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SEISMIC STRATIGRAPHIC FRAMEWORK OF THE ABU MADI FORMATION , ABU MADI/EL QAR'A FIELD, NILE DELTA , EGYPT

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دراسة الإطار السيزمى الطبقى لتكوينى أبو ماضى فى منطقة حقلى أبو ماضى والقرعة بدلتا النيل فى مصر

الخلاصة: تم تحديد الإطار السيزمى الطبقى لتكوين أبو ماضى فى منطقة حقلى أبو ماضى والقرعة بدلتا النيل فى مصر باستخدام البيانات السيزمية المرحلة الثنائية الأبعاد. كما تم تفسير وتخريط السطوح العاكسة بالقرب من السطح العلوى لتكوينى أبو ماضى وسيدى سالم وربطها بالسيزموجرامات الاصطناعية من قياسات الآبار .

وقد أوضحت الدراسة أهمية البحث الاستكشافى للبترول بأنه لا ينبغى أن يتركز على الرواسب الضحلة والمتوسطة والتى تعود إلى العصر الكريتاوى والعصر الثلاثى حيث أن الرواسب العميقة قد تحتوى على خزانات ذات طاقة بترولية كبيرة.

ABSTRACT : *The sequence stratigraphic framework of the Abu Madi Formation of the Abu Madi/El Qar'a field area (AM/EQ) was determined using "Vail" seismic sequence approach on 2D migrated seismic data and geovalidated by "Galloway" depositional sequence approach from associated borehole information. Operationally, those reflectors corresponding to a composite tuning of those layers near the top of Abu Madi Formation and top of Sidi Salem Formation were interpreted and mapped on a full grid of seismic lines in the area, through tying with synthetic seismograms generated from existing boreholes.*

The Abu Madi Formation unconformably overlies the Highstand System Tracts (HST) of the Qawasim and Sidi Salem formations. This type I unconformity defines the geometric limits of the sedimentation whose main incised channel deposits comprise the proximal reaches of a Lowstand System Tract (LST). The overlying depositional sequence, whose upper boundary surface is marked by the Top of Level III-A, and interpreted as a maximum flooding surface of a Transgressive System Tract. The eastward and westward limits of the main channel area as well as the relative culmination area of the Qawasim Formation were structured in the Pre-Abu Madi time. This NNW-SSE oriented area then developed lateral seismic facies and vertical thickness variations in the Level III-A and III.

Supporting evidence for the existence of prolific petroleum systems in the Abu Madi /El Qar'a field area comes from basin modeling of the area, which incorporated an analysis of the petroleum system criticals. While oil exploration is now appropriately focused along the shallow to intermediate depth Late Cretaceous and Tertiary migration paths. These results suggest deeper sections, especially those of the Lowstand and Transgressive System Tracts that may have reservoirs charged with significant unrealized gas potential.

INTRODUCTION

A seismic stratigraphic interpretation was carried out for Abu Madi Formation in Abu Madi/El Qar'a field, in order to integrate the geological well data and to provide a complete description of the depositional sequences on all the field areas. The definition of the sedimentological setting of the Abu Madi Formation was completed by means of the analysis of the relationships with the underlying Qawasim and Sidi Salem Formations in order to describe properly the distribution of the accumulated sediments.

The present study is to define the depositional sequences on the seismic lines,that are recognized in the reservoir rock unit, as interpreted on log and core data, and then to define their development in the study area as the distribution and possible facies variations. To achieve these results, the following procedure was adopted:

- Well-seismic data comparison by utilizing synthetic seismograms adequately processed and migrated seismic data to individuate the seismic signals relevant to the main stratigraphic surfaces and to the lithological markers interpreted on core and log data.
- Interpretation of the available seismic grid of the seismic horizons representative of the significant stratigraphic surfaces and to study the relationships with the underlying strata surfaces of Qawasim and Sidi Salem Formations.

The study area lies within the onshore present-day Nile Delta at the midway between Lake Burrulus to the west and Lake Manzala to the East. Two former interdistributary bays presently rimmed by barrier islands (Fig.1).

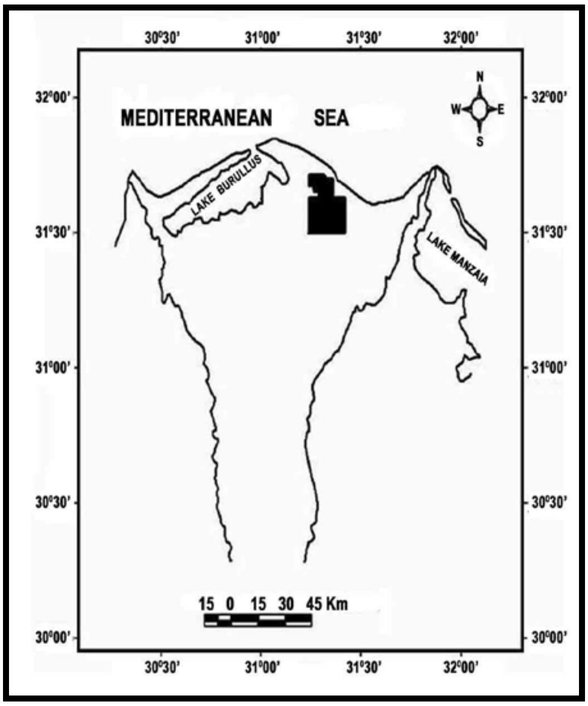

Fig.1: Location map of the study area.

Data Utilized and Methodology

- Borehole controls of the study area.
- Well logs from 20 wells drilled over a considerable time interval (Fig. 2).
- 20 wells for synthetic generation.
- Previous geological andgeophysical works conducted in the area.
- Shot point location map of the study area revealing the three separate surveys, which were integrated for the study (Fig. 3).
- Kingdom Suites for seismic Interpretation.
- ArcView.
- Erdas Imagine.
- Arc GIS.

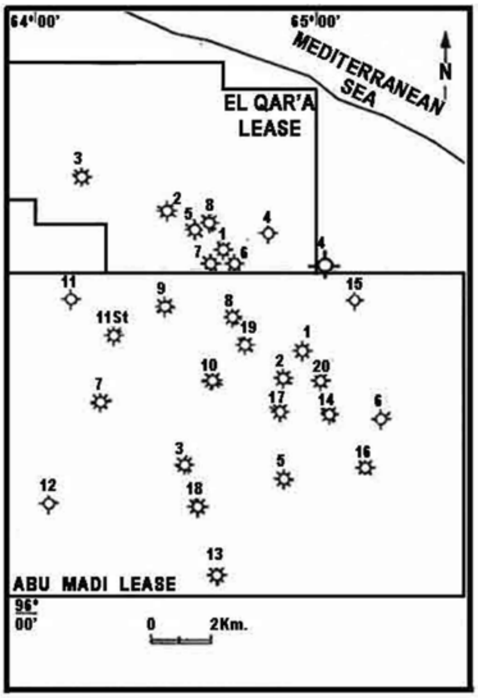

Fig. 2 : Well control location map.

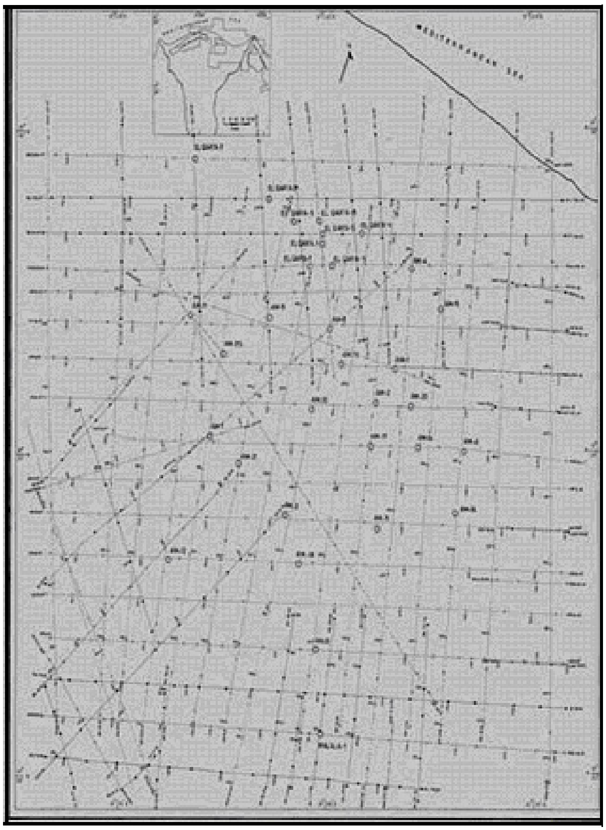

Fig. 3: Shot point location map of seismic lines.

REGIONAL GEOLOGICAL SETTING

Stratigraphy of the area

Regional geological studies of the considered area have been carried out, among others, by Palmieri and Catrullo (1985), Rossi and Rogledi (1986) and Dalla (1991). According to these studies, the Upper Miocene section is punctuated by regional unconformities, mostly related to tectonic phases and partly enhanced by sea level changes. These unconformities bound different depositional sequences, which practically correspond to the established lithostratigraphic units. Taking into account only the AM/EQ area, the involved units and unconformities are used in this study as the following (modified from Dalla , 1991)

Upper Messinian units
Intra Messinian event
Lower Messinian unit
Uppermost Tortonian-lower Messinian
Tectonic phase
Serravalian/Tortonian unit
Serravallian Tectonic Phase
Aquitanian to Langhian unit (Qantara Fm)

The Qantara Formation consists of shelfal bioclastic sediments, passing basinward into marly deposits. It is not penetrated by AM/EQ wells even if it could be present in the AM-11 well structural high (Rossi and Rogledi, 1986). The Serravallian/Tortonian unit is made up by turbiditic deposits in the lower part , followed upsection by a highstand shelfal/slope prograding complex.

The latter interval of Tortonian age, mostly consisting of fine grained marly deposits, is formally known as Sidi Salem Formation and represents the unit underlying the Abu Madi sandstone reservoir in the central part of the AM/EQ field.

The Early Messinian unit is represented by a complicated alluvial depositional system,probably passing to fan-delta or marginal marine deposits, which are on the whole grouped into the Qawasim Formation. This unit underlies the Abu Madi sandstone in the marginal areas of the AM/EQ field.

The Late Messinian unit is represented by the Abu Madi Formation, which consists of alluvial deposits filling a paleovalley incided down the Qawasim and Sidi Salem units.

ABU MADI FORMATION STRATIGRAPHIC FRAMEWORK

The generalized stratigraphic section (Fig. 4) for the region, of which the fluvial – marine depositional systems of the Messinian Abu Madi Formation form the investigated operational seismic sequences. The stratigraphic scheme used in this study for the Miocene units is derived from Palmieri (1990) and El Heiny et al. (1990). As far as the Later Messinian Abu Madi Formation is concerned, it is here applied the established subdivisions in levels, with level III, level IIIA, level II and level I, with respect to classical scheme, the present scheme slightly differs since it considers the whole stratigraphic section from a sequence stratigraphic point of view and not only from a lithological point of view. Therefore, also the shaly horizons, which separate the sandstone levels, are meaningful being parts of genetic units related to depositional environments.

