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SEISMIC SIGNATURE MODELING FOR THE LOWER CRETACEOUS RESERVOIR SANDS, SOUTH UMBARKA AREA, WESTERN DESERT, EGYPT

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نموذج الاشارة السيزمية لرمال خزان العصر الطباشيرى بمنطقة جنوب امباركة، الصحراء الغربية– مصر

الخلاصـة: تقع منطقة جنوب امباركة فى الجزء الشمالى من الصحراء الغربية لمصر وهى تبعد حوالى ٤٥٠ كيلومتراً جنوب غرب مدينة الإسكندرية. وتعتبر رمال أسفل العصر الطباشيرى (رمال علم البويب) الخزانات الرئيسية للهيدروكربونات. وتتواجد فى طبقات على أعماق متغيرة من بئر الى آخر، ولوحظ تغيير واضح فى سمك هذه الرمال وما تحتويه من طفلة ومساميتها . وتساعد دراسة تأثير هذه التغيرات على الإشارات السيزمية لهذه الرمال على فهم أوضح عن طبيعتها وتوزيعاتها.

وقد استخدمت فى هذه الدراسة برامج الحاسب الالى للحصول على نماذج صناعية فى اتجاه واحد واتجاهين لمعرفة تأثير التغيرات لكل عامل وأوضحت النماذج أن العديد من هذه الرمال يكون لها سمك أرفع كثيراً من حدود التحليل السيزمى (أقل من ١٥٠ قدماً) وهى مجتمعة معا وتعمل كحزمة واحدة ووضح نموذج الرمال والطفلة كيف أن الفاصل بين رمال وطفلة علم البويب لا يمكن تحديده بدقة وبين أن نموذج المسامية يكون له الأثر الأكبر على سعة الموجه السيزمية .

كما أوضح النموذج ثنائى الأبعاد أن الفاصل بين رمال وطفلة علم البويب يغير من سعته وزاوية طوره وبين أن رمال علم البويب تتكون من عدسات رملية متراكمة فوق بعضها ويفصلها شرائط رفيعة من الطفلة.

ABSTRACT : *South Umbarka area is located in the northern part of the northern Western Desert of Egypt, about 450 kilometers west of the Alexandria city. The Lower Cretaceous sands (Alam El Buieb "AEB" sands) are the main hydrocarbon reservoirs. They are found to be stratigraphically variable from well to another. The thicknesses of the sands, their shale content and porosity were found to be obviously variable. Studying the impacts of these variations on the seismic signatures of these sands would help in understanding their environment and distribution.*

1-D and 2-D modeling packages were used to synthesize the effects of variations of each parameters. The modeling shows that many of these sands thickness are much thinner than seismic resolution limits (< 150 feet) and they are combined together and imaged as package. The shale-out/sand-out model demonstrates how lithology can disguise the interface between AEB-C shale-AEB-D1 sand to the point that it will be inaccurately picked. The porosity model indicates that porosity can have a large effect on the seismic amplitude.

2-D modeling shows that the interface between AEB-C shale-AE-D1 sand changes its amplitude and phase while the AEB-D1 sand consists of overlapping sand lenses separated by thin ribbons of shale.

INTRODUCTION

Seismic modeling, when used in conjunction with the integrated well data and seismic data, enhances the development of more accurate or even new models of stratigraphic traps. The use of seismic modeling techniques has a great impact on the understanding of the seismic response of both reservoir and non reservoir layers. In the south Umbarka area, play types were shifted from structural traps to ore subtle stratigraphic traps. Identification of these traps required detailed integration of large 3D seismic data sets with well log data.

South Umbarka area covers 04779 acres block located in the northern part of the Western Desert. It lies between longitudes 31 00 E and 30 30 E, and latitudes 26 30 N and 27 00 N (Fig. 1).

Alam El Bueib (AEB) sand Formation is the main producing Formation in the study area. Oil and gas shows were encountered in several intervals from Paleozoic to late Cretaceous, so, South Umbarka block is considered as a multi-exploration target area. A total of fourteen wells were utilized in this study. Figure 1 shows the main exploration targets and their corresponding reflection characters.

South Umbarka area has experienced very complicated tectonics that varied from deeper to shallow horizons. Left to right lateral shears with minor compressional movements were encountered. Drilling locations for both shallow and deeper targets are very hard due to complicated tectonic setting. Both deep and shallow targets are sand reservoir. The deeper sand is composed of transitional sand intercalated with shale. Such sand is very sensitive for low frequencies. The facies variations and depositional environments of these sands need to be studied. So, the depositional environment and seismic signature modeling is essential for the exploration of this sand.

The proposed seismic modeling was performed to illustrate the impacts of thickness and porosity variations on the seismic signature of the different horizons by applying the Incremental Pay Thickness Techniques (IPT). The objective of this model is to check for the shale-out and sand-out effects, sand-porosity effects and define the magnitude of lateral facies change if any.

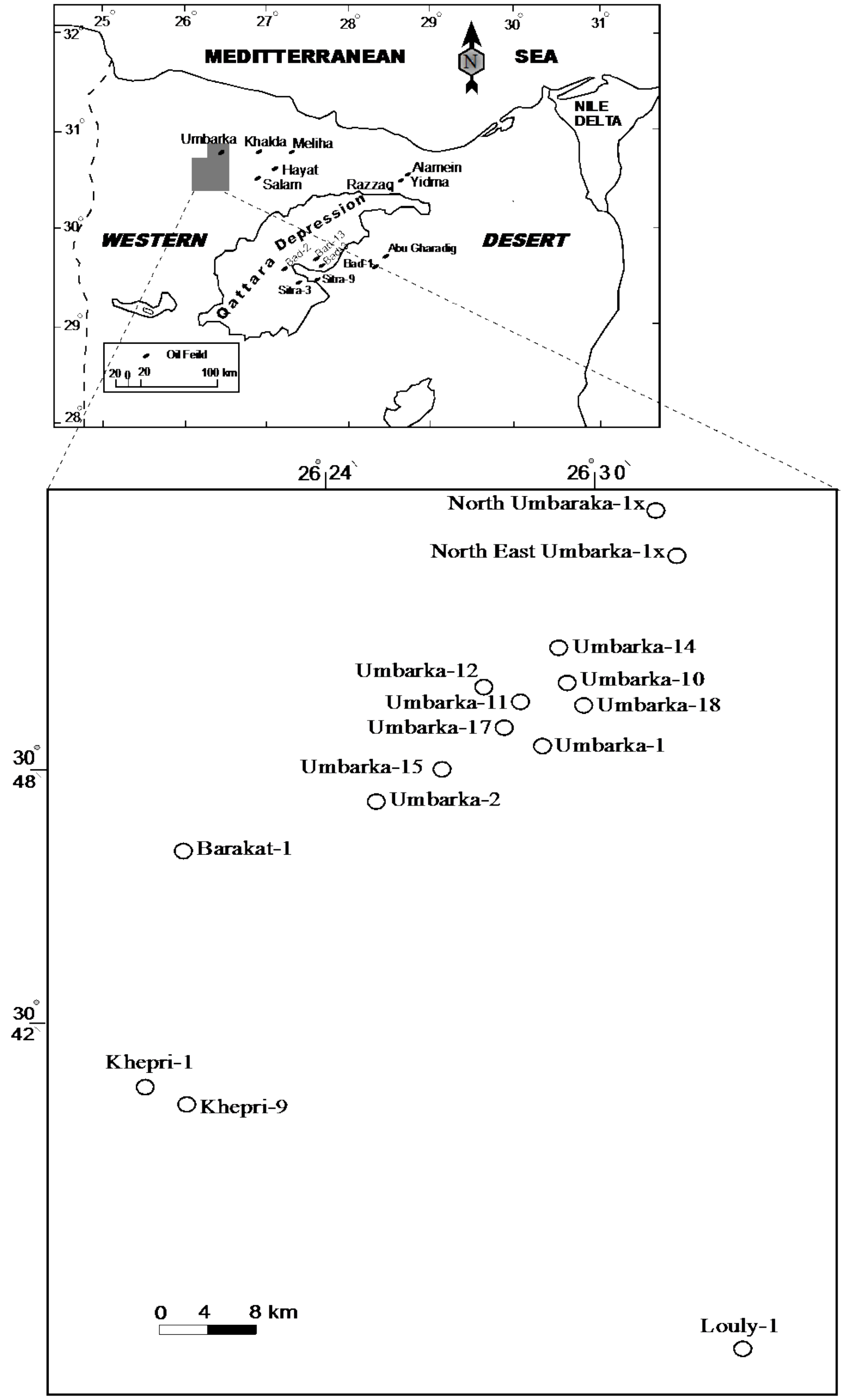

Fig. (1): Location map of the study area.

In this work, careful studying of the seismic model using 1D and 2D seismic can add more reserve and optimize new drilling locations and study as well the impact of thickness and porosity variations on the seismic signature of the different horizons.

