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STRUCTURAL SETTING AND HYDROCARBON POTENTIAL OF KHARITE-NUQRA-KOMOMBO RIFT BASINS, SOUTH EGYPT: A PROSPECTIVE APPROACH

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Abstract— **The sedimentary basins of Kharite, Nuqra, and Komombo are outlined with the potential geophysical data where the southern N-S Egyptian Nile course separates Nuqra and Kharit as the East Nile basins. Two commercial discoveries of Al Barka and West El Barka oil fields have been declared in the West Nile basin of Komombo. This work presents our insights on the structural setting and hydrocarbon system of these basins through our integrating results in form of interpreted seismic profiles and structural mapping on the different horizons, 1D basin modeling, geochemistry, and geologic maps based on high-resolution satellite images. Structurally, these rift basins are developed as NW-trending asymmetric fault-bounded half-grabens (oblique to the Red Sea trend) through the reactivation of a major Precambrian Pan African tectonic zone by the Neocomian extensional tectonics. The high potential source rock with up to 7wt. % TOC of kerogen II are proved in the Komombo basin. The seismic and drilling results show Neocomian-Barremian maximum subsidence and the possible occurrence of similar Neocomian source rocks in the eastern Nile basins. Additionally, the convenient clastic reservoir rocks occurred in the entire stratigraphic succession and seal capacity in the upper interval of Senonian-Paleocene. Good opportunities for hydrocarbon structural trapping take place in form of rotated fault blocks by the Early Cretaceous extensional rift and mildly inverted structures by a long span of Late Cretaceous to post-Early Eocene Syrian Arc compression in South Egypt. These elements were verified by Al Baraka discovery and present a promising play concept for hydrocarbon potential in the Kharit and Nuqra basins. The geochemical data indicate different basins exhumation and maturation levels, as the 0.5% calculated vitrinite reflectance "Ro" values occur at the depths of 1200ft and 2100ft in Nuqra and Komombo basins, respectively.**

Keywords— **Rift Basin, South Egypt, half-graben, inverted structure**

I. INTRODUCTION

Since the first Egyptian hydrocarbon discovery of Ras Gemsa along the western coast of the Gulf of Suez rift in 1906 [1], the exploration and production activities in Egypt were mainly directed to this rift basin and later extended to the north Western Desert and Nile Delta. A long time ago and by the potential geophysical data (gravity and magnetic), three interior basins around the Nile Valley in south Egypt have been outlined long time ago (Fig.1), these basins have received attention only after successful exploration programs in the Sundance rift basins.[2][3][4]

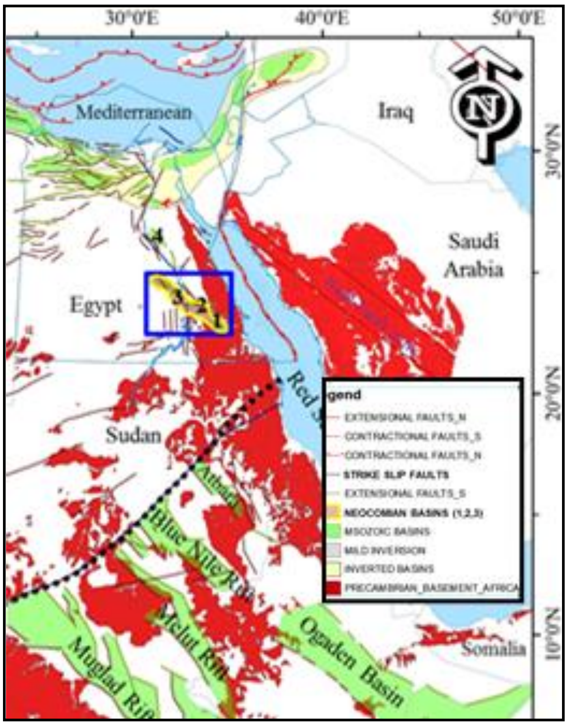

Fig. 1. Location map shows the three studied basins (1 Kharit, 2 Nuqra, 3 Komombo), and Mesozoic sedimentary basins (green color) in Egypt and Sudan (modified after Bosworth, 2008)

This work aims to throw light and give some insights into the structural setting and hydrocarbon potential of these Upper Nile Valley basins in south Egypt, which are located between latitudes 24°-25° N (Fig.1&2). These basins are mainly arranged in NW direction and geographically separated by the Nile Valley into Kharit and Nuqra basins in the east and Komombo basin in the west (Fig.1). The low reaches of these basins were receiving the Nile flooding sediments before building the High Dam in south of Aswan.

Although these basins hold an area that resembles the size of the Gulf of Suez, exploration activity until 2006 was represented only by the four 2D seismic wide gride ventages and few drilled boreholes (Fig.2). This limited exploration activity was fortified by the local discoveries in the Komombo basin of Al Baraka and West Al Baraka oil fields in 2007&2012. [5] [6]