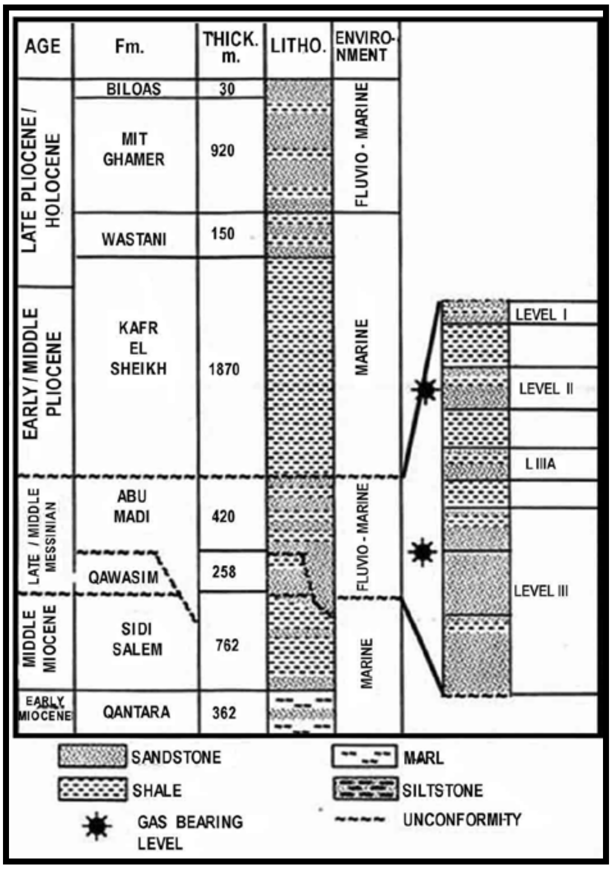

Fig. 4: Composite Stratigraphic Column of the Study area (modified after El Heiny et al.,1990).

Operational Seismic Sequence

It is an acoustic impedance contrast defined package, which exhibits two basic assumed properties: the reflectors encapsule isochronous windowed series of strata, and these strata are genetically related.

Mechanically, it is defined by terminations of opposite vertical polarities at its boundaries (i.e. toplap or truncation pointing downward from above the boundary) . Formally, an operational seismic sequence is a parasequence set, e.g. HST, LST, or TST.

Well seismic data processing

Processing of the synthetic seismograms has been carried out for the wells : EQ-2, EQ-5, EQ-6, EQ-7, EQ-8, and AM-17.The well seismic data set already existing was completed by processing acoustic impedance traces time converted for the wells : AM-3, AM-6, AM-2, AM-10, and AM-7. The well to the available seismic data for the drilled wells of El Qar'a and Abu Madi fields are shown in (Figs. 5 and 6). Furthermore, the processing of the VSP data acquired in the well EQ-7 was carried out with the aim of providing additional information for the well-seismic data comparison. In this way, an optimization of the interpretation of seismic relative acoustic impedance data has been studied in a critical area, as to the well-seismic data matching.

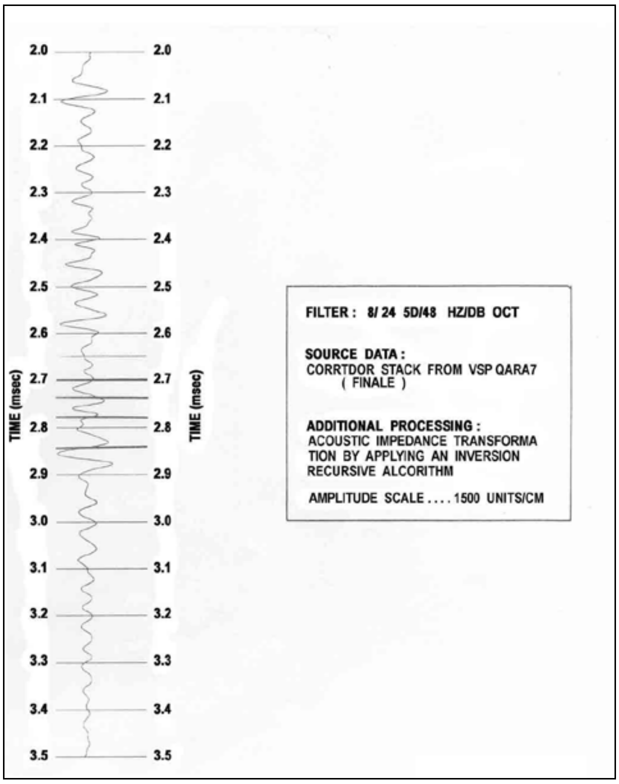

Fig. 5: Acoustic impedance relative values for well EQ-7.

INTERPRETATION OF SEISMIC DATA

The seismic stratigraphic interpretation has been carried out using a grid consisting of thirty four 2D migrated seismic lines belonging to seismic surveys acquired and processed in different times. For Abu Madi area, Abu Madi (AM) survey has been utilized, of which for the area neighbouring the main channel, unprocessed data of this survey have been used for the extension to the west of the interpretation. BIL survey has been mainly utilized for El Qar'a area. For thickening, some lines of MAN survey has been used.

Seismic–well tie has been performed, based on the major formations cuts and the most significant stratigraphic horizons properly updated and revised, based on the previous sedimentological analyses performed in this area (El Heiny et al.,1990). Lithological and reservoir data obtained from the previous geological studies have been considered.

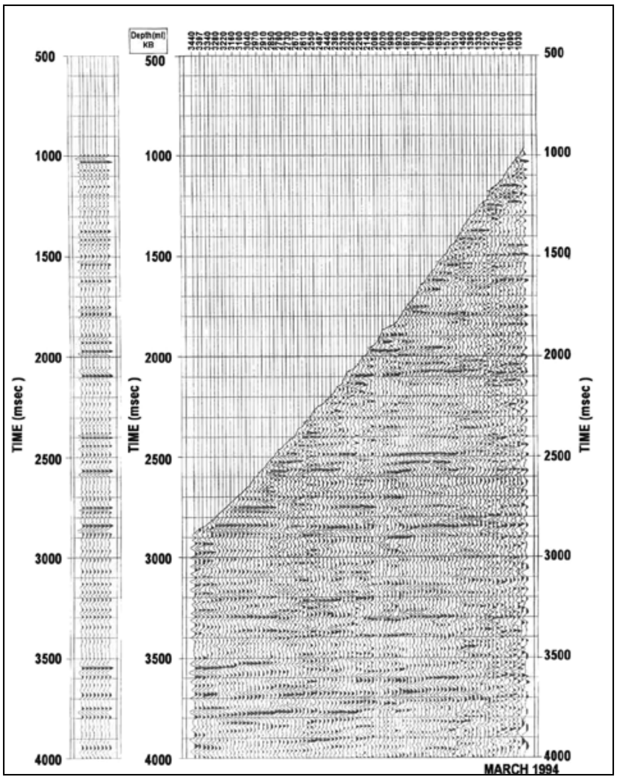

Fig. 6: Upgoing wavefield after deconvolution and corridoe stack.

Acoustic impedance logs (depth-converted) relating to 16 wells have been analyzed, in order-to obtain a preliminary acoustic characterization of log response. This operation allowed to identify the major acoustic discontinuities connected to lithological and petrophysical variations, which correspond on seismic data to signals having greater reflectivity characteristics (Figs. 7 and 8). Time conversion of well data has been achieved by means of the synthetic seismograms and VSP of 13 wells (8 wells for Abu Madi field and 5 wells for El Qar'a field).

The horizons selected and interpreted, having assign code, are the following:

Top Abu Madi Fm	TAM
Bottom Level II	BII
Top Level IIIA	TIIIA
Top Level III upper	TIIIU
Bottom Abu Madi Fm	BAM
Top Sidi Salem Fm	TSS
Pre-Abu Madi Formations	

Sidi Salem Formation and Qawasim Formation are the sedimentation base of Abu Madi reservoir, since they belong to the most ancient depositional sequence, which terminates its cycle within the interpreted horizon BAM, that is an unconformity seen on the seismic data considered to the main sequence boundary. These two formations are separated by TSS, which is an unconformity as well.

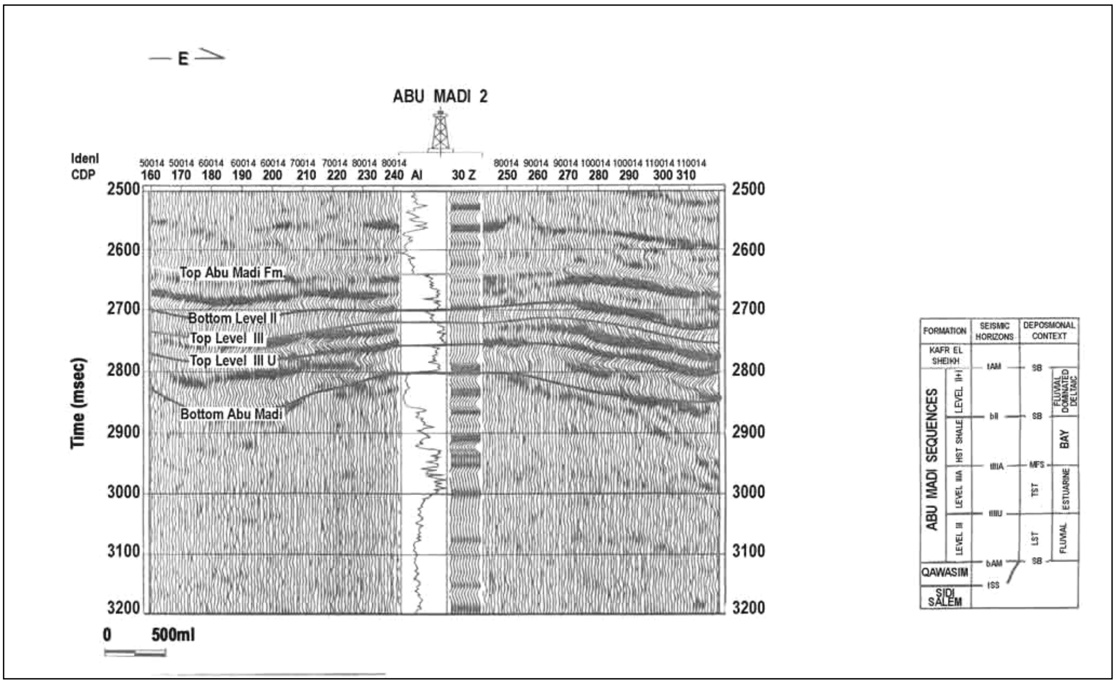

Fig. 7: Well seismic tie between AM-2 well and seismic line AM-14-81

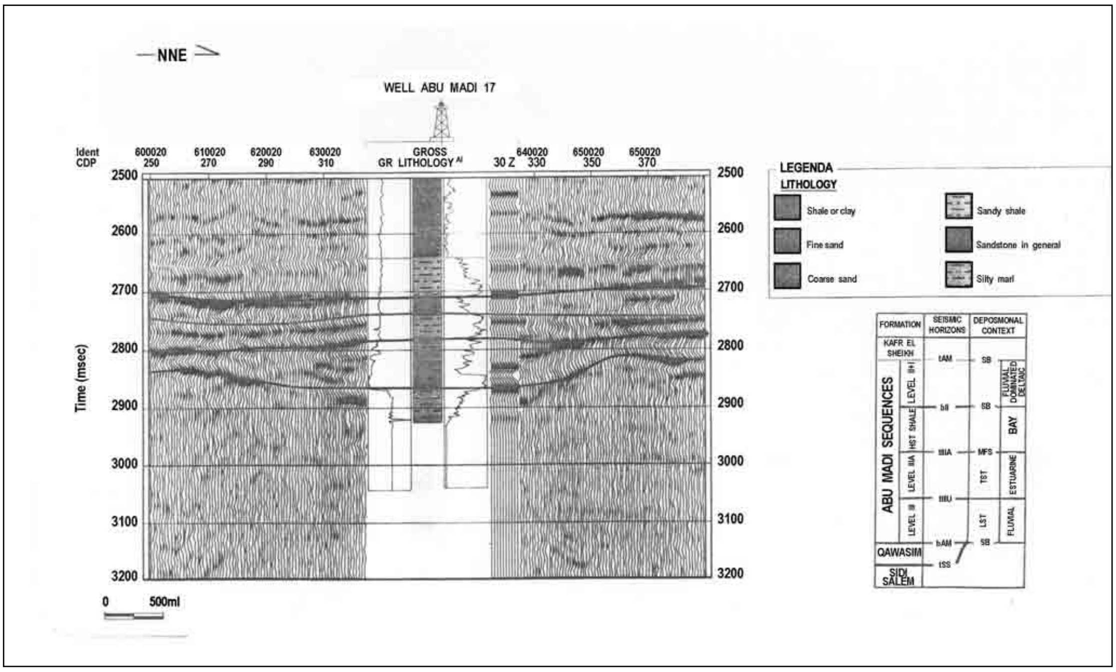

Fig.8: Well seismic tie between AM-17 well and seismic line AM- ?? 81

This horizon is cut by several direct faults, which subdivide the interval comprised within Sidi Salem Formation, having marly lithology, into tilted blocks having sub-parallel configuration seismically recognizable. The structural setting of these blocks affected the morphology, over which the subsequent sedimentary sequences deposited, thus creating some local high structures, which have controlled the deposition of fluvial sediments of the deepest portion of the Abu Madi Fm. (level III).

