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Structural Evolution of the Mesozoic Faghur Rift Basin at the Northwestern Desert of Egypt

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THE Faghur Rift Basin (FRB) is a Jurassic to Cretaceous asymmetric extensional rift located in the far west of the Northwestern Desert of Egypt and has a considerable petroleum potential, first discovered in 1989. This work proposes a structural evolution scenario for the FRB based on the results of 3D seismic interpretation, borehole data and 1D-basin model. The FRB is bounded to the north by a major E-W striking, extensional, multi-history, basin bounding fault system where the Jurassic and the most Early Cretaceous succession are missing in the upthrown Waha platform. To the south, the whole succession is present where four major Mesozoic tectonic phases during the rift history were recognized through the FRB evolution as follows: 1) The Late Jurassic rift initiation phase which was expressed by the deposition of the earls syn-rift sequence of Khatatba clastics in four localized E to ENE-striking extensional half-grabens and ended by a marine transgression and the deposition of the Masajid limestone, 2) The Valanginian to Hauterivian/Early Barremian main rift phase which had rapid subsidence and deposition of the laterally complex siliciclastics syn-rift sediments of Alam el Bueib Member. A second regional transgression occurred in the early Aptian resulted in the Alamein carbonate deposition. 3) The third rift phase of Aptian to Albian time deposited the syn-rift siliciclastics of Kharita Member and continued with the deposition of Bahariya Formation in the Early Cenomanian 4) The fourth rift phase; during the Turonian-Santonian and was expressed by the deposition of limestone and shale of the Abu Roash Formation.

During the first and second phases, Late Jurassic-Early Barremian, the extension direction was mainly due the N to the NNW, resulted in E-W to ENE-WSW extensional faults.

By the end of the second phase, mainly post Alamein or late Aptian, the extension direction rotated to the NE, and continued to the end of the fourth phase to cause superimposing of a younger NW-SE extensional faults on the older E-W fabric.

Thermal sag was determined during the Campanian-Tortonian, the FRB was distinguished by a widespread and long-lived carbonate deposition.

Keywords: Faghur rift basin, structural evolution, half-graben, basin model, subsidence.

Introduction

The Northwestern Desert basins of Egypt, spreading from the Nile River to the border with Libya (Fig. 1), have proven to be an important petroleum province since the first commercial field was found in porous Aptian age dolostones by Phillips Petroleum in 1966 (Metwalli and El-Hady, 1975; Egyptian General Petroleum Corporation, 1992). The intensive exploration and development activities have revealed their

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complex structural nature and their development during the Mesozoic times as a series of discrete E-W to ENE-WSW and NE-SW oriented half-graben basins within the northward-thickening continental passive margin to be characterized into Abu Gharadig, Alamein, Kattaniya, Matruh, Shoushan and Faghur basins (Sultan and Halim, 1988; Emam et al., 1990; Taha, 1992; Moustafa, 2008; Bevan and Moustafa, 2012) (Fig. 1). The latter represents the westernmost basin what is referred to as the Faghur Rift Basin, in reference to the earliest exploration wells drilled in this region (Fig. 1). The FRB is the closest basin to the Libyan border and has become a significant producing region of oil and gas that are genetically related to single source rock, (Bosworth *et al.,* 2015). Now, more than twenty fields produce from Paleozoic to Albian age siliciclastic reservoirs and very locally from dolomitized Aptian carbonates.

Petroleum traps are mostly faulted, upthrown three-way dip closures. A few successful downthrown three-way closures have been drilled and several four-way dip closures have been found along basin axes. Several fields are interpreted to have a stratigraphic component, often related to fluvial channel geometries.

The study area is approximately 1,249 km2 covering a large part of the FRB and the southern margin of the Waha platform which is known as West Kalabsha area by the petroleum industry and government regulatory agencies (Fig.1). The present work aims to recognize the different tectonic phases which formulated the FRB and illustrate the changes in rift geometries and kinematics during the extensional events and associated subsidence. Due to the availability of several generations of high-quality 3D reflection seismic data and more than 60 exploratory wells, the timing of rifting can be closely constrained in the present work.

Geologic setting

The far Western Desert basins record a complex geologic past that spans from the Neoproterozoic to the Recent. Major controlling fault zones date back to the Pan-African orogenic events that set the stage for subsequent episodes of basin evolution (Guiraud et al., 2005). The early and mid-Paleozoic saw the deposition of continental siliciclastic and shallow marine carbonates along a low relief, the north-facing passive continental margin that bordered the evolving Paleotethys. This was interrupted by the complex Hercynian orogenies that occurred in the Late Carboniferous to Early Permian (Bosworth *et al.,* 2015). The Hercynian orogeny resulted in the widespread development of intra-cratonic sags and intervening faulted platforms. Deposition of predominantly fluvial siliciclastic units resumed in the Late Permian and continued into the early Mesozoic.

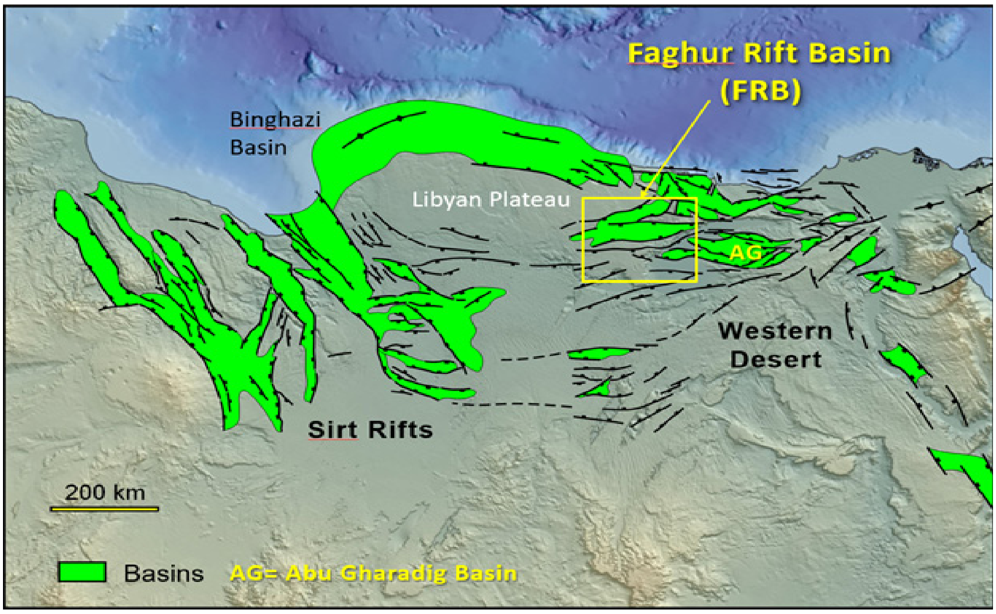

Fig. 1. Location map of the Northwestern Desert of Egypt (NWD) Faghur Rift Basin (FRB) and Abu Gharadig (AG) rift basins are highlighted. Onshore digital terrane model (GLOBE Task Team, 1999) and offshore Seasat-derived bathymetry (Smith and Sandwell, 1997)