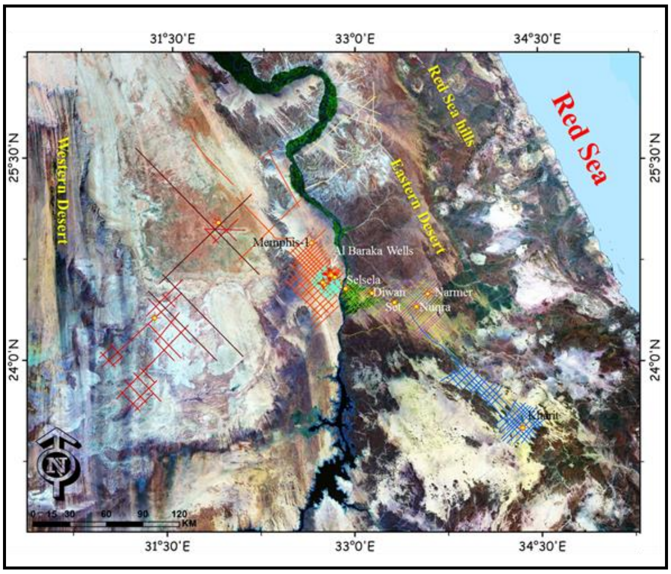

Fig. 2. Lansat image shows the location of the seismic coverages with different colors, and boreholes in the study.

II. Database and Methodology

A. Dataset of Seismic and borehole data

The available regional 2D seismic data, provided by GANOPE, covers four areas; Kharit, Nuqra, and Komombo basins and Sin El Kaddab plateau (Fig.). The 2D seismic surveys cover about 9410 km^2 of the basinal area of the Neocomian Upper Egypt Rift. The seismic lines are generally oriented in a NW and SE directions forming a grid of 4*4 km. The 2D grid spacing ranges from 0.5 to 4 km. A 3D seismic cube was acquired over the Komombo basin in 2008 covers the Al Baraka and West Al Baraka oil fields. The quality of seismic reflections ranges from fair to good according to the area of survey. In the Kharit basin, the seismic imaging is poor due to the rough morphology of the area and the effect of volcanic intrusions. In the Nuqra basin, it is fair to good. The quality of seismic data is good in the Komombo basin except for the cultivated land. The borehole data (Fig. 2) includes the petrophysical logs of several wells drilled in the Komombo basin and three wells drilled in the Nuqra basin (Set-1, Nuqra-1, and Narmer-1), and one well drilled in the Kharit basin (Kharit-1). Also, geochemical data and published surface geological maps are used.

The rugged surface morphology and cultivated land of the basins and their margins, especially Nuqra and Kharit, was a big challenge in the planning of classical seismic shooting techniques. Also, the presence of sporadic hard rock inliers on the surface with a variable thickness of the Nile sediments and Wadi-fills add difficulties on surface statics, replacement velocities, and noises filtrations during the seismic processing. These technical challenges imposed low seismic quality where the subsurface imaging is hardly imitating the intricate surface geology of the areas.

B. Methodology

The main objective of the 2D seismic data interpretation is to investigate all the possible subsurface structural elements affecting the basins and to define the rift geometry and margins within the areas of interest. 2D seismic data interpretation was performed using Schlumberger® PETREL software. Interpretation is achieved through a grid of 2.5×2.5 km of NW and NE-oriented lines. The seismic reference datum of the project is the Sea Level and hence, the PETREL project, the velocity maps, and all maps are referenced to this datum. The project coordinate system is Red Belt-WGS 84- 36 N. The depth conversion of the interpreted time horizons was performed using velocity maps constructed from all the available wells drilled in the areas of study.

III. Geologic Setting

A. Stratigraphic framework

The surface stratigraphic course on the peripheries of the basins and in penetrations is quite different from the known provinces in northern Egypt (Fig.3&4). The general stratigraphic correspondences of the area with both the Gulf of Suez and North Western Desert are given in Figure 3. Although the Paleozoic sediments have widespread occurrences in North Africa [7][8][9][10][11] and are hydrocarbon productive[12][13][14], they are completely absent in the Nile Valley basins.

The study area of Egypt had witnessed the first sedimentation during the Early Cretaceous rifting. The Early Neocomian sedimentation was restricted to the deep basinal portions with deposition of lacustrine shale and sand of Komombo Formation (Fig.4). These sediments are completely absent in the shallow parts of the basins. Rifting was accelerated during the Late Neocomian-Barremian time where larger areas had been lowered and received thick non-marine sand and shale of the Six Hills Formation. Continuous subsidence during the Aptian time depositing was expressed by deposition of the non-marine sand and shale intercalations of Abu Ballas Formation. The three Upper Egypt basins are characterized by an angular unconformity between these sediments and the overlying Albian- Lower Eocene overlying section [5][6]. This represents the termination of the Early Cretaceous rifting and could be correlated with the same event in the north Western Desert basins (Fig.4).

The Albian to Cenomanian sequence consists of a basal non-marine section grading upward into coastal marine deposits and known as Sabaya and Maghrabi formations. They are mainly composed of alternating shale and fine-grained sandstones with Cenomanian fossil fragments. The sands display different facies of tidal channels and bars. The pervasive tidal influence confirms the coastal position of the sands in the basins[5][6]. Phases of rift-related volcanics eruptions of Cenomanian-Turonian are identified are known as Natash volcanics [15][16][17]. These volcanics are intruded with Senonian by trachyte plugs [16]. these volcanics are not recorded within the basinal area by drilling and exposed on the eastern uplifted margins of Nuqra and Kharit basins (Fig.3).