GENERAL STRUCTURAL AND STRATIGARPHIC SETTING

South Umbarka area as a part of the northern Western Desert seems to be affected by three tectonic events. The oldest (most probably of Paleozoic to Jurassic in age) resulted in NW or WNW trend structures which was followed by another event (mainly of Cretaceous age) that resulted in ENE (Syrian Arc)trend structures (Meshrif,1982). The previous two tectonic trends may be explained to be due to the couple force affecting north Africa at that time. The third tectonic event (most probably of Late Oligocene in age) resulted in NW-SE (Suez) and NNE (Aqaba) trend structures. This may be explained as to the collision of Africa with Asia which resulted in a north horizontal compressive force.

The stratigraphy across South Umbarka concession exhibits strong lateral facies variations. This is due to the constant reactivation and eustatic sea level changes that caused transgressions and regressions to dominate deposition across the area (Norman, 1979 and Saxena, 1986). The main oil potential section are Neocomian (AEB sand) and Cenonmanian (Bahariya sand).

Rocks of Triassic through Cretaceous age beneath the Western Desert (Fig. 2) record three large-scale transgressive sequences. Each sequence began with dominantly non-marine sands, and graded upward to a thick marine carbonates. These sequences include Ras Qattara to Masajid, AEB to Alamein, and Kharita to Abu Roash. This study focuses on the rocks of the Lower Cretaceous Alam El Bueib (AEB).

Alam El-Bueib Formation

Through the studied wells (Fig. 3) the Alam El Bueib Formation is mainly made up of sandstone with shale, siltstone, and dolomite interbeds. The lower contact of the Alam El-Bueib Formation with the underlying Masajid Formation is between the shale and sandy shale of the lowermost of the Alam El-Bueib Formation and the limestone, shale and sandy shale of the uppermost of the Masajid Formation in Khepr-1, Khepri-9, Umbarka-1x and north east Umbarka-1x wells. The lower contact of the Alam El-Bueib Formation at Umbarka-2x well with the underlying Paleozoic is between the sandstone of the lowermost of the Alam El-Bueib Formation and the sandy shale of the uppermost of Paleozoic rocks. The upper contact of the Alam El-Bueib Formation with the overlying Alamein Dolomite is placed between the dolomite of the lowermost of the Alamein Dolomite and shaly sandstone of the uppermost of the Alam El-Bueib Formation, expect at Khepri-9, Umbarka-1x, Umbarka-11 wells the uppermost of the Alam El-Bueib Formation is sandstone. In both Umbarka-15 and Umbarka-11 wells the drilling stopped in Alam El Bueib Formation. Thin dolomite beds are present especially near the top in all wells except for Umbarka-11 well. Shale beds are distributed through the studied wells, which it is concentrated near the top in Umbarka-2x well and it may concentrate near the base in Umbarka-15 well. Siltstone interbeds encountered in both khepri-1 and Umbarka-15 wells that concentrated near the base.

The thickness of the Alam El-Bueib Formation is recorded in Khepri-1x, Khepri-9, Umbarka-1x, Umbarka-2x and North East Umbarka-1x wells, while it is not recorded in Umbarka-15 and Umbarka-11 wells because the drilling was stopped there. The thickness increases from the center (Umbarka-1x) well towards the northeast and southwest. The maximum thickness (3713 feet) is recorded in Khepri-9 well and the minimum thickness (2465 feet) is recorded in Umbarka-1xwell (Fig. 4).

Alamein Dolomite

Through the studied wells (Fig. 5) Alamein Dolomite is made up of dolomite except in Umbarka-15 well where thin shale bed occurs near the top. The contact of the Alamein Dolomite with the underlying Alam El-Bueib Formation is between the dolomite of the lowermost Alamein Dolomite and the sandstone of the uppermost Alam El-Bueib Formation in Khepri-9, Umbarka-1x, Umbarka-11 wells, whereas the uppermost of Alam El-Bueib Formation is shale and sandy shale in the other wells. The upper contact with the overlying Dahab Shale is placed between the dolomite of the uppermost Alamein Dolomite and shale of the lowermost Dahab Shale expect in Umbarka-15 well where it is placed between the sandstone of the lowermost Dahab shale and the dolomite of the uppermost Alamein Dolomite.

The thickness of Alamein Dolomite increases toward the northeast direction with maximum thickness of (244 feet) in Umbarka-15 well and with minimum thickness of (96 feet) in Khepri-1 well (Fig. 6).

Dahab Shale

Through the studied wells (Fig.7) the Dahab Formation is mainly composed of the shale with dolomite interbeds in some wells, while in Umbarka-15 well it is composed of sandstone with shale interbeds. The lower contact of the Dahab Shale with the underlying Alamein Dolomite is between the shale and shaly sandstone of the lowermost of the Dahab Shale and the dolomite of the uppermost Alamein Dolomite. The upper contact with the overlying Kharita Formation is placed between the shale and shaly sandstone of the lowermost Kharita and shale to shaly sandstone of the uppermost Dahab shale, expect at Umbarka-15, Umbarka-1x, Umbarka-11 wells the lowermost part of the Kharita Formation is sandstone and the uppermost of Dahab Shale is dolomite in Umbarka-2x well.

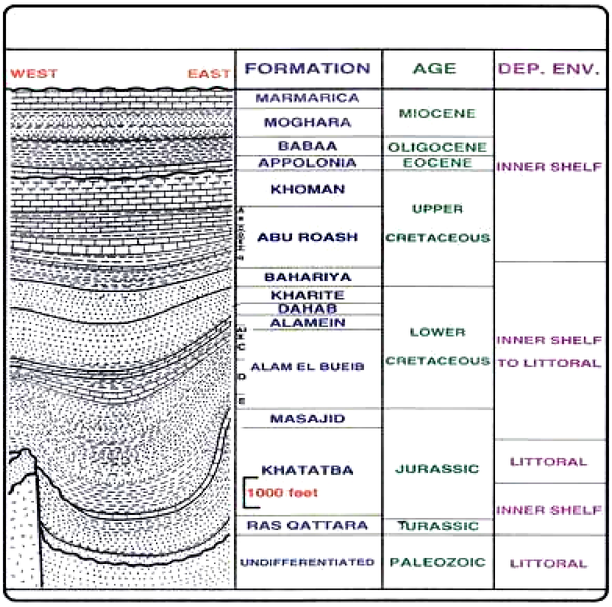

Fig. (2): Simplified Stratigraphic Column, South Umbarka Concession (Modified after Aram et al. 1988)

The thickness of the Dahab Formation increases from the center (Umbarka-2x well) toward the southwest (Khepri-9 well) and also increases from the center toward the northeast until Umbarka-11 well toward the northeast direction (North East Umbarka-1x well). The thickness recorded through the studied wells ranges from (282) feet in Khepri-9 well to (105) feet in both North East Umbarka-1x and Umbarka-10 wells (Fig. 8).

GEOPHYSICAL INTERPRETATION

Increased resolution of the 500 and 600 seismic series was the result of optimized vibroseis source and array parameters and improved wavelet processing techniques. A comparison of a portion of vibroseis line 628 (Fig.9) vintage weight-drop line, parallel and one kilometer away, line 2455 (Fig. 10), indicated an increased frequency content, 10-65 Hz in the newer vintage, compared to 5-10 Hz in the older data. This raised the question of whether stratigraphy could be mapped with the new data. Based on 1-D/2-D modeling, amplitude and facies analyses., seismic resolution is not sufficient to detect individual sand package, but seismic facies can indicate depositional environment, and seismic amplitude empirically correlates to a producing trend in developed areas with well control. Seismic character (seismic facies) and seismic amplitude of selected reflections or intervals were mapped. Criteria for recognition of seismic facies included amplitude, geometry, and continuity of reflections.

Seismic Modeling

Seismic response of the Mesozoic section in the Umbarka-South Umbarka region was modeled using 1D/2D Seismic Kingdom Suite Software. With using these computer aids, it is possible to simulate lateral and vertical changes in lithology or porosity to determine limits of detection and resolution of their beds, and to tie seismic sections to well data.

Synthetic Seismogram Analysis

Synthetic seismogram is one-dimensional seismic modeling of the total seismic response of the numerous reflection interfaces in the subsurface. It provides a means for linking borehole logs with actual seismic records. Its principal uses are reflections identification, and determination which event relates to a particular interface or sequence of interfaces (Wood, 1982).

Synthetic seismogram of the Umbarka and South Umbarka wells were generated and tied to seismic data. The MIRA geophysical analysis system was used to generate synthetic seismogram from sonic logs only or from a combination of sonic and density logs. A zero-phase, 5-10-55-65 Hz, reverse polarity a trough equals a compression wavelet with a 100 ms AGC produced an optimal tie for all wells in the study area. Fig. 11 shows the typical fair to point match of synthetic to actual seismic data. The example indicates the high amplitude continuous, peak-trough-peak character of the top of the Alamein Dolomite reflection. The character at the top of the AEB-C zone is also consistent as a continuous peak-trough-peak event, although the doublet may merge into a low frequency peak-trough for short lateral distances. In contrast, the character at the top of the AEB-D1 zone is modeled in all synthetic seismograms as a peak-over-trough, yet the seismic data show this interface as a discontinuous event which laterally changes the amplitude and phase. Various changes in lithology and porosity were modeled to explain the differences between variations in the amplitude and phase response of the actual seismic data and the consistent, but variable amplitude, peak-over-trough response of the synthetic data.

