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RESEARCH ARTICLE

SOURCE ROCKS EVALUATION AND THERMAL MATURITY EVOLUTION OF THE DHAMAR ALI FIELD, SAB'ATAYN BASIN, YEMEN

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ABSTRACT

The Upper Jurassic samples of Dhamar Ali field, NW Sabatayn Basin, western Yemen were used to determine the source rock characteristics and petroleum generative potentials. Organic-rich sediments within the Meem and Lam members (Madbi Formation) were analyzed using organic geochemistry. The obtained data show that the total organic carbon content (TOC) values for the Meem and Lam source rocks are between 0.2 and 1.68 wt% indicating fair to good source rocks. The bulk geochemical results showed Lam and Meem Members displaying generally Type III kerogen, which have the ability to generate mainly gas accumulations under thermal maturation level. The results of thermal maturation by vitrinite reflectance (VR) and Tmax shows that the analyzed Meem source rocks are generally plotted in the mature zone, while the results of Lam source rocks samples show that the source rocks is still immature zone and marginally mature zone. 1D basin modelling was performed to analyse the hydrocarbon generation and expulsion history of the study area. The burial/thermal history models shows regular trend pattern with no significant subsidence or uplift events in the Dhamar Ali field of NW Sab'atayn Basin. Meem source rock has been reached required level of thermal maturity while Lam unit did not enter the main oil generation phase due to shallower depth and insufficient temperature in the study area. Therefore, the Meem Member can be consider as generative potentials of prospective source rock horizons in Dhamar Ali field, NW Sabatayn Basin.

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INTRODUCTION

The Sab'atayn basin, which preserved Mesozoic succession in its stratigraphy, contains the whole petroleum system elements (Source, Reservoirs and Seal rocks). The Lam member is the first target of source rock assessment and hydrocarbon exploration because of organic matter richness and greater potential. The Meem member is consider the second target of source rock assessment. In the past decades, several wells have been drilled in NW part of Sab'atayn Basin (Fig. 1) but unfortunately the results unpromising. The drilling wells and samples are little in the NW part of the basin, because this area has not been subjected to extensive conventional oil and gas targets. Due to necessity to reevaluate this part of the basin by using the available geochemical data form the source rocks. Therefore, it is necessary to evaluate systematically the characteristic of the source rocks and their maturity evaluation within this part of the basin. This evaluation can provide the basis for the evaluation for the resource estimation for the Lam and Meem members.

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The characteristics of source rock evaluation include the organic matter abundance, kerogen type and source rock maturity. For investigation, thermal maturity of source rocks primarily includes vitrinite reflectance and pyrolysis Tmax. The quantity of organic matter is commonly measured by determining the total organic carbon (TOC) contained in a rock. Quality is assessed by the types of kerogen contained in the organic matter. Thermal maturity is most often estimated by using vitrinite reflectance measurements and data from pyrolysis analyses. Basin modeling method which integrated all geological, geophysical, and geochemical processes to model burial/thermal history and hydrocarbon generation and expulsion in effective manner. The aim of this work is to provide a comprehensive study on the source rock characteristics of the Lam, Meem Members (Madbi Formation) in the Aljawf sub-basin, NW Sabatayn Basin, so as to provide an overview on the organic matter type, richness, and its thermal maturity and hydrocarbon generation potential. Consequently, in the paper, based on the results of source rock evaluation, source rock thermal maturity evolution was modeled using advanced basin simulation software from typical wells and source rock strata. Moreover, favorable oil

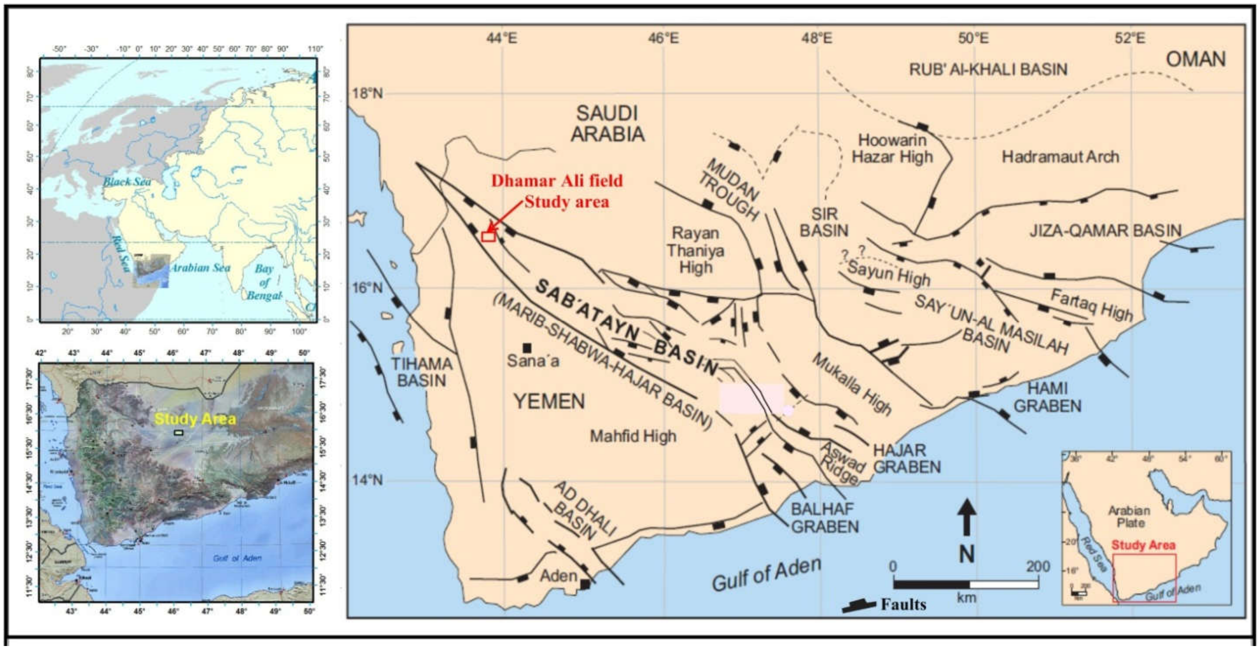

Figure 1. Location map showing the Dhamar Ali field within the NW Sabatayn Basin, western Yemen (Sachsenhofer *et al*., 2012; Al-Areeq *et al*., 2018)

Geological setting

The NW-trending Sab'atayn Basin (also called Marib-Shabwa-Hajar Basin) is a Mesozoic rift basin in the Arabian Peninsula that follows a deep-seated Proterozoic structural trend (Redfern and Jones, 1995). Basin formation was a consequence of an extensional phase related to the separation of India from Africa-Arabia (Redfern and Jones, 1995; Ziegler, 2001). The stratigraphic subdivision of the basin fill according to Beydoun *et al*., (1998) is displayed in (Fig. 2). The development of Sab'atayn Basin can be subdivided into three tectono-stratigraphic megasequences: (a) a pre-rifting phase (Permian-Oxfordian/Kimmerdgian), (b) a syn-rifting phase (KimmerdgianTithonian) and (c) a post-rifting phase (Early Cretaceouse). Pre-rift deposits are represented by non-marine to shallow-marine clastic rocks (Kuhlan Formation; Beydoun *et al*., 1998) overlain by shallow-marine carbonates (Shuqra Formation).

