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Research Article

An Integrated Approach for Identifying the Influences of Nubia Swells on Aquifer Distributions and Potentialities

Ahmed F Yousef*

Department of Geology, University of Desert Research Center, Cairo, Egypt

ABSTRACT

There are a lot of broad basins in Africa surrounded by irregular swells. In East Africa, Nubia swell refers to a complete active east-west trending structure in south Egypt and north Sudan that extended more than 1000 km with a width reach 200 km. The influences of swell on aquifer distribution and potentialities are the main objectives based on huge data sets. Kom Ombo area south Egypt was selected as a case study for testing, where the hydrological setting does not understand. Swell many controls the distribution of landforms and rock units, drainage pattern, the course of River Nile, forming three depressions (Nuqra, Kom Ombo, and Gallaba), and the sources of groundwater recharge. Examination of their influence on hydrogeologic setting lead to shedding new lights on the Quaternary aquifer and discovery of karst and Nubian aquifer systems with saturated thickness reach to 1200 m. The Quaternary aquifer has moderate potentialities with salinity 605 to 1620 ppm that recharged largely from deep Nubian aquifer through fault plain, Lake Nasser, and system of irrigation. Upward leakage owing swell is supported by the higher temperature of the water near E-W fault plains, deep meteoric water genesis, salts, and of Na-Cl-SO_4 water type. Karst has moderate potentiality with thickness 200 to 900 m and salinity 3856 to 4164 ppm. The Nubian aquifer system is a highly productive and potential aquifer in the study area with thickness from 345 to 700 m. The aquifer characterized by high hydrostatic pressure, relatively high temperature, and depleted water.

Keywords: Nubia swell; Aquifer distributions; Potentialities; East Africa

INTRODUCTION

Water shortage in East Africa could affect human welfare and economic activity stability in the region. Several efforts are needed to avert the expected crisis and to avoid potential conflicts that might arise. Perhaps the most important of these activities is exploring alternative renewable water sources. Faced with overpopulation problems and demand for the development of new agricultural lands to support its increasing population, Egypt adopted aggressive policies to develop new agricultural communities outside and near the overpopulated Nile Delta and Nile Valley .Some national projects are underway in Wadi El Nuqra (65,000 feddans) and surrounding alluvial plains, which is will divert Nile River water. Although Egypt is using nearly its full share of the Nile River water (55.5 billion m^3/year) for agriculture and human consumption, water for these projects will come from the Nile River water budget. The planned rationalization of water usage will be painful, given that the annual per capita availability in Egypt will decline [1].

The Nile (6825 km long) transports water from high rainfall regions in Ethiopia and Equatorial Africa across the Sahara Desert to Egypt. Bedrock fabrics are an important control of the Nile. Basement structures of different age control much of the Nile's course in northern Sudan; northward-flowing segments of the Nile follow Precambrian basement fabrics, whereas east-west segments follow faults of much younger age .These faults may reflect recent uplift of the Nubia swell and deflections of the river to the SW to form the great bend of the Nile .Nubia swell refers to a complete, east-west trending structural high in southern Egypt and northern Sudan (Figure 1) that indicate the tectonic uplift during Cenozoic time [2].

From North Aswan to the Mediterranean Sea, the Nile drains a broad floodplain, whose fertile soil has sustained Egyptian

Correspondence to: Ahmed F Yousef, Department of Geology, University of Desert Research Center, Cairo, Egypt, Tel:20 1061756002; E-mail: ahmedfawzy63@hotmail.com

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civilization for more than 5000 years. This segment, known as the Egyptian Nile, is underlain by a buried canyon that was carved that of the during and the Late-Miocene desiccation of the Mediterranean and has subsequently been filled with sediment. The buried canyon disappears south of Aswan, where the Cataract segment of the Nile has a limited floodplain localized along short stretches of the river. Here the Nile is a youthful stream, following narrow, structurally controlled channels that are controlled by faults and shear zones and frequently bifurcate as the river tumbles over rocky cataracts. The First Cataract at Aswan marks the boundary between the Egyptian Nile to the north and the less fertile Nile immediately to the south (Figure 1a) [3].