For all wells in the study area, the top of the AEB-D1 zone is picked on the sonic logs at the sharp break between the slow velocity shales at the base of the AEB-C zone and the higher velocity sands which compose most of the AEB-D1 zone. This type of lithological break results in a modeled trough seismic response (Fig. 12). In most of the synthetics this response is also amplified by constructive interference of the transitional sand-to-shale interface within the lower part of the AEB-C zone. Without such interference, this transitional interface produces a lower amplitude peak reflection. Also, this transition zone may produce a series of peaks and troughs, depending on the thickness of the transitional shale and intervals within it containing more abrupt changes in lithology. With the given seismic resolution, the two interfaces usually combine to produce a peak-over-trough event, with the top of the AEB-D1 interval picked in the trough.

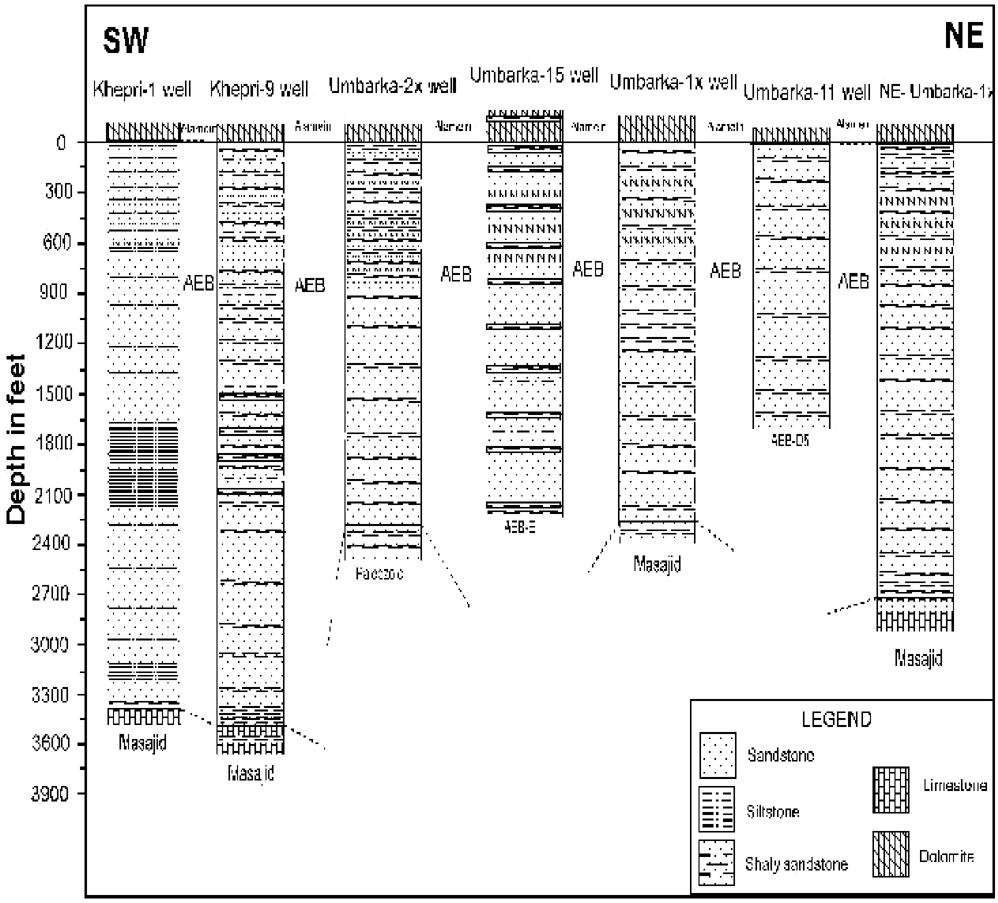

Fig. (3): Lithostratigraphic correlation of the Alam El Bueib Formation in the study area.

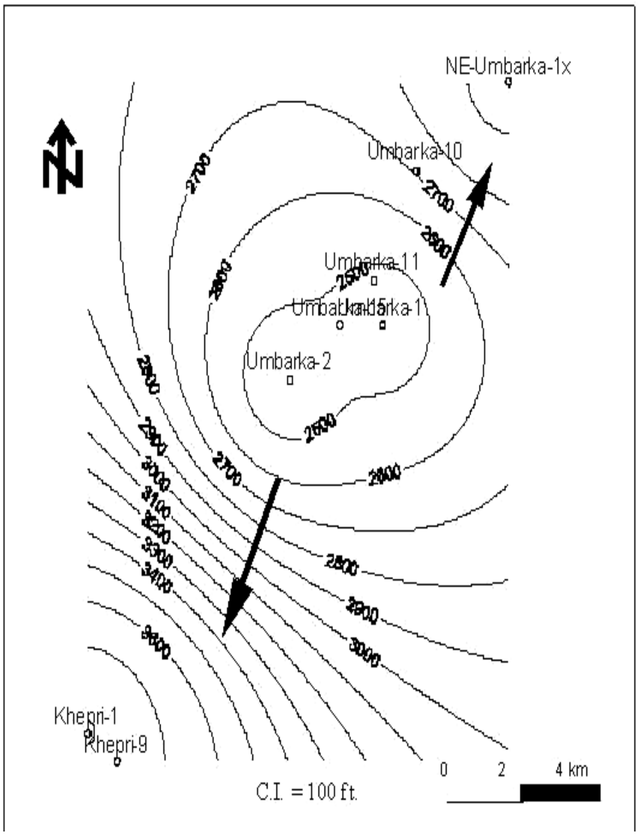

Fig. (4): Isopach map of the Alam El Bueib Formation through the study area.

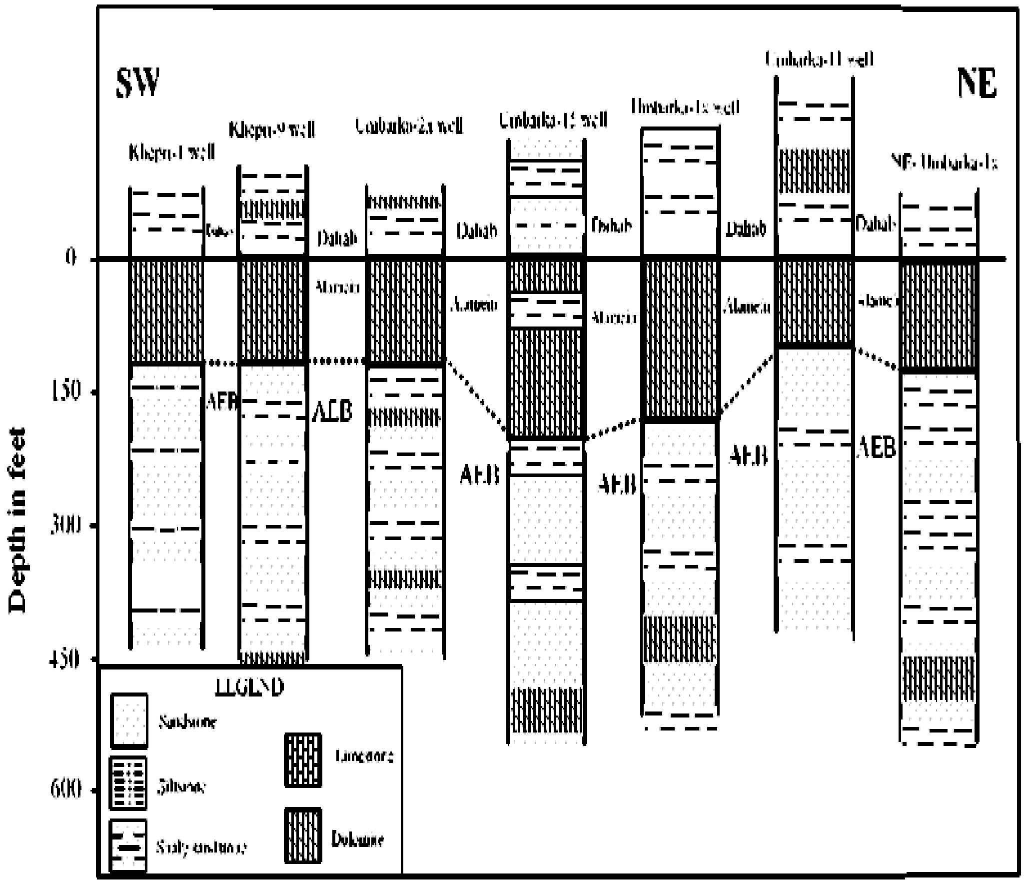

Fig. (5): Lithostratigraphic correlation of the Alamein Formation in the study area.

