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THE IMPACT OF SEISMIC ATTRIBUTE TO DELINEATE THE EROSION SURFACE OF MATRUH CANYON AT EMRY OIL FIELD, WESTERN DESERT, EGYPT.

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ABSTRACT

Base Matruh Canyon is an erosional surface had an impact on the reservoir continuity of (Hauterivian age) (Alam El Bueib IIIG), the unconformity related to Matruh Canyon. It is a high risk, in case the unconformity surface does not delineate, several wells will drill with negative results. The main object of the study is working to delineate the Base Matruh Canyon within the lower cretaceous for Matruh basin, the delineation of Matruh Canyon is a key factor to apprise and develop the area. For this reason, the well data and the 2D seismic data were exercised to expose the unconformity surface. Fornaciari said that the available 2D normal seismic data does not help to track this surface and would not solve the stratigraphic complexity. Consequently, seismic attributes were applied to define the limit for the unconformity surface. The workflow started by well correlation, the synthetic seismogram was initialized, and the workflow ended by the delineation of Base Matruh Canyon by using the seismic attributes. The results are time, velocity and depth maps for Alam El Bueib IIIG Sand I and Sand II. The conclusion, relative acoustic impedance, instantaneous phase and variance attributes reveal the the geometry of the Base Matruh Canyon. Spectral whitening was used to increase the frequency spectrum, and it was used as input for relative acoustic impedance to differentiate between Alam El Bueib IIIG Sand I and Sand II. It is high area was highlighted as a lead to the South-East direction from Emry oil field.

Keywords: Seismic attribute; Stratigraphic interpretation; Matruh Canyon; Western Desert; Egypt.

1. Introduction

Most of the potential fields placed in the North Western Desert of Egypt (Figure 1A) [1]. The study area sited between latitudes 30° 03' and 30° 54' N and longitudes 27° 00' and 27° 18' E (Figure 1B), and it is located 68 km SW of Matruh coastal town. Alam El bueib Formation in Shushan and Matruh basins is spilt into Alam El bueib I, II, III (A, C, D, E, F, G), Alam El bueib IV, 5 (A, B), and Alam El bueib VI. The facies of Alam El bueib differs to sandstone which is hydrocarbon reservoir, while the shale layers define as source rocks.

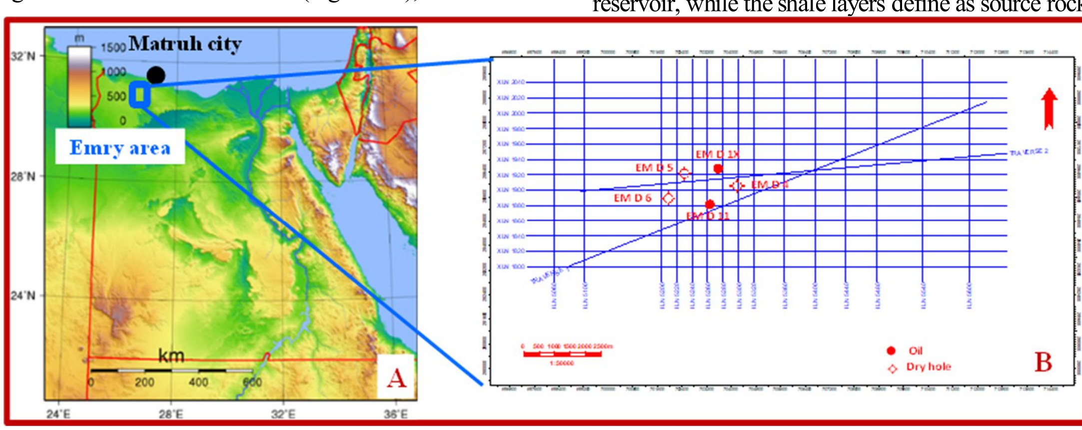

Figure 1. (A) Geographic map of Egypt, and (B) well locations and seismic grid of Emry field.

In Qasr oil field, the main target is Alam El bueib 3D, it is covered by the shale of Alam El bueib IIIC [2]. Alam El bueib IIID, IIIE and IIIG are the main productive zones in Jade oil field and the reservoir porosity ranged from 11% to 20% [3]. In the offshore of Matruh basin, it was defined the Canyon of Matruh shale and it is d defined the infill shale of the canyon to be as a seal [4]. Emry Deep 01X drilled in 2012 and confirmed major discovery in Alam El Bueib IIIG, the hydrocarbon column is about 76 meters. Emry Deep 04, 05 and 06 are dry wells, because the Canyon of Matruh affected Alam El Bueib IIIG and the sand replaced by shale of [5]. The complexity was raised not only after Deep 04 which is the appraisal well but also with the negative results during the development plan due to the unexpected disappearing of Alam El Bueib IIIG. Without the unconformity surface delineation, the negative results will continue. The investigation of the current study was used the well data and seismic sections, in order to interpret the erosional which, affect the reservoir consistently. Another important object is related to interpret Alam El Bueib IIIG (Sand I and Sand II). The carry out of the study is starting by the synthetic seismogram within Alam El Bueib Member, added to that it was created the most important seismic attributes which is linked to the unconformity surface such as relative acoustic impedance, instantaneous phase and variance.

