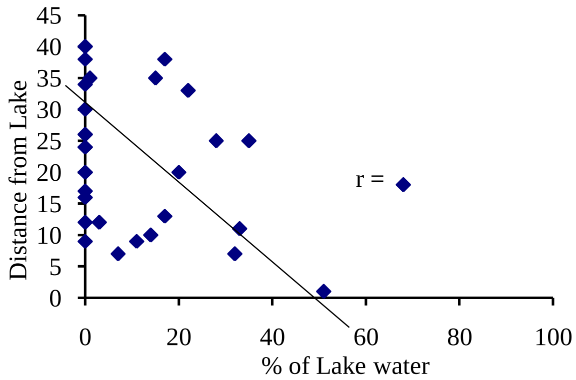

Figure 22: Relationship between percentages of Lake water and the distance from the Lake.

6- Conclusion

The vertical and horizontal facies changes in the Nubian Sandstone aquifer in Toshka area affect directly its hydrologic properties, recharge from Lake Nasser and groundwater quality. The Nubian sandstone aquifer is mainly composed of sand and sandstone with considerable intercalations of clay and shale or sandy clay which are encountered at different depths. These intercalations increase in the wells towards the middle and northern parts while they decrease in the southern and southeastern parts towards Lake Nasser. Accordingly the transmissivity and the hydraulic conductivity show generally low values in the north and northwest parts and in some wells of the middle part. The groundwater salinity shows a general increase from the southeast direction towards the northwest and changes in hydrochemical facies from Ca or Na HCO_3 TO NaCl (i.e. from the direction of Lake Nasser towards Toshka depression and Nakhlai - Aswan uplift). This result support lithologic differences and recharge from Lake Nasser. The areal distribution of percentage Lake water in groundwater samples does not show a well defined pattern but proves the connection between Lake Nasser and the adjacent groundwater aquifer. The distribution of Lake water could be related to structure complex and lithofacies heterogeneity. The distance beyond which contribution of Lake water disappear is about 40 km.

References

A. I. Aly, M. A. Sadek, K. A. Dahab and Salem, W. M.: 2004, Implication of structural elements and lithofacies on groundwater flow and recharge at Toshka - Abu Simble area, International Eight Conference of Nuclear Science and Applications, 7 -12 February.

CONOCO: 1987, Geological map of Egypt, NF 36 NW El Sad El Ali. Scale 1:500000. The Egyptian General Petroleum Corporation. Conoco Coral.

Craig, H.: 1961, Science, 133. 1833.

Durov, S.A. (1958): Classification of natural water and graphic representation of their composition. Doklady Akad. Nurk, USSR, No.1, pp 87-90 in Russian.

El Sabri, M.A.SH: 2006, Evaluation and management of groundwater resources in the area between Abu Simbel and Toshka, southwestern Desert, Egypt. Ph.D. Thesis, Fac. of Sci., Menoufyia University, 242p.

El Shazly, E.M.; Abdel Hady, M.A.; El Ghawaby, M.A.; Soliman, A.B.; El Kasssas, I.A.; Khawaski, S.M.; El Amin, H.; El Rakaiby, M.M.; El Aasy, I.E.; Abdel Megid, A.A. and Mansour, S.I.: 1980, The geologic map of Egypt, the structural lineation map of Egypt, and the drainage map of Egypt based on LANDSAT-1 Imagery interpretation and field investigations: Remote Sensing Center, Academy of Scientific Research and Technology, Cairo: Oklahama state University, Stillwater, Oklahama and United Nations Environment Program (GEMS): 12 maps. Scale 1:100000.

Epstein, S. and Mayeda, T.: 1953, Geochemica Cosmochemica Acta, 4, 213.

Geological Survey of Egypt "GSE": 1981, Geology, geomorphology and geophysical investigation on the Egyptian Component Transitional Nubian Sandstone Project. Report to Groundwater Research Institute, Giza, Egypt.

Jacob, C.E.: 1950, Flow of groundwater in engineering hydraulic. John. Wiley and Sons, New York, pp.321-386.

Mokhtar, M.: 1988, Some geological and hydrogeological studies on the area south West of Egypt, Ms.c. Faculty of Science, Minufiya University, 1988.

Sontag: 1983, Toshka basin project, High Dam Authority, Egypt, Int. Report.

Theis, C.V.: 1935, The relation between the lowering of the piezometric surface and the retread duration of discharge of a well using groundwater storage: *Am. Geophys. Union Trans.*, Vol.16, p.510-424.

الاتصال الهيدروجيولوجى بين بحيرة ناصر وخزان الحجر الرملى النوبى بمنطقة توشكى, جنوب الصحراء الغربية, مصر

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التغيرات الليثولوجية الرأسية والأفقية في خزان الحجر الرملي النوبي في المنطقة بين أبوسمبل وتوشكي لها تأثير ملحوظ علي الخصائص الهيدرولوجية والتغذية من بحيرة ناصر ونوعية المياه. خزان الحجر الرملي النوبي يتكون من رواسب الرمل والحجر الرملي مع تداخلات من الطين والطفلة والتي تتواجد علي أعماق مختلفة. تتزايد هذه التداخلات في الجزء الشمالي والشمالي الغربي وفي منطقة الوسط وتقل كلما اتجهنا جنوبا وجنوب شرق المنطقة في اتجاه بحيرة ناصر. يقل معدل التناقلية ومعدل التوصيل الهيدروليكي تدريجيا في الجزء الشمالي والشمالي الغربي وفي منطقة الوسط، مع زيادة ملوحة المياه الجوفية في الجزء الشمالي والشمالي الغربي وتقل باتجاه الجنوب والجنوب الشرقي وتغير سحنتها من كربونات كالسيوم وصوديوم إلي كلوريد صوديوم مما يؤكد تأثير التغير الليثولوجي علي الخصائص الكيميائية للمياة وعملية التغذية المستمرة من بحيرة ناصر. لا توجد علاقة واضحة بين نسبة مياة البحيرة في المياة الجوفية ولكنها تعتمد كليا علي تغير السحنات والتراكيب الجيولوجية والمسافة التي تختفي عندها كمية التغذية وهي حوالي 40 كم من البحيرة وذلك اعتمادا علي القياسات النظائرية في مياة الابار ونتائج تحليل تجارب الضخ.