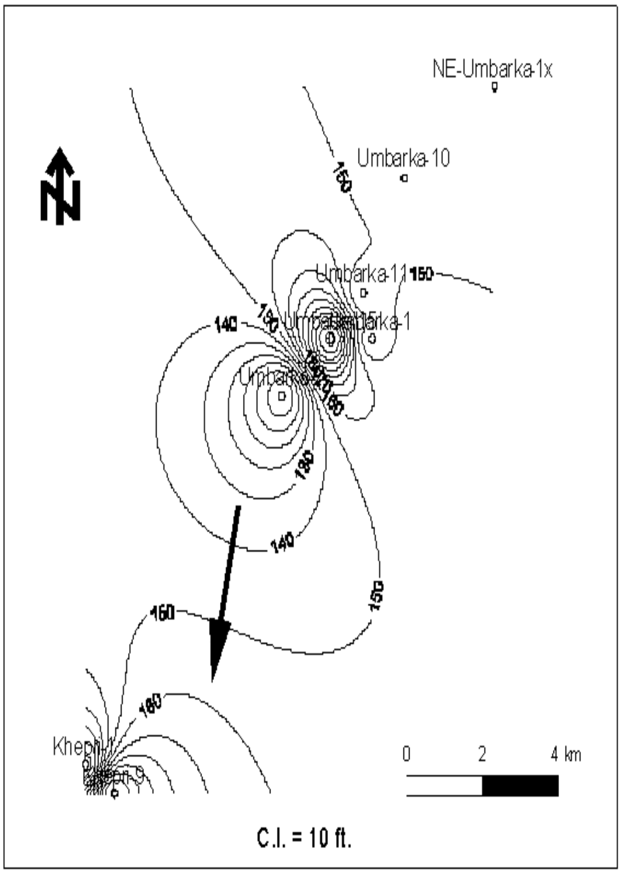

Fig. (6): Isopach map of the Alamein Formation through the study area.

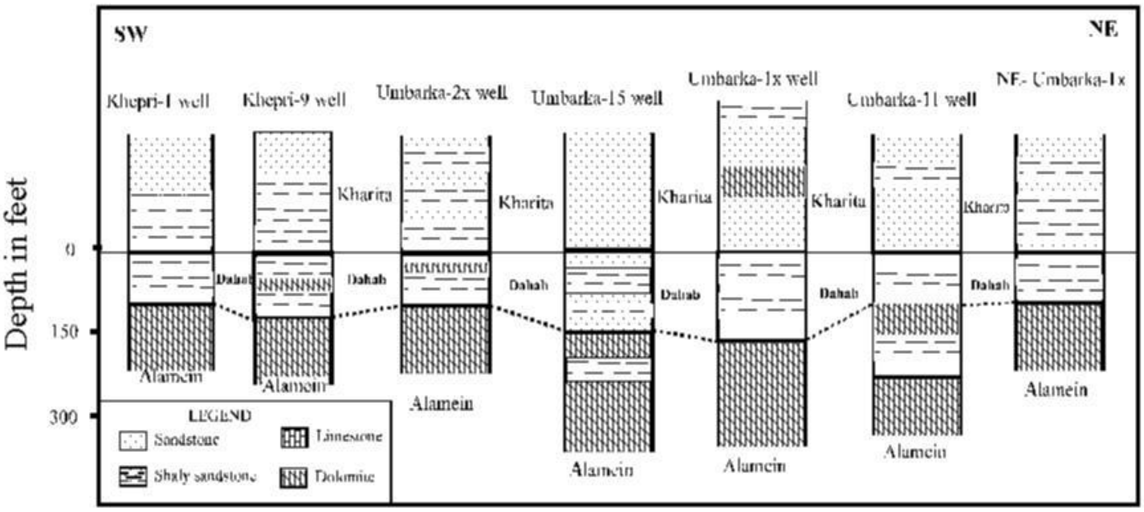

Fig. (7): Lithostratigraphic correlation of the Dahab Formation in the study area.

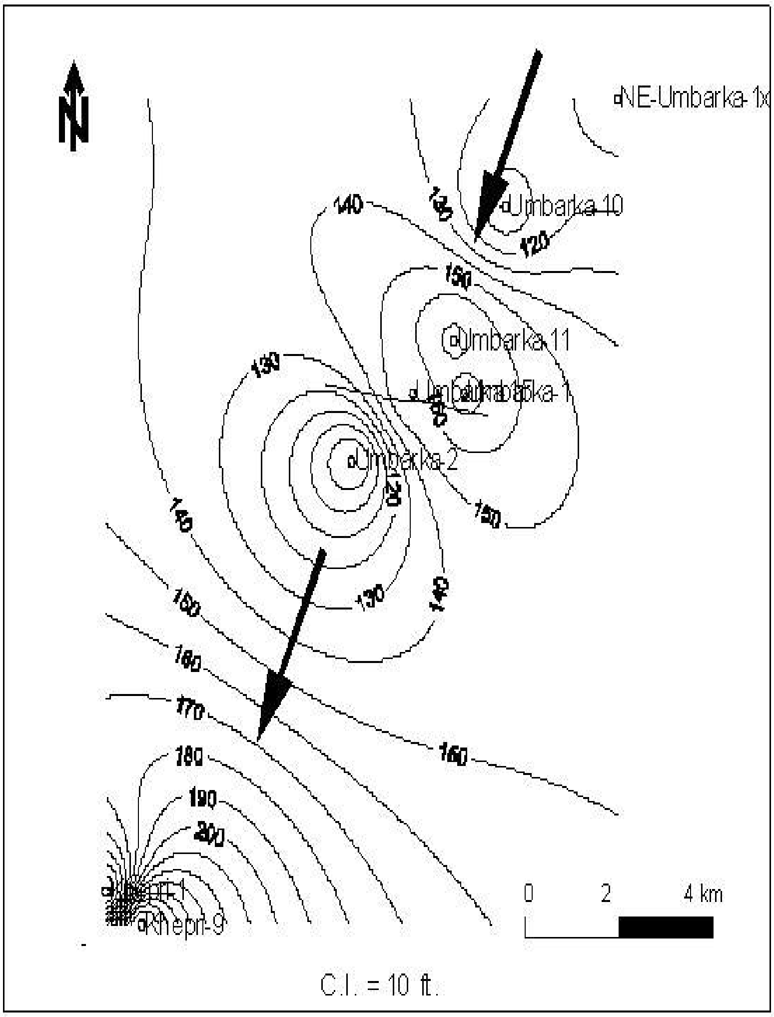

Fig. (8): Isopach map of the Dahab Formation through the study area.

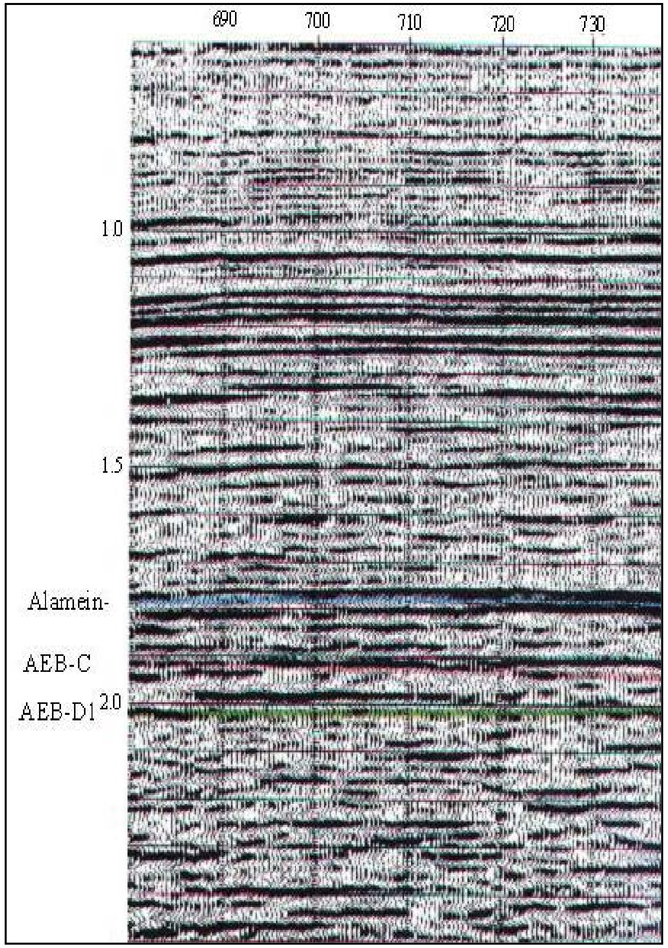

Fig. (9): South Umbarka Line 628.

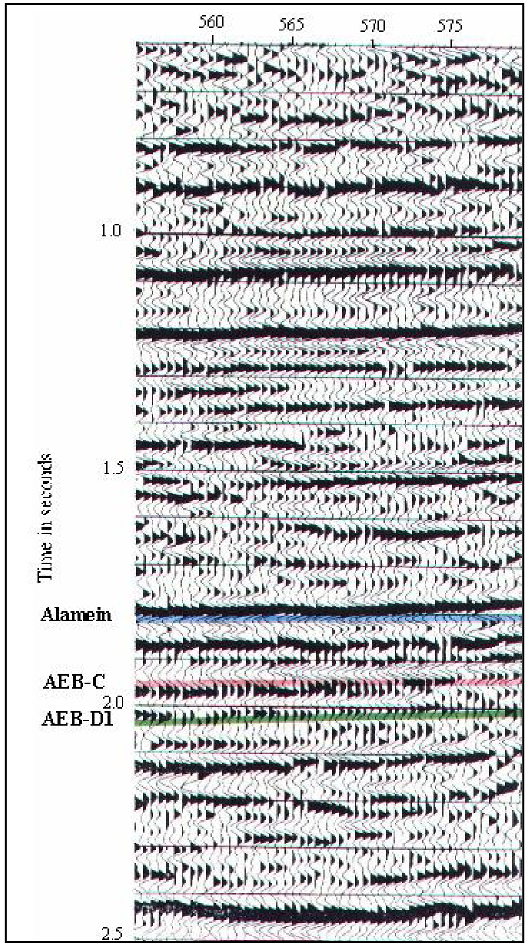

Fig. (10): South Umbarka Line 2455.