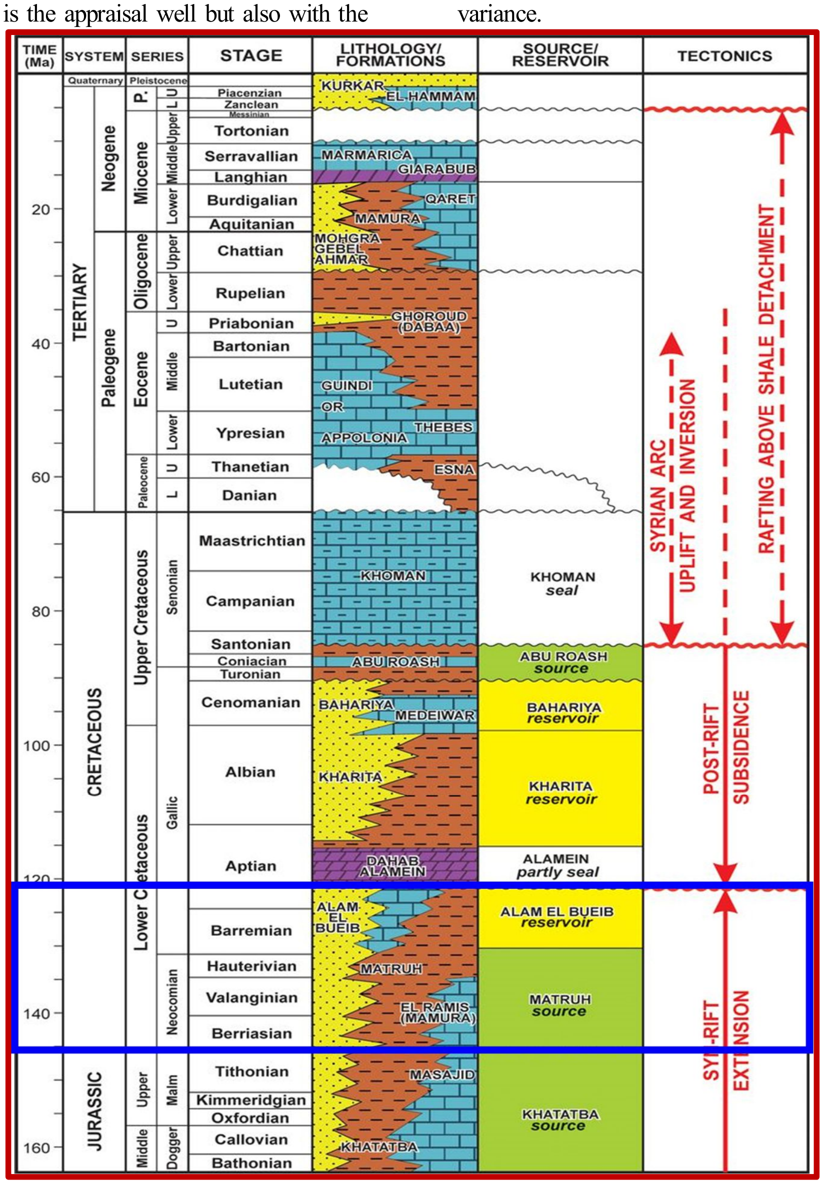

Figure 1. Simplified stratigraphy focusing in Alam El Bueib Formation of Matruh Basin [4].

2. Geological setting

Emry area relevant to Shushan and adjacent Matruh basins and these basins are created as a single rift during the Permo-Triassic and later created in a pull-apart structure [6]. Shushan basin is approximate enclosed by WSW to ENE and the faults are bordered with the same orientation. Matruh basin is bounded by NNE to SSW. The late cretaceous rift impacted on the area and it is controlled by NW to NNW-SE faults system, these faults was created during the syn-rift [7].

Throw the Late Cretaceous, the compressional forces NW to NNW-SE to SSE that created the Syrian Arc System in Egypt, this event is due to of the intersection between Arabian-African and Eurasian plates [8][9]. Most of the hydrocarbon field in the Western Desert are due to the Syrian Arc system [10]. The complexity of tectonic in the Western Desert is the main reason for the unconformities [11]. Many authors have discussed the tectonic in the area of interest for example [12][16]. The Cretaceous Formations has been exposed to a lot of classifications and different names [17]. Alam El Bueib, Alamein and Kharita, these Formations are related to the Lower Cretaceous. The oldest and the deepest Formation is Alam El Bueib which is a thick section of clastic rocks deposited unconformable above the eroded surface of the Masajid Formation, which is Jurassic age [17] [18]. Alam El Bueib Formation is divided into three members, the first one is Matruh Member and the age is (Neocomian, lower Aptian). Matruh Member is consists of sandstones and shales. The second Member is Umbarka Member, the age is (Barremian), and the third is Mamura Carbonate Member which is mainly composed of limestone [18]. Alam El Bueib IIIG is one of the main reservoirs in Matruh-Shushan basins such as Emry and Jade oil fields [19]. Alam El Buieb is predominantly white to yellow sandstone with siltstone and with gray shale, small carbonate beds (limestone and dolomite) occur in most areas [20]. Matruh Shale or Matruh Canyon is unconformity within Alam El Bueib Member [22], the infill of the Canyon by dark brown shale to dark grey with incidental arenaceous and calcareous interbeds (Figure 2). Matruh shale is laterally equivalent to Alam El Bueib by unconformity, Matruh Canyon started from the Mediterranean Sea and reached the North Western Desert of Egypt. The rift evolution controlled on the sedimentary facies distribution [21].

3. Materials and Methods

Thirty 2D seismic lines and five wells were anticipated with their electrical logs. All the wells contain the main logs (Gamma ray, Density-Neutron and Resistivity logs) and all the wells covered the interested reservoir of Alam El Bueib IIIG. It is recommended to have 3D seismic data in this type of studies, for using the time slice. The work flow started by the well logs were used in the lithological correlation, stratigraphic identification and to detect the erosional surface (Figure 3). The second step is to expose the erosional surface from the seismic data and seismic attributes [22]. The analysis of the reflection coefficient for the synthetic seismogram and the seismic data to find anomaly matched with the unconformity surface. Seismic attribute is a technique to enhance visually or highlighting features for the interpretation [23]. It is important to link between the seismic and geology, the methodology by analysis the reflection termination, the change in the seismic response is related to the change in the boundary between each layer and it is called interfaces [24]. Basically, Seismic attributes are extracted from the basic seismic components such as (time, amplitude, frequency) [25]. Several seismic attributes were introduced by [26], for example instantaneous frequency, envelope, instantaneous phase, polarity, dip, etc. The normal seismic data contains real components, which originally impeded inside the seismic data. Hilbert transforms were used to calculate complex component from which various physical components such as (amplitude, phase, etc.…), each seismic attribute is linked to demand geological feature [27]. Instantaneous phase is an angel measures in degree, it is proved tool for the seismic discontinues and seismic stratigraphy patterns such as (onlap and offlap), instantaneous phase is not independent on the trace strength, so it ruins by amplitude [28]. The seismic variance attribute calculates the semblance in waveform between the traces of the seismic. High variance values indicate the existence of discontinuities such as faults or stratigraphic elements, so variance attribute is usable to interpret the stratigraphic features such as the unconformities surfaces [28]. The spectral whitening introduces by [29], it is a method for spectrum restoration. The spectral whitening is a technique based on the changes in the relative amplitudes by enhancing the lower frequencies to coincide the signal force of the higher frequencies [30]. It is an important tool of seismic attribute called relative acoustic impedance has been used for lithology delineation based on the seismic data. The whole work was performed using the training Schlumberger Petrel software [31].

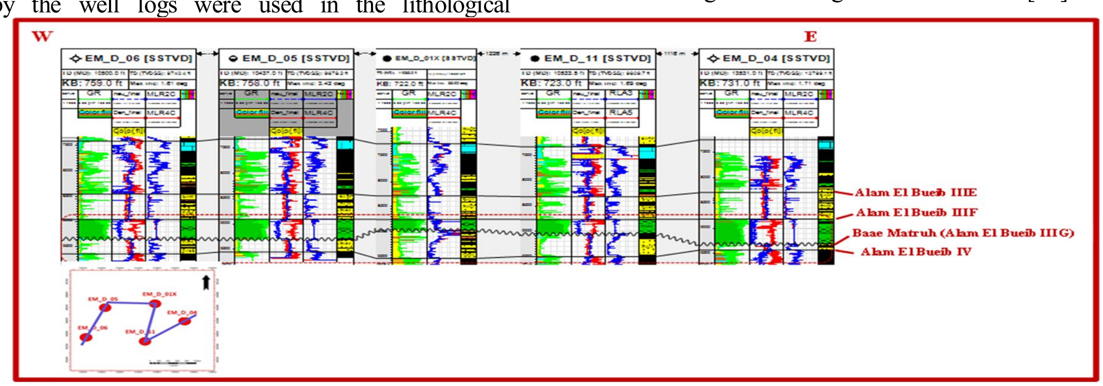

Figure 3. Regional correlation for Alam El Bueib Member between Emry Deep 05, Emry Deep 06, Emry Deep 11, Emry Deep 1X and Emry Deep 04, note that the erosion of Matruh Canyon.