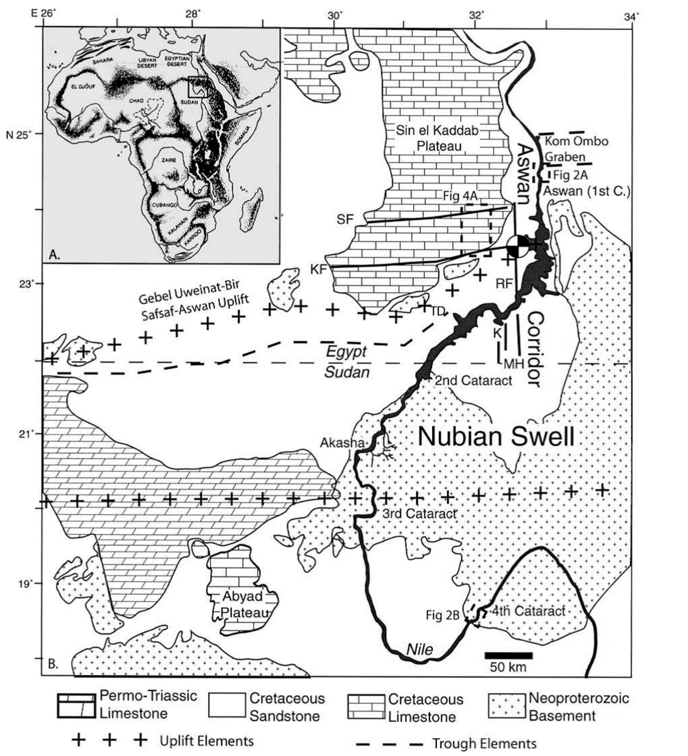

Figure 1a: Africa is described as a region of broad basins surrounded by irregular swells generalized geologic map of the Nubia Swell, modified after SF=Seiyal Fault; KF=Kalabsha Fault; RF=Rofa Fault; 1stFC=first Cataract, K=Korosko;MH=Madiq Hogback. Focal mechanism of the 1981 earthquake.

The main objective of this article is an integrated approach of huge data sets to identifying the impact of Nubia swell on the aquifer distributions and potentialities in East Africa. Kom Ombo area north Aswan of Egypt was selected as a case study for testing, where the hydrological setting of this area does not understand. Recent exploration and drilling for oil by different companies (such as Courtesy, Centurion, Prior, Transglobe, and Repsol) in the area revealed a lot of subsurface information that encourages the selection of the area. Also, due to the serious limitations of the intensive use of Rive Nile water, groundwater in the area become the source of water supply to reclaim the planned area in Kom Ombo and more extension in Atmur Nuqra Depression to the east. The area is delimited by latitudes 24°10\ and 25°00\ N and that longitudes 33°05\ and 34° 35\ that distinguished by arid conditions, i.e. high temperature, no rainfall, low relative humidity, and a relatively high rate of evaporation. The area is drained by many wadis such as Shait, Natash, Kharit, al Lawi, Abu Suberia, and Kobbania (Figure 2) [4].

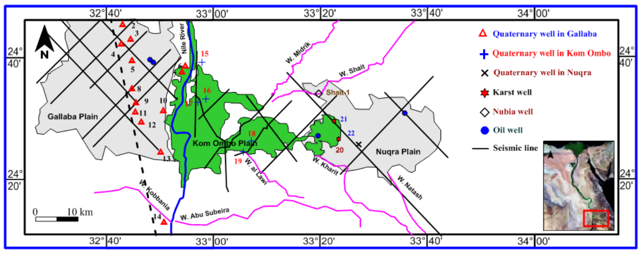

Figure 2: Location map of Kom Ombo showing Seismic lines, oil and groundwater wells.

MATERIALS AND METHODS

The study is based on:

• Surface data includes remote sensing, topographic (1:100,000 and 1:50,000) and geological maps (1:500,000 and 1:250,000) after CONOCO (1987) and EGSMA (1979, 1999, 1999a and 2001).

• Magnetic data

• Data of oil wells carried from Courtesy of Sea Dragon-Egypt Company:

- Wire-line logs from 24 wells,

- Borehole images from 10 wells,

- Description and interpretation of core material from 6 wells,

- 20 2D seismic lines (10 line in Nuqra Basin with distance between 1 and 17.5 km, and 10 line in Kom Ombo Basin with distance between 5.3 and 9.3 km), and

- One seismic line from the 3D seismic survey.

• Well logging data (Narmer-1 and Set-1 wells drilled in 2007 by Transglobe in Nuqra Basin, and Komombo-2 and St-1 exploratory well drilled.

• Detailed paleontological description and biostratigraphic zonation for oil wells.

• Surface and subsurface data were integrated into a Geographic Information System (GIS) for studying the surface and subsurface lithology and structures [5].

• Groundwater wells from different sources (e.g. Farms, Green Valley Company and Brother Company), and the interpreted shallow geophysical data [6].