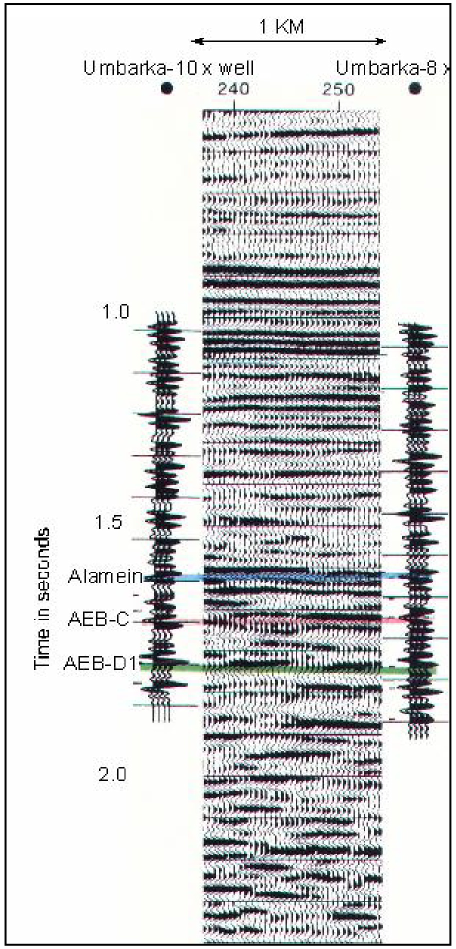

Fig. (11): Matching of synthetic seismogram of Umbarka-10 and Umbarka-8x wells to seismic section 515.

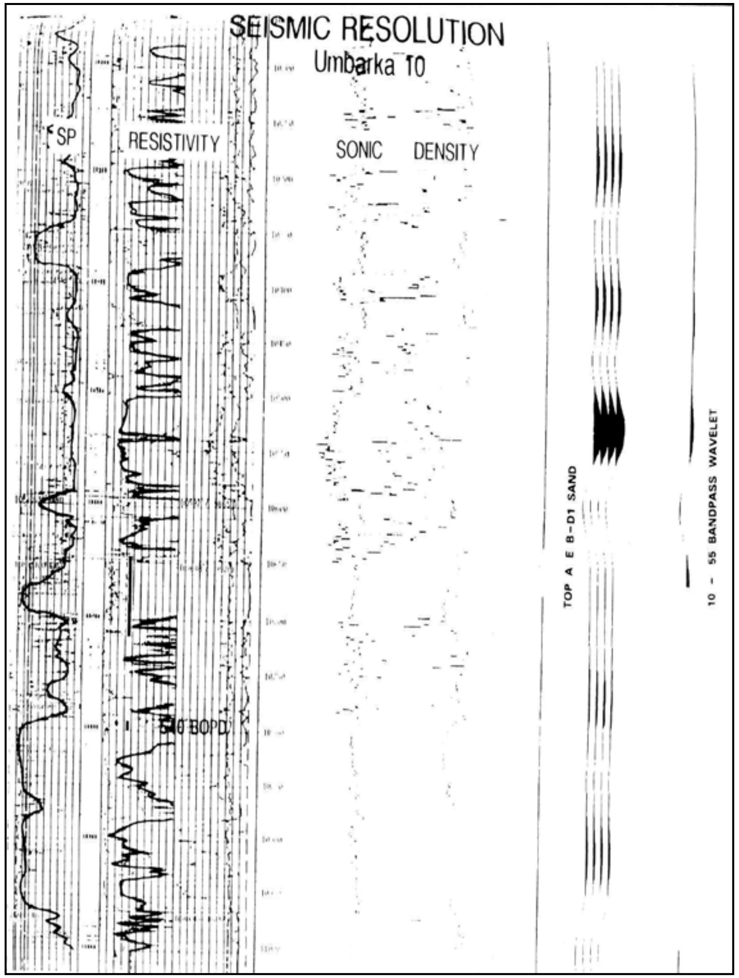

Fig. (12): AEB-D1 zone Seismic Resolution Capabilities.

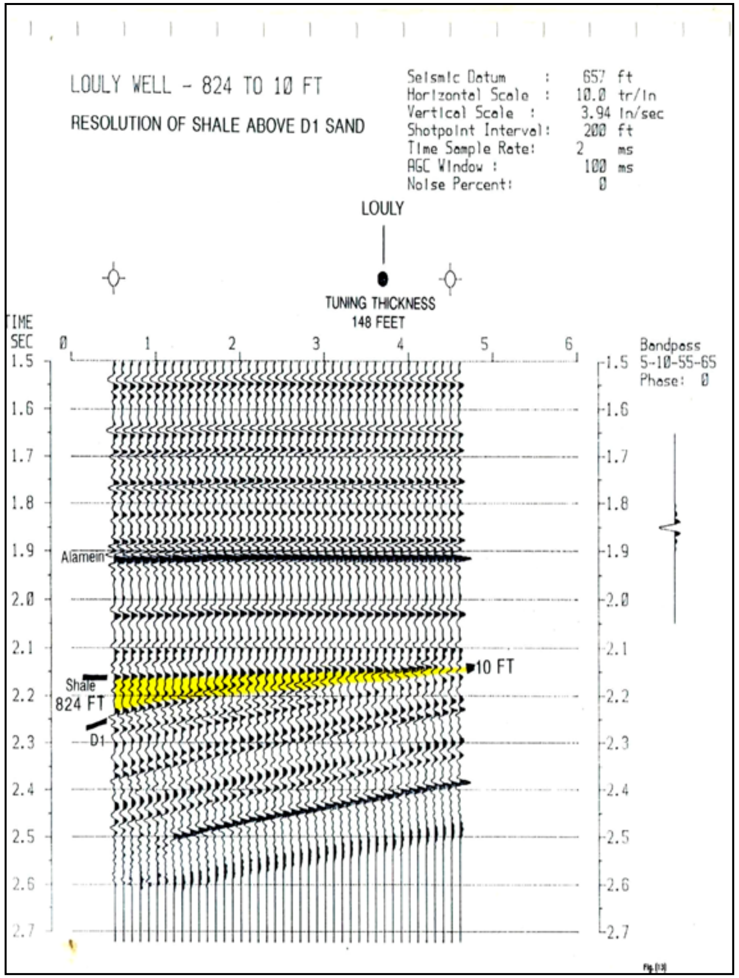

Fig. (13)

1-D Modeling

Because of the sealing potential of the basal AEB-C shale over the AEB-D1 reservoir, emphasis of 1-D, as well as 2-D, modeling was on the AEB-C to AEB-D1 interface.

(A) Resolution - Thin Bed Model

Using the sonic log from the Louly well, a modified synthetic seismogram was constructed which expanded the sonic response of the basal AEB-C shale to a hypothetical thickness of 824 feet. Another synthetic of the Louly was modified to thin the basal AEB-C shale to 10 feet. Using the modified and the actual synthetics, a 1-D interpolation was produced to illustrate how the seismic character changes with thickness (Fig. 13). With a thickness of 824 feet, the responses from the top and bottom of the shale can be individually resolved in time as peak and a trough, respectively. The shale is 148 feet thick at the Louly well. This thickness coincides with the thickness of 1/4 wavelength which is the theoretical limit of resolution using a dominate frequency of 40 Hz and an interval velocity of 12,000 ft/sec. The peak-over-trough amplitude increases at this position, which is indicative of tuning, the constructive interference of the two interfaces. As the shale thins to less than tuning thickness, the two interfaces are no longer time-resolved, and the amplitude decreases, but remains detectable as a peak-over-trough event.

The Louly well has the thickest shale interval of all the wells within the pilot study area. The basal AEB-C shale is not, therefore, resolvable within the limits of the new seismic data. All of the shale and many of the sand units are much thinner than 150 feet, and are seismically combined and imaged as packages.

(B) Shale-out/Sand-out Model

Using the Umbarka-1x sonic log, the synthetic seismogram was modified to decrease the velocity of the basal AEB-C shale (Fig. 14). Another modified synthetic changed the velocity of the basal AEB-C shale to match the velocity of the AEB-D1 sand. The 1-D interpolation model (Fig.15) shows the characteristic peak-over-trough only in the region of the actual Umbarka-1x synthetic, located in the center of the model. Where the AEB-D1 sand has been effectively shaled-out, on left side of the model, the peak and trough are separated with trough occurring at 2.04 seconds, rather than just under the peak at 2.01 seconds. As the velocity of the AEB-D1 sand increases but is still lower than the velocity of the sand below it, two small troughs resulted from the two abrupt steps of velocity increase. To the right of the Umbarka-1x well, the basal AEB-C shale velocity has been altered to a sand velocity. This results in a replacement of the peak-over-trough event by a series of ringing peaks and no troughs, that is the result of interference of unresolvable thin beds within the AEB-C and AEB-D1 intervals.