4. Results

4.1. Stratigraphic correlation.

The correlation panel consists of the E-Logs of the wells, the first track is the depth below the seal level the second track is the gamma ray while the third track related to density and neutron logs finally the fourth track related to the resistivity logs (Figure 3). The correlation indicates conformable from Alamein formation to Alam El Bueib IIIF while Alam El Bueib IIIG (sandy reservoir) is affected by erosion due to the submarine Canyon (Late Hauterivian–Early Barremian age) (Figure 3).

4.2. Synthetic seismogram

The stratigraphic interpretation started by the well to seismic tie to match between the seismic and the well data (Figure 4). The synthetic seismogram of Emry Deep 04 was extracted, the wavelet calculated from the closest seismic line, the cross-correlation is 0.73. The synthetic seismogram for Emry Deep 04 was displayed on the section (Figure 4). The seismic response of Alamein formation and Masajid formation is strong trough on the seismic and the synthetic seismogram but Alam El Bueib IIIE and Alam El Bueib IIIF show as a positive weak reflector but Alam El Bueib IIIG is a strong trough.

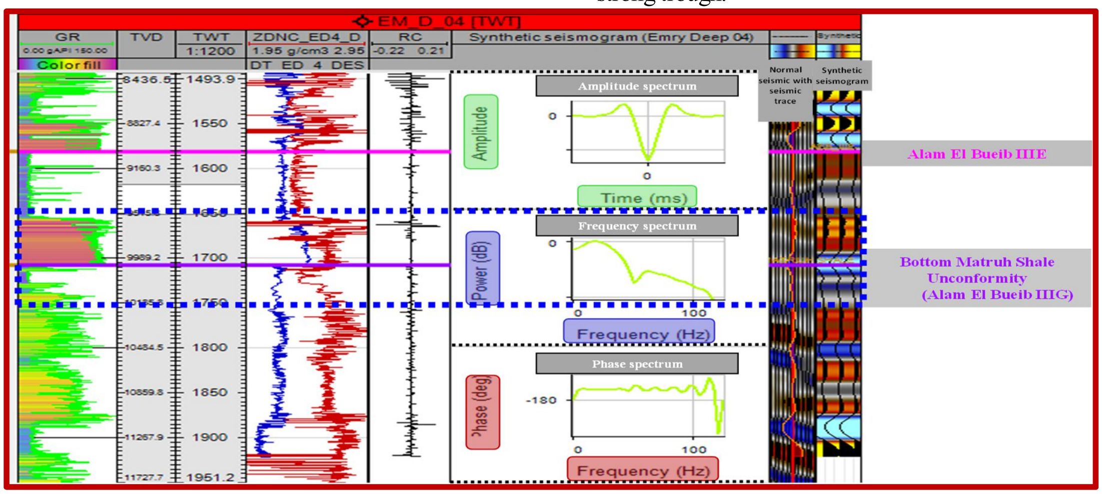

Figure 4. Synthetic seismogram for well Emry Deep_04, within Alam El Bueib Member.

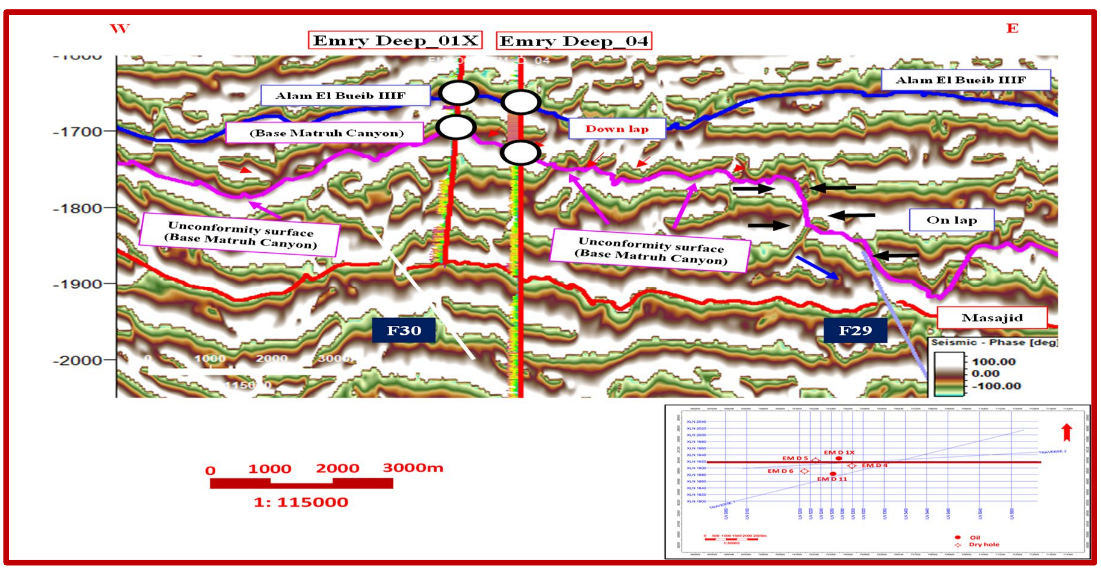

Figure 5. Instantaneous phase for XLN 1920, with the stratigraphic terminations.

5. Discussions

Fornaciari highlighted that after Emry Deep 04, the trap mechanism definition could be a stratigraphic component and it is a boundary separate Emry Deep 01X from Emry Deep 04. Also, he mentioned that, the normal seismic is not capable to solve the complexity of the trap geometry. The problem of the area, without delineation the boundary will calculate wrong number for the hydrocarbon in place. The normal seismic is good enough to interpret the structure components, but it is not capable to delineate the unconformity surface. Therefore, the seismic attribute tool (instantaneous frequency and instantaneous phase) can be assisted to delineate sand – shale boundary and it is prescriptive in the stratigraphic interpretation [32]-[33][34].

In the Western Desert, many studies discussed the structure and the facies by using the seismic attribute. The faults trend in Mtaruh basin match with the investigated area NW-SE [35]. Variance (coherency) and curvature attributes are robust tool to interpret the faults and the channels in Shushan basin [36]. Mostly of the researches in the Western Desert focused on the structure elements and the facies analysis such as the study in Qasr, Jade and Salam fields. The current study, it is the first time to apply the seismic attribute to delineate the erosional surface of Matruh Canyon.