• Field work was carried out by collecting the hydrogeological data (e.g. well location, depth to water, and some well logs). Nineteen groundwater samples are collected from the drilled wells which are distributed along the Gallaba, Kom Ombo and Nuqra plains .Samples are collected in polyethylene bottle and preserved using the standard methods of the American Public Health Association where Electric Conductivity (EC), PH, CO_3 and HCO_3 are measured in the field [7].

• The concentrations of major ions in the collected water samples are analyzed in Laboratory of Desert Research Center, Cairo (DRC), using Ion chromatography (ICS-1100, Dionex, Sunnyvale, CA, USA). The result of sodium, potassium, calcium, magnesium, carbonate, bicarbonate, chloride and sulfate ions are used as input data through AQUACHEM software v.3.7 [8].

DISCUSSION

The impact on geomorphology

Based on the satellite image, geologic map, topographic maps, field observations and measurements, and literature; the geomorphologic map is made. Nubia swells much control the locations, distributions, and features of landforms that distinguished into four main distinct units namely; mountainous area, depression, fluvial plains, and cultivated land as follows (Figure 3).

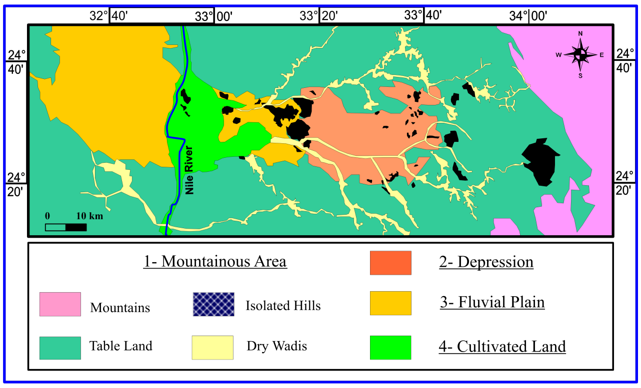

Figure 3: Geomorphical features of Kom Ombo area.

Mountainous area

The mountainous area is classified into mountains, tableland, isolated hills, piedmont plain, and dry wadis sub-unit:

• Mountains differentiated into the basement and sedimentary mountains. Basement mountains represent the highest (+600 to +1200 m) and salient to the east that acts as a water divide between the Red Sea and Nile Valley. The famous of them are Muweilha, Sufra, Um Quraf, An Nuhud, Abu Khuruq, Hamrat Salma, Mijif, Mudarjaj, and Ras Shait are rugged and highly dissected by faults and fractures, steep slopes. They consist of gneisses, metavolcanics, serpentinites, metagabbros, and granitoid rocks intruded by dykes and ring complexes. Sedimentary mountains are represented by Nuqra in Nuqra plain to the east and Al Baraqa to the west in Gallaba plain [9].

• Tableland or plateau occupies almost all sedimentary cover and attains moderate elevation (+200 to +600 m). The table can be distinguished into two extensive plateaux bounding the Nile Valley which formed mostly a result of a series of NW-SE and NNW-SSE fault blocks. The eastern tableland decrease of their elevation westward (toward the Nile) and is covered by Abu Ballas, Taref, and Quseir formations as well as Natash volcanics. It is characterized by some isolated hills and cut by a great number of wadis such as Shait, Kharit that debouch their water to the River Nile. The western portion represents a part of Sin El Kaddab Plateau that has an irregular surface and rises to more than +240 m. It is dissected by a number of wadis such as El Kobaneia flowing generally westerly towards the Nile Valley [10].

• Isolated Hills can be differentiated into volcanic and sedimentary hills. The volcanic hills are recorded to the east of Atmur Depression with ground elevation +400 to +600 m and are composed of Natash Volcanics. The sedimentary hills are restricted to the west of Atmur Nuqra with ground elevation from +270 to +205 m which are consisting of sand and shale belonging to Upper Cretaceous, Paleocene, and Pliocene. The famous hills are Gabal (G.) El Muqil, G. Hilaywat, G. Naq Shait, and G. El Nuqra, G. Sirir Um El Battikh, G. El Mizan, G. Midrik, G. El Maghrabi, and G. Hamd Orab.

• Piedmont or foot slopes are located to the east and west of the edges of tablelands towards alluvial plains. It consists of gravels and coarse sand that is subject to interchanging flow dynamics depending on the strength and magnitude of individual flood events.

