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The Subsurface Geology And Source Rocks Characteristics Of Some Alam El Bueib Reservoirs In Tut Oil Field, North Western Desert, Egypt

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ABSTRACT

The present study deals with subsurface geology and source rock characteristics to evaluate Alam El Bueib (AEB) Formation. Basin-mode 1D software is used for construction and prediction of either geological or geochemical models. On the other hand, calculation of tectonic subsidence and sedimentation rates in the study area through time, using tectonic sedimentation time plots were carried out to make a relation between geological processes and maturation through time. The lithostratigraphic cross sections, thickness variations, and lithofacies of some Alam El Bueib reservoirs are discussed to distinguish the shape, the extent of sedimentary basins and the environment of deposition. The geochemical study assisted in the identification of potential source intervals within Alam El Bueib Formation. The evaluation of the source rocks in the study area includes geochemical parameters; Total Organic Carbon (TOC wt %), Free Hydrocarbon Percent (S1), Residual Petroleum Potentiality (S2), Hydrogen Index (HI) and vitrinite reflectance (Ro %) of TUT–21 well. Besides, the prediction of thermal hydrocarbon maturation, maturity profiles and generation were calculated in the study area. The studied Alam El-Bueib Formation reservoirs include three main units; AEB-1, AEB-2 and AEB-3(A, D and E subunits). All tops of Alam El-Bueib units are higher in TUT-3 well (lies in northern part) than the other wells, furthermore horst or anticlinal block found in area around TUT-3 well. These reflected that the north direction in TUT oil field is more prospective than the south direction. Triangle facies maps showed that sandy shale and argillaceous sandstone facies are predominance in the most studied units changing to calcareous shale and argillaceous limestone in the AEB-1 and AEB-2 units respectively. These facies variations reflect continental fluvio-deltaic environment in AEB-3 unit, while AEB-1 and AEB-2 units indicate shallow marine environment. The geochemical results showed that the Alam El Bueib source rock in TUT oil field vary from poor to very good organic richness with kerogen of type III and characterized by immature to mature rocks. As well as, higher tectonic subsidence with high sedimentation rates in the studied area are observed at the Cretaceous and Neogene ages and hydrocarbon generation for Alam El Bueib Formation started during the Turonian (about 87 My).

Key words: Geochemical characteristics, source rock, subsurface, TUT oil field, Western Desert, Egypt.

Introduction

TUT oil field lies in the northern part of the Western Desert. The Western Desert has numerous oil potentialities and may soon jump as a great oil province. It lies at 4-5 km north and northwest of Salam field at the northern edge of the major Safir-Salam-TUT ridge at Khalda concession in the northern part of the Western Desert. The study area locates between Latitudes 30° 44' 15''– 30° 46' 03'' N and Longitudes 26° 57' 18''– 27° 00' E (Fig.1). The general structural and stratigraphical aspects of the Western Desert have been the subject of many studies, such as; Amin (1961), Said (1962 and 1990), Norton (1967), Parker (1982), Meshref (1982), El-Khadragy and Sharaf (1994), Shalaby et al. (2000), Zein El-Din et al. (2001), El-Khadragy et al. (2010) and others.

The generalized stratigraphic column of the northern Western Desert includes most of the sedimentary succession from Pre-Cambrian basement complex to Recent (Fig.2). Generally, the total thickness increases progressively to the north and northeast directions and ranges from about 6000 ft in the south and to about 25,000 ft in the coastal area. The main producing horizon in TUT oil field is Jurassic reservoirs (Khatatba-2B middle, 2F lower and 2F upper), Lower Bahariya, Alam El-Bueib (AEB-1, AEB-2, AEB-3A, AEB-3D and AEB-3E) and Upper Bahariya.

The Alam El-Bueib Formation becomes one of the most producer formations in the Western Desert especially in Khalda concession. It rests conformably on the Masajid Limestone change, by. It may rests...
unconformably on the Khatatba Formation or older units (Fig.2). The lithology of Alam El-Bueib Formation contains thick massive sandstone, argillaceous and calcareous limestone. It is intercalated with shales. It ranges in age from Barremian to Aptian with at least one time gap identified within this unit.

Fig. 1: Base map showing the drilled wells and correlation chart profiles (A-A’ &B-B’).

Materials and Methods

The fundamental materials which applied in this work include ten representative wells. These wells are: (TUT-3, TUT-8, TUT-19, TUT-21, TUT-38, TUT-44, TUT-76, TUT-77, TUT-79 and TUT-80). The available well logging data in these wells are density, neutron, gamma ray, resistivity, caliper, sonic and composite logs. These data are obtained from Khalda Petroleum Company. In addition, a geochemical analysis data of TUT-21 well are used to evaluate the source rock.