Paleozoic strata thin toward the east of the study area along an angular unconformity due to erosion during Late Paleozoic to early Mesozoic associated with the opening of the Tethys Ocean, as well as onlap around pre-existing basement highs (Guiraud et al., 2005).

Major Pre-Tethyan transform faults formed during NW-SE late Triassic and early Jurassic extensions associated with the breakup of the Pangea mega-continent (Bentham, 2011). In northern Egypt, the dominant deep rift basin boundary fault trends are thus oriented NE-SW and these deep rift basins extend from the Western Desert into the Levant Basin, underlying the proven oil and gas trends (Dolson et al., 2014).

Subsidiary faulting associated with the trans-tensional evolution of the Jurassic and later early Cretaceous rift basins often strike 45°-75°, from these regional fault trends. These faults control syn-rift structures and deposition on a sub-basin scale and are associated with many fields in the Western Desert, especially in the Faghur and Shushan Basins (Dolson et al., 2014).

These rifting events led to the formation of a series of sub-rift and pull-apart basins within the Far Western Desert province, which roughly trend in a NE-SW direction at the present day. Those basins have been filled with a mix of shallow-water marine and terrigenous-derived sediment up to 25,000 ft. in thickness during Jurassic, Cretaceous, and Paleogene times. (Bosworth et al., 2015; Guiraud et al., 2005). (Fig. 1).

Abrams et al. (2016) concluded that the Egypt Far Western Desert reservoir fluids display highly variable fluid gravity (33.0°-71.2°), as well as whole oil gas chromatography signatures. Biomarker and high-temperature gas chromatography data indicate that the Matruh, Obayed, Shushan, and Faghur basin well head oils belong to a single genetically related family and suggest that the source rocks were deposited in a fluvio-deltaic setting. This environment appears to have received significant input of terrigenous organic material superimposed on a background of algal/bacterial organic matter from the water column. A comparison of the molecular characteristics for the wellhead oils and reservoir rock extracts to published oil and source rock petroleum geochemistry data suggested that the reservoir oils originated from the Jurassic Khatatba Formation. (Fig. 10).

Dataset and methodology

The entire study area is covered by 3D reflection seismic data, acquired in numerous acquisition campaigns between 2005 and 2018 (Fig.2). Fifty-four exploration and numerous

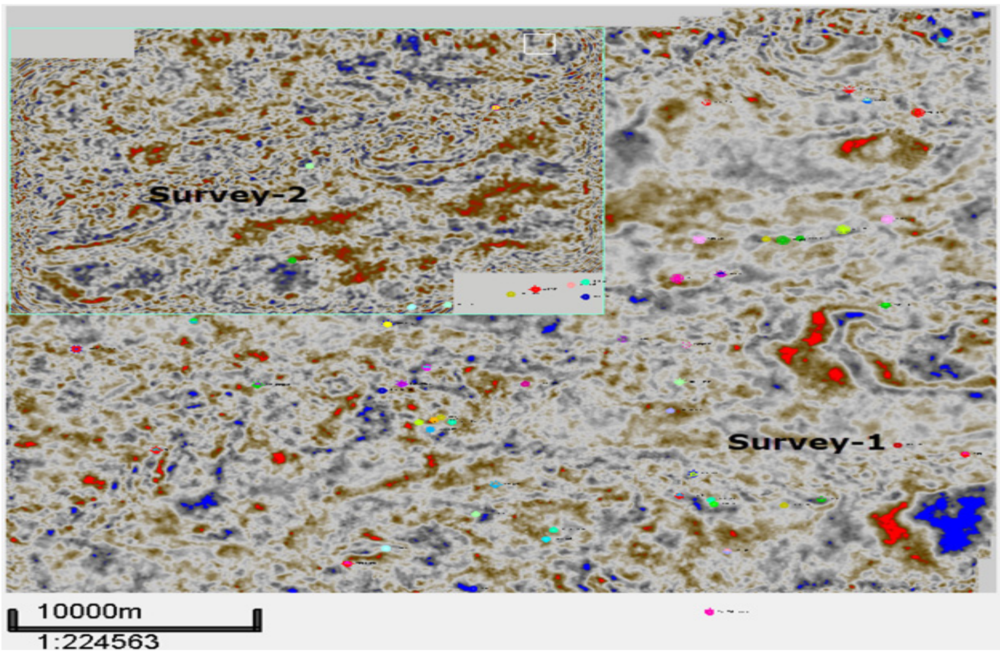

Fig. 2. Location map of the West Kalabsha area showing the used 3-D seismic surveys and key well locations. Courtesy, Apache Egypt.

development wells have been drilled in the Faghur basin and its adjacent, shallower platforms. Wireline logs and geochemical data are available for almost all the key wells, and many include velocity seismic profiles. Seismic data quality is good to excellent and the ties to wells are very reliable. The seismic interpretation and 1D basin modeling and techniques are applied in an integrated approach where the picked horizons were representing the onset or termination of a rift or a subsidence phase. Isochron maps were constructed from these horizons and integrated with the 1D well subsidence models to create tectonostratigraphic architecture and evolution of the basin. Source rock characteristics were correlated to oil molecular and biomarker data and timing of expulsion was estimated from the 1D subsidence models. Integration of these results with the structural model was used to produce a basin-scale view of the Faghur petroleum system and the resulting hydrocarbon potential of the basin.

Results

Faghur basin structural and tectonic evolution

The development and the evolution of sedimentary basins are highly controlled by the geological inheritance, topography, and rheological behavior of their basement substrate. These are mainly depending on the lithological composition, the intensity and character of the structural fabric of the basement terrain (Wescott et. at, 2011). The studies on the basement configuration of the Western Desert showed the strong structural fabric with dominant E-W and ENE-trends in the northern part.