Therefore, it follows that, in the central part of the Au Madi /El Qar'a field, where, the depocenter for level III deposition is existed, Sidi Salem Formation is directly in contact with BAM, whereas Qawasin Formation, results to be limited to peripheral zones.

As far as seismic facies analysis is concerned, Sidi Salem Formation. is the stratigraphically deepest formation and generally exhibits reflector facies having a subparallel to chaotic discontinuous low amplitude configuration. Reflectors have unconformity character with erosional truncation type terminations against the unconformity bordering at the top.

The structural high parts of the formation are generally characterized by packs of continuous reflectors having high amplitude and parallel configuration. Within Qawasim Formation, two main facies can be recognized: to the west, reflectors exhibit sub-parallel configuration with high amplitude, good continuity; whereas to the east, they have lower amplitude and are discontinuous and sub-parallel. In both cases, reflectors unconformably lie as erosional truncation type terminations against the overlying BAM.

It has to be observed that, within Qawasim Formation, the presence of other unconformities is clearly marked by reciprocal relationships among reflectors. These unconformities present local character and can be hardly areally followed.

Abu Madi Formation

Faulted and tilted blocks of Qawasim and Sidi Salem Formations give a complex morphology, on which Abu Madi Formation deposited in fluvial environment with tidal and marine-marginal influx. They create the shoulders, which limit the extension of the alluvial plane and the intra-basinal high parts, which control the deposition of the overlying formation.

The importance of these intrabasinal highs is marked by thickness variations of Abu Madi Formation levels, by reflectors relationships and by their terminations against highs, as it can be observed in the E-W direction.

Level III is the level, which shows greatest thickness variations, being the one that is most affected by intra-basinal highs. On the E-W trending seismic sections, the external configuration of level III is lens-shaped, which tridimensionally develops like a large channel fill constituted by several depocenters, with roughly NW-SE orientation.

Seismically, the top of level III is characterized by three seismic signal modulations type peak-trough-peak, where the deepest peak represents the TIIIU. These reflections are clearly developed in the thickest zones, whereas in reduced-thickness zones they interfere.

The unconformity of BAM is underlined by erosional truncation type terminations of pre-Abu Madi Formations, and by onlap and downlap terminations of internal reflectors. It represents the sequence boundary, that marks the beginning of the new depositional cycle of Abu Madi Formation.

Based on the reflector's internal configuration and their terminations, different erosional events can be recognized, sometimes marked by onlap fill at different scales (Seismic lines AM-10-81 of Figs. 9-10; AM-18-81 of Figs. 11-12; and BIL-841-85 of Figs. 13-14). These types of erosion, that mapped and referred to TIII, indicate the extent of the development of fluvial talweg ,which propagate at level III time, roughly NW-SE trending juxtaposing.

Locally, some prograded fill type reflectors configurations can be recognized, connected to high parts, from which they seem to prograde (seismic line AM-08-81 of Figs. 15-16), whereas other times they appear to be associated to zones far from greater energy areas, as represented by channels main axes (seismic line BIL-726-81 of Figs. 17-18).

Level IIIA is bordered at the top by TIIIA, that is a major stratigraphic surface, being considered a maximum floading surface based on sedimentological data. Seismically, it is represented by the trough, having high amplitude, lying above the double signals of TIIIU.

This level presents a reduced thickness compared to the underlying levels and a sheet drape external configuration with weak thickenings in the morphologically upthrown parts (seismic lines AM-04-81 of Figs. 19-20 and AM-19-81 of Figs. 21-22).

These figures illustrate the combination of Type I-structural unconformity, which underlies the Abu Madi operational sequences. The interpretation of the operational sequences suggests that : Level III is LST incised valley. Level IIIA represents a TST estuarine drowning of the incised valley. Followed by a HST Shale inter-distributary Bay facies and which is prograded upon by a HST Level I-II fluvial dominated delta.

Also, they show consistent pattern of truncated Pre-Abu Madi rocks with overlying toplapping LST Level III facies, onlapping Level IIIA shales and sands, and capped by HST shales and fluvial dominated deltas with erosional unconformities above .

The representative seismic facies of this interval on the E-W trending sections is a double signals having subparallel configuration, good continuity and medium to high amplitude. On the N-S trending sections, the reflectors internal configuration is chaotic, locally prograding (seismic line AM-11-81 of Figs. 23-24) having medium-high amplitude.

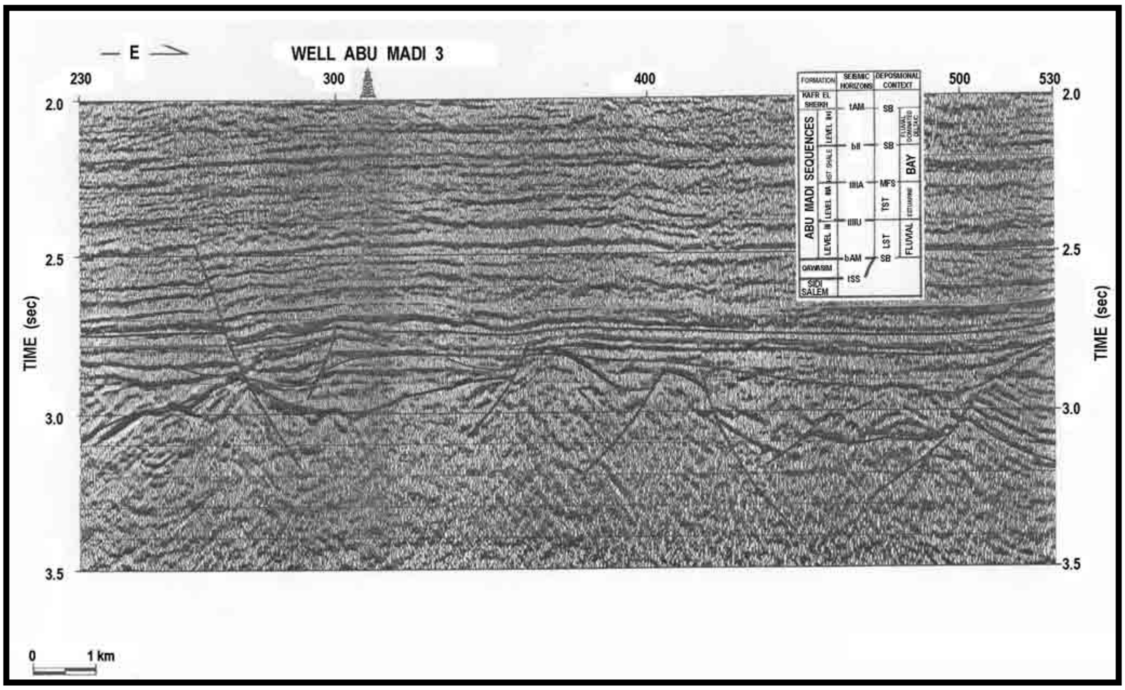

Fig. 9: Interpreted seismic line AM-10-81.