The syn-rift sequence is characterized by horsts and nested fault blocks that were developed during Late Jurassic to Lower Cretaceous time (Redfern and Jones, 1995). Syn-rift sections of the Madbi, Sab'atayn and Nayfa formations were deposited during the Jurassic in marine settings in the structurally lowest areas (Smewing, 1997; Smewing *et al*., 1998). The Madbi Formation is composed of porous lime grainstone to argillaceous lime mudstone. This Formation is divided into two members, the lower member (Meem Member) consists of source rock-quality shales, and sandy turbidites which form the reservoir rocks in some oilfields of the western Sab'atayn Basin (Beydoun *et al*., 1998). The Upper Lam Member is mostly composed of laminated organic rich shales and considered to be the most prolific oil-prone source rock in the basin (Brannan *et al*., 1999; Csato *et al*., 2001). During Tithonian time, late stages of the syn-rift phase, ocean circulation in the Sab'atayn Basin became restricted, and an evaporitic succession (Sab'atayn Formation) with an estimated original thickness of about 300 m was deposited (Seaborne, 1996). The Sab'atayn Formation is divided into four members named as Safir, Alif, Seen and Yah Members (Fig. 2). Yah Member is dominated by fluvio-deltaic sandstone, mudstone and evaporate, followed by Seen Member, which is the second evaporite-clastic sequence. Alif Member is composed of sandstone with minor shale, which form main reservoir in Sab'atayn Basin. Safir Member consists of predominantly of halite with subordinate anhydrite divisible into several bodies separated by interbedded organic-rich shale and sandstone with minor argillaceous, dolomite and limestone. The Safir Member constitute an excellent seal to the underling Alif Member reservoir and contain within them some potential good local reservoir seal pairs in the intra evaporate clastics and the evaporates (Beydoun *et al*., 1998).

The transition to the post-rift stage is represented by shallow marine limestones (Nayfa Formation) and clastic rocks (Sa'ar Formation). The post-rift sediments comprise the Saar, Qishn Formation and Tawilah Group (Fig. 2). The Saar Formation is mainly composed of limestone and dolomite, with mudstone and sandstone intercalations (Beydoun *et al*., 1998). It conformably overlies the Nayfa Formation and unconformably underlies the Qishn Formation (Fig. 2).

The Qishn deposits represent a transgressive marine sequence progressing from east to west across Yemen that grade laterally westward into clastics of the non-petroleum-bearing Tawilah Group (Fig. 2). A regional hiatus spanning the Late Eocene to ?Late Oligocene probably represents regional uplift which preceded rifting and seafloor spreading in the Gulf of Aden and the Red Sea. The Upper Cretaceous Tawilah Group partially was eroded after uplift related to the Red Sea rifting, which the erosion thickness has been estimated as 1000 m in the Marib sector of the Sab'atayn Basin (Mitchell and Galbiati, 1995).

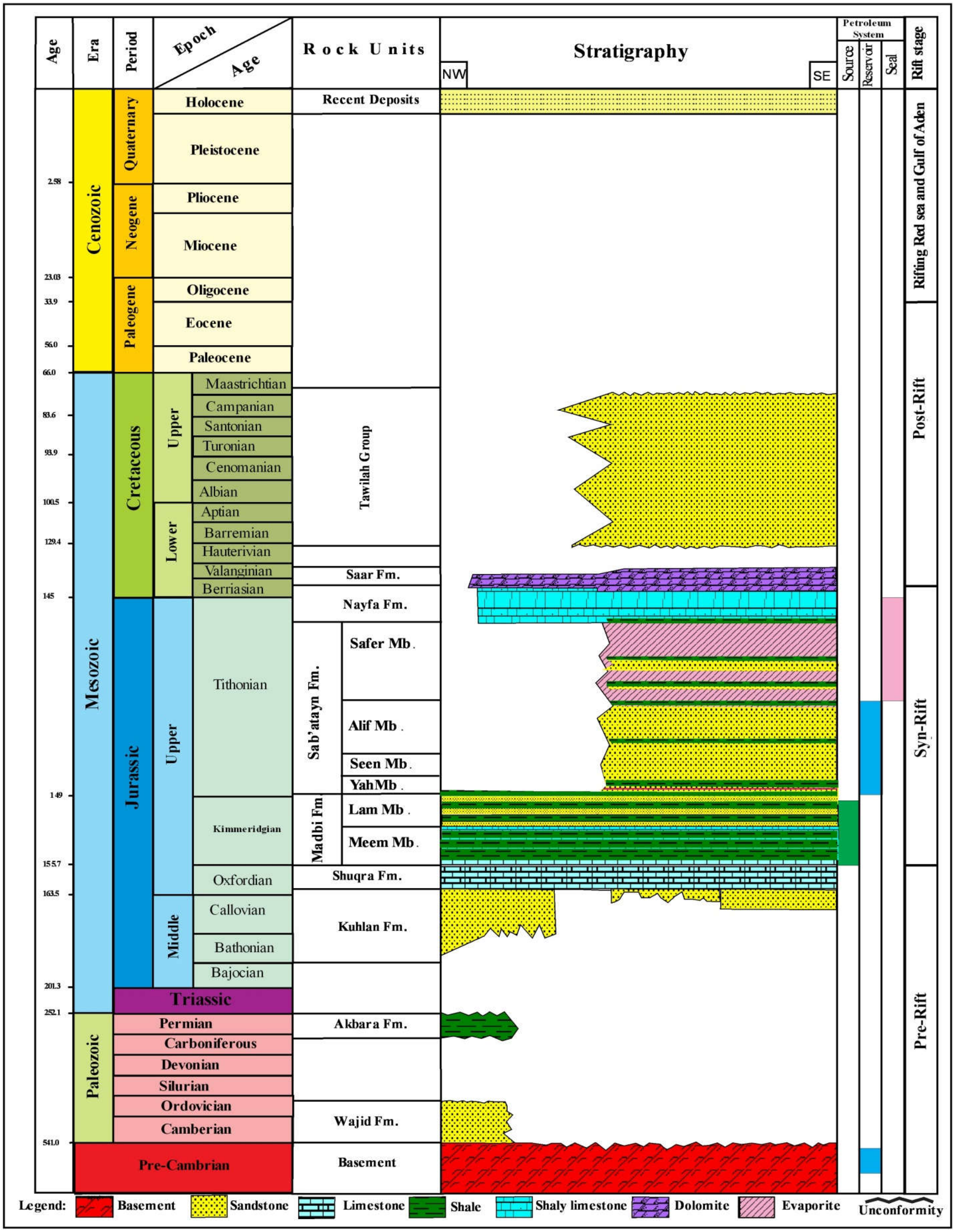

Figure 2. Regional stratigraphic nomenclature of Sab'atayn Basin, Yemen (Al-Areeq *et al*., 2018)