• Mountains and plateau are highly dissected with a dense network of dry drainage that has steep scarp faces following the regional N-W, E-W, and N-S structural tend such as Shait, Kharit, Natash, al Lawib, and Medrik. They responded to the past wet climatic conditions and their surface is either bare or covered by a thin layer of boulders and gravels the upstream and filled with sand and silts the downstream. The alluvial fans are not common in the study area as the wadis are debouching into low laying areas of Kom Ombo Plains and Nile flood plain, and most of the areas are now occupied by agricultural lands.

The kom omboatmur nuqra depression

This unit stretches for 70 to 80 km from east of the River Nile until G. El-Nuqra. It is nearly flat plain and extends east-west. Structurally, it is considered as a graben type structure, where the depression is bounded by normal fault segments striking east-westerly and sinking about 80m below the surrounding highland . The detailed geomorphological evolution of this depression can be found .Its floor is covered by Quaternary deposits including playa, wadi deposits, beside outliers of Nubian Sandstone which stretch for 15 km in a north-south direction with 5 km width in the east-west direction and rises about 100 m above the floor. Additional evidence suggests that structural elements of the Nubia swell have a long history. It inferred from regional facies and stratigraphic relationships that the E-W trending Uweinat-Aswan uplift first formed in late-Paleozoic or early-Mesozoic time. It appears that the Kom ombo graben controlled Middle to Upper Pliocene marine sediment deposition, suggesting that Nubia swell structures were well-developed by this time. This is consistent with the fact that there appears to have been a significant drainage divide associated with the Nubia swell during the late-Miocene development of the Egyptian Nile.

Fluvial plain

Fluvial plain is represented by Gallaba Plain west River Nile which is under intensively cultivated. Gallaba extends from the Nile River in the east to the Sin El Kaddab scarp in the west and extends northward from Aswan, through Kom Ombo to Idfo. On the western bank of the Nile, the flood plain almost disappears and the plain is covered by gravels and sand sheets. The basal sand and conglomerate of the fluvial sediments overlaying the Cretaceous bedrocks are derived from igneous and metamorphic rocks of the Eastern Desert .Wadi Kobbania is a salient feature of this plain, drains from the western limestone plateau of Sinn El Kaddab.

Cultivated land

Most of the cultivated lands are located to the east of the Nile River (e.g. Kom Ombo Plain) that increased eastward along Wadi Kharit, Wadi Shait, and the western parts of the Nuqra Plain. They are composed of multiple thick layers of clay, sand, silt, and gravels that were developed as a result of the successive floods of the Nile. The course of the 5 Nile cuts the plain close to the eastern side and flows in S-N direction. The surface of this plain is generally flat and has an elevation ± 90m above sea level.

The influence on the paleohydrology

The course of the Nile through northern Sudan and southern Egypt has been strongly affected by the continued uplift of the Nubia swell as manifested by the youthful geomorphology of the northern Cataract Nile .The relatively youthful nature of the northern Cataract Nile is also shown by the fundamentally different nature of tributaries that flow into the Nile to the north and south of Aswan. North of Aswan, the drainages mark deeply incised, buried canyons, whereas tributaries south of Aswan have shallow bedrock floors .These buried canyons mark where streams cut down to the lower level of the Nile canyon established during the Messinian stage (late-Miocene) when the Mediterranean was desiccated at 5.3-6.0 Ma. This implies that the drainages to the south were not active during the Messinian and thus are much more recent features than the northern drainages. Additionally, we see no new evidence for the south-flowing Nile as has been highlighted by and contested .

Examples of shallowly buried paleochannels and fossil rivers that preserve a history of Nubia swell tectonic movements are remarkably displayed by SIR-C/X-SAR radar imagery. Five examples of these drainages are (1) the change of old N-S River Nile course south Kom Ombo Town, (2) the changes of the main drainage lines from SW to become NW north Esna and the variation of directions are due to the effect of Nubia Swell, recorded examples adjacent to Wadi Kobbania (3), beneath the Selima Sand Sheet (4), and along the Fourth Cataract in Sudan (5).

The radar image shows the course of N-S River Nile was shifted westward and bent east-west near Kom Ombo Town due to the activities of east-west faults. The same phenomena were achieved using the electric geophysical method and the displacement is about Six kilometers east of Kom Ombo .The radar image shows Wadi Kobbania and Wadi Abu Subeira may be remnants of older drainage. Wadi Kobbania which now flows SE into the Nile may have originally the downstream continuation of Wadi Abu Subeira .Another remnant of small old drainage in Gallaba Plain flow SE into the Nile while their extension east the Nile not clearly. However, SIR-C/X-SAR imagery provides spectacular evidence of the hypothesis those tributaries of north-flowing drainage till Esna were affected and disrupted by the Nubia Swell, where they extended around the Nile and flow into the Nile . Future advances in imaging radar, such as data collected from the Shuttle Topography Radar Mission (SRTM) will further improve our understanding of this dynamic region of the River Nile and North Africa.