Hundreds of boreholes, good seismic coverage, and regional gravity and magnetic surveys have revealed several sedimentary basins in the north of the Western Desert of Egypt (Fig. 1). These basins are oriented in E-W to ENE directions. Most of the basin-bounding faults in this area strike east-west to east–northeast/west–southwest, parallel to the old Neotethyan continental margin to the north (Bosworth et al., 2015). Changing the basin trends and the various and differential thicknesses and facies of the entrapped sedimentary column triggered their different initiations and growth through time and space.

Depositional history analysis with 1D basin modeling, 3D seismic interpretation of faults, mapping of selected six key horizons, and selected isochron maps have helped to identify Four rift phases in Faghur basin in the Jurassic-Cretaceous time span. No significant Cenozoic rifting (Red Sea) was identified in the area, which may be partially due to the lack of a seismic event at the top Apollonia because of the unique Faghur basin Dabaa limestone instead of being shale in most of the Western desert basins, or because of a limitation of the seismic resolution, thus lacking the needed acoustic impedance differences between the two units. The generalized stratigraphic column of the Faghur basin is shown in Fig. 3.

Faghur Basin Mesozoic Rifting

Triassic-Early Jurassic Rifting in Faghur Basin

Triassic-Early Jurassic Rifting in Faghur Basin is missing, although there are some uncertainties regarding Ras Qattara sandstone age dating. Neither Wadi Natrun nor Yakout formations were recorded in the basin, indicating the missing of that rift phase. Safa sandstone is mainly the first deposited Mesozoic strata in the basin, given a Late Jurassic age, so represents the first sediments deposited during the initiation of the Mesozoic rift.

Faghur Basin Late Jurassic Rifting (1st phase)

Rifting initiated in the late Jurassic had witnessed the deposition of a thin, widespread Safa sandstone unit (~80 ft. average), then the Zahra Siltstone and Shale representing a source and a seal rock (~650 ft. average), finished by Masajid formation. Masajid limestone looks to lock this phase of rifting (~80 ft. average) deposited relatively during a long period of time with a low rate of subsidence, as shown from the 1D model (Fig. 4).

The lack of the early Jurassic rift phase in the Faghur basin, which lies in the most west part of the western desert, and the presence of this rift due east, could be interpreted as rift migration through time from east to west during the Jurassic time. The current day geometry of the basin is expressed by the Masajid two-way time map (Fig. 5). Showing the basin bounding fault to the north and the main grabens of the basin to the south.

Since the Khatatba depth map represents the deformation at the present time, both the top Paleozoic to top Masajid isochron map (Fig. 6.a) and the 1D model was used to re-establish the deformation history. The isochron map explains that the basin opened as small discrete non-connected sub-basins, subsided as a half-graben, terminated to the North by Waha major bounding fault, thus has a fault contact to the North. The faults were not active completely along their

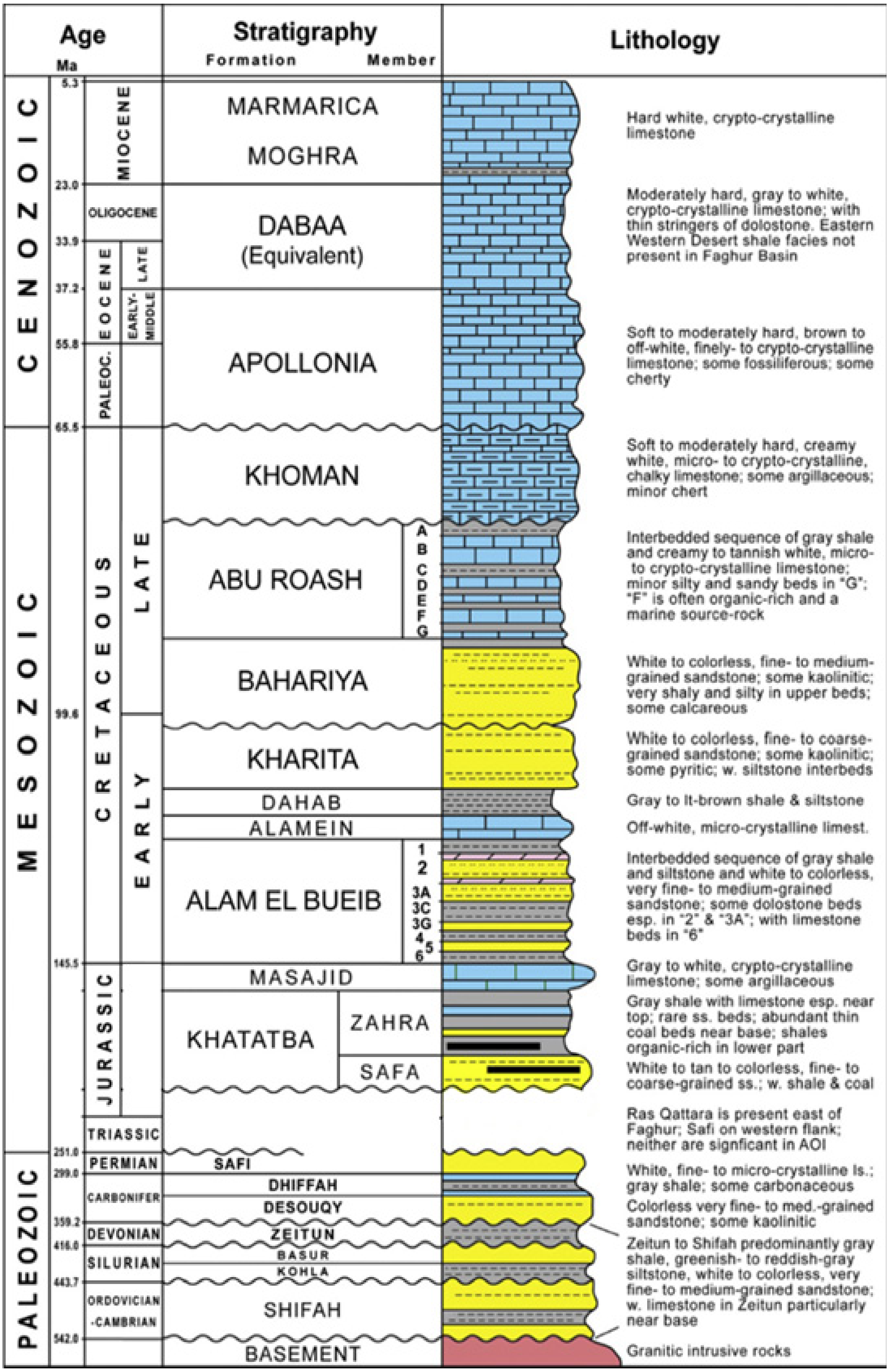

Fig. 3. Generalized stratigraphic column of the Faghur basin, Modified after Bosworth, et al., 2015.