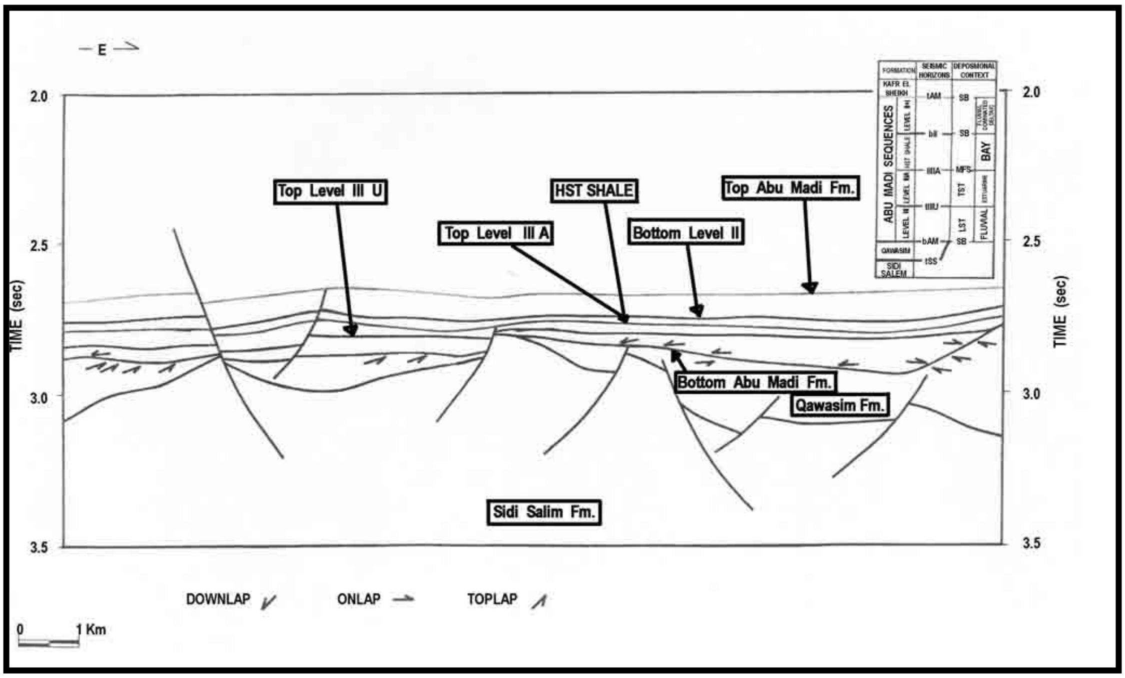

Fig. 10: Interpreted geoseismic cross section along seismic line AM-10-81

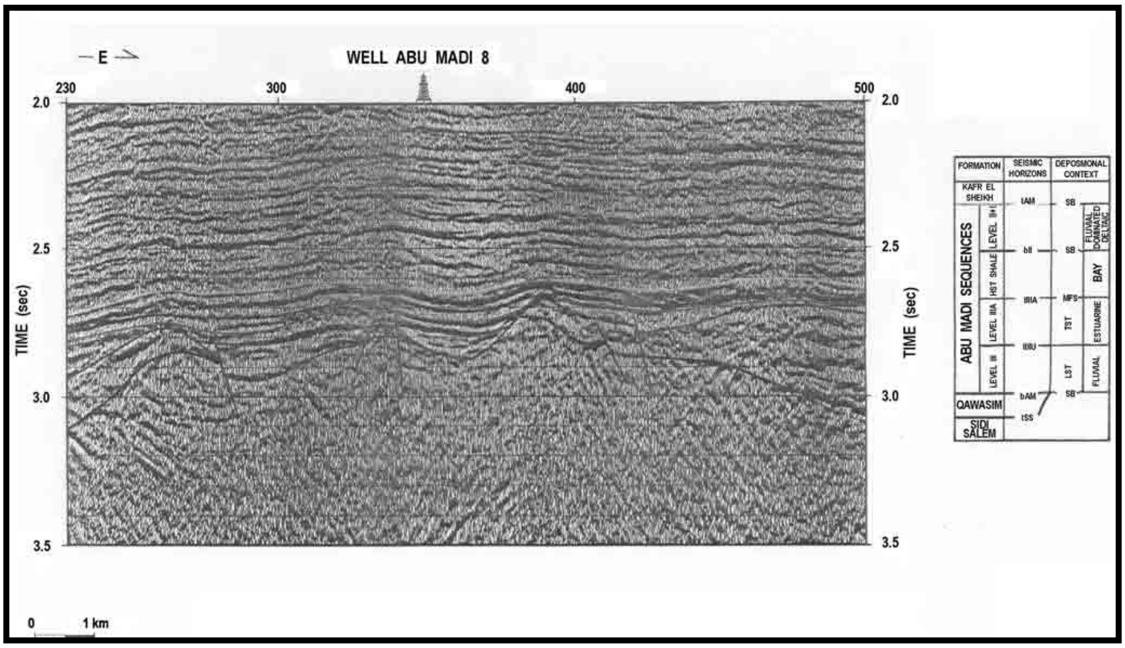

Fig. 11: Interpreted seismic line AM-18-81

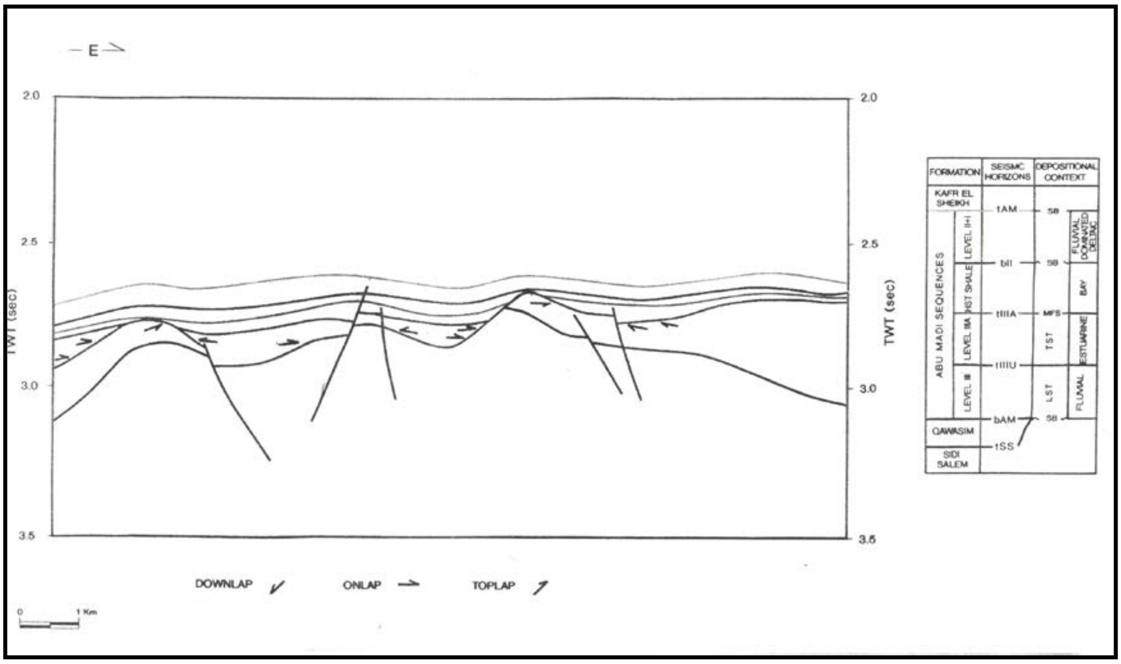

Fig. 12: Interpreted geoseismic cross section along seismic line AM-18-81 (Legend refer to Fig.10)

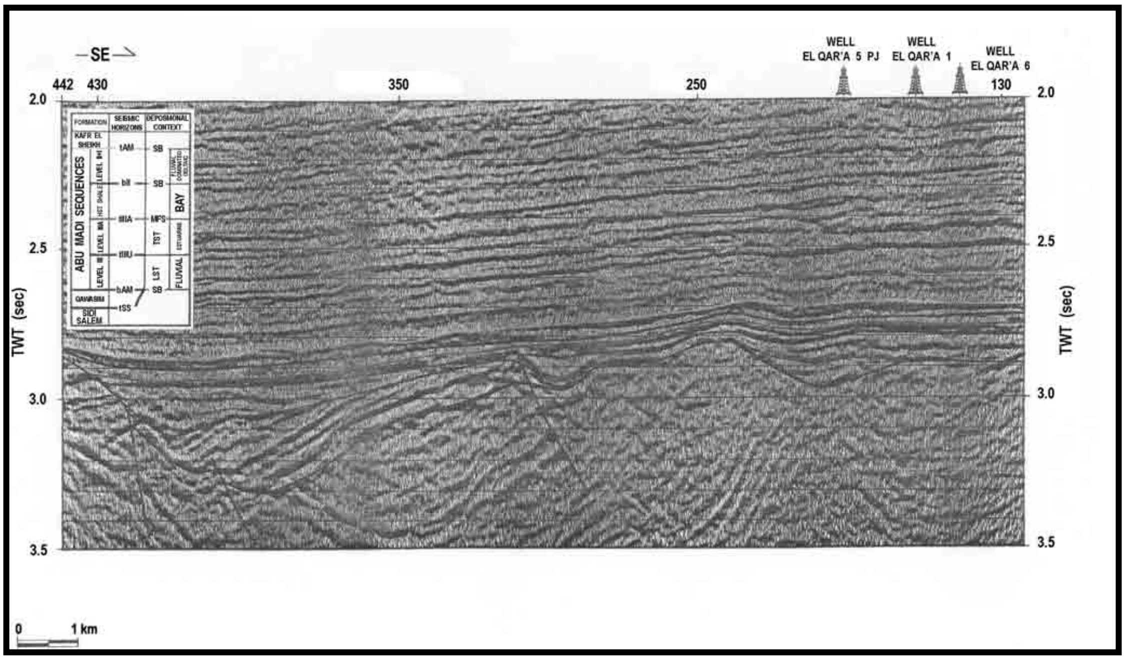

Fig. 13: Interpreted seismic line BIL-841-85.

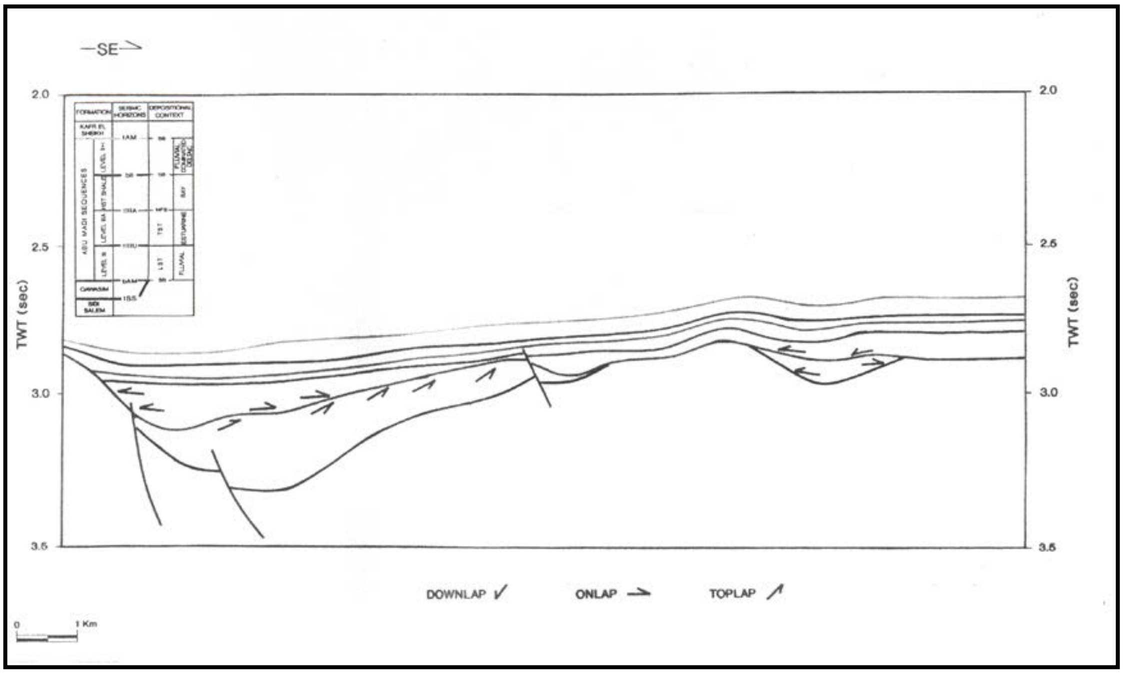

Fig. 14: Interpreted geoseismic cross section along seismic line BIL-841-85 (Legend refer to Fig.10).

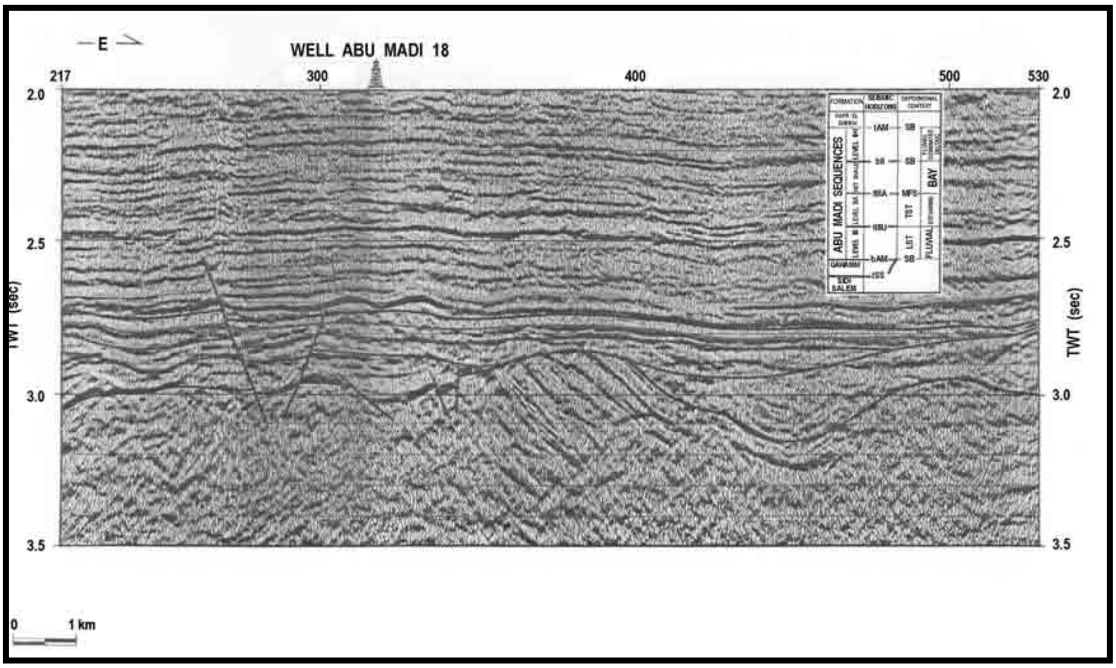

Fig. 15: Interpreted seismic line AM-08-81.