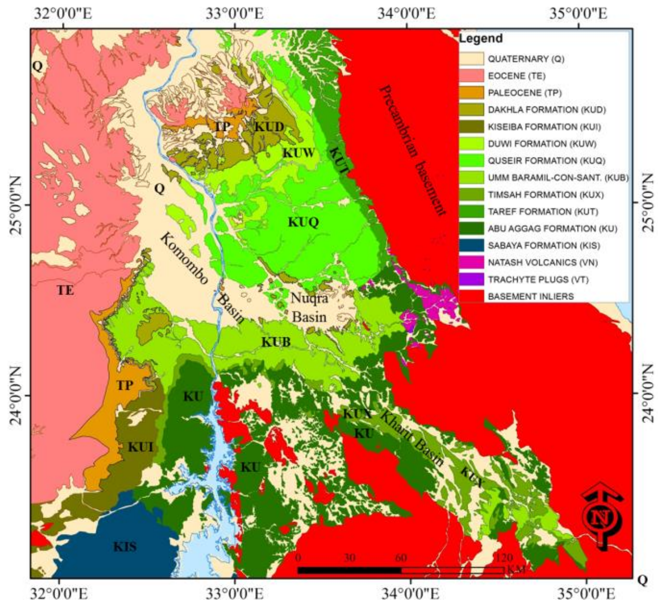

Fig. 3. A simple geologic map shows the aerial distribution for the exposed stratigraphic units and their classification in the study area (adapted from Geological maps of Egypt, 1987).

Marine influence was continued through the deposition of the Turonian Taref Formation and the clastics of Abu Aggag Formation (Fig.3&4). Signs of positive tectonic inversion during the Coniacian-Santonian cause uplifting of some areas. This phase is corresponding to the Syrian-Arc tectonics that was affecting northern Egypt [16][18][19][20]. The syn-inversion sedimentation persisted in the structural low areas to receive shale of the Quseir Formation and its laterally changed facies of shallow marine deposits of Timsah Formation. At the southern up-dip reaches of the Nuqra basin, the latter Formation is distinguished with four coarsening-upward sedimentary cycles and the deposition of oolitic ironstones [21].

Shallower facies in the structural highs are described by the clastics of Um Baramil Formation. Lateral change to deeper marine facies in the basinal trough of Nuqra is observed by deposition of Quseir shale in the area of Set-1 well and the northern footwall exposures of the basin.

The marine Campanian Duwi marl, Kiseiba shale, Maastrichtian Dakhla shale, Paleocene Esna shale, and Early Eocene carbonates of Thebes Formation were assumed deposited in subsided areas. These sediments are recorded in the subsurface of the Komombo basin and crop out on the basin margins and further south. On the contrary, these Campanian- Eocene succession is missed in the Nuqra-Kharit basins and their restriction to farther north areas (Fig.2). Missing of the Campanian-Lower Eocene section is possibly attributed to the exhumation of the Nuqra and Kharit basins associating the uplifting phase of the Eastern Desert basement terrain during the Red Sea rifting. Since the Mid Eocene, the complete territory is exposed and suffered from extensive erosion until resuming of Nile sedimentation in Pliocene-Quaternary.

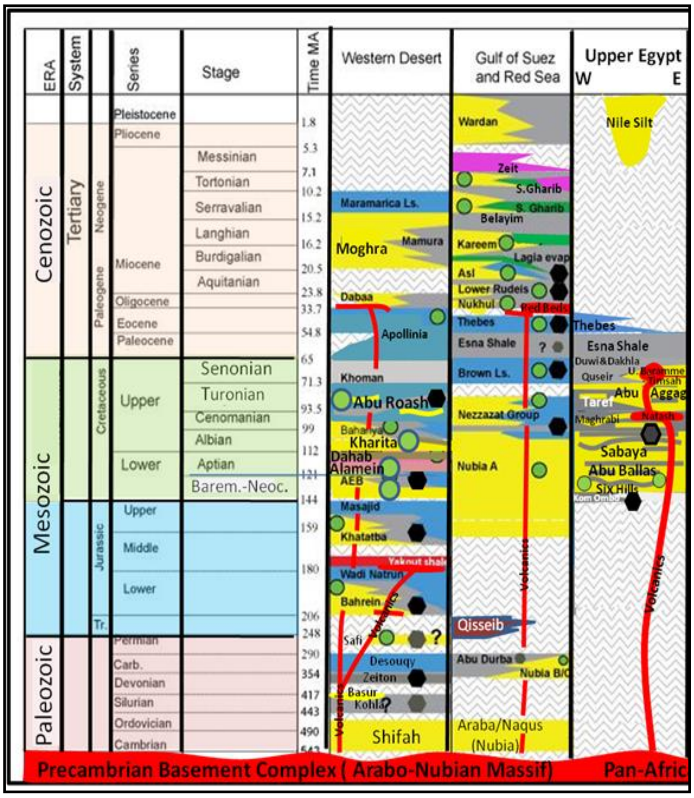

Fig. 4. Stratigraphic correlation between Upper Egypt, Gulf of Suez, and the North Western Desert with oil occurrence and source rock intervals.

The earlier works proposed the development of Upper Egypt basins to Jurassic rifting [22], but the boreholes paleontological analysis indicated the missing of the Jurassic sediments in Upper Egypt basins [5][23]. Moreover, Upper Egypt is not affected by the Early Mesozoic rifting that dominated North

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Africa and formed extensive basins in the north Western Desert [24][25][26].

B. Petoleum Geology: Reservoirs, Seal and Source Rocks

The first evidence of a working petroleum system in the Nile Valley basins was proven in 1993 and the commercial discovery of Al Baraka was in 2007. The penetrated stratigraphic section contains several sandstone intervals with established multiple pay intervals [5][22] and oil shows at different depths. The produced oil in Al Baraka field is derived from two pay zones: the shallower (3,000-4,000 feet) Six Hills of unit "E" and the deeper (average depth of 8,000 feet) Komombo [5][6][27]. The Basal Komombo paying intervals of units "A and C" are found separated by the oil source beds of unit "B" [28].