MATERIALS AND METHODS

Source rock evaluation: Source rock evaluation within the study area depends on the determination of organic matter (TOC). The hydrocarbon potentiality depends on the type and quantity of organic matter (kerogen) preserved in the petroleum source rock, thermal maturity and finally the

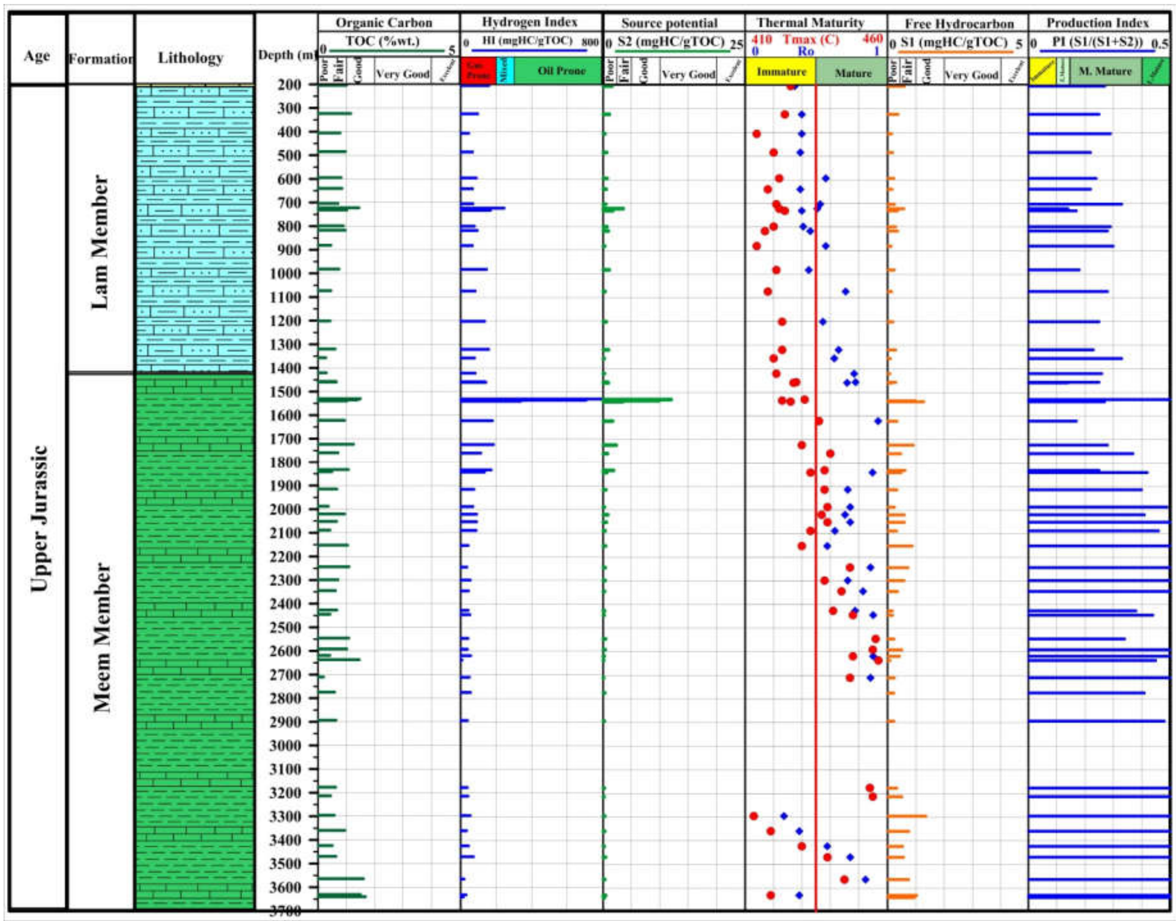

Figure 3. Organic geochemical log of the Upper Jurassic source rock samples in the Dhamar Ali field according to Rock-Eval pyrolysis and TOC content results

The geochemical data such as total organic carbon (TOC), Rock-eval pyrolysis data, and vitrinite reflectance are presented and discussed for the proposed Upper Jurassic rock units in Dhamar Ali field, North-west part of Sab'atayn Basin. TOC determination and Rock-Eval pyrolysis analysis were performed on 100 mg crushed whole rock samples, heated to 600° C in a helium atmosphere, using a Rock-Eval II unit with a total organic carbon module. The Rock-Eval pyrolysis data provide information on the quantity, quality and maturity of organic matter contained within the Lam and Meem rock units (Fig. 3). A total of 55 rock samples were collected from shales of the Lam and Meem Members in the studied well. Initially, the studied shale samples were cleaned of contaminants from drilling mud additives by washing the samples with water several times until no mud was visible on their surface. Parameters measured include Total organic carbon (TOC), free hydrocarbons (S1) in the rock, remaining hydrocarbon generative potential (S2) mgHC/g rock, and temperature of maximum pyrolysis yield (Tmax) (Fig. 3). Hydrogen (HI), production yield (PY), and production indexes (PI) were calculated. Details on the Rock-Eval method and parameters as well as a summary of interpretive guidelines for Rock-Eval data are available in (Espitalie *et al*., 1977; Peters, 1986; Peters and Cassa, 1994). Source rock properties such as total organic carbon content (TOC), hydrogen index (HI), as well as kinetic parameters are used to incorporate into basin modelling for hydrocarbon generation simulation. Vitrinite reflectance (% Ro) measurements were carried out under oil immersion in a

Mean vitrinite reflectance (% Ro) determinations were carried out on particles of vitrinite that are not associated with strong bitumen staining using an oil immersion objective.