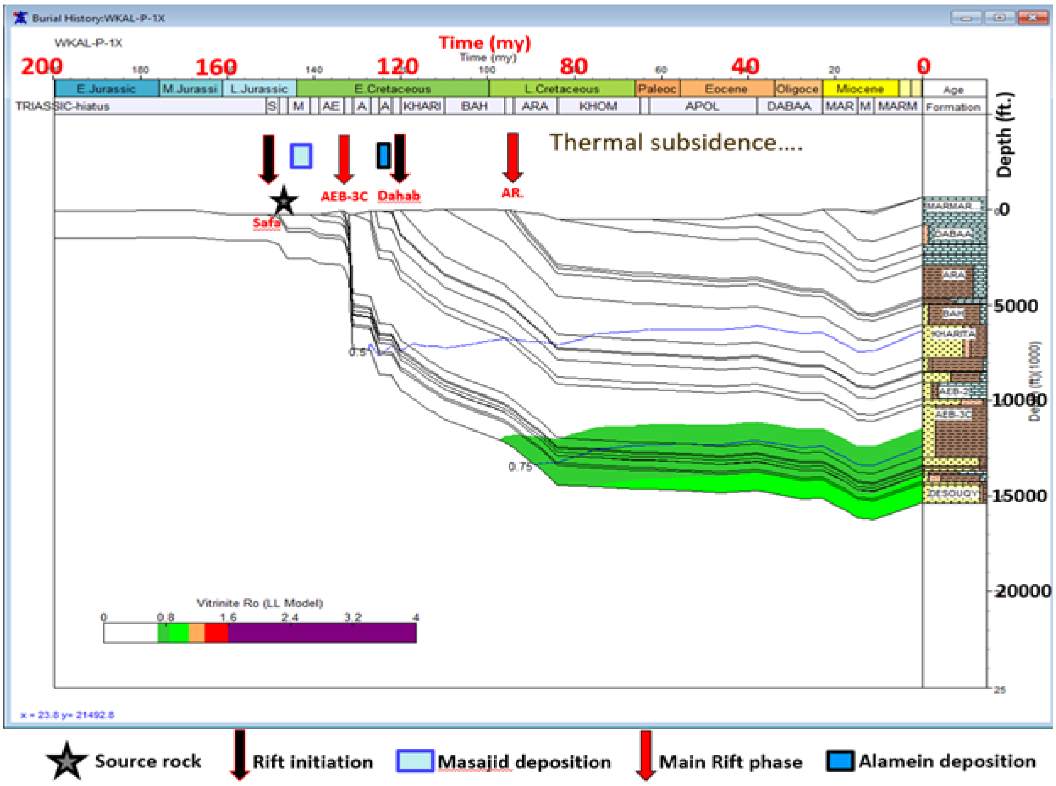

Fig. 4. 1D model for WKAL-P-1X well in Faghur basin showing the main rift phases. the fourth rift phase causing Zahra source rock to enter the generation window for the first time.

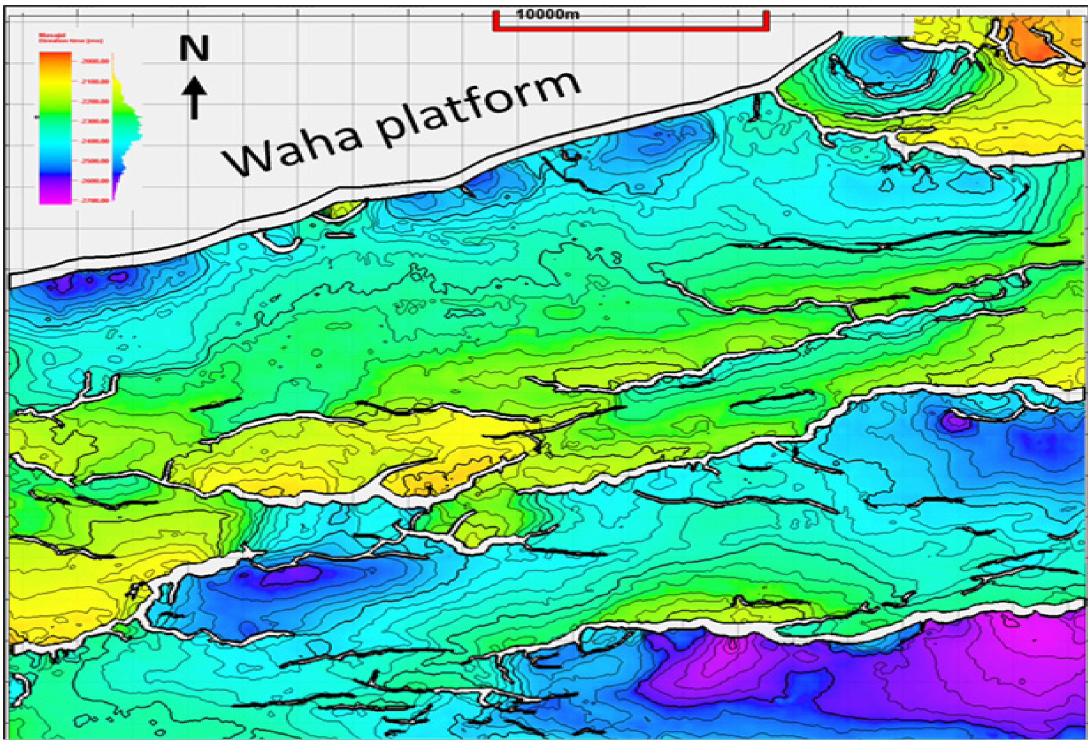

Fig. 5. Top Masajid Formation TWT map for the West Kalabsha area, Faghur basin.