The tight reservoir quality enhancement through hydraulic fracturing has increased production, and reserves have grown from 0.6 to 5.23 MMBO in the Al Baraka field. Application of new drilling and completion techniques such as horizontal drilling could increase the production and recovery rates. The oil is 37 °API, with wax content likes that produce from Sudanese rift basins [22]. The very low gas/oil ratio (GOR) assists the application of water floods to enhance the oil recovery from some reservoirs.

The shale intercalations within the gross reservoir thickness act as an intra-formation seal, while the top seal is offered by the thick shale intervals within the upper part of Komombo and the lower part of Six Hills formations. These intervals are efficient in small faults juxtaposition and might act as ductile shale smears gauge sealing. The upper thick shale of Sabaya - Quseir formations play as a regional top and lateral footwall seal against the down faulted reservoirs.

While the shale intervals in the Sabaya Formation and deeper levels have a relatively high background of total organic carbon (TOC) up to >2wt. % in average, the basal section of the Neocomian Komombo shale is strongly lipid-rich and is regarded as the main source rock (Fig.5). The highest organic contents are in unit "B" and partially in unit "C" with TOC up to 7wt.% and 4-5wt.%. on average. Geochemical correlation of source rock data of Al Baraka-1, Komombo-2 in Komombo basin, and Narmer-1 in the Nuqra basin indicates their matching in kerogen type (Fig.5). The Oxygen-Hydrogen indices relationship helps to recognize the kerogen of type II with some influence of types I and III in both basins. The geochemical borehole logs of these shales proved the good potential level of oil-prone source rocks [29]. The maturation level modeling based on the thermal alteration index (TAI) and the vitrinite reflectance (Ro) of kerogen samples indicates high maturity at the level of 8400 ft in Komombo-2 and post maturity at the depth of 8660 ft in Al Baraka-1 (Fig.6). The constructed burial curves display Cenomanian time for oil generation, whereas the expulsion and migration occurred in Eocene time. The expected oil expulsion at Ro value of 0.7% has been reached in the Komombo basin wells at an average depth of 4000 ft, while the shallower expulsion level at 2000ft was reached in Narmer-1 in the eastern Nuqra basin (Fig.6).

The surface samples in Komomo-2 attained a Ro value of 3.8% is an indication of basin uplifting and erosion. The extrapolation of the TAI and Ro maturity curves in the Komombo basin to Ro of 0.2% indicates an exhumation level of around 1640 ft, and 4000 ft of eroded roofing section [28][29]. The east Nile basins experienced severe erosion and basin sediments unroofing as exposing the Sabaya Formation on the surface in Kharit-1 and the Maghrabi Formation in Narmer-1. The latter well shows a 0.62% Ro value at 1200ft where the extrapolated maturity curve to the 0.2 % Ro value indicates 4000 ft of exhumation.

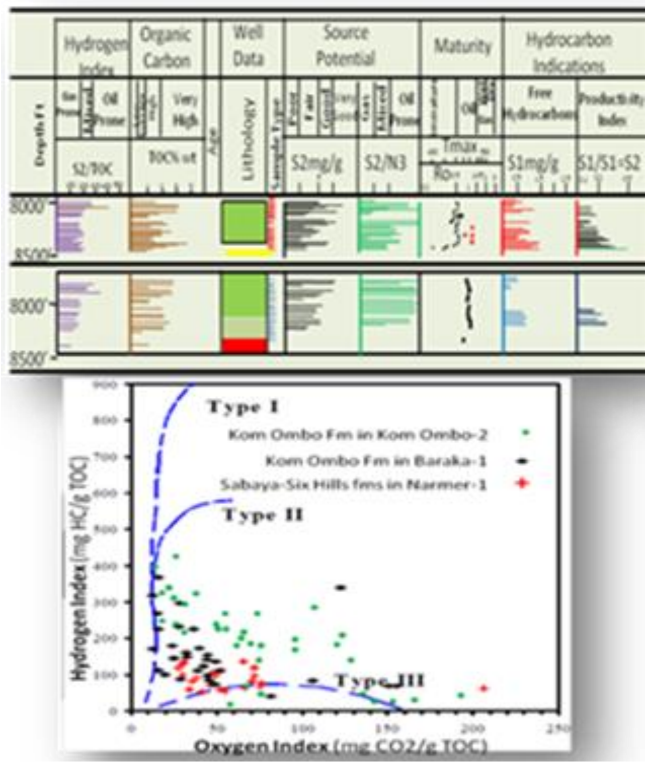

Fig. 5. Geochemical log characteristics of Komombo source rock Komombo-2 well (upper) and AlBaraka-1 wells (middle) and Hydrogen-Oxygen Index diagram for Komombo source rock in AlBaraka-1 and Komombo-2 wells and Sabaya-Six Hills interval in Narmer-1 (bottom).