Basin Modeling

1-D Basin modelling, was used for the reconstruction of the burial and temperature histories of the studied wells. Subsequently, the maturity of the source rocks and the timing of HC generation and expulsion in the basin could be modeled (Hakimi and Abdullah 2013; Al-Areeq *et al*., 2018). Good knowledge of the lithologies of the sedimentary section, their ages, and periods of deposition and erosion are necessary for the evaluation of basin evolution (As-saruri, 2010; Sachsenhofer *et al*.; Hakimi and Abdullah 2013; Albaroot *et al*., 2016; Al-Areeq *et al*., 2018). This method has become an important tool and successfully applied to search for new petroleum plays or for the evaluation of exploitable oil and gas accumulations around the world (e.g. Baur *et al*, 2001; Hakimi *et al*, 2010; Alaug *et al*., 2011; Al-Areeq *et al*., 2018; Al-Areeq, 2018). In this study, quantitative one dimensional basin modeling is performed for evaluating the thermal histories and timing of hydrocarbon generation and expulsion of the Lam and Meem source rocks in the NW part of Sab'atayn Basin. The reconstruction of the burial, thermal and maturity histories were modeled in order to evaluate the remaining hydrocarbon potential using Schlumberger's PetroMod (1D) modeling software. Dahamr Ali-01 exploration well was created as a

Table 1:Input data for modelling of depositional and erosional events of studied well (Dhamar Ali-01) in the NW Sabatayn Basin

Rifting	Age	Formation	Lithology	Dhamar Ali-01 well			Deposition age		Erosion age		Erosion (m)
				Top (m)	Bottom (m)	Thick (m)	From (Ma)	To (Ma)	From (Ma)	To (Ma)	
Post-Rift	Recent	Surface deposits	Gravel and sand	0	45	23	25	0	-	-	-
Syn-Rift	Upper Jurassic	Madbi (Lam Member)	Shale (organic rich, typical)	45	1442	1397	154	152.1	-	-	-
		Madbi (Meem Member)	Shale&Lime	1442	2350	908	157.3	154	-	-	-
Pre-Rift		Shuqra Fm.	Limestone (shaly)	2350	3945	1595	166	157.3	-	-	-
		Kuhlan Fm.	Sandstone	3944	3971	27	170	166	-	-	-
	Basement rocks		Granite and metamorphic rocks	3971	3995	24	180	170	-	-	-

used (Table 1). The geologic model consisting of the depositional, non-depositional and erosional events, was compiled using stratigraphic data were provided from well reports, the data bank of Petroleum Exploration and Production Authority (PEPA), Yemen and previous stratigraphic studies (e.g., Beydoun *et al*, 1998, As-saruri, 2010) (Table 1). Hydrocarbon generation modeling was based on TOC and HI of the Lam and Meem source rocks in the Dhamar Ali field, NW Sab'atayn Basin and the maturity modeling was calculated using the EASY% Ro model of (Sweeny and Burnham, 1990). The modeling results are also calibrated with measured vitrinite reflectance and borehole temperatures (BHT) in the study area.

RESULTS AND DISCUSSIONS

Source rock characteristics: The viability of any prospective reservoir depends on an effective source rock. Petroleum geochemistry is proving its value in helping operators evaluate source rocks and quantify the elements and processes that control the generation of oil and gas. The impact of quality and quantity of the organic matter (TOC) in the sediments are very important for hydrocarbon generation. The quality term of organic matter is refer to whether the source rock organic matter is oil prone or gas prone, and that is that different types of organic matter have different hydrocarbon generating potential or quality. However, the amount of organic matter in source rocks is the results of a wide variety of environmental influences (Tissot and Welte, 1984; Peters and Cassa, 1994; Peters, 1986) presented a scale for the assessment of source rocks potentiality, based on the TOC% and Rock–Eval pyrolysis data, such as S1 and S2. The obtained data show that the total organic carbon content (TOC) values for the Meem source rocks are between 0.2 and 1.68 wt% indicating fair to good source rocks (Fig. 3). Also, the values for the Lam source rocks are between 0.3 and 1.45wt% indicating fair to good source rocks (Fig. 3).

These conclusions are confirmed by the plots of total organic carbon (TOC wt%) versus remaining hydrocarbon (S2 mgHC/g rock) (Fig. 4). The total organic carbon is mostly very poor in studied samples. The Rock-Eval pyrolysis data reveal that most of the samples consist of reworked organic matter with no interesting source rocks potential. On the other hand, the plot of Tmax versus production index (PI) (Fig. 5) provides an indication of source rock maturity and hydrocarbon genesis. Thermal maturity is influenced by source rock organic matter the other factors like mineral matter, content, depth of burial and age (Tissot and Welte, 1984). The degree of thermal evolution of the sedimentary organic matter was deduced from Tmax (°C), Production Index (PI) and Vitrinite Reflectance (% Ro). The increase of maturity level of organic matter corresponds to an increase in Tmax. This phenomenon is related to the nature of chemical reactions that occur through thermal cracking. The weaker bonds breakup in the early stages while the stronger bonds survive until higher temperatures in the late stages (Whelan and Thompson, 1993). Combining and finding relations between the essential Rock-Eval parameter, Tmax, and calculated Rock-Eval parameter, PI, is a valuable method for indicating the maturity of organic matter. The following relations between Tmax and PI are observed:

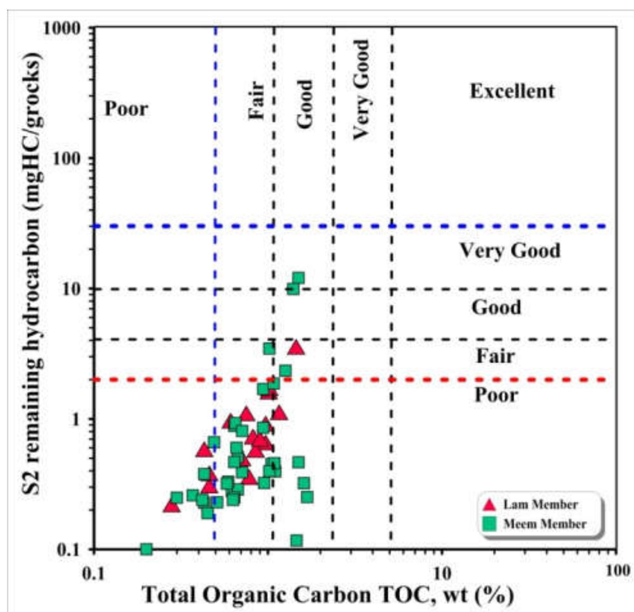

Figure 4. Pyrolysis S2 versus total organic carbon (TOC) plot showing generativesource rock potential for the Lam and Meem units in the study area