This shale-out/sand-out model shows how lithology can disguise the AEB-C-AEB-D1 inferface to the point that it will be inaccurately picked (the shaled-out sand) or the interpretation becomes doubtful (the sanded-out shale), as the usual peak-over-trough disappears.

(C) Sand-To-Silt Model

The uppermost sand of the AEB-D1 is non productive silt in the Umbarka-1x well. Interpolation from Umbarka-8x well, exhibits a much cleaner sand at the same uppermost part of the AEB-D1, to the Umbarka-1x well with increasing silt in the AEB-D1 zone (Fig.16). This change in character is minor, but when combined with the more significant response due to lithology and thickness, it adds to the complexity of the character analysis.

(D) Sand Porosity Model

Using the Umbarka-1x well, effects of porosity on sonic log were determined for the AEB-D1 sand. A interpolation model was built using modified synthetics at porosity of 5% , 10%, 15%, 20%,25% and the actual porosity of 18% (Fig. 17). At the low porosity, the sonic log illustrates relatively high velocity sand which appears seismically as higher amplitude trough below a very low amplitude peak. The peak increases in amplitude as the velocity contrast at the top and bottom of the shale becomes equal in magnitude. At 15% porosity, the AEB-D1 sand has enough slow velocity to cause a second smaller peak-over-trough event at the interface of the AEB-D1 sand with the faster velocity sand interval underneath. This model indicates that the porosity can have a large effect on the seismic amplitude, although the modeled character does not show the degree of phase variation presented in the actual seismic data.

2-D Modeling

An interpolation or 1-D model was constructed between the Umbarka -10x and Umbarka-8x wells (Fig.18). Comparison of this model to the actual seismic data (Fig. 11) indicates that changes occurred within the AEB-D1 units more rapidly than the straight-line interpretation can simulate over the one kilometer between the two wells. Information from cores and seismic facies analysis (Metwalli and Bakr, 2001) suggests that tidal environments existed at South Umbarka area during most of the deposition of the AEB-D1 interval. Using this inferred depositional facies, a 2D model was constructed for the AEB-D1 zone between the Umbarka-10x and 8x wells, which limited the thickness of the sand bodies to 50 feet. Figures 19 and 20 show this model and the zoomed part of the AEB-D1 interval respectively. This model consists of overlapping sand lenses (15000 ft/sec velocity). The basal AEB-C shale and the uppermost part of the AEB-D1 sand was designed to have a consistently positive impedance, which should produce a trough event according to the polarity convention of the seismic data.

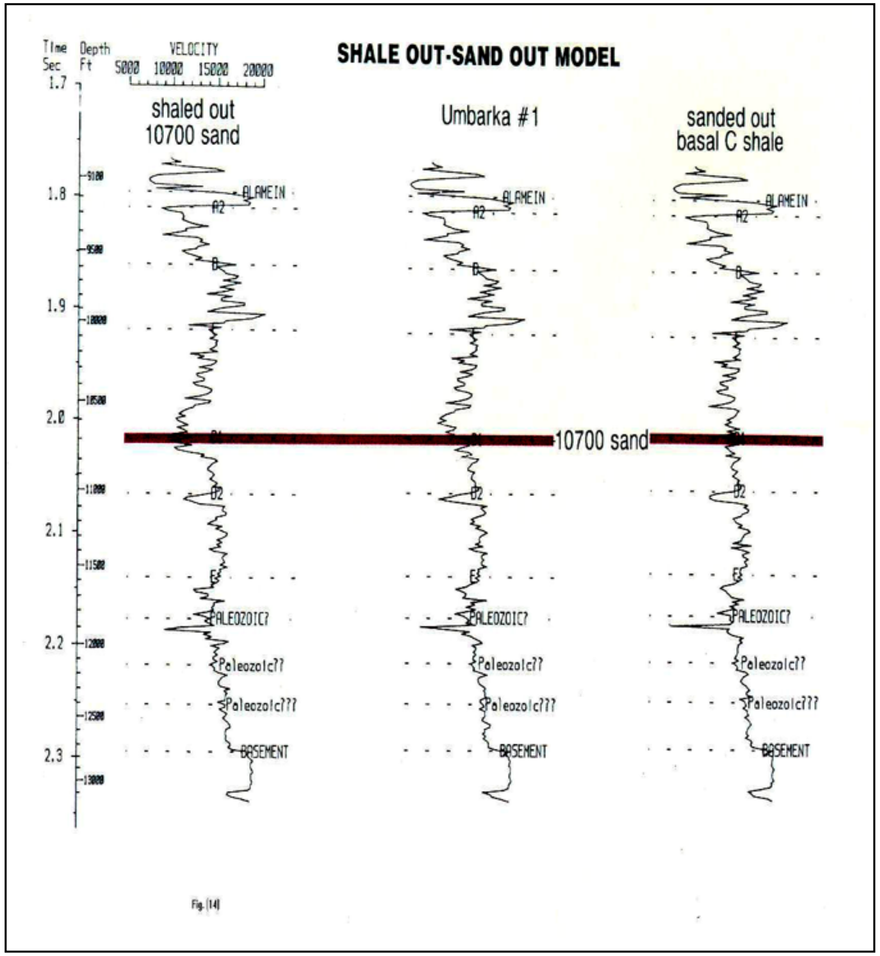
SHALE OUT-SAND OUT MODEL
Time Sec
Depth Ft
VELOCITY
5000 10000 15000 20000
shaled out 10700 sand
Umbarka #1
sanded out basal C shale
ALAMEIN
A2
B
D1
D2
E
PALEOZOIC?
Paleozoic??
Paleozoic???
BASEMENT
10700 sand
1.7
1.8
1.9
2.0
2.1
2.2
2.3
9100
9500
10000
10500
11000
11500
12000
12500
13000
Fig (14)

Fig. (14)

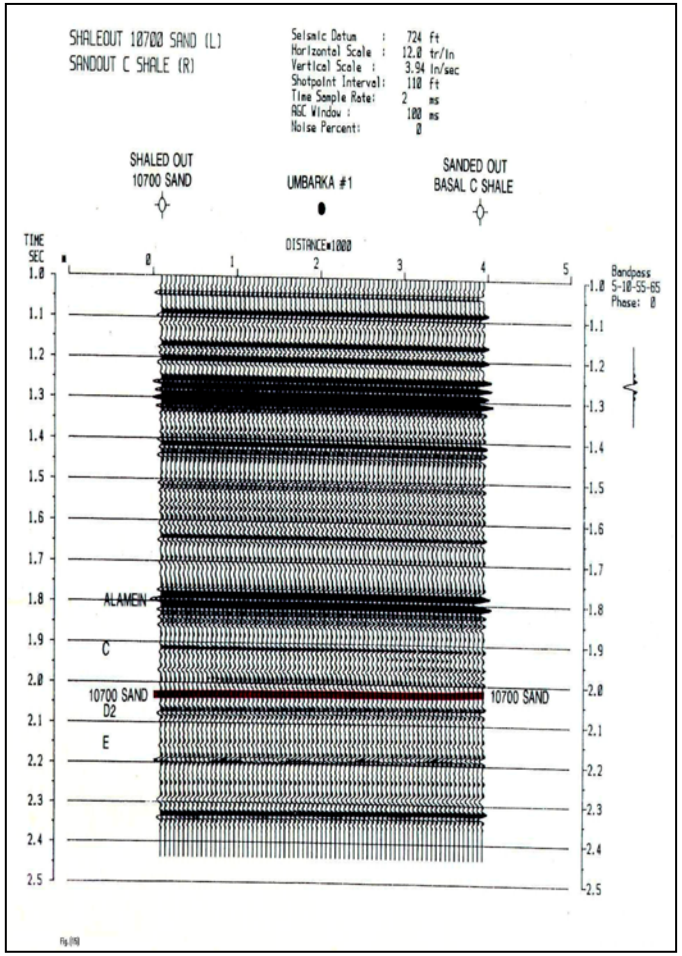
SHALEOUT 10700 SAND (L)
SANDOUT C SHALE (R)
Seismic Datum : 724 ft
Horizontal Scale : 12.0 tr/In
Vertical Scale : 3.94 In/sec
Shotpoint Interval: 110 ft
Time Sample Rate: 2 ms
AGC Window : 100 ms
Noise Percent: 0
SHALED OUT 10700 SAND
UMBARKA #1
SANDED OUT BASAL C SHALE
DISTANCE*1000
0
1
2
3
4
5
TIME SEC
Bandpass 5-10-55-65
Phase: 0
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
ALAMEIN
C
10700 SAND
D2
E
10700 SAND
Fig (15)

Fig. (15)