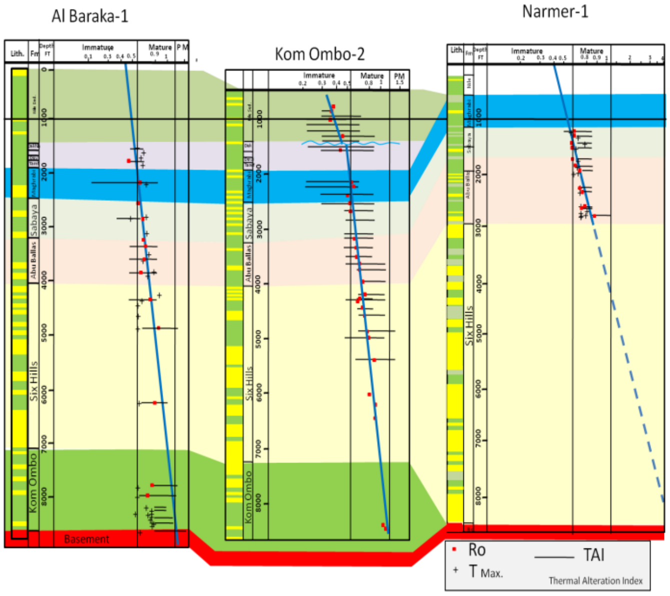

Fig. 6. Vitrinite Reflectance logs of AlBaraka-1, Komombo-2, and Narmer-1 with the correlation of the different rock units.

IV. STRUCTURAL SETTING AND TRAPING STYLE

While the Nile Valley basins are poorly constrained to the development of the Northeast African Rift [3][4][30], others suggest their association to the development of the Western Desert basins [5]. The detailed seismic interpretation of the northern Nile Valley basin (East Beni Sueif) from the latitude of 24° N to the 29° N revealed their existence along a major system of extensional faults oriented along the NW direction [31]. The Cretaceous affinity of these basins is remarkably different from the North Egypt (north of Western and Eastern Deserts) basins which are more oriented along the E-W direction [24][32][33]. Furthermore, the Cretaceous basins in North Egypt are developed either through rejuvenation of the older Jurassic faults or along new faults within the periphery of the old Jurassic basins [24][32]. On the other hand, the Nile Valley basins are completely initiated in the Early Cretaceous time. The changes of basins polarities might be attributed to the reactivation of the NW structures (oblique to the Red Sea) related to the extension of the well-known left-lateral Najd fault system [34]. The latter was predominating inherited fabric in the Precambrian basement of Southern Egypt at the time of rifting. The Najd fault system is represented as mega-shears in the basement rocks on both sides of the Red Sea including the southeast extension of Wadi Kharit. The subsurface top basement relief map is showing the presence of this tectonic zone in the Nile Valley and its extension in a further northwest direction via the central Western Desert (Fig.7).

Structural interpretation of the Nile Valley basins has incorporated seismic and borehole data with surface geology and satellite and google images mapping. The three interpreted basins have asymmetric half-graben tilting toward the NE-direction with the existence of many tilted blocks forming good structural traps.

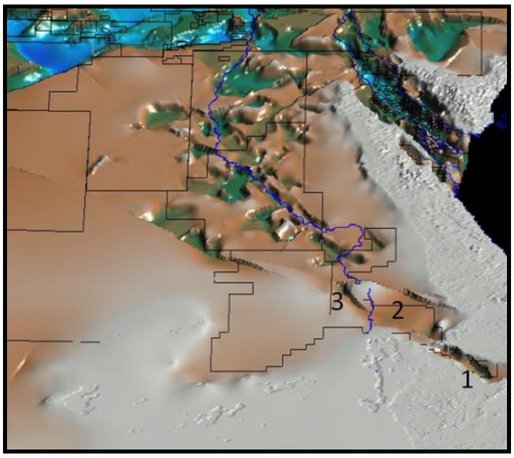

Fig. 7. Oblique view of basement relief map from subsurface data with numbers 1, 2&3 showing Kharit, Nuqra, and Komombo basins aligned on a NW major tectonic zone [35].

At the surface, the Kharit basin is a NW physiographic depression exposing the Upper Cretaceous sandstones of Abu Aggag and Timsah formations which are engulfed by highly denudated Precambrian basement terrain (Figs.2 and 8a). Many faults mainly of NW trend can be traced on the satellite image and verified in the field (Fig.8a). The eastern shoulder of the basin shows the low relief of Cretaceous outcrops in juxtaposition with the Precambrian rocks whereas the Cretaceous outcrops form a high topography to the west (Fig.8a). The interpreted seismic lines across and along the Kharit basin show an asymmetrical half-graben bounded from the east by master synthetic faults dipping to the SW direction (Fig.8b). Smaller counter faults are recognized in the hanging walls of the major faults producing intrabasinal lows and highs within the main basin. The general rotation of the fault blocks was recognized in the NE direction. The thickening of the different sedimentary packages indicates younger fault movements in the eastern side of the basin (Fig.8c). Structurally, we could notice that the Kharit-1 well was falsely targeting one of the deep intrabasinal structural lows however, it is bottomed in basement rocks at a measured depth of 7300 ft and did not penetrate the Komombo source rock interval (Fig.8b&c).

Constructed simple seismic depth map on the top basement level shows basinal subsidence along the eastern master faults delimiting the Kharit rift basin (Fig.8d&e) with a maximum basement depth of 90000 ft in the central part of the basin. Additionally, the interpreted seismic profiles along that central part of the basin show a sedimentary package overlying the basement and restricted to the trough area with a similar seismic signature and early rift setting as the organic-rich Komombo sediments of the Komombo basin (Fig.8d). Furthermore, the Sabaya and Abu Ballas formations are showing wrench-related anticlines of possible ENE-direction associating mild basin inversion (Fig.8d).