Two lithostratigraphic cross sections were constructed to illustrate the subsurface geological conditions, and to study lithostratigraphy and trends of lateral change in thickness and lithofacies of the studied reservoirs. Also, isopach and lithofacies maps were established to show the thickness and facies variation of different rock units in the study area.

The evaluation of the source rocks in the study area depends on the geochemical parameters including (TOC wt%, S1, S2, HI) and vitrinite reflectance (Ro %) of TUT-21 well. Besides the prediction of hydrocarbon maturation and generation was carried out on the seven wells; TUT-3, TUT-8, TUT-19, TUT-38, TUT-44,
TUT-76 and TUT-77. As well as, tectonic subsidence and sedimentation rates through time, using tectonic sedimentation time plots are studied in order to make a relation between geological processes and maturation through time.

Fig. 2: Generalized litho-stratigraphic column of the North Western Desert after (Khalda 2012).

**Results and Discussion**

**Lithostratigraphic Cross Section:**

The constructed lithostratigraphic cross sections illustrate the change in lithologic characters or any break in the depositional continuity. These sections show the equivalency of stratigraphic units, and exhibit thickness variation. Borehole data from ten composite logs are used to construct two correlation charts in the N-S and E-W directions (Fig.1).
Correlation Chart A-A:

The first correlation chart (A-A’) extends along N-S direction, and passes through Tut-3, Tut-76, Tut-8 and Tut-19 wells (Fig. 3). The chart shows three main units, they are AEB-1, AEB-2 and AEB-3 arranged from top to base respectively. AEB-3 unit is subdivided into four subunits (A, C, D and E). AEB-3 unit is more thickness than the other units. All tops of Alam El Bueib units are higher in Tut-3 well (at the north direction) than the other wells. This means that the northern area may be subjected to uplifting. They are differing in lithology from one unit to another. AEB-3 consists mainly of sandstone, siltstone, especially in subunits A and E with subordinate intercalation of shale and limestone, while, C-subunit consists mainly of siltstone toward the south direction with intercalation of shale and subordinate sandstone toward the north direction. D-subunit contains sandstone especially toward south direction with intercalation of siltstone, shale and limestone. AEB-2 unit consists mainly of limestone with subordinate sandstone, siltstone and shale. Meanwhile, AEB-1 unit comprises mainly of sandstone with intercalation of siltstone, shale and limestone at the top parts. Alam El-Bueib Formation capped by dolostone rocks of Alamein Formation.

Correlation Chart B-B:

The second correlation chart (B-B’) extends along W-E direction and runs through TUT-38, TUT-76, TUT-80 and TUT-79 wells (Fig.4). The chart records three main units namely; AEB-1, AEB-2 and AEB-3(A, C, D and E) arranged from top to base respectively. The thicknesses of Alam El Bueib units are variable from well to another. The tops of units in TUT-76, TUT-80 and TUT-79 wells are uplifted than TUT-38 well. Alam El Bueib-2 is relatively less thickness than the other units, while Alam El Bueib-3 unit is more thickly than the others. As well as the chart shows the different in lithology from unit to another. AEB-3 A and E subunits predominately consists of sandstone and siltstone with subordinate intercalations of limestone. Meanwhile, AEB-3 C and D subunits formed of siltstone and shale with subordinate intercalations of sandstone and limestone .As well as, in AEB-3C sandstone recorded in TUT-38 well and disappeared in other wells. El Bueib-2 consists of limestone with subordinate siltstone, shale and sandstone, while AEB-1 consists of siltstone and sandstone with intercalation of limestone and shale; the two later increase toward the top parts of the unit.

Isopach and Facies maps:

Five isopach maps are constructed for Alam El Bueib-1, 2, 3(A, D, and E) units, to demonstrate and clarify the variation and direction of thinning and /or thickening in relation to the shape of the depositional basins. As well as, triangle facies maps are constructed for studied reservoirs to illustrate the facies distribution within the basin and interpret environment condition during Lower Cretaceous times. Generally, the varying proportions of sandstone, siltstone, shale and carbonate indicate different environments of sedimentation, although the limestone definitely is marine, the sandstone and shale is related to continental, fluvi-deltaic and fluviomarine or marine conditions.

Alam El Bueib-1 unit:

Lithologically, Alam El Bueib-1 unit consists mainly of sandstone, siltstone and shale with some streaks of limestone.