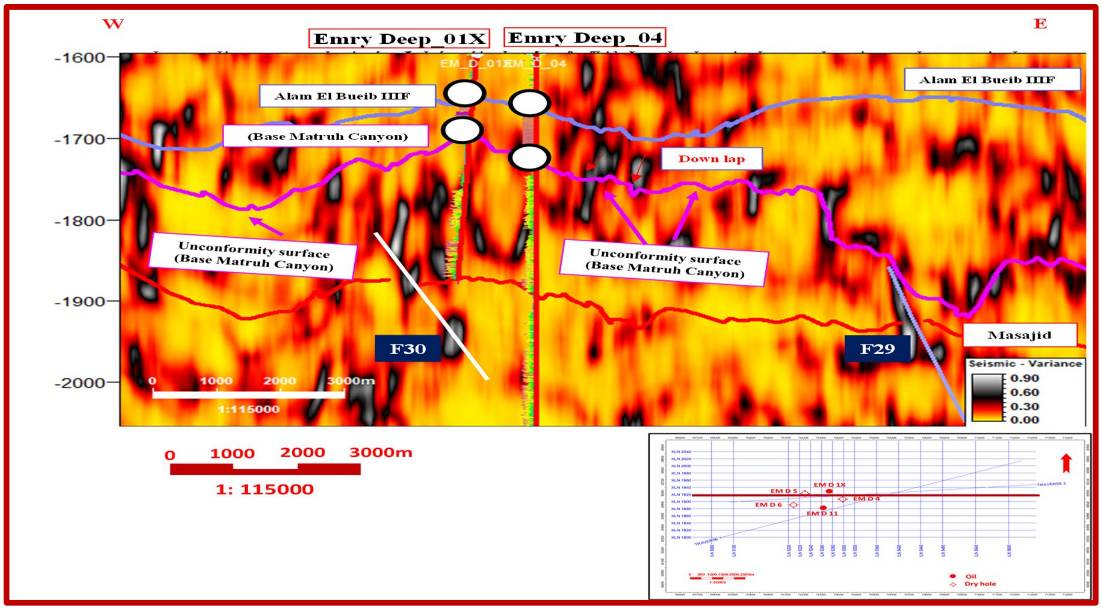

Figure 6. Variance attribute at XLN 1920, the erosional surface is in purple color.

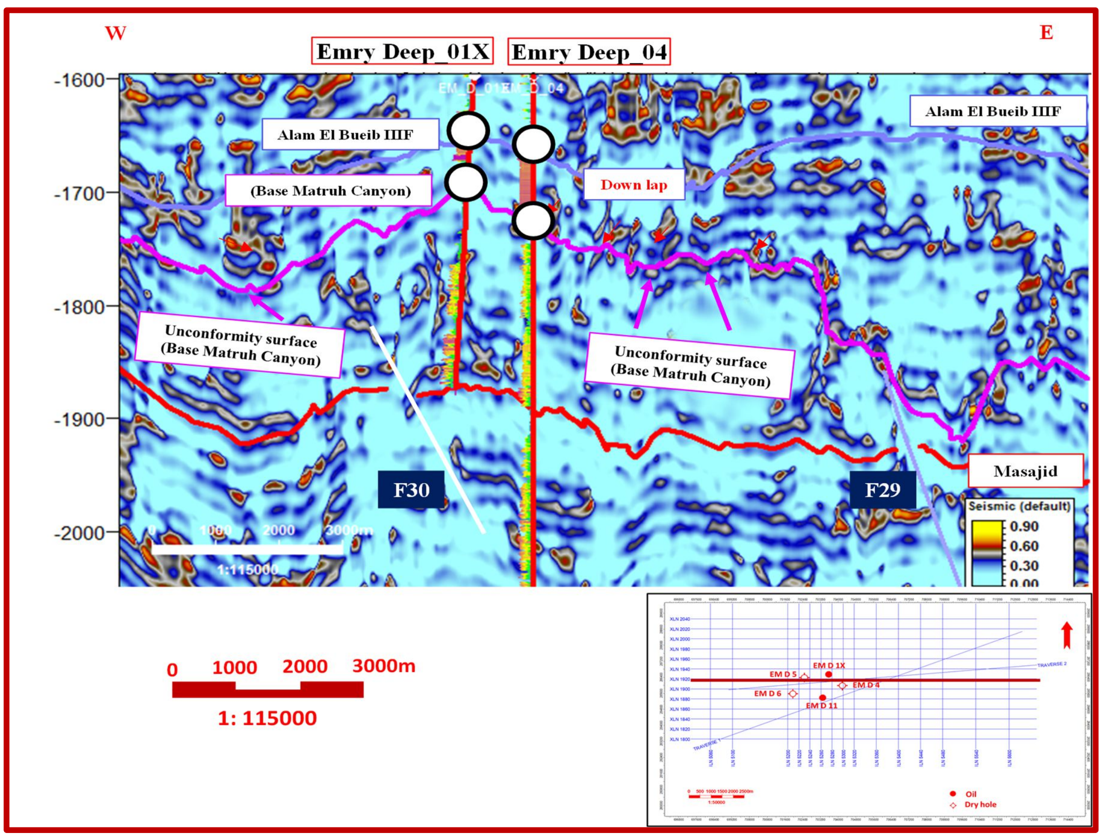

Figure 7. Iso frequencies component (50 hz) for XLN-1920, the geometry of Base Matruh is evident.

5.1. Seismic attribute at Emry oil field

5.1.1. Delineating Base Matruh Canyon by Instantaneous Phase, Variance, Iso Frequency Component and Relative Acoustic Impedance.

Base Matruh Canyon is obvious based on the instantaneous phase, variance and iso Frequency Component (Figures 5, 6 & 7). The main valley is clear in the eastern part from Emry area, and the erosion is closed to Masajid formation (Figures 5, 6 & 7). The western valley is small and the isochron is around (30 ms). The geometry of the two valleys interpreted as pull down. The stratigraphic termination on the both sides on the unconformity is evident on the instantaneous phase (Figures 5). It is downlap terminations are adjacent to upper surface of the Base Matruh Canyon in red color (Figures 5 &6). The variance indicates the similarity between the seismic data, the black circles in the variance means discontinuity (Figures 6). The geometry of Base Matruh is detectable based on the variance attribute, so the Variance is important tool to understanding the interpretation of the submarine Canyon [37]. Based on the variance attribute, the infill of the eastern valley differs from the western one (Figures 6). Iso-frequency attribute is implemented in reservoir characterization studies to derive high-resolution of seismic information [38]. In the current study, it was generated Iso-frequency at 50 hertz, the dark yellow color is the discontinuous, while the interpretation of Base Matruh unconformity is visible. The two valleys are evident, the infill of the eastern valley is stratified layers while the facies in the western valley is chaotic (Figures 7). The relative acoustic impedance indicating the erosional surface of Base Matruh shale in purple color (Figures 7). The thickest effect of the erosion centralized to the eastern part from Emry oil field, while the thickness in two-way time around (250 ms). It is clear onlap termination in black color at the eastern and western side from Emry oil field.

5.1.2. Discriminating Alam El Bueib IIIG SI and Alam El Bueib IIIG SII by using Relative Acoustic Impedance and spectral whitening.

The sand facies in Alam El Bueib IIIG classified in to sand I and sand II. Sand I is dirty facies compared to Sand II. It is a shaly layer separated between the Sand I and Sand II (Figure 9). The thickness of Alam El Bueib IIIG reduced incase the thickness of Matruh shale increse such as Emry Deep 04, Emry Deep 05 and Emry Deep 06. Matruh shale defines as a high and flat gammar ray reading (Figure 9). The thickness of Sand I is variable in Emry wells, the thickest SI recorded in Emry Deep 01X and Emry Deep 11 respectively. The thickest Sand II logged in Emry Deep 01X, while the smallest thickness is evident in Emry Deep 04.