River Nile Paleochannel from geoelectric sounding. The drainage pattern south Egypt shows the impact Nubia swell south Esna that shows the influence of Nubia swell that changed the direction of E-W and NE-SW to SE-NW and NW-SE. c L-hh SIR-C images of recently reorganized drainages on the flanks of the Nubia swell in Kom Ombo . White areas are regions of high radar backscatter; dark areas are regions of low radar return.

Effect on rock unit distribution

Further evidence of Cenozoic uplift of the Nubia swell comes from the distribution of limestone of Lower Tertiary age found south of the Nubia swell on the Abyad Plateau in northern Sudan (These outcrops represent the southernmost outliers of the southern Tethys shelf, which was once continuous across Egypt and northern Sudan . Intervening exposures of Precambrian crystalline basement and late-Paleozoic and early-Mesozoic sedimentary rocks now separate these limestone outcrops from correlative units in the Sin el-Kaddab Plateau in southern Egypt by 350km ,Tertiary limestone deposits between the Sin el-Kaddab Plateau and the Abyad Plateau are interpreted to have been removed by erosion along the Nubia swell during mid- to late-Cenozoic time. Also, the influence of Nubia swells extended northeastward to restricted the limestone outcrop east of the River Nile near Qena (north Kom Ombo).

The rocks distribution and detail features of Kom Ombo much controlled by Nubia swell. Precambrian basement rocks crop out at the eastern parts and are composed of metasediments, metavolcanics, and granites. The Cretaceous rocks occupy a large portion around plains and represented by Abu Ballas (shale with thin sandstone layers), Sabaya and Taref (Abu Aggag, Timsah, and Um Baramil members) (coarse to fine sandstone intercalated with thin shale layers), Quseir and Duwi Formations (shale with sand layers). Paleocene Kurkur and Garra Formations (limestone with shale and sand layers), and Pliocene Issawiya Formation (shale with sand beds) are outcropped only in the western part. The Quaternary deposits cover the depression areas and wadi floors. Where the surface stratigraphy has been mapped and discussed.

Control the structural setting

Within the Nubia Swell, two sets of E-W trending uplifts and associated troughs can be identified .The northernmost set includes the relatively narrow (~150 km) Kom Ombo graben .This graben has also been referred to as the Kom Ombo-Atmur Nuqra Depression.The Kom Ombo graben is flanked to the south by the Gebel Uweinat-Bir Safsaf-Aswan Uplift System exposing the Precambrian crystalline basement . It inferred from regional facies and stratigraphic relationships that the E-W trending Uweinat-Aswan uplift first formed in late-Paleozoic or early-Mesozoic time. It appears that the Kom).

Ombo graben controlled Middle to Upper Pliocene marine sediment deposition suggesting that Nubia swell structures were well-developed by this time. On other hand, the second set includes a trough defined by the Toshka Depression which is located west of the Nile. The northern boundary of this uplift lies near the Kalabsha Fault, an active E-W trending dextral strike-slip fault .This complex, N-S trending structure, which we call the Aswan corridor also serves to truncate important E-W trending structures such as the Kom Ombo graben and the Seiyal and Kalabsha faults .where these tectonic movements opened up a corridor for the Nile to flow across the Nubia Swell.

E-W faults are still active now, where earthquakes have been documented in southern Egypt since Pharaonic times. The toppled head and torso of one of the four Ramses statues at Abu Simbel resulted from the seismic activity about 1210 BC .In November 1981, a 5.6-magnitude earthquake occurred 45 km SW of the Aswan High Dam Up to 40 micro-earthquake events were recorded per day since then. The majority of the epicenters concentrated in the vicinity of Gebel Marawa, where the E-W Kalabsha fault intersects a major N-S trending fault. These E-W trending faults are two of numerous Cretaceous and younger faults Focal mechanisms and field mapping indicate dextral strike-slip displacement along the E-W trending Kalabsha fault. On March 22, 2003, an earthquake (MD 4.0) occurred in the west Kom Ombo area and its surroundings, and the event was followed by two aftershocks with magnitude 2.7 and 3.0.