- Immature organic matter has Tmax and PI values less than 430°C and 0.10, respectively;
- Mature organic matter has a range of 0.1 – 0.4 PI. At the top of oil window, Tmax and PI reach 460°C and 0.4, respectively;

- Mature organic matter within the wet gas-zone has PI values greater than 0.4;
- Post-mature organic matter usually has a high PI value and may reach 1.0 by the end of the dry-gas zone (Peters, 1986; Peters and Cassa, 1994; Bacon, *et al*, 2000)

In Dahamr Ali field, most of the samples of Meem source rocks especially in the lower part have Tmax more than 445 °C and PI of 0.34 – 0.73. This indicate that the lower part in mature stage, while the upper part are in early mature and immature stage. Most of the samples are non-indegenous hydrocarbon except for few samples which fall within the hydrocarbon generation zone. Some samples have elevated Tmax more than 445°C making them peak mature. Samples from aforesaid wells are in main stages of hydrocarbon generation. The reset samples are non-indigenous hydrocarbons (Fig. 5). Most of the samples from the Lam source rocks in the study area are have Tmax less than 435 °C, making them immature.

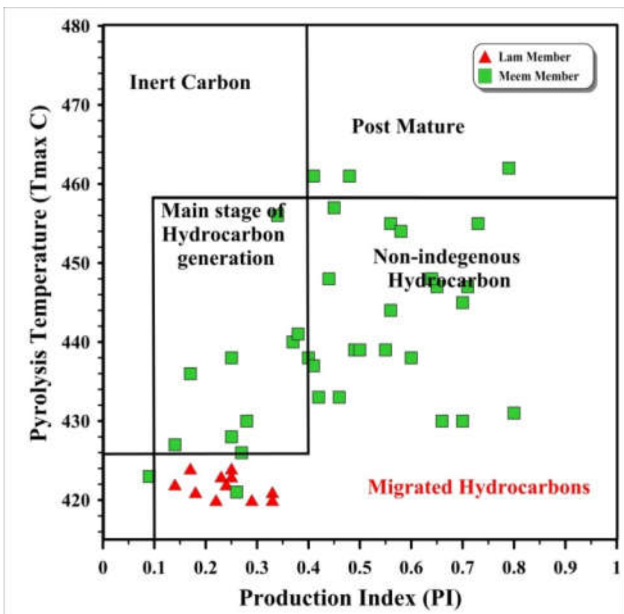

Figure 5. Quality and quantity of organic matter of Meem and Lam source rocks, Dhamar Ali field

Generating potentialities

The generating potential of source rocks is used to evaluate their capacity for hydrocarbon generation and can be determined by using the results of pyrolysis analysis. Tissot and Welte, (1984) proposed a genetic potential (GP = S1 + S2) for the classification of source rocks. According to their classification scheme, rocks having GP of less than 2 mg HC/g rock correspond to gas-prone rocks or non-generative ones, rocks with GP between 2 and 6 mg HC/g rock are moderate source rocks, and those with GP greater than 6 mg HC/g rock are good source rocks. Based on the above criteria, the Meem source rocks with a GP of less than 2 are non-generative rocks (Fig. 6). Furthermore that those source rocks with exceptionally high GP values in order of more than 10 mg HC/g rock may provide either an excellent source rock in Dahamr Ali-01 well, if the burial depth is sufficient to build is classified as moderate source rocks. It is worthy to mention that both of the source rocks are located in shallow depth in the study area even more exposed on the surface for some wells location.

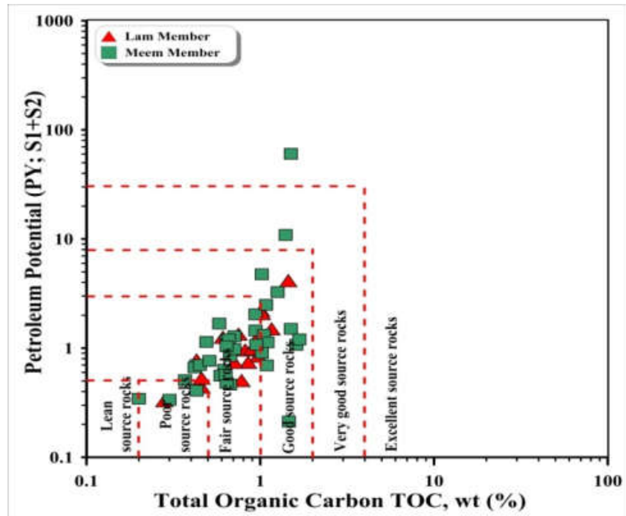

Figure 6. Generating potentialities of Meem and Lam source rocks, Dhamar Ali field

Genetic type of organic matter

The initial genetic type of organic matter of a particular source rock is essential for the prediction of oil and gas potential. Waples, (1988) used the hydrogen index values (HI) to differentiate between the types of organic matter. Hydrogen indices <150 mg/g indicate a potential source for generating gas (mainly type III kerogen). Hydrogen indices between 150 and 300 mg/g contain more type III kerogen than type II and therefore are capable of generating mixed gas and oil but mainly gas. Kerogen with hydrogen indices >300 mg/g contains a substantial amount of type II macerals and thus are considered to have good source potential for generating oil and minor gas. Kerogen with hydrogen indices >600 mg/g usually consists of nearly type I or type II kerogen, they have excellent potential to generate oil. Kerogen type for Lam and Meem source units can be deduced by the cross-plots of pyrolysis parameters, such as HI vs Tmax (modified van Krevelen diagram; Fig. 7) and TOC versus S2 (Fig. 4), which are probably resulted from deposition of more terrigenous type III organic matters sourced from land. Type III kerogen is composed of terrestrial organic material that is lacking in fatty or waxy components. Cellulose and lignin are major contributors. Type III kerogen have much lower hydrocarbon-generative capacities than do Type II kerogen and, unless they have small inclusions of Type II material, are normally considered to generate mainly gas. Majority of study area is dominated by type III kerogen, which is attributed to terrestrial environment where land derived organic matter is prevailed. This type of kerogen is characterized by small amount of Hydrogen is present, However this type of kerogen can generate gas only.