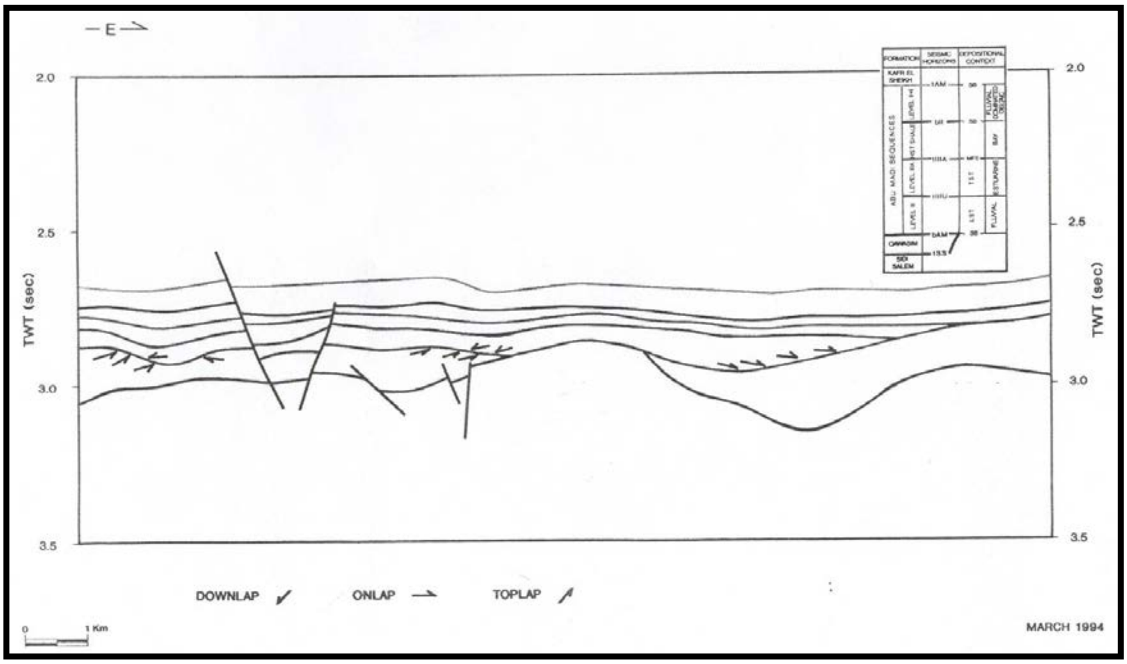

Fig. 16: Interpreted geoseismic cross section along seismic line AM-08-81 (Legend refer to Fig. 10).

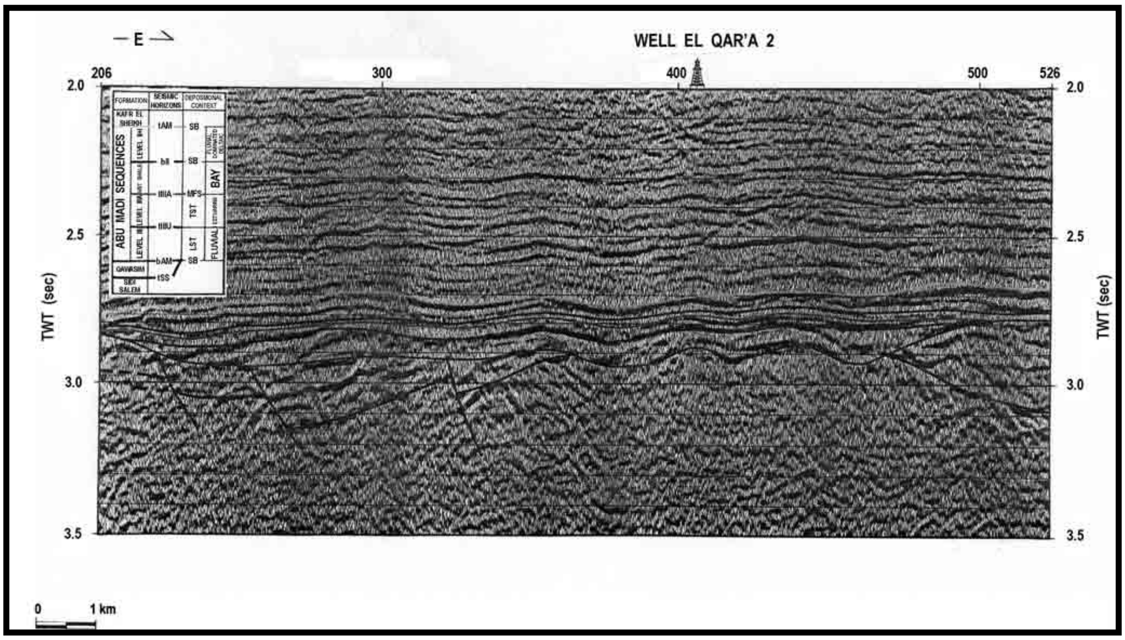

Fig. 17: Interpreted seismic line BIL-726-81.

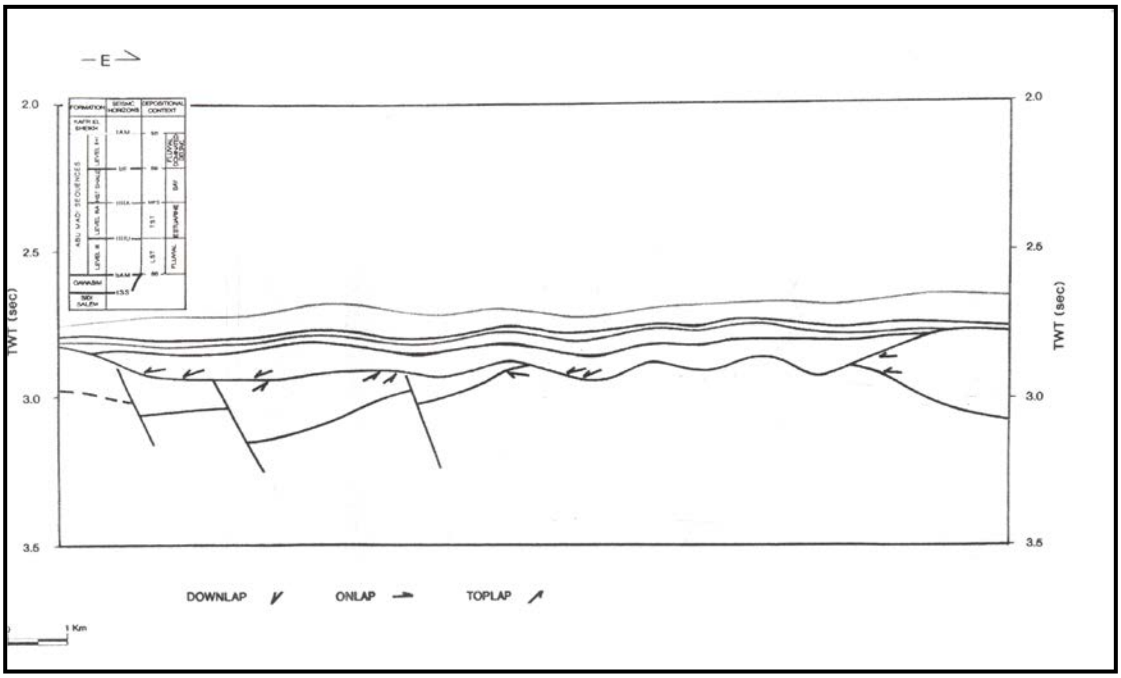

Fig. 18: Interpreted geoseismic cross section along seismic line BIL-726-81 (Legend refer to Fig. 10).

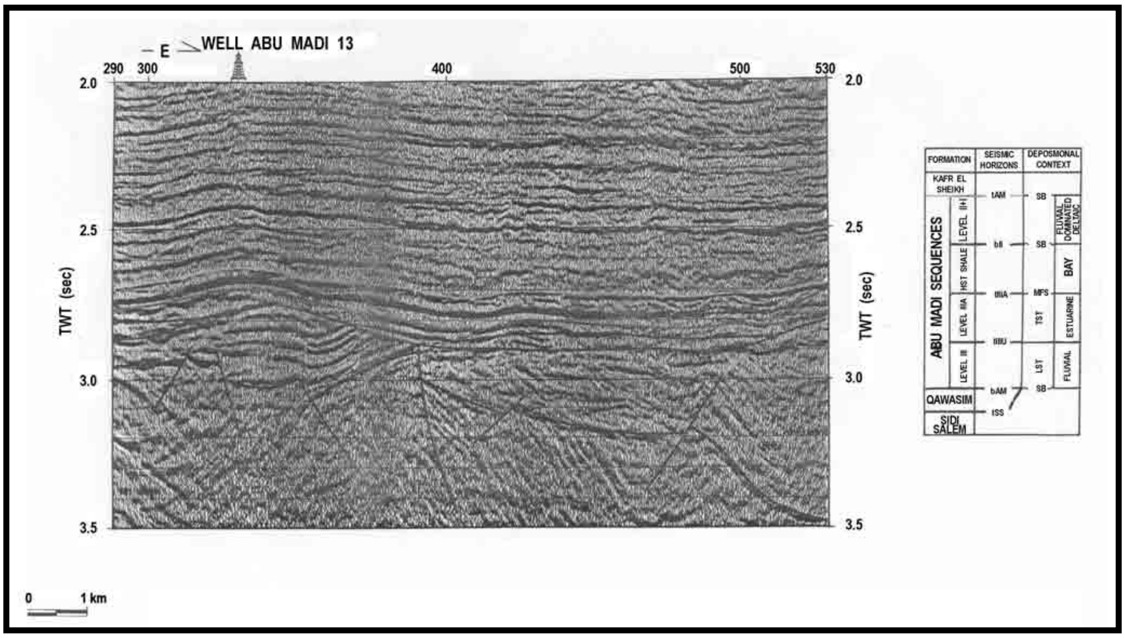

Fig. 19: Interpreted seismic line AM-04-81.

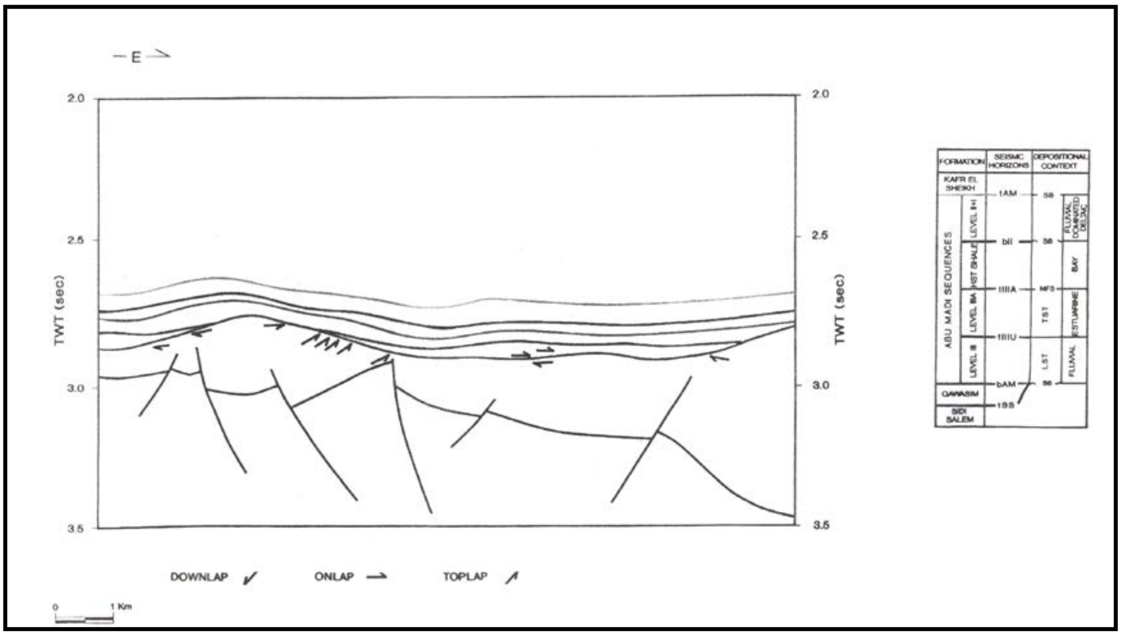

Fig. 20: Interpreted geoseismic cross section along seismic line AM-04-81 (Legend refer to Fig. 10).