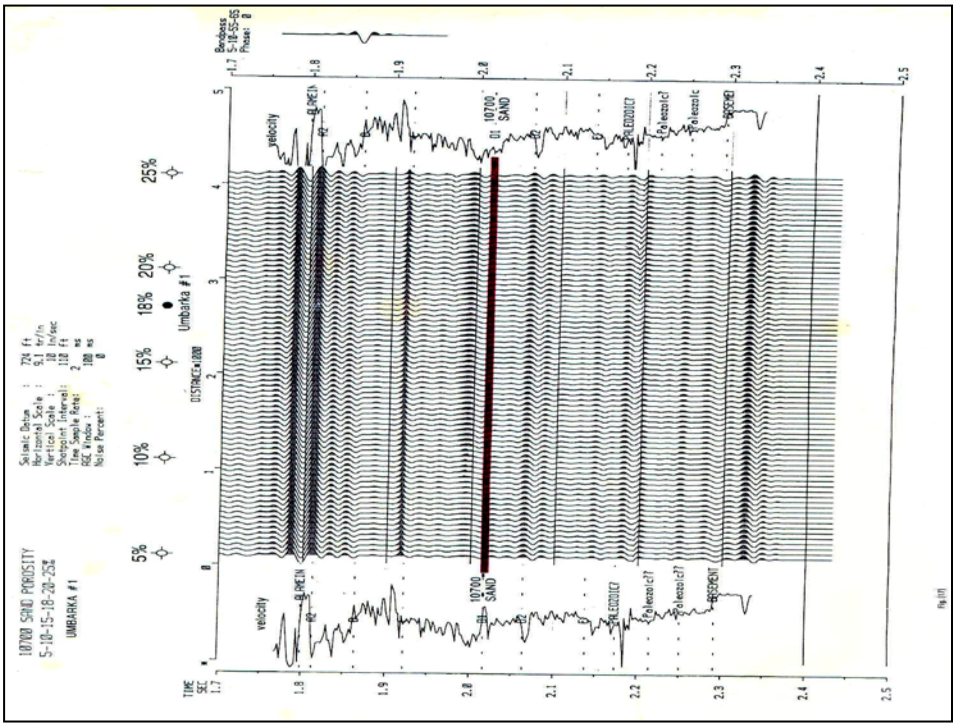
10700 SAND POROSITY
5-10-15-18-20-25%
UMBARKA #1
Seismic Datum : 726 ft
Horizontal Scale : 9.1 tr/in
Vertical Scale : 10 in/sec
Shotpoint Interval: 110 ft
Time Sample Rate: 2 ms
AGC Window : 100 ms
Noise Percent: 0
5%
10%
15%
18%
20%
25%
Umbarka #1
DISTANCE*1000
velocity
ALAMEIN
10700 SAND
PALEOZOIC?
Paleozoic?
BASEMENT
Bandpass 5-10-55-65 Phase: 0
TIME SEC
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5

Fig. (17)

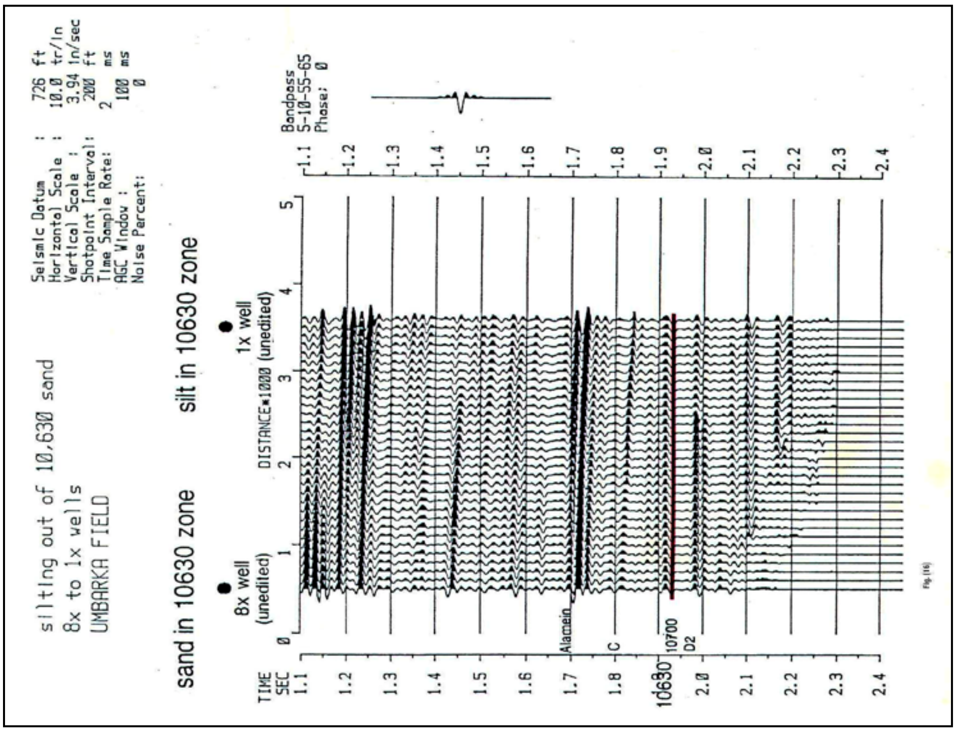
silting out of 10,630 sand
8x to 1x wells
UMBARKA FIELD
Seismic Datum : 726 ft
Horizontal Scale : 10.0 tr/in
Vertical Scale : 3.94 in/sec
Shotpoint Interval: 200 ft
Time Sample Rate: 2 ms
AGC Window : 100 ms
Noise Percent: 0
sand in 10630 zone
silt in 10630 zone
8x well (unedited)
1x well (unedited)
DISTANCE*1000
Bandpass 5-10-55-65 Phase: 0
Alamein
C
10630
10700
D2
TIME SEC
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4

Fig. (16)

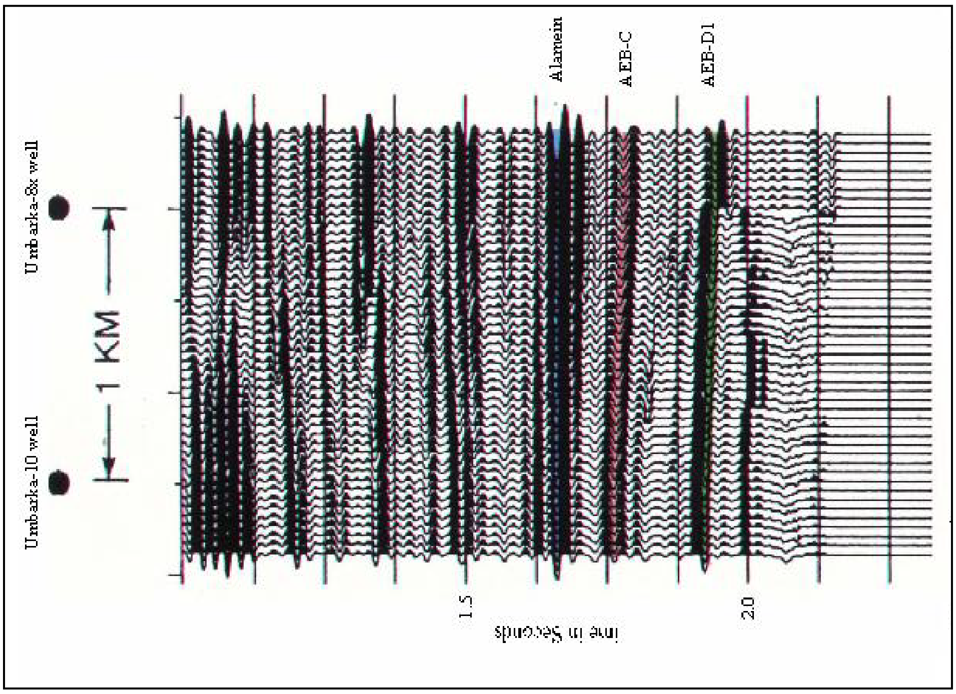

Fig. (18): Straight line interpolation between Umbarka wells 10x and 8x.

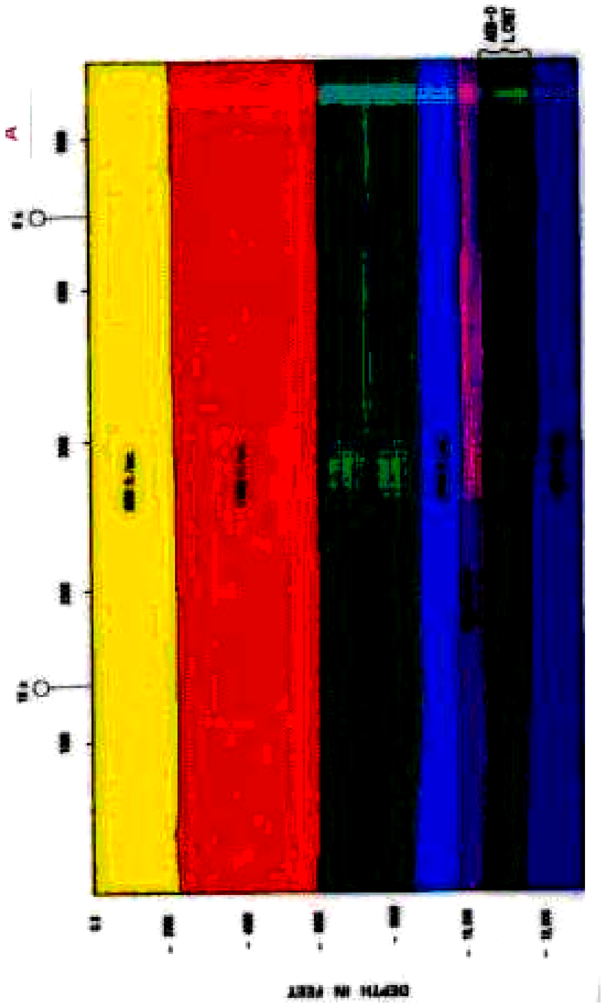

Fig. (19): 2D Model Close to Umbarka Concession.