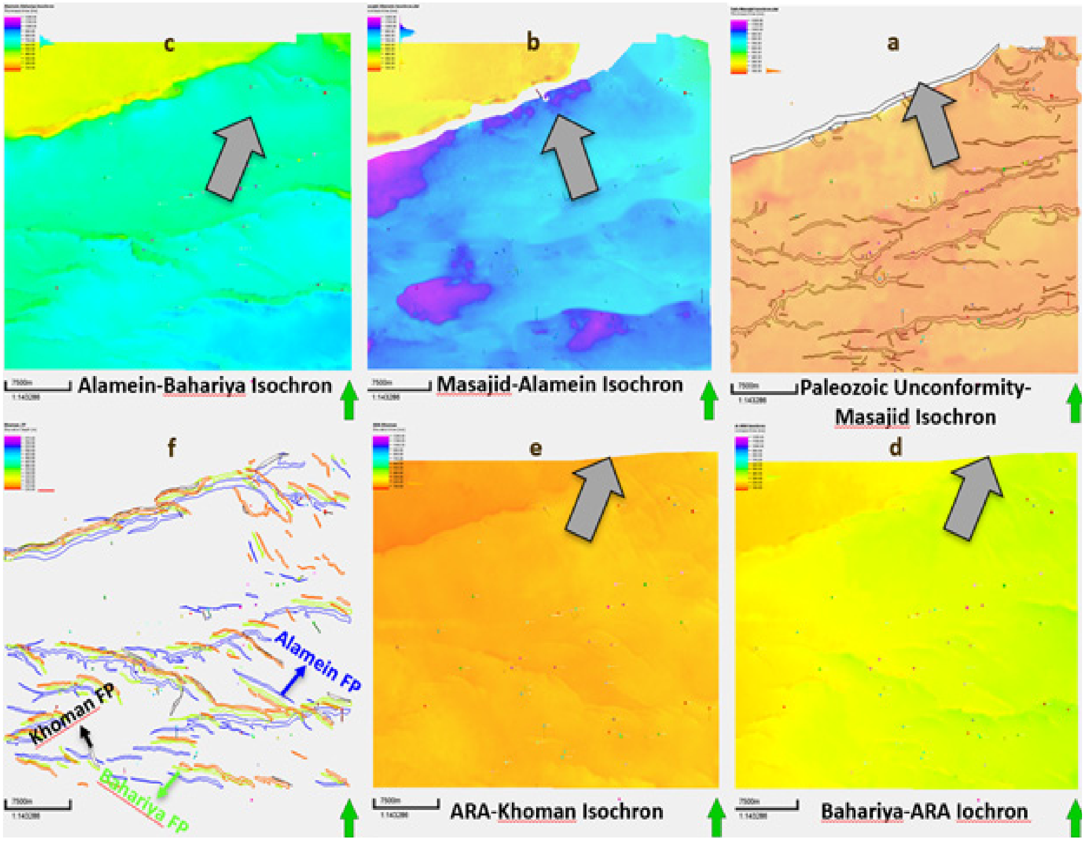

Fig. 6.a. Top Paleozoic-Top Masajid isochron map, with Masajid fault polygons posted on, and a proposed extensional direction at Middle to Late Jurassic time, showing the small magnitude of the rift at that time, and the small sub-basins. b; Masajid-Alamein isochron map showing the main rift phase with same polarity. c; Alamein-Bahariya isochron showing a stress field rotation. d; Bahariya-AR isochron map showing the fourth rift phase with the new polarity prevailed. e; ARA-Khoman mainly a thermal subsidence. f; different fault polygons directions at E-W for the deeper horizons, NW-SE for the shallower due to stress field rotation.

strike, so a small difference in relative thickness between the up-thrown and the downthrown sides of the faults at that rift phase is observed, except for Waha major fault where this rift phase sediments are absent.

The 1 D model explains a similar story as well (Fig. 4). The slow rate of subsidence is shown, starting in the Late Jurassic, and the rift phase ended with Masjid deposition at the top in Upper Jurassic. Masajid Formation covered the section of this phase and deposited under a very low rate of sedimentation.

Fault propagation at that time occurred through pure extension where the faults cut Paleozoic and formed sub-basins, or through monoclinal flexures. These faults will be reactivated later during the main second rift at ~135 ma (Fig. 6.b).

At the top Masajid- top Paleozoic isochron map, a symmetric NNW extensional extension is proposed at this stage of rifting (Fig. 6.a). The time span of this phase is +/- 10 ma and resulted in the deposition of 600-900 ft. of sediments.

Faghur Basin Early Cretaceous Rifting (2nd phase)

Unlike the weak Late Jurassic first phase of rift, at the Early Cretaceous rift phase, at ~135 ma, Faghur basin witnessed the main rift phase. During this time the small and disconnected Middle Jurassic sub-basins were connected, and the basin subsided as a half-graben. As shown from the 1D model (Fig. 4), this rift phase started mainly at 135 ma or slightly older (Valanginian-Hauterivian time).

This main rift phase resulted in the deposition of AEB6-4, AEB-3G, low Net/Gross thick unit

AEB-3C, AEB-2, AEB-1, and was locked by the Aptian Alamein limestone at a very slow rate of sedimentation.

When examining the isochron map of Alamein-Masajid and comparing it to that of Masajid-Paleozoic, it looks like the rift was more intense at the western side of the study area. The thickness variations are much great in relation to the position from up thrown to the downthrown side of the active faults, and the extension direction remains the same as the initiated Middle Jurassic direction, but much stronger and more developed (Fig. 6.b). The resultant normal faults have mainly ENE-WSW strike direction except the long-lived NW-SE fault at WKAL-A field to the most Northeast of the map. If the deposition and erosion scenario was excluded, the Waha platform started to receive the Mesozoic strata for the first time during the latest period of this rift phase.

Although the above-mentioned NW-SE striking extensional faults could be observed, which may lead to a conclusion of the onset of extensional flipping polarity, the authors observed a more robust polarity change at the next rift phase, resulting in a more noticeable NW-SE growth faulting.

The second rift time span is about 18 my, resulting in deposition of +/- 7000 ft. of sediments, the greatest thickness going to AEB-3C unit which can reach 3720 ft. thick (Fahur-N-1X well). With a low Net/Gross, deposited mainly as shale at the main rift phase with a relatively higher rate of sedimentation, this unit represents a major seal and delineating exploration at the shallower levels in the basin unless a re-activation of some of the major E-W faults is there as will be discussed.