Thermal maturation

Thermal maturity is the extent of heat-driven reactions that alter the composition of organic matter. The concentration and depend on both the type of the organic matter and its degree of thermal alteration (Tissot and Welte, 1984; Longford *et al*, 1990). In the present paper, the thermal maturity level of the source rocks for Meem and Lam members has been determined by the study of the geochemical parameters as Rock–Eval temperature pyrolysis ''Tmax''with Hydrogen index ''HI'' (Fig. 7). Based on pyrolysis data kerogen classification diagrams were constructed using the HI versus Tmax plot as carried out by previous workers (Espitalie *et al*, 1985), which is used to determine the kerogen type and maturity (Fig. 7). The results show that the analysed Meem source rocks are generally plotted in the mature zone of type III kerogen. Some samples are upgraded to marginally mature zone. The wide variation in maturity level of Meem source rocks attributed to overburden rocks and depth. Results of Lam source rocks samples show that the source rocks are still immature to marginally mature studied well. These results have led to classify the Meem member as fully mature source rocks, while the Lam member is immature source rocks in the study area, because the structural setting show the deepening of Meem member and shallowing of Lam member (Fig. 8).

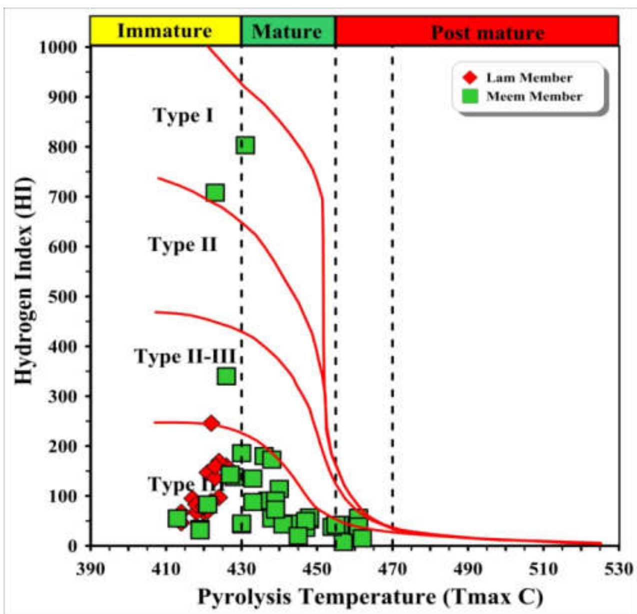

Figure 7. Kerogen type and thermal maturation of Meem and Lam source rocks, Dhamar Ali field

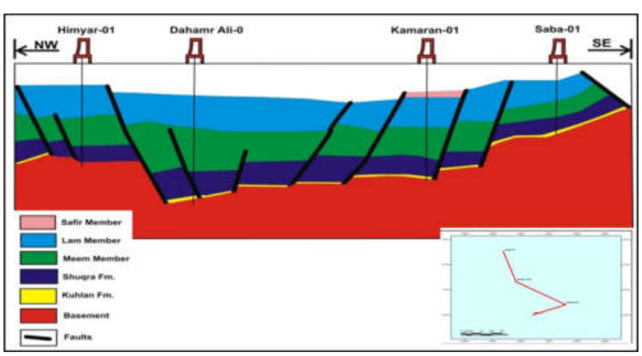

Figure 8. Structural cross section of NW Sab'atayn Basin

Basin modeling

Burial and thermal history: The burial history reconstruction of Dahamr Ali-01 well (Fig. 9A) located in northwestern most part of the study area shows regular trend pattern with no significant subsidence or uplift events. The study area is not affected by any tectonic activity. Cretaceous and tertiary strata are missing from Dahamr Ali-01 well, so the erosion event not extended beyond this well. The burial-history reconstruction at Dahamr Ali-01 well illustrates the lowest burial depth in the study area. From 150 Ma up to present time, subsidence/sedimentation rates appear to be fairly constant and relatively in linear trend. Based on burial/thermal history model, the burial temperature within this well ranges from 24.46 °C to 96.46 °C for the Meem Member and from 12.31° C to 24.65 °C for Lam Member. The maximum temperature has been recorded in Meem Member where it reached 96.46 °C at depth of 1487m. The measured (Ro) in (Fig. 9B) have been shifted from calculated line with proximity to top of the basement. This is due to presence of igneous intrusive. The heat flow histories used in the calculations are also plotted in **(**Fig. 9C**)**. In Dahamr Ali-01 well, heat flow values range between 55.04 and 60.04 mW/m^2. It maintains relatively same value from Middle Jurassic with slightly decreases in present time.

Source rocks maturation history: The level of maturation history is based on measured and calculated vitrinite reflectance (%Ro) scale for each burial history location. The timing of maturation and hydrocarbon generation is related to burial and temperature exposure of the source rocks. In thermal history reconstructions of the study area, the influence of the tectonic evolution on the heat flow distribution through time was applied. Thermal maturity levels of the Upper Jurassic source rocks is calculated based on the Easy% Ro routine (Sweeney and Burnham, 1990) using one dimensional modeling of single well. The detailed maturity history model of source rocks was used to determine the time when source rocks passed through the oil window. The modeled hydrocarbon generation of the Dahamr Ali-01 well is shown in (Fig. 10). The model shows that the Meem source rock in this well has reached the required level of thermal maturity to onset of the oil window (0.55-0.7 %Ro) from about 152.81 Ma at depth 2076m. Main oil generation occurred at 142.23 Ma at a depth of 2592m for the calculated VR value (0.7-1 %Ro). Based on burial/thermal history model; the burial temperature within Meem unit ranges from 24.24 °C to 96.46 °C. In addition, Lam source rock reached the required level of thermal maturity to onset of the oil window (0.55-0.74 % Ro) from about 102.99 Ma at depth of 1495m. Main oil generation occurred at 30.22 Ma at a depth of 1477m for the calculated VR value (0.7-1 %Ro). Based on burial/thermal history model; the burial temperature within Lam unit ranges from 20.44 °C to 24.65 °C.

Timing of hydrocarbon generation and expulsion: The source rocks once they have reached their expulsion threshold may expel the hydrocarbons upward into the reservoirs. The timing of petroleum generated and expelled from the Upper Jurassic source rocks were modeled. Oil generation is defined in this study by transformation ratios between 10% and 50%. Immature source rocks have transformation ratios less than 10% (no generation). Peak oil generation occur at a transformation ratio of 50% when the main phase of oil generation is reached. The calculation of the transformation ratios is based on the IES_TII_Kimmeridge_Clay_2C kinetic model for the Upper Jurassic source rocks. The hydrocarbon generation and expulsion modeling of Dahamr Ali-01 well is