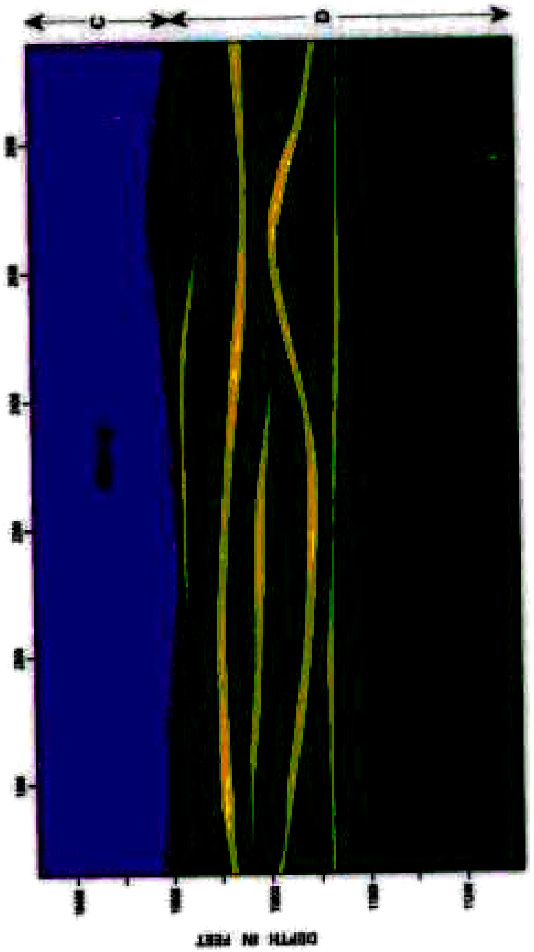

Fig. (20): 2D Model Close up of AEB-D Layers.

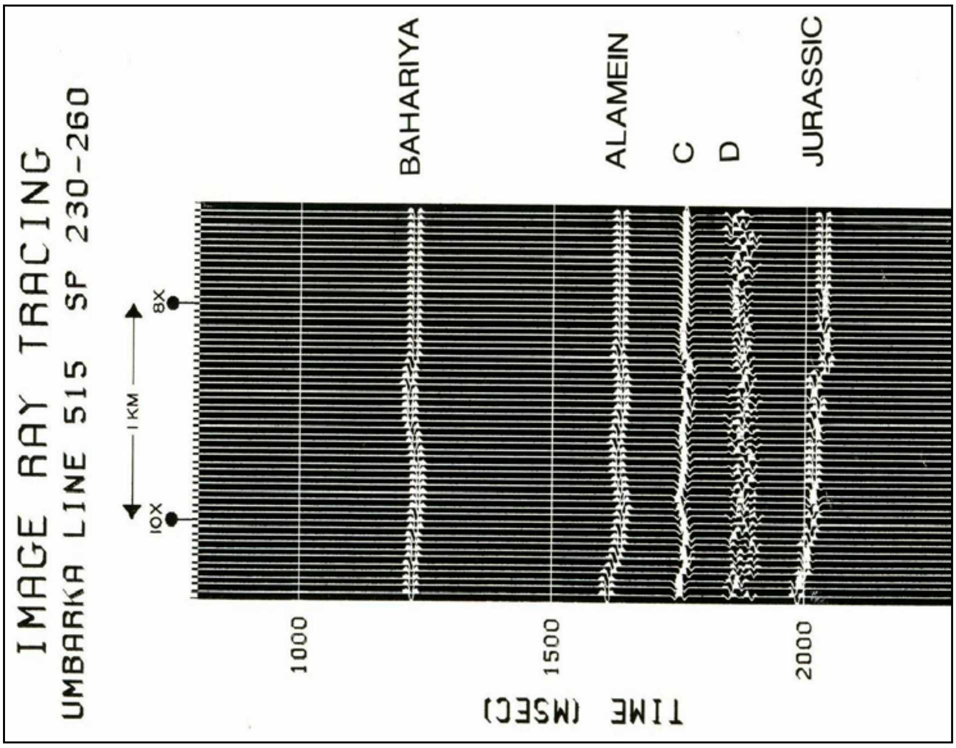

Fig. (22): Image flay Tracing – Umbarka Line 515 SP 230-260

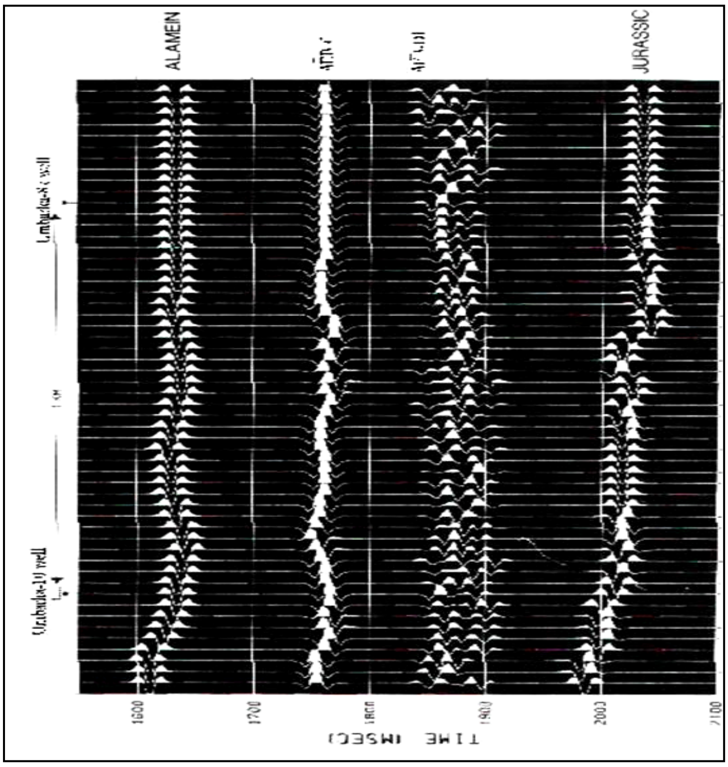

Fig. (21): Image Ray Tracing (Umbarka line 515 SP 230-260.

Image ray-tracing using a Sierra 2D ray trace S/W to convert the depth model to time (Figs. 21 and 22) produced a seismic section, which resembles the actual data much more than did the interpolation model. Events within the AEB-D1 zone have a discontinuous parallel to chaotic character. The AEB-C- AEB-D1 interface changes amplitude and phase, become more comparable to the actual data (Fig.11). This non-unique 2-D modeling solution satisfies the composed geologic boundary conditions of using small individual sand bodies to compose a larger sand package. The derived the seismic section can be used to analyze the seismic facies character of the real data, and in conjunction with geological constraints, determine depositional environments.

CONCLUSIONS

For resolution of thin bed model at AEB-D1 level, the response of the top and bottom of the shale above AEB-D1 can be individually resolved in time as peak and trough respectively, and as soon as it reaches 148 feet or more, i.e. about 1/4 wavelength. As been unresolved, the amplitude interface begins to be unresolved and the amplitude decreases but remains detectable as peak or trough event.

Shale-out/sand-out model demonstrates how lithology can disguise AEB-C-AEB-D1 interface to the point that it will be inaccurately picked or that the interpretation becomes doubtful and the usual peak-over-trough disappears.

Sand to silt model shows a very slight amplitude and frequency decrease with increasing silt in the AEB-D1 zone.

Porosity model indicates that porosity can have a large effect on the seismic amplitude.

The 2-D modeling indicates that changes occur within the AEB-D1 unit more rapidly than straight line interpolation can simulate over the one kilometer distance between 8x and 10x wells.

Resolution is limited by the following factors : Tuning thickness for the seismic data is approximately 150 feet. The pay sands for the D1 zone average 50 feet thick. Many of the AEB-sands are fluvial. Fluvial sands are chaotic, and lack seismic continuity, numerous faults break up the reflectors,complicating correlation, and seismic noise masks the signal.

In general, the results of this modeling indicate that components affecting the seismic response (porosity, lithology, structure and stratigraphy) work together to influence the reflection amplitude and phase of the AEB-C and AEB- D1 units. No component dominant and well logs suggest that all components vary unpredictably. Individual units are irresolvable, and the interferences of all parameters make the analysis of each impossible, although valid facies analysis for depositional environment is possible.

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