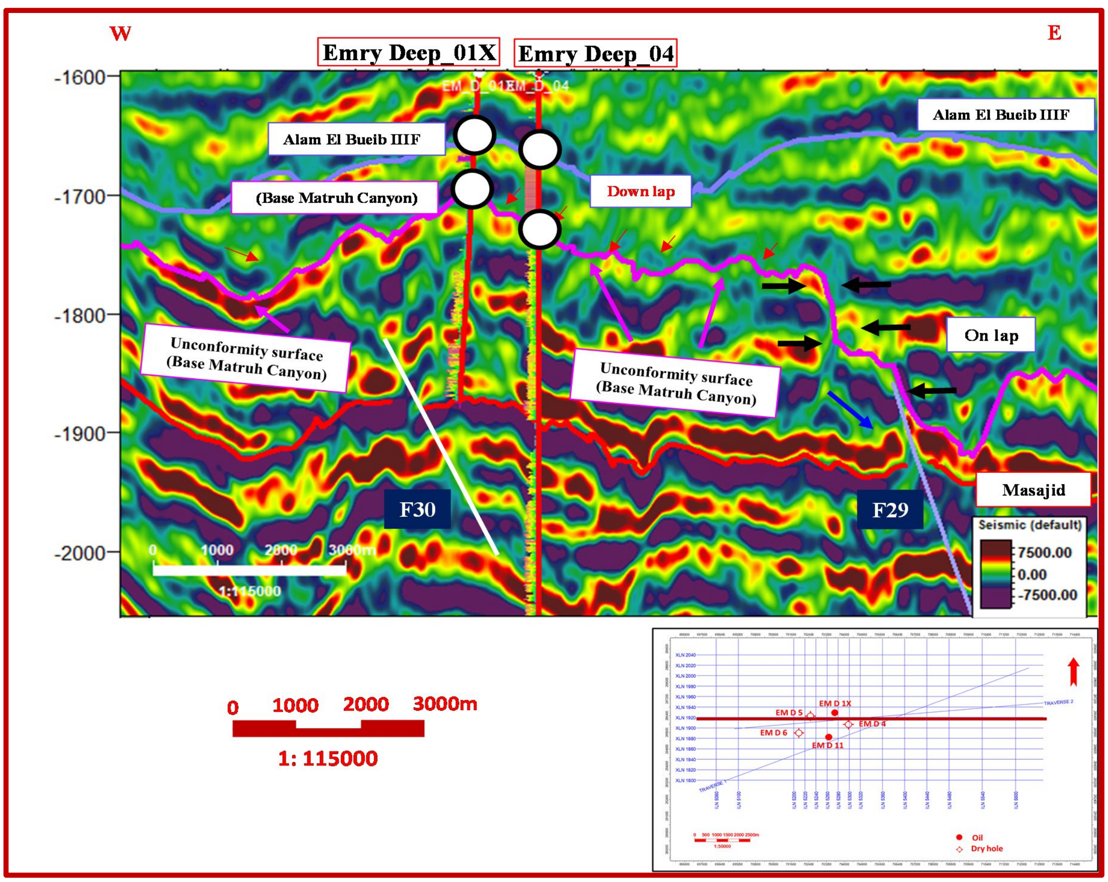

Figure 8. Relative acoustic impedance on XLN-1920, onlap and downlap terminations are obvious in the eastern valley.

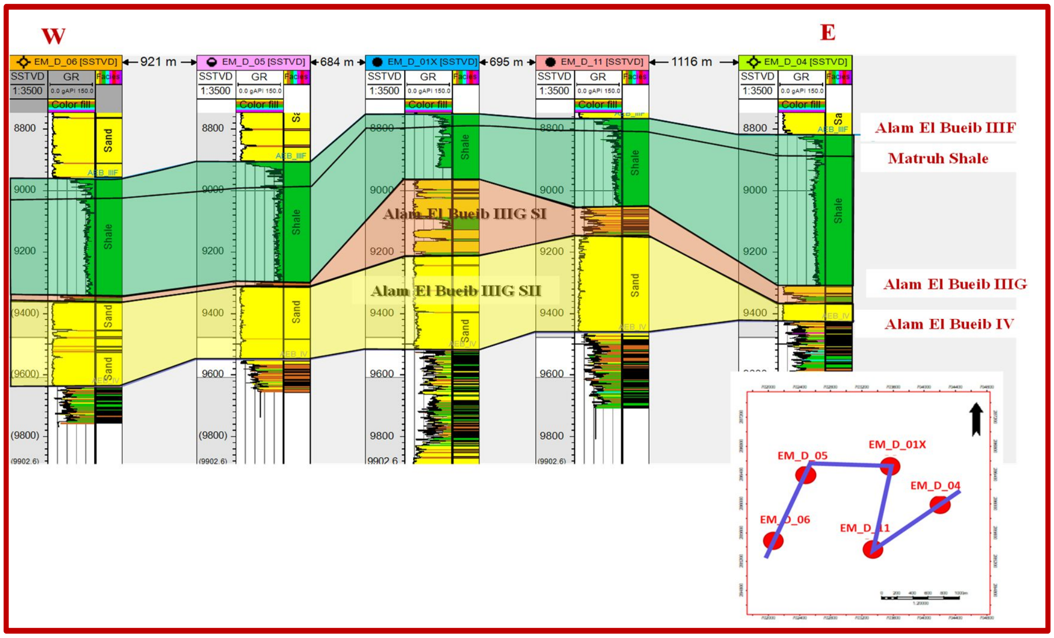

Figure 9. Zoomed correlation for Alam El Bueib Member, illustrating the differentiation between Sand I and Sand II.

The thickness of Sand I and II reduce due to the erosion of Matruh Canyon. Based on the normal seismic data, the differentiation between Alam El Bueib IIIG SI and S II is not visible (Figures 10A and 11A). To increase the seismic frequency at Emry oil field, it was generated spectral whitening attribute, the frequency range reached to 80 hz (Figure 10). The spectral whitening is used as input for relative acoustic impedance. The attempt is performed by using seismic high resolution by applying workflow of spectral whitening and relative acoustic impedance. The relative acoustic behavior for Alam El Bueib IIIG SI represented as moderate yellow color, this phenomenon is clear at Emry Deep 01X (Figure 11). It is shale layer after Alam El Bueib IIIG SI, it displayed as blue color in the relative acoustic impedance (Figures 10B and 11B). Based on the seismic interpretation for thirty seismic lines, two maps were created, the geometry of Alam El Bueib IIIG is defined as four-way dip closure the highest well is Emry Deep 01X. The geometry is related to combination element (structural and stratigraphic), most of Alam El Bueib IIIG sand I was eroded by the Canyon, it is thin section is preserved (Figure 11). The distribution of the Alam El Bueib IIIG SIII is exist in all the wells, but from the seismic interpretation and the attributes analysis show that away from Emry wells, Alam El Bueib IIIG SII is benching out in West and East direction from Emry area (Figure 11 B).

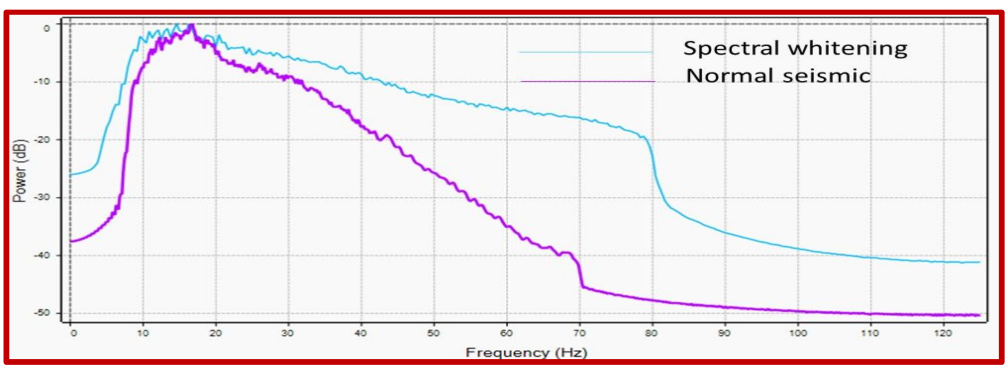

Figure 10. Frequency spectrum for normal seismic and spectral whitening at Xline 1920.