Utilizing data sets and field observation and measurement to identify the surface structure of the study area which reflects NW-SE is the major fault trend followed by the long lengths E-W to NNE fault trends and the N-S is subordinate. E-W system (the oldest) control Wadi Shait course, are highly pronounced in Kharit and Natash wadis, and cross Sin El Kaddab Plateau. NW and NE control the main tributaries. Lineament trends are NW-SE, E-W, NNW-SSE, WNW-ESE, NE-SW, and N-S in descending order. A lot of folds were detected flow NW, N-S, and E-W trends. NW-SE folds are recorded in Wadi Kharit and Nuqra plain. N-S plunging and doubly plunging anticlines and synclines are dominated between the Nile Valley and Sin El Kaddab plateau. E-W folds are recorded in Wadi Natash.

Based on Aeroservice's data 3 D view of the model depth to the basement was made to show the subsurface configuration of grabens or depressions Nuqra and Gallabal depression are shallower than Kom Ombo that controlled by the E-W fault system. Seismic lines illustrate that Nuqra is asymmetrical half-graben bounded from the east by SW faults and affected by long length NW-SE which dissected by NE-SW faults forming grabens and horsts. The depth to basement ranges from 550 m to 2560 m. It recorded the accommodation zone runs E-W in the Kom Ombo-Atmur Nuqra graben. The Kom Ombo graben formed during the Jurassic-Early Cretaceous.The depth to basement ranges from 3660 m in the deepest location to 460 m in the shallowest one that affected by two NE-SW and NW-SE fault trends forming horst and graben structures.

Contribution on the hydrogeological setting

The above mentioned huge data sets, well logging of available oil and water wells, hydrogeologic cross sections collected water samples and literature such as; reveal that the occurrence of Quaternary and discovery karst (Paleocene Kurkur and Garra) and Nubia (Cretaceous Taref and Sabaya) groundwater aquifers. They are separated from deep oil bearing Six Hill Formation by the shale of Abu Ballas Formation.

Quaternary aquifer

• The Quaternary is a widespread aquifer that made up of Pleistocene fluvial sands and gravels with clay beds that overlain by Holocene silt and clay layer and underlain Pliocene shale i.e. free to semi-confined. Twenty (20) water samples were selected to represent the aquifer Groundwater thickness, water level, hydraulic head level, sources of recharge, and salinity of groundwater varies from plain to others as follows:

• The groundwater thickness ranges from 80 to 150 m in Gallaba Plain, water level varies from +81 to +110 m above sea level and the hydraulic head level increases from SSE to NNW which point to the main source of recharge is Lake Nasser through four NNE-SSW fault plains (Khour el Ramla, Kurkur, Abu Derwa, and Ghazal faults) and River Nile There is a hydraulic connection with the kart aquifer .The estimated aquifer productivity ranges between 60 and 130 m^3/h indicating that this aquifer is moderate productive. The total dissolved solids (TDS) range between 877 and 3797 mg/l with the groundwater flow direction in that aquifer due to leaching the aquifer matrix that leads to the increase of soluble salts ((e.g. Na_2SO_4, $MgSO_4$, $CaSO_4$ and $Ca(HCO_3)_2$.

• The aquifer thickness varies from 34 to 90 m in Kom Ombo plain water level ranges from +93 to +125 m above sea level and the hydraulic head level increases from east to west, which reveals that the groundwater recharged comes mostly from irrigation and drainage systems. They're also a hydraulic connection with the kart aquifer .The TDS ranges between 605 and 880 mg/l with the groundwater flow direction in that aquifer due to leaching the aquifer matrix that leads to the increase of soluble salts (e.g. Na_2SO_4 and $Ca(HCO_3)_2$.

• The aquifer thickness ranges from 80 to 140 m in Nuqra plain, the water level is +124 m, and the hydraulic head level increases from west to east, which indicates the system of irrigation and drainage of cultivated area are the main source of recharge. There is a hydraulic connection with the kart aquifer that increases the salinity of the aquifer to 3560 mg/l.

• All groundwater samples have $Na\text{-}Cl\text{-}SO_4$ water type, while the River Nile and has $Mg\text{-}Ca\text{-}HCO_3$. They are plotted in sodium-chloride-sulfate zone of Piper trilinear diagram (1944), which indicates that the groundwater has a secondary salinity.

According to Suiln's diagram (1946) of the genetic classification, they are plotted in the lower quadrant indicating the deep meteoric water genesis.

• Groundwater samples of Kom Ombo are suitable for drinking purposes (TDS>1000 mg/l) according to, while most of the others are unsuitable. According to McKee and Wolf 1963, they are very satisfactory to satisfactory for livestock. According to the US Salinity Laboratory Staff's classification , Kom Ombo samples are suitable of irrigation purposes, while most of the others are intermediate to moderate classes.