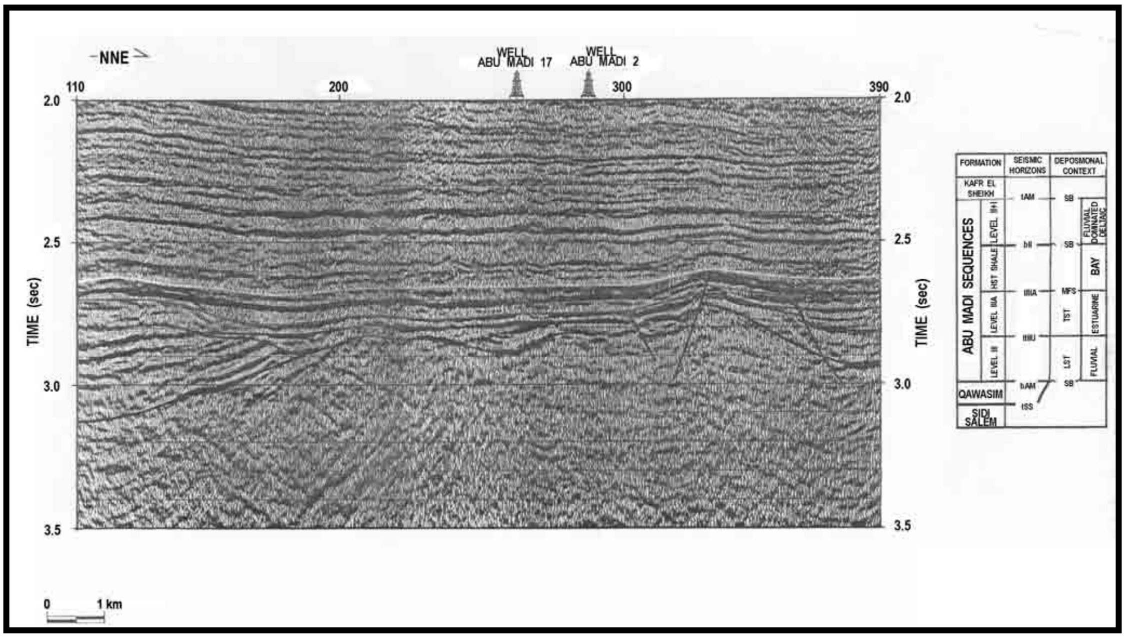

Fig. 21: Interpreted seismic line AM-19-81

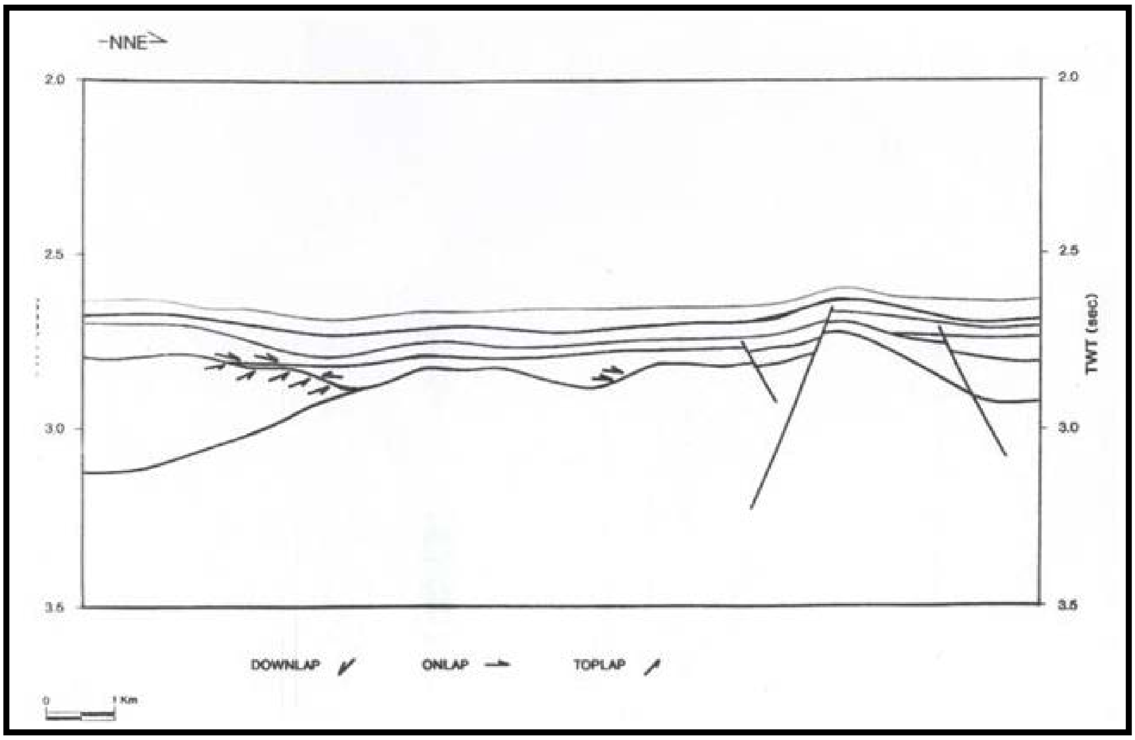

Fig. 22: Interpreted geoseismic cross section along seismic line AM-19-81 (Legend refer to Fig.10)

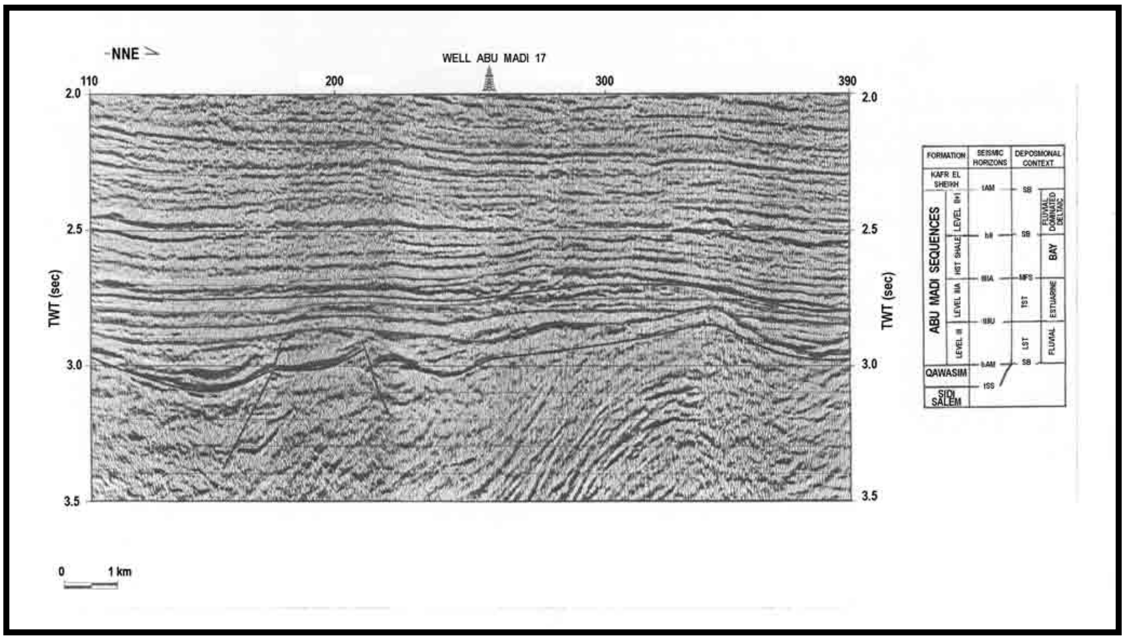

Fig. 23: Interpreted seismic line AM-11-81

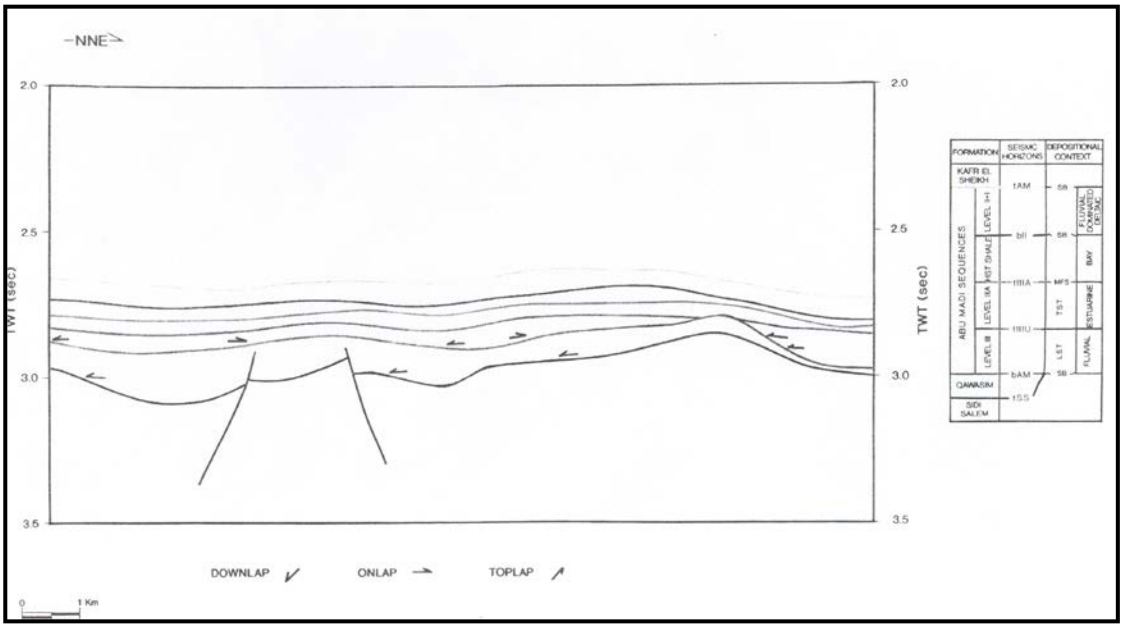

Fig. 24: Interpreted geoseismic cross section along seismic line AM-11-81 (Legend refer to Fig. 10)

HST Shale exhibits an approximately tabular external configuration, with reduced thickness (on average 50 msec). BII is seismically represented by discontinuous medium-amplitude peak, which tends to go tunning in high zones with strong overlying peak. This seismic horizon is the first among those interpreted, which covers intrabasinal highs and passes beyond the shoulders of the alluvial plain and has been recognized to be a sequence boundary mainly from the study of well data. The characteristics of this interval have been studied.