5.1.3. Mapping for Alam El Bueib IIIG SI and SII by using Relative Acoustic Impedance.

The maps of Alam El Bueib IIIG SII is defined as a combination trap, the highest position at the Emry Deep_01X, the deepest value base on the time is to the North and the South respectively. The fault trend in Alam El Bueib IIIG is NW-SE direction (Figure 12). Emry area is bounded from the North and the South by (F1 and F19). Average velocity maps were used for Alam El Bueib IIIG SI and SII. Generally, the velocity decrease to the East for Alam El Bueib IIIG SI and SII. The slowest velocity for Alam El Bueib IIIG SI is 5.47 ft/ms while the fastest one is to the West 5.25 ft/ms (Figure 13 A), also the velocity ranges from 5.29 ft/ms to 5.51 ft/ms Alam El Bueib IIIG SII (Figure 13 B). The highest well for Alam El Bueib IIIG SI is Emry Deep

01X and impact the map with -8965 ft., while the lowest well is Emry Deep 06 (Figure 14 A). Emry Deep 11 is the shallowest well at Alam El Bueib IIIG SII (Figure 14 B). The effect of the erosion of Matruh Canyon is evident in Alam El Bueib IIIG SI and SII, the remnant part of Alam El Bueib IIIG SII is bigger than Alam El Bueib IIIG SI (Figure 14). Based on the relative acoustic impedance and the maps (Figure 12 and 14), it is a possible lead to the South-East direction from Emry field.

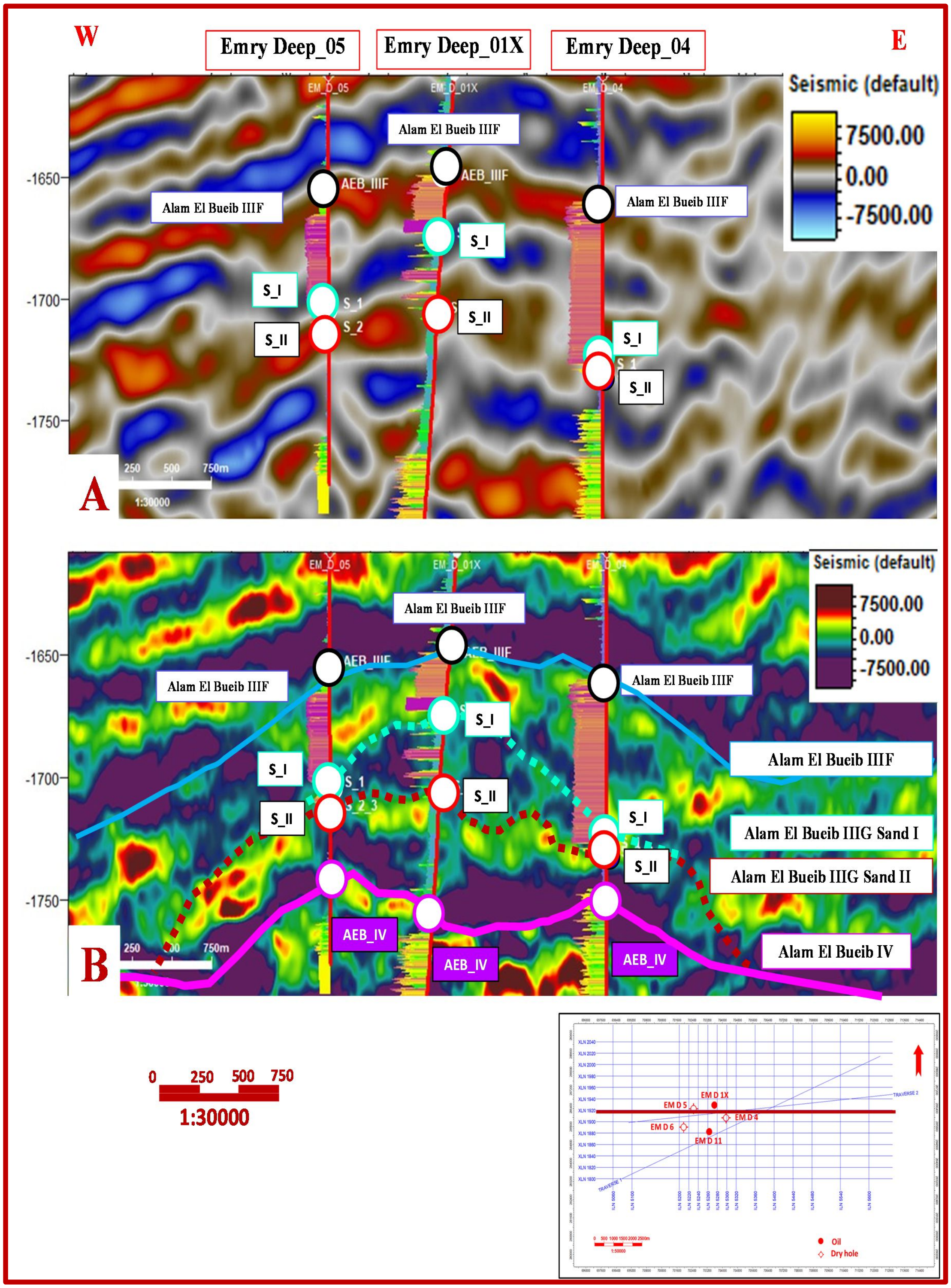

Figure 2. (A) Normal seismic section zoomed on XLN-1920, (B) Revealing spectral whitening with relative acoustic impedance.