Hydrogeochemical features of collected Quaternary water samples reveal the effect of E-W fault systems that causes upward leakage from the Nubian sandstone aquifer system along their plain especially in well nos. 8 and 10 in Gallab (west), and wells nos. 16 and 17 east Kom Ombo that have a high percentage of NaHCO3 salt. On the other hand, the interaction between NW and E-W fault systems increases the rate of upward leakage from deep aquifers which appear in wells nos. 6, 7, 11, 12, and 14 in Gallaba (west) and well nos. 15, 18, and 19 east Kom Ombo that have a high percentage of $Ca(HCO_3)_2$ salt. The higher temperatures of the water in these wells than surrounding (from 27.3°C and 31.3°C) reflect also the upward leakage from the Nubian aquifer (~38°C). This conclusion is supported north and south of the study area. This hypothesis should be further tested by means of traversal deep geophysical cross-sections.

Karst aquifer

Karst or fissured limestone aquifer system has a wide distribution on the surface to the west and north Kom Ombo and is consists of Paleocene Garra and Kurkur Formations with thickness varies from 200 to 900 m that are hydraulically connected through faults and facies. Karst is overlain by Pliocene shale and underlain by shale of Upper Cretaceous Duwi Fm shale i.e. confined to the semi-confined aquifer. It is made up of limestone with shale and sand layers that deposited under the marine environment. The groundwater of the karst aquifer is of much lower potentiality than that of the Nubian sandstone aquifer. Where groundwater may occur as local pockets or perched at contacts with an impervious clay layer.

Two water wells are recorded in the western portion of Nuqra Plain taping the aquifer. The depth to water ranges from 19 to 25 m and water level ranges from +125 to +131 m above sea level and the hydraulic head level increases from west to east, which reveals that the groundwater recharged comes mostly from irrigation and drainage systems of Nuqra cultivation project, and upward leakage from deep Nubian aquifer related the effect of the swell. It proved the upward leakage of the artesian water contained in the underlying Nubian aquifer in Egypt, Libya, and Sudan. There is also a hydraulic connection with the Quaternary aquifer .The TDS range between 3856 and 4164 mg/l with the groundwater flow direction in that aquifer due to leaching the aquifer matrix that leads to the increase of soluble salts (e.g. $Ma(HCO_3)_2$ and $Ca(HCO_3)_2$. Groundwater samples have $Na\text{-}Cl\text{-}SO_4$ water type, secondary salinity, and deep meteoric water genesis. They are unsuitable for drinking purposes and moderate for irrigation purposes.

Nubian sandstone aquifer system

ubian covers about 2 million square kilometers in Egypt, northern Sudan, northeastern Chad, and southeastern Libya. It consists of several sedimentary basins filled with sediments up to 5000 m in thickness .The Nubian aquifer system is the main aquifer in the study area and represented by Cretaceous Taref and Sabaya aquifers that are hydraulically connected through facies and fault systems. Nubian is covered by Quseir and Duwi and underlain by Abu Ballas shale formations i.e. confined to the semi-confined aquifer. It has huge thickness varies from ~ 700 m in Nuqra well to ~ 345 m in Kom Ombo-3 well that decreases in the edges of the plains. The variation of aquifer thickness owing to the impact of Nubia swell which affects the texture of aquifer to become coarse to fine sandstone intercalated with thin shale layers. It is deposited under the continental conditions that deposited under the fluvial environment .The Nubian aquifer is recharged largely from the precipitation on the outcropped Nubian sandstone rocks around the area, fractured basement rocks through fracture systems, Lake Nasser, and in addition to water that was stored during pluvial times. There is also a connection with the karst aquifer system through facies and fault systems .

The groundwater is characterized by high hydrostatic pressure in most regions of the area, where, the groundwater of relatively high temperature (~38°C) is recorded near the ground surface in Shait-1 and Shait-2 water wells. The isotope 18O and D values of Shait-1 are -9.53 and -73.1 that indicates the depleted water. The Nubian aquifer is a moderate to a highly productive aquifer.

SUMMARY AND CONCLUSION

Water shortage in East Africa could affect human welfare and economic activity stability that needs efforts to avert the expected crisis and to avoid potential conflicts that might arise. Swell phenomena surrounded a lot of broad basins in Africa that is called Nubia swell in East Africa. It is refer to a complete active east-west trending structure south Egypt and north Sudan that extended more than 1000 km with width reach to about 200 km. In my article, the objectives are identifying the influence of Nubia swell on distribution and potentialities of groundwater aquifers for future development. A lot of subsurface informations gained from recent oil exploration and deep wells in Kom Ombo area north Aswan of Egypt; encourage selecting it for testing, where the hydrological setting of this area does not understand. The study is based on integrated data sets of remote sensing, topographic and geological maps, geophysics (magnetic, gravity, seismic, electromagnetic, electric and well logging), deep oil wells, groundwater wells, paleontology, water samples and chemical analyses, field works and measurements, GIS and softwares.