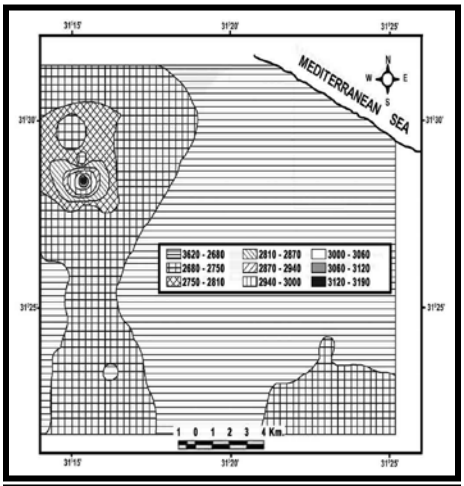

Fig. 25 Isochronous grid GIS map of the Top AM Formation, AM/EQ area (left).

Levels I+II This interval is upperly limited by TAM, third sequence boundry of AM Formation, which upperly limits the formation itself. This seismic horizon is represented by a trough having high continuity and amplitude. Its pervasive character is reflected by the whole Level I+II, that in the whole area closes the morphological variations created by the pre-Abu Madi Formations. It presents tabular external configuration, medium-amplitude internal reflections, good continuity and subparallel configuration.

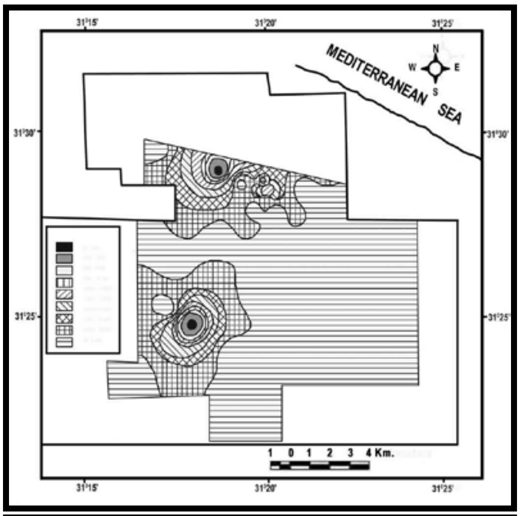

Fig. 26 Isochronous grid GIS map of the top level II, AM Formation, AM/EQ area (Right).

Isochronous Grid Maps

Figures 25-28 show mapped isochrons of the operational seismic sequences, demonstrate lateral thickness variations. Generally, the isochronous maps of the different tops reflect moderate time variation inside each map and high time variations between different maps, which indicate structural effect in the form of faulting on the area .

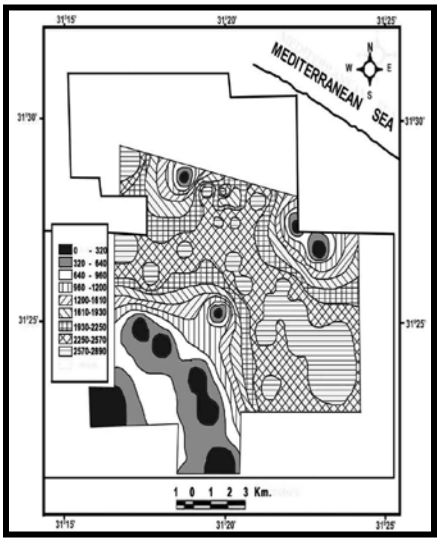

Fig. 27 Isochronous grid GIS map of the top level III, AM Formation, AM/EQ area (left).

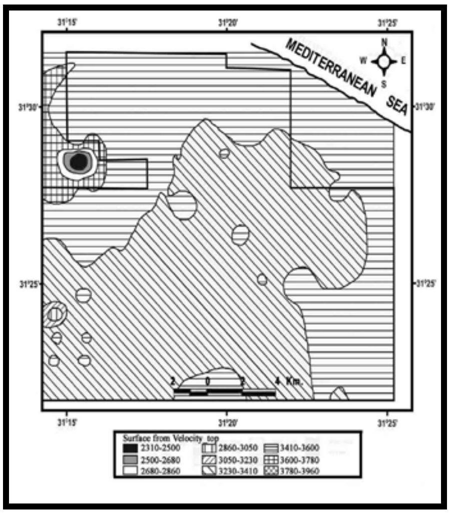

Fig. 28 Isochronous grid GIS map of the bottom AM Formation, AM/EQ area (right).

Velocity Grid Maps

Figures 29-32, which exhibit the velocity information, reveal two important signals. One is a litholgic signal and the second is a co-mingled pore fuild signal. However, when integrated with the isochrons of the sand-earing units, low velocity anomalies may be indicative of high pressure gas compartments.

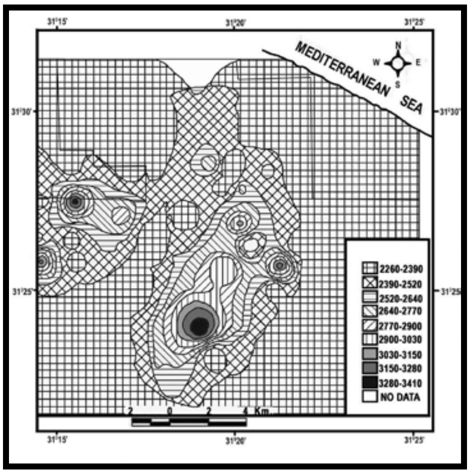

Fig.29 Velocity grid GIS map of the top AM Formation, AM/EQ area (left).

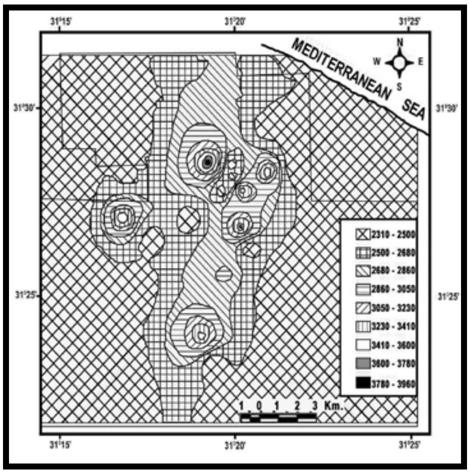

Fig. 30 Velocity grid GIS map of the bottom AM Formation, AM/EQ area (right).

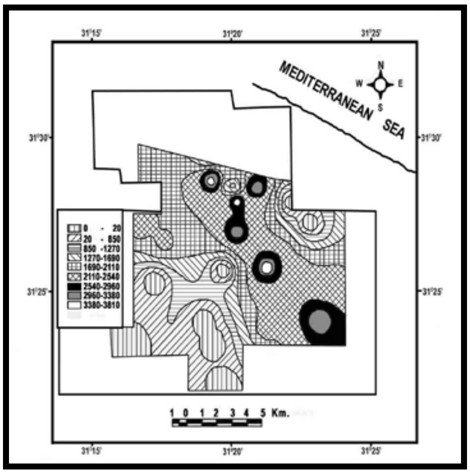

Fig. 30 Velocity grid GIS map of the top level II, AM Formation, AM/EQ area (right).

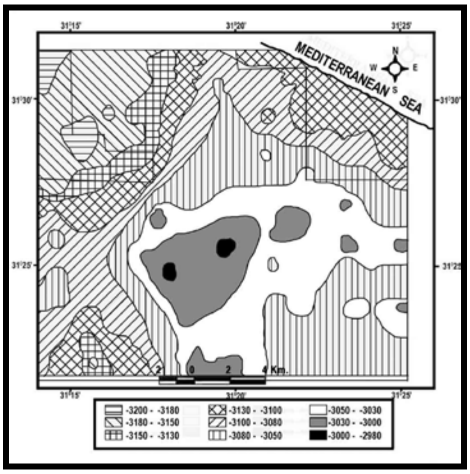

Fig. 33 Depth grid GIS map of the top AM Formation, AM/EQ area (left).

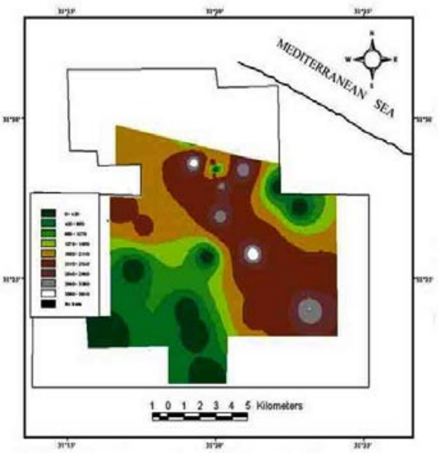

Fig. 31 Velocity grid GIS map of the top level III, AM Formation, AM/EQ area (left).

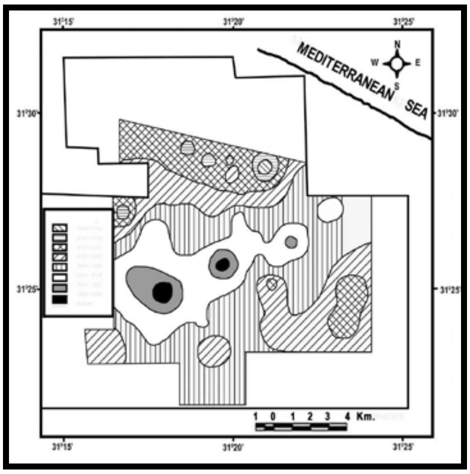

Fig. 34 Depth grid GIS map of the top level II , AM Formation, AM/EQ area (right).

Generally, the average velocity distribution maps illustrate that, the reconstructed paleo- morphology appears controlled by older fault patterns displacing the underlaying horizons and is affected by a gentle dip to the west of the study area.

Depth Grid Maps

Figures 33-36 suggest the time of structural high of the LST level III, together with the high potential reservoir sand content and low velocity anomalies, as a play fairway with elevated opportunity. Generally, the bottom of the Abu Madi Formation varied from 3186 to 3911 m with 700 m thickness and general dip E– W. N-S trending highs are bounding rather wide valleys deeply eroded in the eastern portion of the study area, where the absence of Early Messinian structurally higher situation.

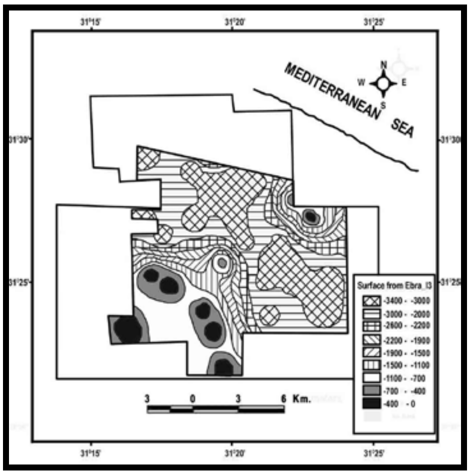

Fig. 35 Depth grid GIS map of the top level III, AM Formation, AM/EQ area (left).

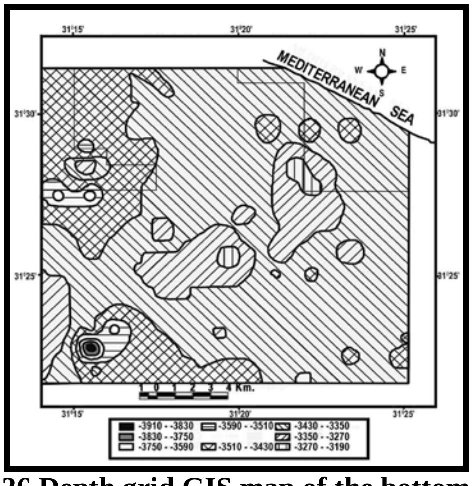

Fig. 36 Depth grid GIS map of the bottom AM Formation, AM/EQ area (right).