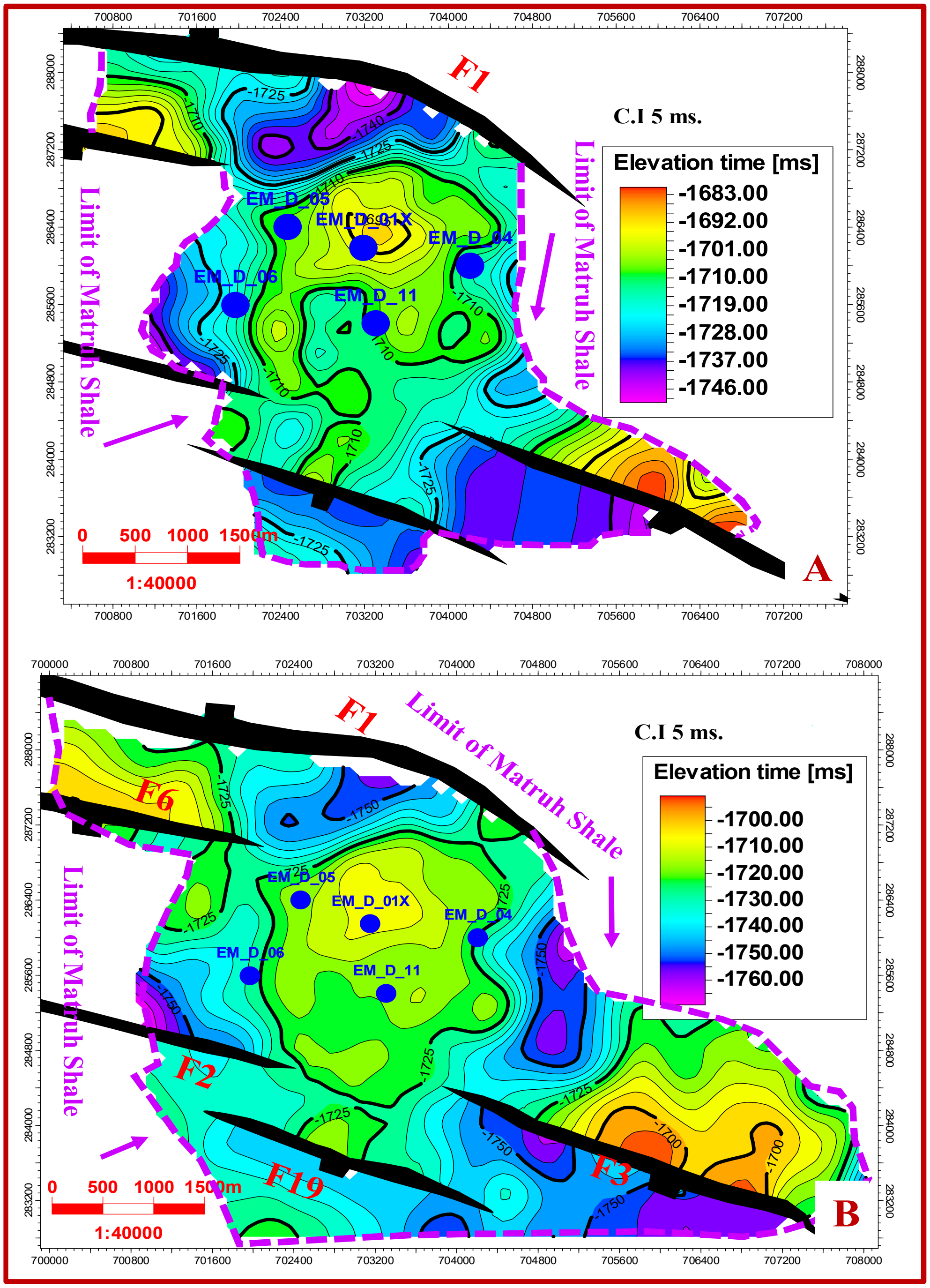

Figure 12. Time maps on top (A) Alam El Bueib IIIG SI and (B) Alam El Bueib IIIG SII), with the boundary of Matruh Canyon.

6. Conclusions

In light of the current study, the erosional surface (Base Matruh Canyon) was delineated based on the correlation and the seismic attribute. The instantaneous phase, variance and iso frequency attributes are proved to be a power tool to delineate the boundary for this feature (Base Matruh). Three reflection seismic reflector have been used to indicate light on the subsurface trap definition which is stratigraphic and structural setting. It is evident two valleys in the eastern direction as well as in the western direction, so these attributes are recommended for edge Canyon detection. The separation between Alam El Bueib IIIG SI and Alam El Bueib IIIG SII is clear based on the spectral whitening after applying relative acoustic impedance. Time, velocity and depth maps were created for Alam El Bueib IIIG SI and Alam El Bueib IIIG SII, resulting in possible lead to the South East direction.

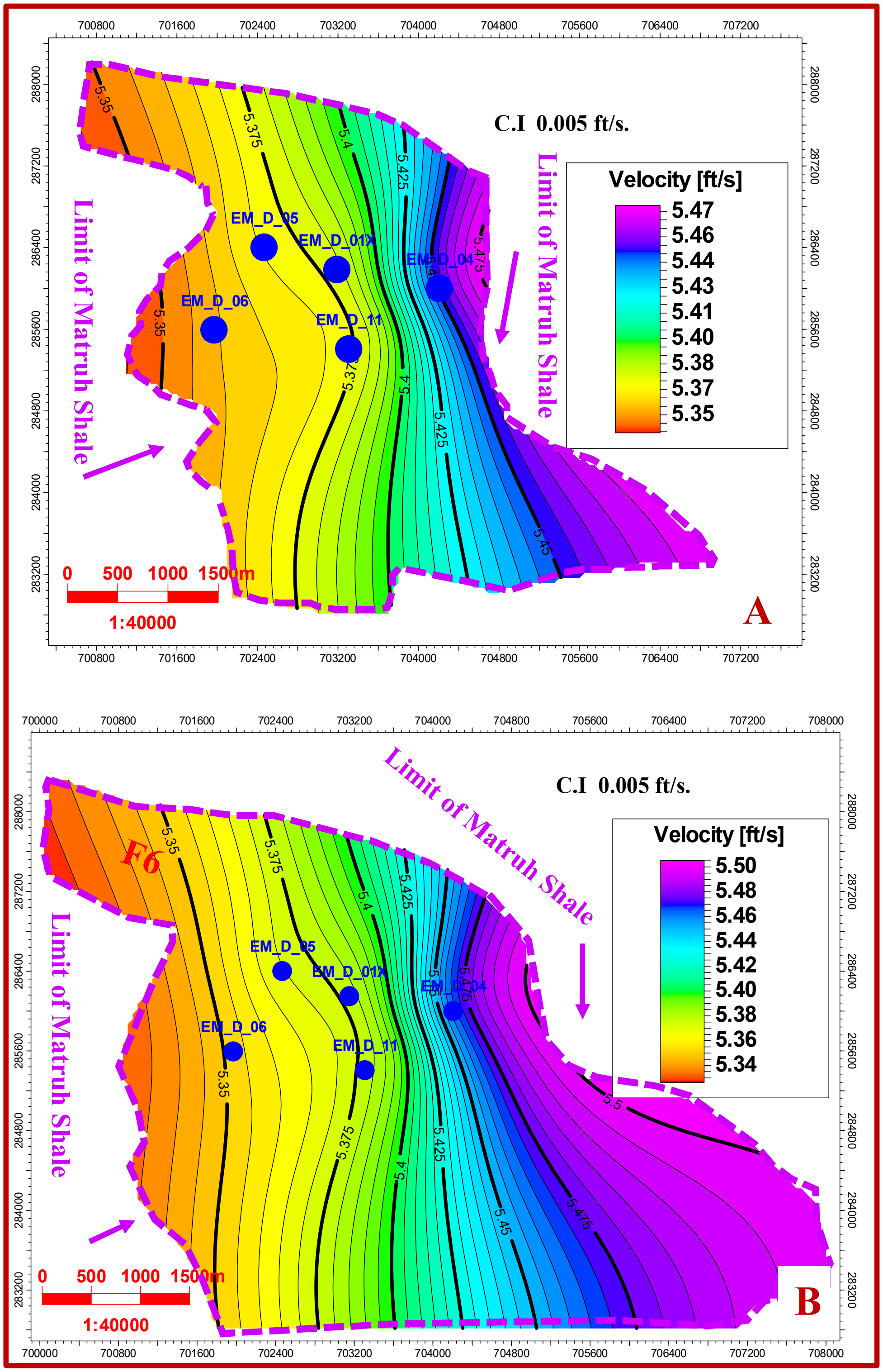

Figure 13. Average velocity maps on top (A) Alam El Bueib IIIG SI and (B) Alam El Bueib SII).