Further northwestward, the Kharit basin merges to the deeper basin of Nuqra with younger exposures of Um Baramil Formation (Fig.2&9a). The Nuqra basin has formed an oval-like flat depression with Nile silt and alluvium and is surrounded by the Upper Cretaceous outcrops (Fig.9a). The exposed rock units at the south are generally older than the northern ones. The eastern shoulder of the basin has outcrops of the Late Cretaceous rift-related Natash volcanics (Fig.2). The simple surface geologic map of the Nuqra depression has a NW-trending ridge of the Quseir Formation outcrop (Fig.9a). Subsurface seismic mapping and testing of this ridge with the Set-1 borehole reveals the presence of inrabasinal ridge coincides with the surface one and separates between two differentially subsided troughs (Fig.9b). The two troughs of the Nuqra basin form the deepest subsided area of our studied basins of Upper Egypt where the top basement is more than 11,000 ft deep (Fig.9b). The western trough is developed as a subsided hanging wall of a major NW- striking fault system supporting the ridge in its footwall side (Fig.9c). The two master faults forming this fault system are represented on the map view as two synthetic approaching faults with a structural linkage in the middle part of the area (Fig.9b). Two separated deeps are formed in the hanging walls of these faults with a structural high in the linkage area (Fig.9c). The southern fault of this system was fossilized in later rifting phases and another fault was propagated from its footwall and grew up to the surface (Fig.9b&c). The northern master fault was advanced during the different rifting phases and succeeded in reaching the surface (Fig.11 left). The linkage area of structural high was penetrated by Diwan-1 and the well is bottomed in basement rocks without catching the Komombo source rock.

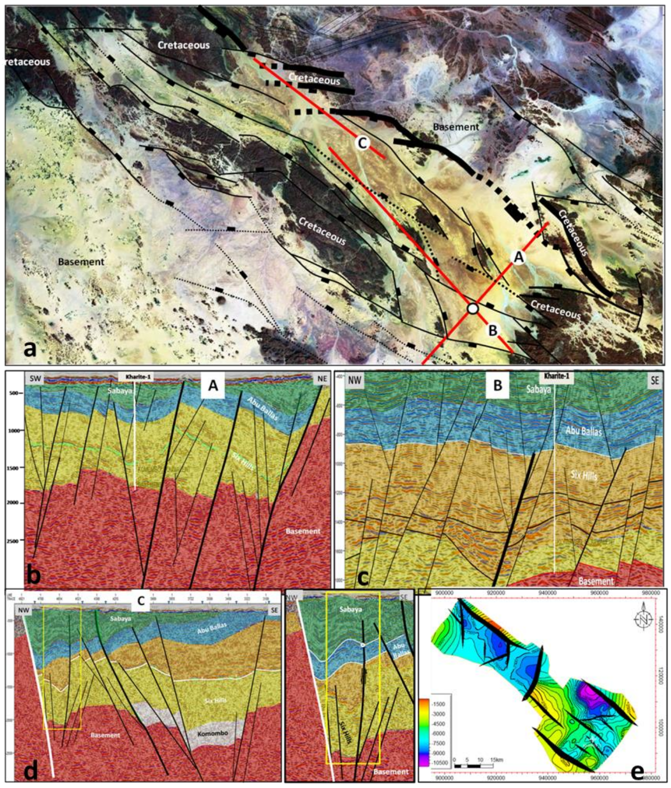

Fig. 8.**Kharit basin:** a) Fault interpretation surface map based on Lanstat image and location of the seismic lines, b) Interpreted seismic profile crossing the basin shows sagging and structural low of Kharit-1 well, c) Basin-parallel interpreted seismic profile shows the structural position of Kharit-1 and effect of NE-fault on the thickening of Six Hill Fm and deep basement to the northwest, d) Basin parallel interpreted seismic profile shows thick syn-rift sediments and Komombo source rock adjacent to the boundary fault and enlarged the area of yellow box to show the inversion and null point of fault displacement, and e) Simple structure setting and basin geometry on structural depth map of the top basement.

The western trough is additionally crossed by several faults in different directions. Among them is the main fault trending E-W and throwing to the south forming another deep (Fig.9b&c lower). This deep is steeply dipping to the north and exposing the basin sediments of Um Baramil bottom basin axis to the surface (Fig.9b&c)

The eastern trough of Nuqra is tilted due east toward the main bounding fault system. The latter owns a linked fault system of NE and N-S segments and supports the presence of Upper Cretaceous sediments and volcanic rocks in its footwall (Fig.9b&d). The fault is generally of asymmetric half-graben geometry with divergent thickness patterns of the syn-rift sediments toward the fault (Fig.9d). Several NNE and NW-trending faults are delineated in the basinal side and mainly throwing to the north. Although the Narmer-1 well encountered strong oil shows, the well was drilled in a structural high area and consequently did not test the Komombo source rock. The deeper area to the southeast of Narmer-1 is anticipated to have the bottom rift sediments of the source rocks (Fig.9). Mild basin inversion is noticed in several areas in the basin, including the Narmer-1 structure (Fig.9d).