The isopach map of Alam El Bueib-1 unit shows the maximum thickness of Alam El Bueib-1 sediments attains 258 ft at TUT-76 well (Fig.5a), while the minimum thickness is recorded 222 ft at TUT-79 well. This isopach map shows one depocenter, aligned in the NE-SW direction and lies in the central part of the area. Around the depocenter the thickness decreases in all directions and then increases again .On the other hand, the circular pattern of isopach lines indicate that the subsidence was contemporaneous with deposition. Furthermore, there is an intensive contour lines of the central part indicate the occurrence of subsidence movement rapid than the other parts.

The triangle facies map shows that the most Alam El Bueib-1(Fig.5b) is characterized by sandy shale facies (in most of studied wells) changing to calcareous shale (west part) in the TUT-38, TUT-44 and TUT-76 wells. These facies reflect to fluvio-marine environment changing to shallow marine environment in west direction. The clastic percentage increases toward east and northeast directions (Fig.5c). Non clastic percentage map increased in the west side of studied area (Fig.5d). Sandstone isolith map attains the greatest thickness of about 94 ft at well TUT-77and attains its lowest thickness about 35 ft, at well TUT-21 (Fig.5e). Shale isolith map of Alam El Bueib-1 shows that shale of Alam El Bueib-1 attains greatest thickness (116 ft) at the middle part in the north side, at well TUT-3 (Fig.5f). It decreases towards the west and east sides, about 20 ft, at well TUT-77. Sand/shale ratio, ranged from 0.21 to 0.82 and the value increases in the east and southwest directions (Fig.5g).
**Alam El Bueib-2 unit:**

The Alam El Bueib-2 deposits lithologically are composed of limestone, siltstone and shale with some streaks of sandstone.

The thickness of Alam El Bueib-2 unit (Fig. 6a) ranges from 97 ft at TUT-19 well to about 132 ft at TUT-77 well. The thickness increases in the east and northeast directions, while it decreases in the southwest and west directions. The wide contour lines at the eastern part may indicate a gentle gradient of deposition than the other parts.

The facies distribution maps of Alam El Bueib-2 show that the triangle facies map (Fig. 6b) is represented by mainly calcareous shale facies changing to argillaceous limestone in northeast and southwest parts. It is reflected shallow marine condition during sedimentation of this unit deeper than Alam El Bueib-1 unite. The clastic percentage (Fig. 6c) is well developed in the study area at western side, and non clastic percentage increases in eastern direction. (Fig. 6d). Sandstone isolith map of Alam El Bueib-2 (Fig. 6e) shows that the...
sandstone thickness increases in the northeastern direction and at the middle and south parts, sandstone attains the greatest thickness 22 ft. at TUT-76 well and the lowest thickness 0 ft. is recorded at the TUT-38 well. Shale isolith map of Alam El Bueib-2 shows the greatest thickness of shale in the northwest direction (Fig. 6f). The maximum thickness of shale is 42 ft. at TUT-44 well, and the minimum thickness is 0 ft. in the southeast and northwest sides at TUT-76 well. The difference in shale thickness of Alam El Bueib-2 may be due to the nature of supply of sediments and/or to structural condition. The sand/shale ratio map indicates that the ratio decreased in the western direction of the study area (Fig. 6g).

Fig. 4: Correlation chart along the profile (B-B').
Fig. 5: a) Isopach, (b) lithofacies, (c) Clastic percentage, (d) Non clastic percentage, (e) Sandstone isolith, (f) Shale isolith, and (g) Sand/shale ratio maps of Alam El Bueib-1 reservoir, TUT oil field.
Fig. 6: (a) Isopach, (b) Lithofacies, (c) Clastic percentage, (d) Non clastic percentage, (e) Sandstone isolith, (f) Shale isolith, and (g) Sand/shale ratio maps of Alam El Bueib-2 reservoir, TUT oil field
Alam El Bueib-3 unit:

AEB-3 unit subdivided into four subunits A, C, D and E. The subunit-C consists mainly of siltstone and shale. Accordingly this unit is excluded.

Alam El Bueib-3A subunit:

The Alam El Bueib-3 A subunit deposits, lithologically are composed of sandstone and siltstone with some streaks of shale and limestone. The Isopach map of Alam El Bueib-3A unit (Fig.7a) attains maximum value of about 361 ft at TUT-38 well and the minimum value of about 303 ft at the TUT-21 well. This map shows two depocenters aligned in NE-SW directions. Wide contour lines at the eastern sector may indicate a gentle gradient of deposition than the other parts.