Nubia swell much controls the distribution of land forms that distinguished into mountainous area, depression, fluvial plains and cultivated land. E-W faults are still active till now, where earthquakes and aftershocks have been recorded around it. Swell affects the course of the Nile through northern Sudan and southern Egypt; where it changes old N-S River Nile course south Kom Ombo Town westward, conversion the main drainage lines from SW to become NW north Esna and restricted the limestone outcrop east the River Nile near Qena (north Kom Ombo). Nuqra (-550 to - 2560 m), Kom Ombo (-460 to -3660 m) and Gallaba (-590 to -2750 m) troughs or depressions from east to west are formed owing swell that affected by NE-SW and NW-SE fault systems forming horsts and grabens. The presence of depressions encourage the author to examine the occurrences of groundwater aquifers and their potentialities in the study area for future developments based on integrated approach of data sets, hydrogeological cross section, water samples and literature. They reveal new lights on Quaternary aquifer and discovery karst and Nubian aquifer systems with saturated thickness reach to 1200 m.

Twenty water samples were collected from Quaternary aquifer which reflects moderate potentiality. The variation of aquifer thickness, hydraulic head level and salinity related to the difference of sources of recharge and Nubia swell. The presence of another active source of recharge from Lake Nasser through four NNE-SSE faults in Gallaba plain changes the hydraulic head level to become from SSE and the salinity greatly from 877 to 1800 mg/l. Dense irrigation and drainage systems in old cultivated area in Kom Ombo west the River Nile also changes the hydraulic level to become from east to west and the salinity greatly from 605 to 880 mg/l. But, the systems in new cultivated area in the western border of Nuqra plain change the water level eastward. The Quaternary aquifer are Na-Cl–-SO_4 water type, deep meteoric water genesis and mostly intermediate to moderate for irrigation purposes.

Hydrogeochemical features of Quaternary water samples support the upward leakage from deep Nubian aquifer through E-W fault system, where water samples around it have temperature round 31°C and high percentage of $NaHCO_3$ salt. The interaction between NW and E-W fault systems led to mixing of upward leakage from Nubian with karst that decrease the temperature to become around 28°C and increase the percentage of $Ca(HCO_3)_2$ salt. This conclusion is supported north and south the study area. This hypothesis should be further tested by means of traversal deep geophysical cross-sections.

Karst is confined to semi-confined aquifer system and consists of Paleocene Garra and Kurkur Fms with thickness from 200 to 900 m. The aquifer tapped only by two wells in the western portion of Nuqra Plain with TDS 3856 and 4164 mg/l and water level from +131 to +125 m that indicate groundwater recharge from irrigation and drainage systems of Nuqra cultivated project and upward leakage from deep Nubian aquifer. Karst has moderate potentiality, Na-Cl-SO_4 water type, secondary salinity, deep meteoric water genesis and unsuitable for drinking purposes.

Nubian aquifer system is highly potential aquifer in the study area and is confined to semi-confined. It represented by Cretaceous Taref and Sabaya aquifer that are hydraulically connected through facies and fault system. It has hug thickness from 345 to 700 m owing the impact of Nubia swell. Nubian aquifer is recharged largely from the precipitation on the outcropped Nubian sandstone rocks around the area, fractured basement rocks through fracture systems, in addition to water that was stored during pluvial times. The groundwater is characterized by low salinity, high hydrostatic pressure, relatively high temperature (~38°C) and depleted water.

The main conclusions of the influences of Nubia swell on aquifer distribution and potentiality are:

• Controlling the distribution of groundwater aquifers and sources of recharge.

• Combination of other faults systems such a NW increase aquifer thicknesses and potentialities.

• Discovering of karst and Nubian aquifer systems with huge thickness.

• Shedding new lights on Quaternary aquifer.

• The intermediate suitability of groundwater aquifers for irrigation purposes.

The article recommended (1) drill deep groundwater wells for cultivation more than 400 thousand faddans in Kom Ombo, (2) examine Nubia swell areas in Egypt and Sudan for groundwater prospecting and (3) utilizing our methodology elsewhere for identification, distribution and potentialities of groundwater aquifers. The recently wells will provided detail information about aquifers and potentialities.

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