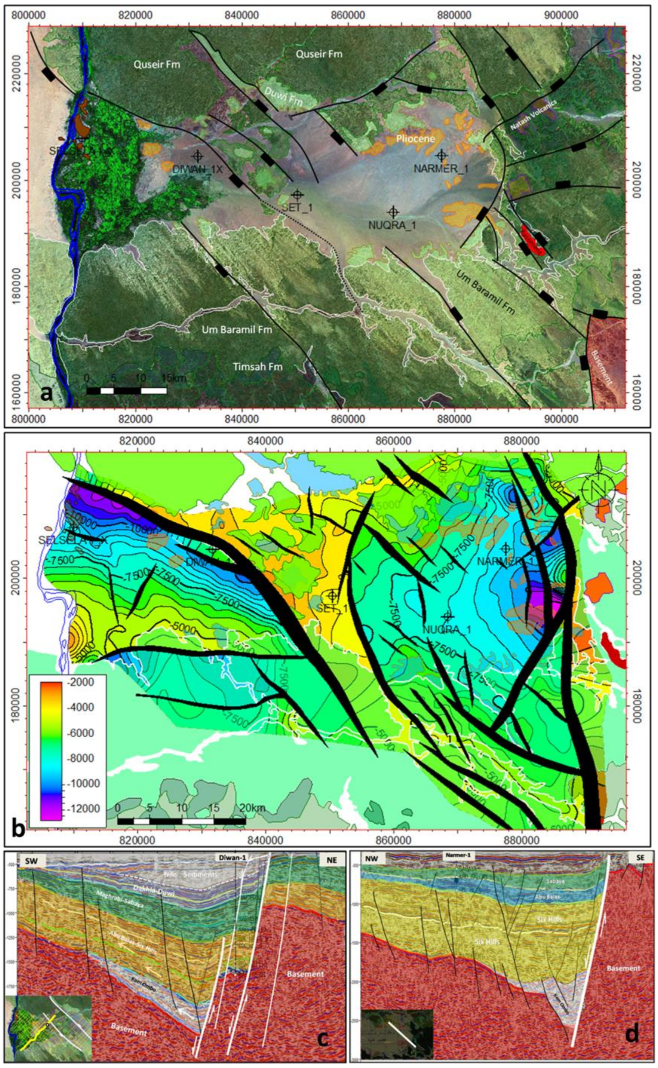

Fig. 9.**Nuqra basin:** a) Simple surface geologic map based on Landsat image with a reference to borehole location, b) Structure contour seismic depth map on the top basement and in feet, with outlines of the surrounding exposures, c) Interpreted seismic profile shows half-graben fault system in the western part of Nuqra basin with the location of Diwan-1 borehole, and d) Basin parallel interpreted seismic profile shows the eastern border fault of the basin with Komombo source sediments adjacent to the fault in a restricted trough.

The third Nile Valley basin in Upper Egypt is represented by the Komombo basin on the western side of the Nile. It occupies an old flat plain of the Nile Valley (Fig.10a). The exposures near the Nile are represented by a NW-fault ridge of Upper Cretaceous rocks correlated with the exposures in the eastern bank of the Nile (Fig.10a). To the southwest of the basin, the Tertiary sediments are coming to the surface are an indication of younger subsidence of the Komombo basin relative to the Upper Cretaceous rocks in the up-reaches of the east Nile basins (Fig.2). The interpreted seismic lines show the achievement of the basin through hanging-wall subsidence along a master NW-trending fault system forming a giant half-graben structure (Fig.10b&C). The general tilting is attained in the NE-direction with increasing thickness of the syn-rift sediments. The footwall block is exposed on the surface by Upper Cretaceous rocks, while the up-dip of the hanging wall to the SW-direction brings the Tertiary sediments to the surface. The bottom rift sediments of Komombo source rocks are encountered in the wells drilled in the deep trough area of the basin (Fig.10c). The bounding fault system is represented by two synthetic faults with the earlier achievement of the basin subsidence on the basin-ward fault. This fault hosts the basal rift sediments in its subsided trough. The other younger fault was propagated in the footwall of the earlier fault during a phase of rift widening. This was resulted in extending the Six Hills depositional area farther to the northeast. Restriction of the Komombo source rock to the older fault resembles the same setting in the Nuqra basin and explains the missing of the Komombo source rocks in Diwan-1 well (Figs. 10c&d). Younger fault activity could be recognized on the bottom Pliocene Nile sediments offset.

The seismic profiles crossing the Komombo basin reveal clear features of basin inversion tectonics in form of reverse faults and anticlines which go up to affect the entire section up to post Paleocene Esna shale (Fig.10d). This refers to a long time of compressional tectonics in the Upper Nile basin in correlation to the first phase of Syrian-arc tectonics in the north Western Desert. This long span of Syrian arc-wrenching tectonics has been documented with the exposures of Kalabsha fault and associated structures [20] (Fig.10f). Structural trapping systems in the North Western Desert were honored to this inversion tectonic phase where several fields lie in the wrench-forming anticlines (e.g., Abu Gharadig, Razzak, Alamein, and Sidi Rahman), and in the three-way dip closures associating the WNW-trending transtensional faults (e.g., BED, Abu Sennan, Ferdaus, Genna) [18][20][25][30][36][37]. The strong culminations associating with wrenching could be associated with heavy fracturing and faults that could break the top seal and breach the trapping system. Several dry holes were testing these structures in the western Desert like Mubarak-1, Abu Roash 1and 2, and Kattaniya-1. Also, tectonic reactivation after the onset of migration can break the trap retention and in some cases, the oil is only retained in poor reservoirs. Possible Mid-Eocene or later secondary migration and charging can be expected from the occurrence of wrench-related anticlines by the Lower Eocene rocks. This might increase the uncertainty of oil retention in the Late Tertiary inverted areas although the successful oil trapping in Al Baraka field proved the validity and seal efficiency in the structural inverted system. Thus, our further work will focus to define the time relation between the migration and trapping formation in the eastern basins of the Nile.