Transformation cycle of the implicated hydrocarbons

Supporting evidence for the existence of prolific petroleum systems in the Abu Madi /El Qar'a/ field area comes from basin modeling in the area, which incorporated an analysis of the petroleum system criticals (Metwalli and Pigott, 2005). For effective exploration, a better understanding of the processes, that led to the generation, migration and accumulation of hydrocarbons are necessary. The purpose of the modeling is to evaluate the maturity of the potential source rocks and to estimate their timing of generation and expulsion. The calculated maturities of the potential source rocks were calibrated against the available measured maturity parameters, which included mainly vitrinite reflectance data (%Ro).

In addition to the evidence revealed from the seismic stratigraphy for Abu Madi-El Qar"a area, inspection of the burial history and tectonic subsidence offers additional insight.

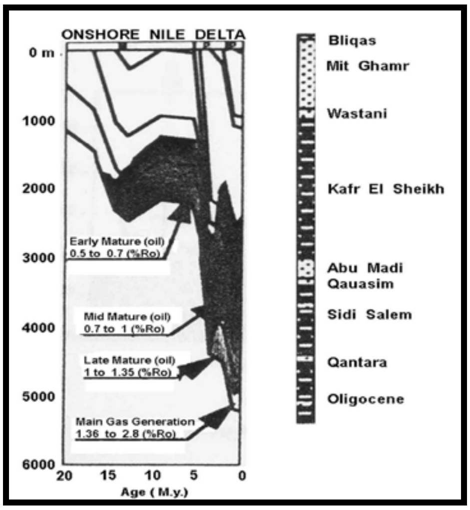

Fig.37 Tectonic Subsidence curve for AM-8 Well

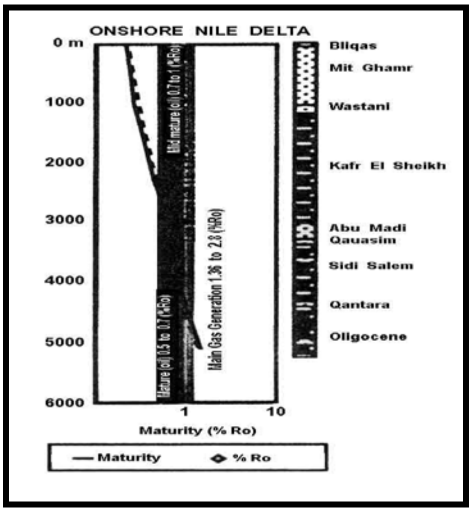

Fig.38 Maturity curve for AM-8 well

The burial history curve (Fig. 37) illustrates the subsidence of the study area to reveal three discrete pulses of subsidence and uplift, from 20 to 14 ma, from 14 to 4 ma, and from 4 ma to the present. However, as subsidence is a cumulative effect of accommodation owing to water loading, sediment loading, sea level datum change and tectonics (Metwalli and Pigott, 2005), it is the tectonic subsidence curve, which is most insightful. The tectonic subsidence curve reveals that, these three episodes of the study region experienced alternating pulses of shortening and extension. The maturation modelings of the study area (Fig.38) revealed that, the hydrocarbon compositions (gas and condensate) of the Abu Madi Formation are sourced from high temperature and more mature source rocks of mixed oil/gas prone.

Migration and Entrapment

Understanding the process of hydrocarbon generation and migration coupled with good geological data will assist to predict the ultimate hydrocarbon accumulations. The generation and migration of the hydrocarbon are thought to have reached their peak at the end of Miocene. This occurred after the main structural features had been imposed on the area and the main reservoirs had been deposited (Kamel et al., 1998).

Migration along faults is responsible for vertical migration pathways from mature source rocks to shallower reservoirs (Fig. 39 and 40). The presence of deep-cut channels, old vallies during Messinian and the unconformities allow a good path for lateral updip migration and further entrapment in the shallow closures (Kamel et al., 1998).

In the study area, where the shallow Pliocene growth faults are not well developed, only the normal fault pattern play the main role in the vertical migration for the generated hydrocarbons and its ultimated entrapement and accumulation in the Miocene and older reservoirs. The possibilities of finding out commercial Pliocene gas accumulation is relatively low and depending on the presence of syndepositional growth faults in the Pliocene.

SUMMARY AND CONCLUSIONS

A comprehensive multidisciplinary study of the Abu Madi/El Qar'a area was carried out for the Abu Madi Formation in order to evaluate the remaining hydrocarbon potentiality, this was achieved through integration of seismic interpretation, well-to-well correlations , petrophysics and Geographic Information System (GIS). The results of the study can be summarized as follows:

1. The well-to-well correlations, based on sonic logs were interactively calibrated with the seismic data taking into account the time-stratigraphic significance of the seismic reflections. This led to a better understanding of the structural setting of levels II and III of the Abu Madi Formation.

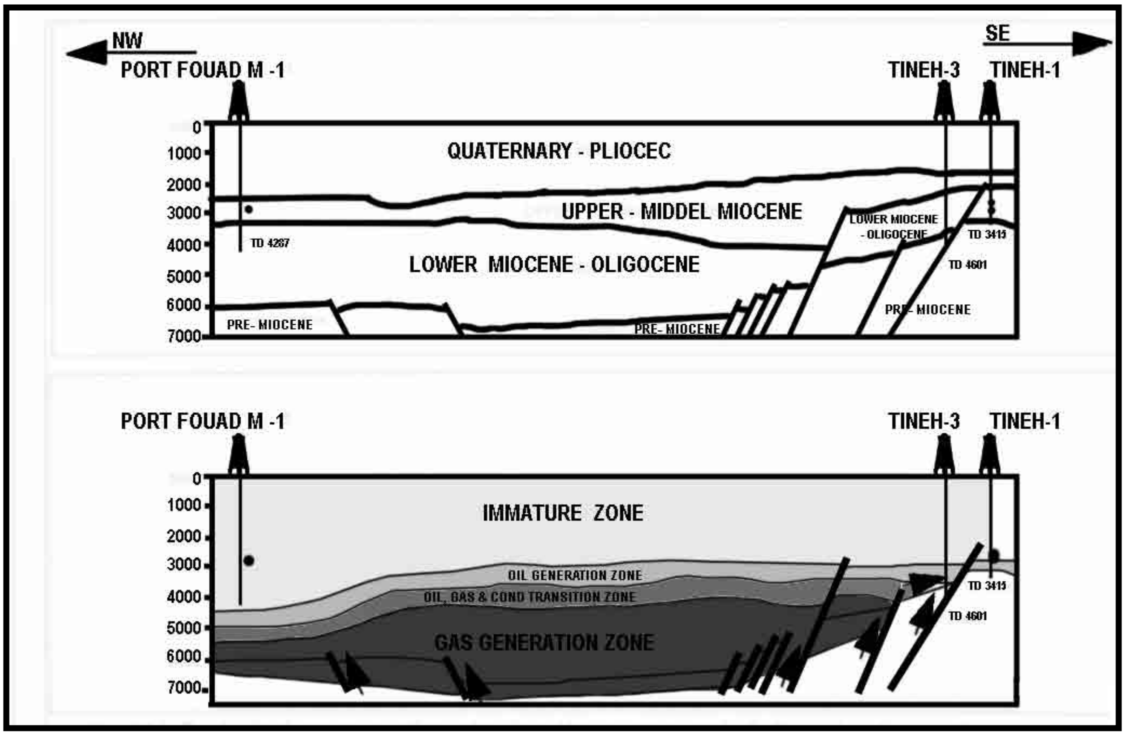

Fig. 39 : NW-SE cross sections showing the migration paths through the Nile Delta (Modified after Kamel et al., 1998).

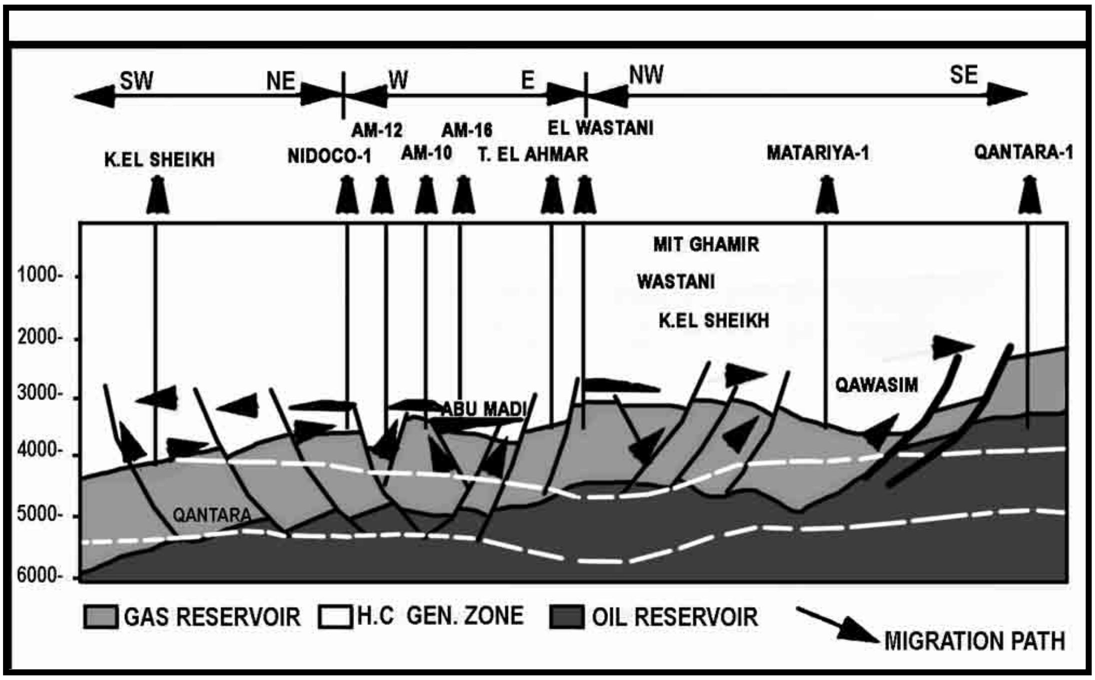

Fig. 40: Hydrocarbon reservoirs and migration paths through Nile Delta (Modified after Kamel et al., 1998).

2. The underlying highly tectonic Sidi Salem Formation, which is characterized by deep -seated faults and steeply dipping strata acted as pathways for the hydrocarbon migration, whereas the shale beds between the different sand cycles acted as cap rocks and played an important role in the gas distribution.
3. Conventional seismic interpretation of reprocessed seismic profiles have modified the level III channel margins resulting in a probable extension of the channel southwards, in agreement with the geological model.

The Lower and Middle level III sands are characterized by a good lateral continuity, high sand/shale ratio and their geometry is a sheet-like bodies. The sediments of lower and middle level III units represent the channel fill phase.

The Upper level III section is heterogenous with rapid lateral facies change producing a poor lateral continuity, It is interpreted as of estuarine environment and represent the channel abandonment phase. Therefore, the lower and middle level III sands are considered to be of a good quality reservoir and the upper level III sands are of a poor quality reservoir.

The structural setting of level III shows a North-South closure, along the western boundary of the Abu Madi area. This area lies outside the boundaries of the currently identified level II sand body, but on the extrapolated trend of a separate rose on facies maps. The possible occurrence of a separate sand body, related to a nearby channel Delta system still needs to be investigated through the extension of the quantitative analysis of seismic attributes into NIDOCO acreage.

While oil exploration is now appropriately focused along shallow to intermediate depths of Late Cretaceous and Tertiary migration paths, these results suggest deeper sections, especially those of the Lowstand and Transgressive System Tracts that may have reservoirs charged with significant unrealized gas potential.

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