It is noted that the depo-centers of this rift phase are concentrated in the western and southern parts of the study area.

Faghur Basin Early-Late Cretaceous rifting (3rd phase)

The Third phase of rifting started in the Late Aptian to Cenomanian and resulted in the deposition of Dahab shale, Kharita which is mainly sandstone, and Bahariya formations. The time span is about 22 ma, resulting in the deposition of +/- 5000 ft. of sediments as shown in the 1D model (Fig. 4).

Now, the extension direction had rotated to NE-SW, which resulted in normal faults with NW-SE strike superimposed on the older E-W fabric. This is unique to that rift phase which can be seen from the isochron map of Alamein-Bahariya (Fig. 6.c). It's noted that most of the major older fabric E-W faults were re-activated however, relay ramps were more developed.

During this rift phase, the main depo-centers were shifted to act mostly due to the south of the study area (Fig. 6.c).

Faghur Basin Late Cretaceous subsidence (4th phase)

The fourth phase of subsidence started in the Turonian, and continued to the Santonian time, resulting in the deposition of the Abu Roash Formation (units G-A) which is mainly limestone with shale beds. The time span for this rift phase is about 10 Ma, resulting in the deposition of +/- 3000 ft. of sediments as shown in the 1D model (Fig. 4).

Like the third phase, the extension still has a NE-SW direction and has a weaker magnitude, resulting in the re-activation of the NW-SE faults, this can be seen from Bahariya-ARA the isochron map (Fig. 6.d).

Although this rift phase direction is like the previous one; NE-SW extension, the basin main troughs now shifted to the eastern side of the study area, only fewer, major E-W trending faults were re-activated at a shorter extent at the strike, and a smaller part of the Waha platform fault was re-activated due west, with the development of relay ramps due East.

It is worth mentioning that since the fourth phase of subsidence, there was a switch to a widespread and long-lived carbonate deposition sustained to the Miocene. Compared to most of the north Western desert, no to minor Dabaa shale was recorded in the area, and limestone was deposited instead. Moghra formation is mostly limestone as well, only some sandstone and shale beds were developed in Moghra formation as recorded in some wells. This Cenozoic stratigraphy is unique to Faghur basin compared to the other northwestern Desert basins.

Late Cretaceous Syrian Arc Tectonics in Faghur Basin

Bosworth et al. (2008) suggested that areas south and southeast of Cyrenaica (the Sirt Basin and the far Western Desert of Egypt including Faghur basin) underwent very little shortening because they occupied a regional strain shadow.

They also believed that the eastern region of the Western Desert and Sinai, which were not sheltered by the stress-absorbing Cyrenaica inversion, recorded strong compression. Not much impact was observed due to the Syrian arc tectonics in Faghur basin regarding trapping formation because of a very mild effect, only observed at locally restricted anticlines at the hanging wall of some extension faults, affecting Abu Roach (AR) strata. Kerogen transformation rate however showed some slower rate because of a lower subsidence rate during the Syrian arc, resumed during the Eocene time to the present day (Fig. 4).

Faghur Basin Petroleum System

The hydrocarbon system encompasses the hydrocarbon source rock and all related oil and gas and includes all the geologic elements and processes that are essential if a hydrocarbon accumulation is to exist (Magoon and Dow, 1994). According to the definition, each source rock creates its own petroleum system, of course in some petroleum systems more than one active source rock may be involved in charging specific structures. The essential elements of a petroleum system include source rock, reservoir rock, seal rock, and overburden rock. The essential processes are generation, migration, and accumulation. The petroleum system chart can easily summarize the petroleum system elements and processes. The generalized petroleum system chart of the Faghur basin is shown in Fig. 7. Faghur basin had only one source rock proven to be working which is responsible for charging all the discovered traps. The discovered oil has a single oil family and could be correlated to the source rock, the Jurassic Khatatba source.

Faghur basin petroleum system chart is shown (Fig. 7) with the defining critical moment to start during the Turonian time, contemporaneous with the fourth phase of rifting.

Oil-Source Correlation

Pristine/phytane ratios of Faghur basin-produced oils are more than 2.5 indicating suboxic conditions. The terpane traces are dominated by pentacyclic terpanes of the hopane series and contain low abundances of tricyclic terpanes (Fig. 8). The C30 hopane dominates the regular hopane series and extended hopanes display an exponential decrease with increasing carbon number (Fig. 8). All samples contain low abundances of gammacerane, suggesting that the water column in which the source rock was deposited was not strongly stratified. The dominance of the C19 and C20 tricyclic terpanes over the C23 and C24 homologues is consistent with source facies containing significant terrestrially derived organic material (Fig. 8). The apparent absence (or trace amounts) of the regular C30 steranes also suggests minimal input from marine algae, supporting a non-marine depositional environment. Significant terrestrial input of organic material into the source facies can be inferred by the distributions of ααα and αβ steranes that are dominated by the C29 homologues and lesser amounts of the C27 and C28 steranes (Fig. 8). (Abrams et al., 2016).

Taken together, the above oil molecular data suggest the greater Faghur area oils have been sourced from organic facies deposited

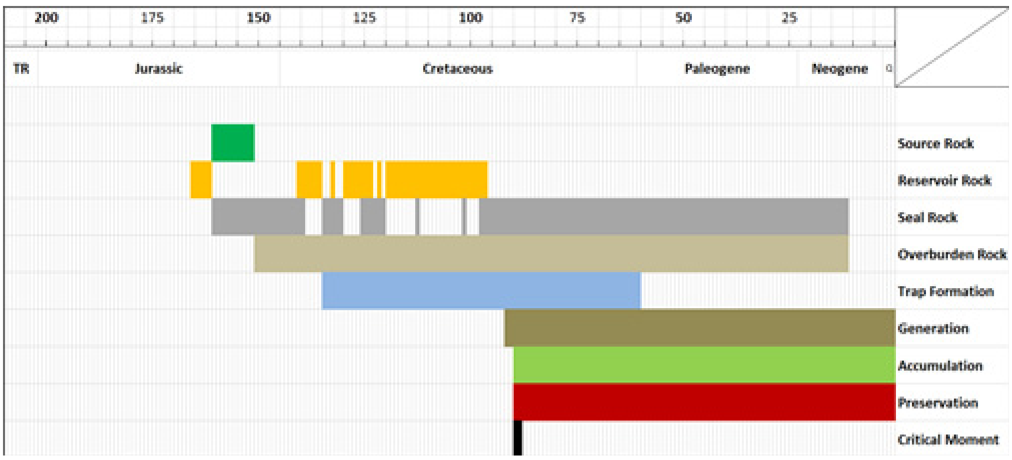

Fig. 7. Faghur basin petroleum system chart. Paleozoic strata only serve as reservoir rocks and no Paleozoic source rocks are known to be working so far. That's the reason this chart starts at Jurassic time.