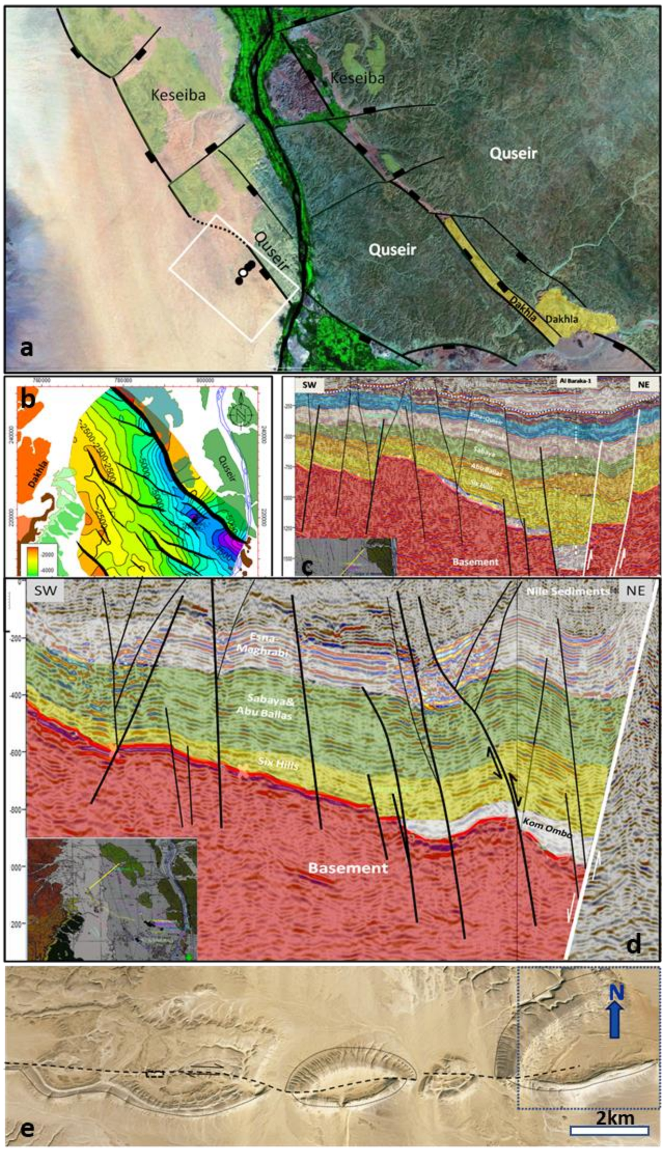

Fig. 10. Komombo basin: a) simple surface geologic map of the eastern basin and major boundary fault based on Landsat image interpretation, with a reference to the location of boreholes, b) Seismic depth structure map on the basement, c) Interpreted seismic profile shows the fault-bounded asymmetric major half-graben structure and different syn-rift sediments and faults within the subsided basin, d) Basin perpendicular interpreted seismic profile shows Komombo source rock entrapment and strong basin inversion on the counter fault (thrust and folding) adjacent to the boundary fault to the east, and e) Structure isolines tracing on Google image of Kalabsha fault at the southern part of Sinn El Kaddab Plateau showing left lateral double plunging sheer folds along the E-W fault in Lower Eocene rocks related to Syrian arc compressional event.

V. SUMMARY AND CONCLUSIONS

The Nile Valley basins of Upper Egypt are developed during the Neocomian rifting tectonics and are directionally deviated from the equivalent basins in North Egypt due to stress rotation and triggering the surface NW-trending (Najd trend, oblique to the Red Sea) basement shear zone. The early phases of rifting had witnessed the deep burial of the Nuqra and Kharit basins relative to the Komombo basin with thickening of the Neocomian-Barremian Six Hills Formation and early maturity of the source rock. Drilling high blocks in east Nile basins is resulted in missing the Komombo source rock which is restricted to the deep troughs in the basins. The three basins were almost subsided by the same rate during the deposition of the Aptian-Turonian section. The compressional structures in comparison with Syrian-Arc tectonics of North Egypt were restricted, especially in Nuqra and Khari, and basins received the younger sediments. The up-dip reaches of Nuqra are represented by the shallow marine sediments of Timsah and Um Baramil in a good indication of basinal facies toward and adjacent to the major boundary fault. The eastern basins were uplifted in later times possibly in association with basement uplifting during the Red Sea rifting. Basin exhumation was resulted in erosion of the basin roof and bringing the maturity level to the depth of 1200 ft. Basin roofing was milder in the Komombo basin and the maturity level is measured at 2100ft.

Herrin, the opportunities of hydrocarbon trapping are offered by the rotated extensional fault blocks associated with Lower Cretaceous rifting and later long-time span Syrian-Arc culminations. The sealing efficiency is proved in Komombo by finding oil in an inverted anticlinal culmination. The mildness of the inversion tectonics in the east Nile basins offers a good opportunity for hydrocarbon preservation, but the remaining risk is attributed to the time of basin exhumation.

The potential source rock and the several intervals of oil shows keep further hope in the area which requires more exploration activities to bring the holding reserve in the underground to the surface.

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