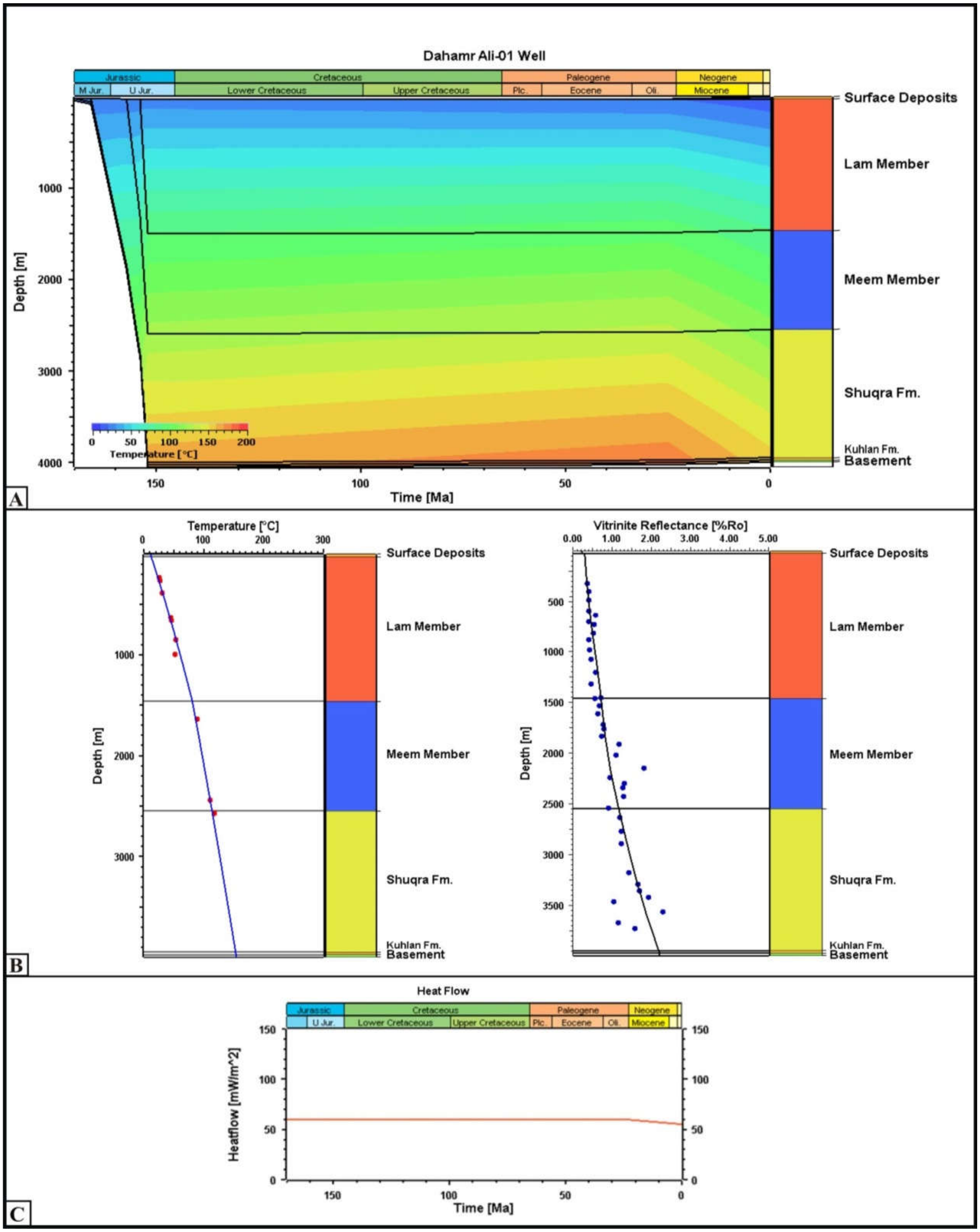

Figure 9. Burial andThermal history reconstruction along with calibration data and heat flow for Dahamr Ali field

The model shows that the Meem Member reached early phase of oil generation in late Jurassic and extended from 152.63 Ma to 125.97 Ma. Subsequently, main phase of oil generation began during lower Cretaceous and extended from 125.97 Ma to 75.21 Ma. The model also shows that the expulsion of hydrocarbon from Meem Member occurred between 75.21 Ma to 25 Ma and peak expulsion at 25 Ma during late Oligocene.

We can conclude that, the process of oil expulsion from Dahamr Ali-01 field has been ceased after rifting associated with the opening the Gulf of Aden and Red Sea has ceased. Furthermore, the Lam Member reached early phase of oil generation in Paleocene and extended from 57.77 Ma to 23.25 Ma. However, Lam Member did not reach the main phase of oil generation and expulsion.