The triangle facies map reflects the predominance of argillaceous sandstone facies changing to sandy shale in the northeastern part (Fig.7b). These facies indicate continental fluvo-deltaic environment. Clastic percentage map clarifies that the elastic percentage increases toward southwest and middle parts in the eastern side (Fig.7c). Non clastic percentage map shows that the carbonate percentage increased in each of the northeast and middle parts of the south direction of studied area (Fig.7d). Sandstone isolith map of Alam El Bueib-3A indicates that the thickness of sandstone increases toward western part of the studied area (Fig.7e). Sandstone attains the greatest thickness 276 ft. at TUT-38 well in the western part and reaches the lowest value, 136 ft. at TUT-80 well in north eastern part. Shale isolith map of Alam El Bueib-3A shows the maximum thickness of shale is recorded in the middle in the north side (Fig.7f). Shale attains the greatest thickness 36 ft. at TUT-3 well, and disappear at TUT-19, TUT-76 and TUT-77 wells. Sand/ shale ratio ranged from 0.8 to 3.4 and the value increases in the southwest directions (Fig.7g).

Alam El Bueib-3D subunit:

The Alam El Bueib-3D subunit deposits, lithologically are composed of sandstone and siltstone with some streaks of shale and limestone. The Isopach map of Alam El Bueib-3D unit (Fig.8a) shows that the maximum thickness attains 86 ft at TUT-19 well, while the minimum thickness of this unit 53 ft is recorded at TUT-80 well. This map shows also wide contour lines at southeastern part may indicate a gentle gradient of deposition than the other parts. As well as, map shows thinning in thicknesses toward northeast and southwest directions.

The triangle facies map of the Alam El Bueib-3D subunit reflects the predominance of sandy shale facies changing to sandstone in the north (Fig.8b). These facies indicate a continental fluvo-deltaic environment. Clastic percentage map shows an increasing percentage all over the area except in the middle part of studied area (Fig.8c). Non clastic percentage map indicates that the carbonate content increases in the middle part of the area (Fig.8d). Sandstone isolith map of indicates that the thickness of sandstone increases from the middle part towards southeast, northeast and east directions (Fig.8e). Sandstone attains the maximum thickness (34 ft) at TUT-44 well. Shale isolith map of Alam El Bueib-3D shows that the thickness increases in southeastern direction and middle part of the north side in the study area (Fig.8f). The shale attains the maximum thickness of about 30 ft at TUT-19 well, and attains the minimum thickness of about 0 ft. at TUT-44 well. The differentiation in shale thickness of Alam El Bueib-3D may be due to the nature of supply of sediments and/or to structural condition. Sand/ Shale ratio various from 0.08 to 0.79 and the values increase in the south direction (Fig.8g).

Alam El Bueib-3E subunit:

The Alam El Bueib-A deposits lithologically are composed of sandstone and siltstone. The thickness of Alam El Bueib-3E unit (Fig.9a) ranges from 64 ft at TUT-77 well to about 178 ft at TUT-3 well. Moreover the thickness increases in the north direction and decreases in other directions. The isopach map reflects two depocenters, one around TUT-8 well and the other sub-basin lies in the northern part of the TUT-3 well.

The facies distribution maps of Alam El Bueib-3E show that the triangle facies map is indicated by sandstone facies changing to argillaceous sandstone in northwestern and southeastern parts (Fig.9b). These facies indicate continental fluvo-deltaic environment. Sandstone isolith map shows that the lowest thickness (51 ft) is recorded at the southeast part, at TUT-77 well (Fig.9c). It is probably due to the less supply of sedimentary materials or may be due to uplifting and erosion. The maximum thickness of sandstone attains about 166 ft at the northern part in the TUT-3 well. This indicated that the development of clastic sediment at the northern part of the study area. Sand/shale ratio is ranging from 0 to 34.7 and the values increase in the south direction (Fig. 9d).
Fig. 7: a) Isopach, (b) lithofacies, (c) Clastic percentage, (d) Non clastic percentage, (e) Sandstone isolith, (f) Shale isolith, and (g) Sand/shale ratio maps of Alam El Bueib-3A reservoir, TUT oil field.
Fig. 8: a) Isopach, (b) lithofacies, (c) Clastic percentage, (d) Non clastic percentage, (e) Sandstone isolith, (f) Shale isolith, and (g) Sand/shale ratio maps of Alam El Bueib-3D reservoir, TUT oil field.
Source rock characteristics:

Organic matter richness (TOC wt. %):

Fourteen shale samples were analyzed from Alam El Bueib Formation illustrated in table (1). These results show that, TOC wt% values range from 0.54 wt. % (at depth 8160 ft) to 3.62 wt. % (at depth 10720 ft) with average value of 1.18 wt. %. Based on the above mentioned values and using the classification of Peters (1986), Alam El Bueib Formation is considered as fair to good source rock (Fig.10a). In addition, the amount of TOC wt% represents a concentration which is able to produce a sufficient amount of hydrocarbons during thermal maturation to overcome adsorption and surface tension effects giving raise a commercially significant expulsion of hydrocarbons from the rock matrix (Katz, 1983).

Types of organic matter:

According to Hollander et al. (1991), the organic matter (OM) content must be enough to establish a continuous kerogen network which leads to a full connectivity of OM in the rock. So, the quantity and type of OM is determined by visual study of kerogen isolates and also by Rock-Eval Pyrolysis. Figure (10b) shows the relationship between the Hydrogen Index (HI) and Oxygen Index (OI) of kerogen samples indicating that Alam El Bueib Formation is characterized by type (III) kerogen.

Hydrocarbon generation potential:

The organic geochemical analysis is made to get the parameters required to define genetic potential (GP), and also to predict the nature and quantity of hydrocarbons that could be generated from kerogen. The pyrolysis derived $S_1$ and $S_2$ values of Alam El Bueib Formation can be plotted to explain the potentiality of source rock. The $S_1$ values in well TUT-21 ranges from 0.03 to 0.13 mg/g rock and the average value of 0.068 mg/g rock. The above mentioned values of $S_1$ indicate a poor potential source rock for generation hydrocarbon (Fig.10c). Also the values of $S_2$ in TUT-21 well, ranges from 0.28 to 4.04 mg/g rock with average value 0.91 mg/g rock. That means, it is ranging from poor to good generating (Fig.10d). Hydrogen index (HI) values indicated that the
Alam El Bueib Formation has mainly kerogen type III, where the HI values are between 50 and 112 mg/g with average 71 mg/g (Fig.10e).

Table 1: Organic geochemical data of Alam El Bueib Formation in TUT-21 well

<table>
<thead>
<tr>
<th>Sample depth (ft)</th>
<th>TOC From To wt%</th>
<th>S1 mg/g</th>
<th>S2 mg/g</th>
<th>S3 mg/g</th>
<th>Tmax degC</th>
<th>HI mg HC/g TOC</th>
<th>OI mg CO2/g TOC</th>
<th>PI</th>
<th>S2/TOC</th>
<th>S3/TOC</th>
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<td>0.82</td>
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<td>152</td>
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<td>0.92</td>
<td>429</td>
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<td>130</td>
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<td>0.83</td>
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TOC: Total organic carbon in weight percent; S1: Free hydrocarbons percent in the rock (mg HC/g rock); S2: Residual petroleum potential (mg HC/g rock); S3 is Released of organically bound CO2 over the temperature range (300–550°C); Tmax: peak temperature (deg C). HI: Hydrogen Index (mg HC/g TOC); OI: Oxygen Index (mg CO2/g TOC); PI: Production Index.

Fig. 10: Source rock characteristics of Alam El Bueib Formation in TUT-21 well.

Maturation of organic matter:

Maturity level of organic matter is determined precisely by vitrinite reflectance values measured for kerogen vitrinites. The results of Ro % analysis of six samples of TUT-21 well are illustrated in figure (10f). The Ro% values indicate that Alam El Bueib Formation lies in the immature and mature stages, where the values of Ro % are ranging from 0.35% to 1.1% with average value 0.74.
Six maturity diagrams were constructing for wells TUT-3, TUT-8, TUT-19, TUT-21, TUT-38 and TUT-44 wells using BasinMod-1D (Lopatin, 1971; Waples, 1985; Waples et al., 1992). The maturity profiles (Fig.11) for studied wells reveal that the Alam El Bueib Formation is located in mid mature and late mature oil window.
Fig. 11: Maturity profiles for six wells in TUT oil field, Western Desert, Egypt.