in a fluvial-deltaic and/or small lake setting with significant inputs of terrigenous organic material superimposed on a background of algal/bacterial organic matter. The geochemical data does not support an open marine or typical deep-water, stratified lacustrine depositional environment (Bosworth et al., 2015). Saturate fraction gas chromatography-mass spectrometry fragmentograms (m/z 191, 217, and 218) for a Faghur basin Khatatba sidewall core solvent extract is shown in Figure 8 (Abrams et al., 2016).

Timing of expulsion

Generation and expulsion of petroleum started due to the fourth phase of rifting subsidence and continued to the present day as the 1D model suggested. Two periods of the highest rate of expulsions can be determined, the first one at ARA-Khoman time due to the accelerated burial and, the second one during the Miocene (20 ma) due to continuous subsidence. It's believed. (Fig. 9).

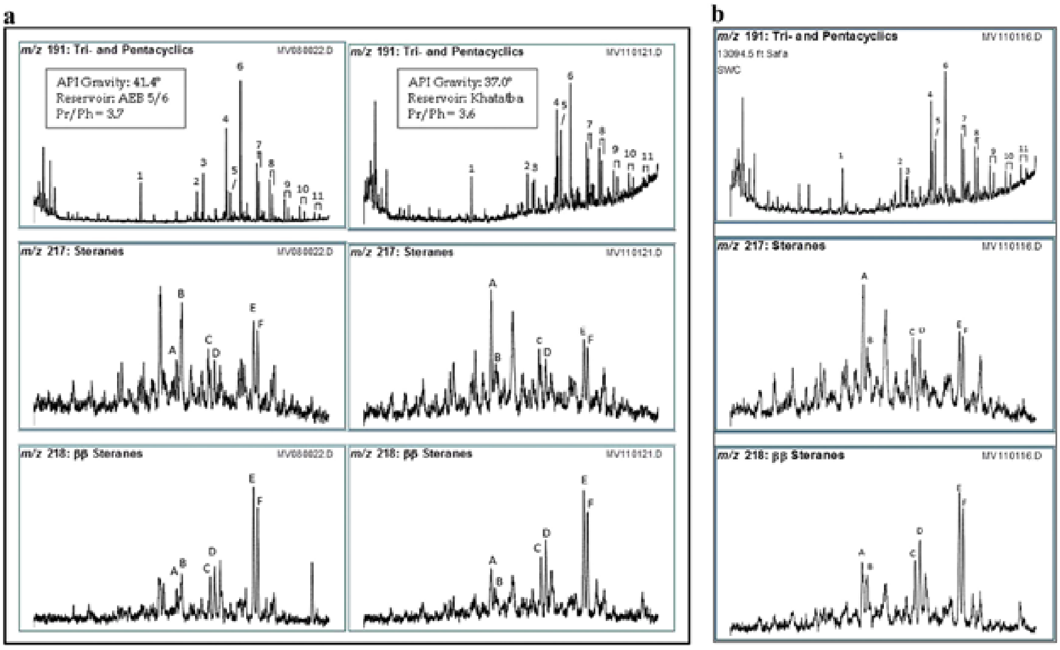

Fig. 8, a. Saturate GCMS biomarker results for Cretaceous AEB 5/6 (left) and Jurassic Khatatba (right) reservoir oils. b. Saturate GCMS biomarker results for a bitumen extracted from Jurassic Khatatba side wall core (see table below with peak identifications). (Michael A. Abrams, et al. 2016).

TABLE 1. With peak identifications.

Peak Label	Compound Name	Chemical Formula (Molecular Weight)
Terpanes (m/z 191)		
1	C_{24} Tetracyclic terpane	$C_{24}H_{42}$ (330)
2	22,29,30-tinorneohopane (Ts)	$C_{27}H_{46}$ (370)
3	22,29,30-trinorhopane (Tm)	$C_{27}H_{46}$ (370)
4	17α(H),21β(H)-30-norhopane	$C_{29}H_{50}$ (398)
5	17α-diahopane	$C_{30}H_{52}$ (412)
6	17α(H),21β(H)-hopane	$C_{30}H_{52}$ (412)
7	17α(H),21β(H)-29-homohopane (22S & 22R)	$C_{31}H_{54}$ (426)
8	17α(H),21β(H)-29-dihomohopane (22S & 22R)	$C_{32}H_{56}$ (440
9	17α(H),21β(H)-29-trihomohopane (22S & 22R)	$C_{33}H_{58}$ (454)
10	17α(H),21β(H)-29-tetrahomohopane (22S & 22R)	$C_{34}H_{60}$ (468)
11	17α(H),21β(H)-29-pentahomohopane (22S & 22R)	$C_{35}H_{62}$ (482)
Steranes (m/z 217 & 218)		
A	5α(H),14β(H),21β(H)-cholestane 20R	$C_{27}H_{48}$ (372)
B	5α(H),14β(H),21β(H)-cholestane 20S	$C_{27}H_{48}$ (372)
C	5α(H),14β(H),21β(H)-ergostane 20R	$C_{28}H_{50}$ (386)
D	5α(H),14β(H),21β(H)-ergostane 20S	$C_{28}H_{50}$ (386)
E	5α(H),14β(H),21β(H)-stigmastane 20R	$C_{29}H_{52}$ (400)
F	5α(H),14β(H),21β(H)-stigmastane 20S	$C_{29}H_{52}$ (400)