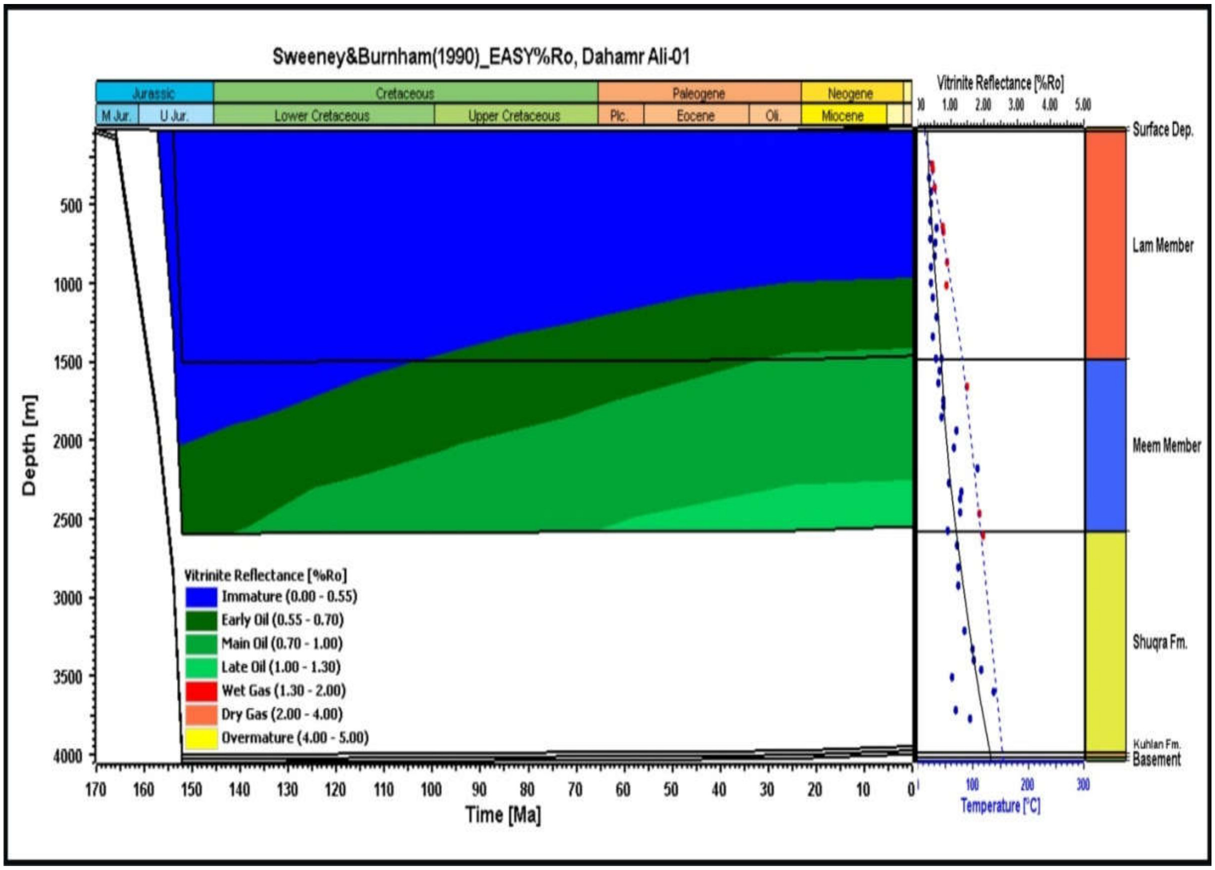

Figure 10. Burial and thermal maturity histories of the Upper Jurassic source rocks for the studied well (Dhamar Ali-01) showing the positions of the oil window. To the right the depth vs. bottom-hole temperature and depth vs. mean vitrinite reflectance data are shown, respectively

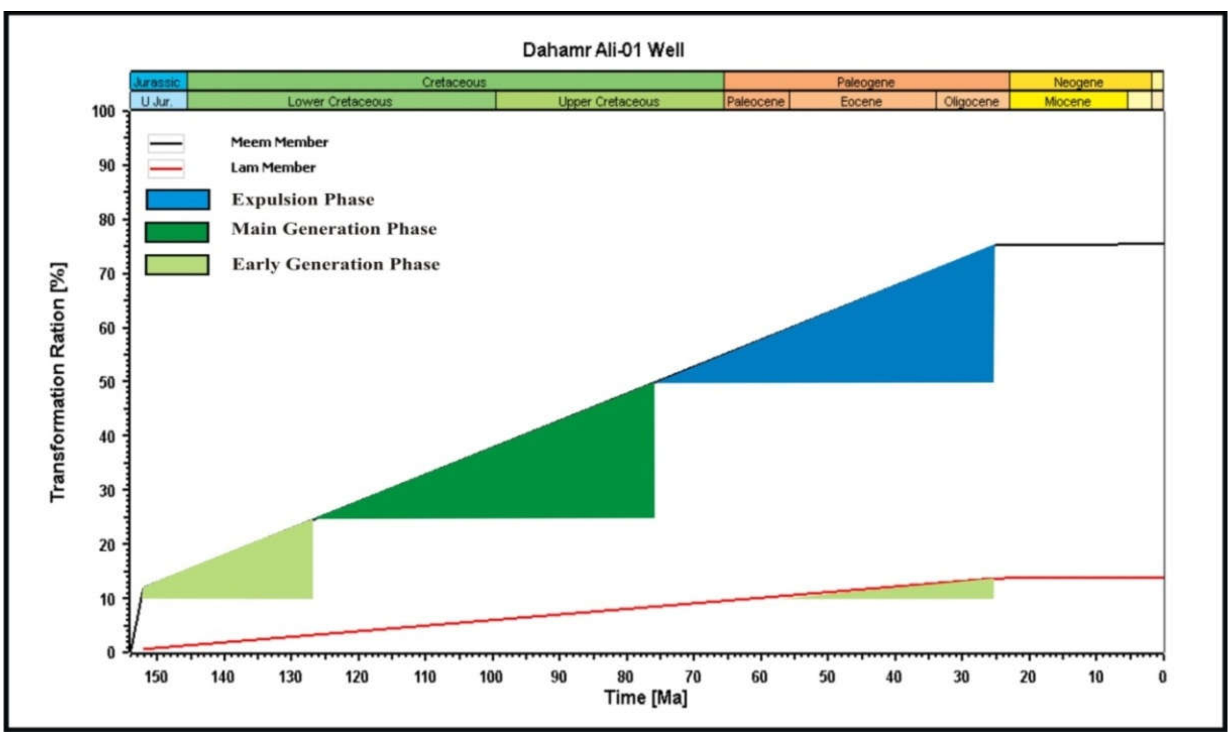

Figure 11. Evolution of the transformation ratio and rate of hydrocarbon generation with age from the Lam and Meem source rocks in the studied well (Dahamr Ali-01 well)

The age of early generation phase, allowing for variable time scale for generation and expulsion, is found to be less than 55 Ma. Temperature and pressure in favor of oil generation and expulsion prevent further generation and expulsion.

Conclusions

Investigation of sediments from Meem and Lam members in the Dhamar Ali field, NW Sabatayn Basin based on organic geochemical characteristics (e.g., total organic carbon content (TOC) and Rock-Eval pyrolysis); in addition, burial and thermal histories and timing of petroleum generation/expulsion have been modelled for two petroleum source rock intervals using one dimensional basin modelling software. The resultant data in this study indicate that:

- The Upper Jurassic source rocks have variable TOC content in therange of 0.2–1.68wt%, meetingthe standard as indicating a fair to good source rockgenerative potential.
- The samples of Lam and Meem members (Madbi Formation) mostly have Type III kerogen, with Hydrogen Index (HI) values in the range of 8–246 mg HC/g TOC, thus consideredto be mainly gas-prone.
- The Lam samples are thermally immature for hydrocarbongeneration, while the Meem samples are matureto peak-mature oil window mature stages for hydrocarbon generation.
- The burial/thermal history model indicate that the Meem source rocks have entered the mature to peak-oil window mature stages for hydrocarbon generation and the mean-oil generation has been reached during lower Cretaceous and extended from 125.97 Ma to 75.21 Ma.,also the expulsion of hydrocarbon from Meem Member occurred between 75.21 Ma to 25 Ma and peak expulsion at 25 Ma during late Oligocene. While, the Lam Member reached early phase of oil generation in Paleocene and extended from 57.77 Ma to 23.25 Ma.,and did not reach the main phase of oil generation and expulsion.
- The Meem Member act as effective source rock and significant amount of hydrocarbons can be expected to generate in the Dhamar Ali field, NW Sabatayn Basin. Therefore, the exploration processes should be focused on the known deeper location of the Lam and Meem members for predicting the source kitchen.

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