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Conflict of Interest and Authorship Conformation Form

The authors declare no conflicts of interest regarding the publication of this paper.

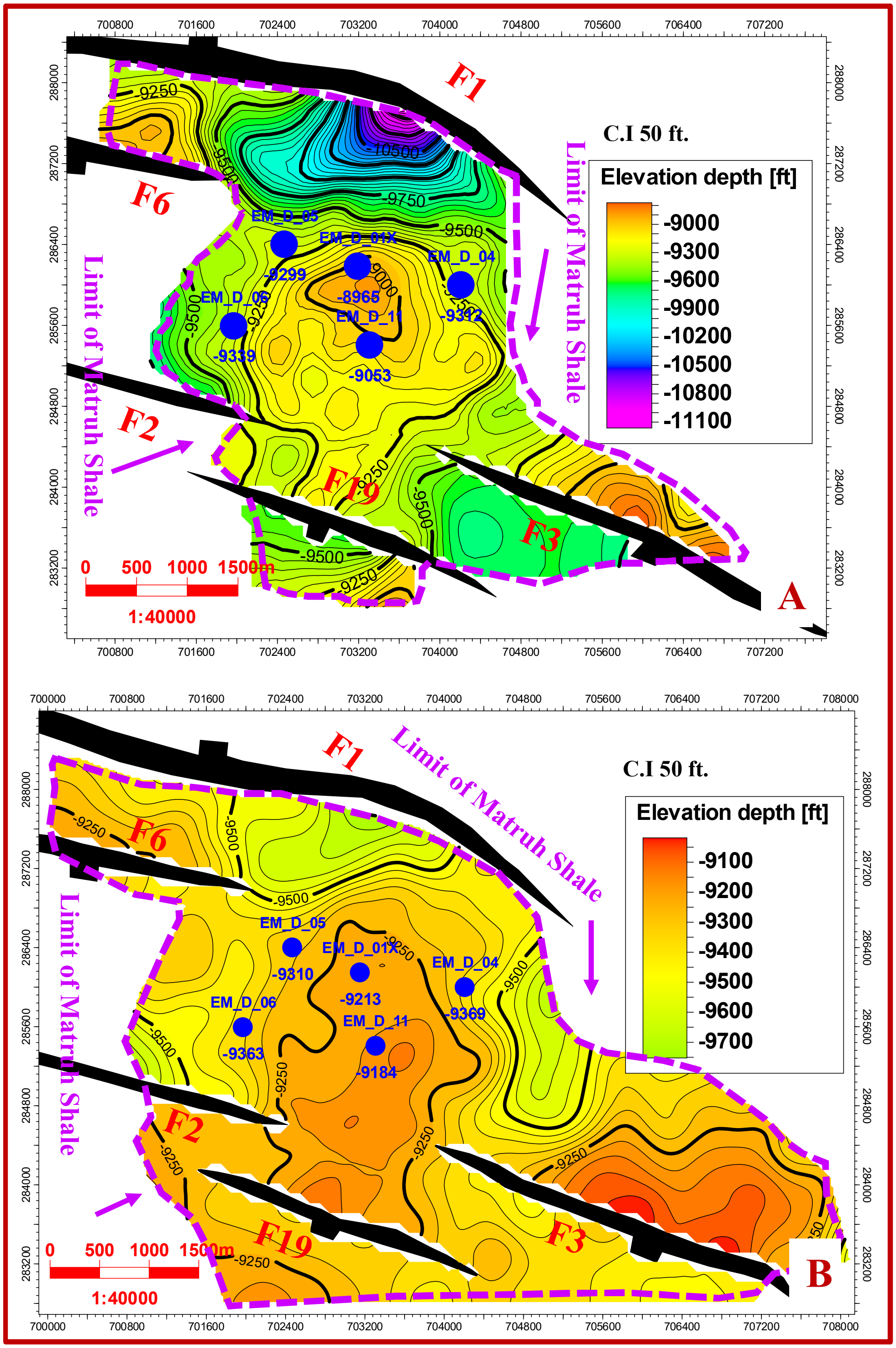

Figure 14. Depth maps on top (A) Alam El Bueib IIIG SI and (B) Alam El Bueib SII).

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تأثير السمات الزلزالية لتحديد سطح تآكل وادي مطروح في حقل إمري النفطي، الصحراء الغربية، مصر

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الملخص:

تقع منطقة إيمرى 65 كيلومتر جنوب غرب شاطئ مدينة مطروح وحدود منطقة الدراسة بين خطي عرض 30 ° 03 'و30 ° 54' شمالاً وخطي طول 27 ° 00 'و27 ° 18' شرقاً. وترتبط منطقة الدراسة بحوضي شوشان ومطروح. المشكلة الرئيسية في منطقة إمري هي أن سطح التعرية كان له تأثير على استمرارية خزان (العصر الهوتيريفي) (علم البويب IIIG). تم حفر Emry Deep 01X في عام 2012 وأكد الاكتشاف المهم في علم البويب IIIG، بوجود عمود الهيدروكربون حوالي 76 مترًا. Emry Deep 04 و 05 و 06 هي آبار جافة لأن وادي مطروح أثر على استمرارية الخزان واستبدل الخزان بالصخر الطيني. في دراسات سابقة حاولت استخدم البيانات الزلزالية العادية ثنائية الابعاد لكنها لم تساعد على تتبع هذا السطح ولم تحل التعقيد الطبقي. ونتيجة لذلك، تم تطبيق السمات الزلزالية لتفسير سطح عدم المطابقة. بدأت خطة البحث بعمل مضاهاة ما بين الابار. الواضح من المضاهاة الحد الأقصى للتآكل المسجل في Emry Deep 004 وأقل سمك تآكل مسجل في Emry Deep 01X. الهدف الرئيسي من الدراسة هو العمل على تحديد سطح عدم التوافق المؤثر على خزان علم البويب IIIG. وهو ما تم في الدراسة الحالية، تحديد (قاعدة وادي مطروح) بناء على بيانات الابار والسمات الزلزالية المختلفة. تم عمل السمات الزلزالية للمرحلة اللحظية (Instantaneous phase) والتباين (Variance)والتردد عند 50 هزة (Iso frequency) تم من خلالهم تحديد سطح عدم التوافق (قاعدة وادي مطروح) كما تم تحديد وادي في الاتجاه الشرقي وكذلك وادي في الاتجاه الغربي، لذلك يوصى باستخدام هذه الصفات للعمل على تحديد أسطح عدم التوافق. ولدراسة تفاصيل أكثر للفصل بين (علم البويب IIIG رمل I ورمل II) وهو ما أصبح واضحًا بناءً على زيادة التردد الطيفي (spectral whitening)ثم تطبيق المعاوقة الصوتية النسبية(Relative acoustic impedance). وأخيرا تم عمل خرائط زمن وسرعة وعمق لكل من طبقتي (علم البويب IIIG رمل I ورمل II). واتضح أيضا احتمالية وجود منطقة مشجعة في اتجاه جنوب شرق من حقل إيمرى.