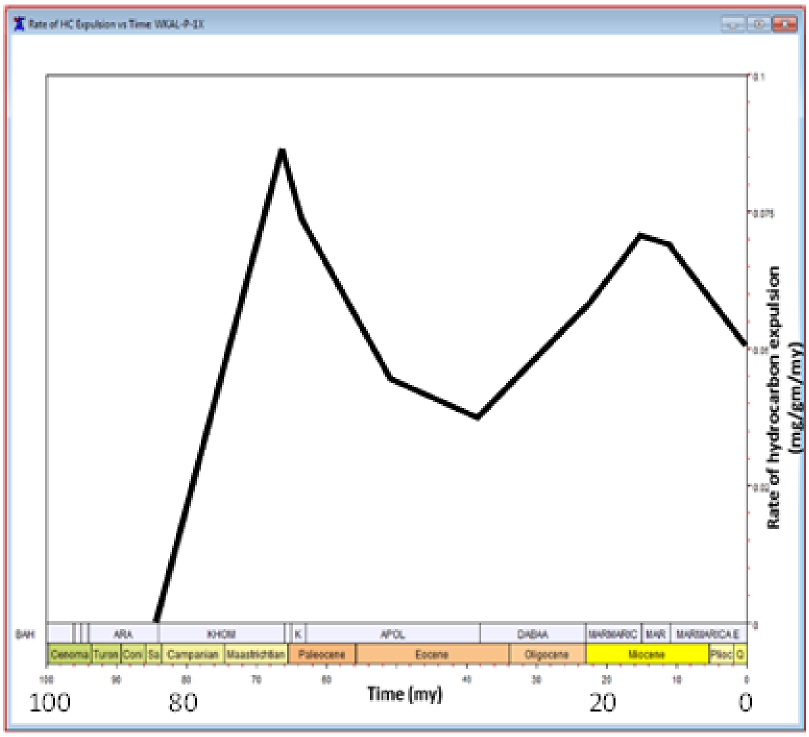

Fig. 9. Rate of petroleum expulsion as a result from the 1D model, two peaks are observed.

Conclusions

Faghur Basin is a mature petroliferous district in the farthest west of the Northwestern Desert of Egypt. The rift was initiated in the Late Jurassic. The petroleum system in the basin is attributed to a single source rock deposited in the early rift phase.

Detailed seismic interpretation of key reflectors in Faghur basin revealed a multi-history structural deformation through time with resolution of the main tectonic events that affected the study area mainly during the Mesozoic Era. The structural interpretation incorporated all available seismic and geologic data in the study area. Six key horizons were picked and interpreted, and they are equivalent to the top surfaces of Khoman, ARA, Bahariya, Alamein, Masajid Formation, and top Paleozoic.

The top Jurassic surface is crossed by several ENE-WSW to E-W trending normal faults, most of the faults are dipping to the South, and the rift was initiated in the Late Jurassic as small dis-connected sub-basins (half grabens), small thickness variation is observed at the first phase. The second rift phase was the major one, the small basins were connected at ~135 ma, the fault trends didn’t change significantly and a variation in thickness is now more obvious, a third rift phase at ~120 ma, with shifting in polarity, the fault trends now NW-SE, re-activation of the some older E-W fabric faults is observed as well, the fourth subsidence phase started at ~94 ma, with same fault trend like the third one; NW-SE, with re-activation of more local parts of the older major E-W faults.

The different rift phases are locked by limestone deposition on top of each, at a very slow rate of sedimentation.

The Waha platform bounding fault trending ENE-WSW was re-activated during all the rift phases. The re-activation of the older, only major E-W faults during the latest subsidence phase contemporaneously with the defined critical moment for Faghur basin, played a major role in providing access to charge for exploring the shallower reservoirs, and hence defining the sweet spot locations.

It’s clear that the generation and expulsion of petroleum in the basin started due to the fourth phase of rifting, hence, due to tectonics which allows for more sedimentation and burial. Having only one source rock from the Jurassic time and AEB-3C unit with a low Net/Gross acting as a thick seal at Early Cretaceous formed because of the main rift, which is unique to Faghur basin tectonic history, this has resulted in the relatively late expulsion timing for the Jurassic source compared to other Western Desert basins. To explore the shallower targets (Kharita and Bahariya), access to charge through vertical migration from the Jurassic source is obviously needed. This can be provided by either 1) a long-lived reactivated fault such as in the case of WKAL-A area or 2) the locations where reactivation of the older E-W fabric was observed during the latter two phases. So, both are fault related with different settings. linking the unique tectonic history/lithology of Faghur basin to the petroleum system can define the sweet spots for further exploring the shallower reservoirs. The success history of WKAL-A field in exploring the shallower targets up to Kharita is believed to be due to the first reason; a reactivation of a long-lived fault system through the basin history and hence, providing the requested access to charge.

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التطور التركيبي والنظام البترولي لحوض فاجور في الحقبة الوسطى شمال الصحراء الغربية، مصر
ربط الجيولوجيا التركيبية وجيولوجيا البتر

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تكون حوض فاجور بدأ فى العصر الجوراسى العلوى حيث تم ترسيب ما يقارب سبعمائة قدم من الصخور مع تكون فتوق وصدوع ضعيعة التطور باتجاهات مضربيه شرقيه-غربيه وهو الطور الأول للفتق.

تكون الطور الثانى فى عصر الكريتاسى السفلى وهو ما أدى الى ترسيب سبعة الاف قدم من الصخور مع نمو قوى للفتوق والصدوع السابقه بنفس الاتجاه. يعتبر الطور الثانى هو الطور الرئيسى والاعنف فى تطور حوض فاجور.

تكون الطور الثالث فى عصر الكريتاسى السفلى الى العلوى وهو ما ادى الى ترسيب خمسة الاف قدم من الصخور مع نمو قوى للفتوق والصدوع باتجاه جديد وهو الشمال الغربى مع اعدة تنشيط لبعض الفتوق الرئيسيه الاقدم.

تكون الطور الرابع فى عصر الكريتاسى العلوى وهو ما ادى الى ترسيب ثلاثة الاف قدم من الصخور مع نمو اقل قوه للفتوق والصدوع باتجاه الشمال الغربى مع اعدة تنشيط لعدد أقل من الفتوق الرئيسيه الاقدم.

تعتبر صخور العصر الجوراسى الاعلى هى صخور المصدر الوحيده المسئوله عن النظام البترولى وعن انتاج الزيت والغاز فى حوض فاجور

الكلمات المفتاحية : حوض فاجور, شمال الصحراء الغربيه, المكامن البتروليه, تطور الحوض الترسيبى,استكشاف الصخور الاحدث.