**Thermal burial history modeling**

The thermal burial history models of the studied wells were constructing using BasinMod-1D (Lopatin, 1971; Waples, 1985; Waples et al., 1992). The data needed to construct the thermal subsidence history are
formation tops or true stratigraphic thickness, geologic age of the time-rock unit, geothermal gradient and magnitude of erosion and the non-deposition periods or hiatus. Accordingly, six thermal burial history and hydrocarbon generation were constructing for TUT-3, TUT-8, TUT-19, TUT-21, TUT-38 and TUT-44 wells. This thermal burial history curves are plotted from the geological data of the studied wells. The source rock maturity is mainly ranging from mid mature to late mature oil widows during Neogene time. The oil window is entered approximately at 18 Ma (Fig.12).
Fig. 12: Thermal burial history for six wells in TUT oil field.

On other hand, the burial history diagrams for the studied wells indicate rapid subsidence during the Cretaceous time. The slope of the burial history curves change at a time interval which corresponds to the Turonian (92 Ma) and become flatter, indicating the dominance of thermal cooling subsidence.
Cumulative hydrocarbon generation:

Six cumulative hydrocarbon generation diagrams were constructed for TUT-3, TUT-8, TUT-19, TUT-21, TUT-38 and TUT-44 wells using BasinMod-1D. The hydrocarbon generation for Alam El Bueib Formation started during the Turonian (about 87 My), as shown in figure (13) and the cumulative generations of TUT-3, TUT-8, TUT-19, TUT-21, TUT-38 and TUT-44 wells are 78, 120, 108, 40, 78 and 132 bbl/acre*ft rock respectively. The figures show that the generation hydrocarbon of Alam El Bueib reservoir in TUT wells is mainly oil with small amount of gas this may be the higher percentage of gas-prone kerogen type III in the TUT wells.
Tectonic subsidence:

Six wells (TUT-3, TUT-8, TUT-19, TUT-21, TUT-38 and TUT-44) in the study area have been studied on the basis of tectonic subsidence and sedimentation rates through time, using tectonic sedimentation time plots. Figure 14 shows higher tectonic subsidence with high sedimentation rates at the Cretaceous and Neogene ages in TUT-3, TUT-8, TUT-19, TUT-21 and TUT-38 wells. On the other hand, higher tectonic subsidence with high sedimentation rates at the Cretaceous and Paleogene ages in TUT-44 well. The variation of maturity and thermal history in the studied area is due to the structure setting and sedimentation rate variation as a result of tectonic events which affected the north Western Desert area.

Conclusions:

1. The Alam El-Bueib Formation becomes one of the most producer formations in the Western Desert especially in Khalda concession. The studied Alam El-Bueib Formation includes; AEB-1, AEB-2, AEB-3(A, D and E) units.
2. Correlation charts illustrate the change of vertical and lateral variation of Alam El Bueib sediments. All tops of Alam El Bueib units are higher in TUT-3 well than the other wells, this means that the north direction in TUT oil field is more prospective than the south direction.
3. Isopach maps showed that AEB-1 unit and AEB-3A subunit have increased in thickness toward southwest and northeast directions. As well as, AEB-2 unit and AEB-3E subunit show thickening toward east and northeast directions. While, AEB-3D subunit shows thickening toward the southeast and northwest directions. All Alam El Bueib units in studied area has been uplifted during the deposition of Alam El Bueib formation or subjected to several stages of erosion which give rise to reduction in Alam El Bueib units.
4. Isolith and triangle facies maps reflect that the sandy shale and argillaceous sandstone facies are predominance in the most studied units changing to calcareous shale and argillaceous limestone in the AEB-1 and AEB-2 units respectively.
5. The lithofacies variations result of studied formation reflects that AEB-1 and AEB-2 units were deposited in shallow marine environment. AEB-2 unit indicates more deeper than AEB-1 one. AEB-3(A, D and E subunits) unit reflects continental fluvio-deltaic environment. These results are coincident with the geochemical data and other authors such as Hanter, 1990; Ibrahim, 2002 and El Nady and Ghanem, 2011.
6. Alam El Bueib Formation is considered as fair to good source rock and characterized by type III kerogen.
7. The Alam El Bueib Formation is located in the immature and mature stages, where the values of vitrinite reflectance are ranging from 0.35% to 1.1% with average value 0.74%.
8. The source rock maturity ranges from mid mature to late mature oil windows during Neogene time and the oil window is entered approximately at 18 Ma.

9. Burial history diagrams for the studied wells indicate rapid subsidence during the Cretaceous time. Higher tectonic subsidence with high sedimentation rates in the studied area are observed at the Cretaceous and Neogene ages.

10. The hydrocarbon generation for Alam El Bueib Formation started during the Turonian time (about 87 My).
Fig. 14: Tectonic subsidence and sedimentation for six wells in TUT oil field.

References


