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FOLLOW UP THE SEDIMENTARY SUCCESSION BY USING THE SHALLOW SEISMIC REFRACTION STUDIES IN SOUTHWESTERN SINAI, EGYPT

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تتبع التتابع الرسوبى باستخدام الدراسات السيزمية فى منطقة جنوب غرب سيناء، مصر

الخلاصة: المنطقة تحت الدراسة تغطى حوالى ٥٠ كم٢ و تقع بين خطى طول 33^{o} 19.3′ - 33^{o} 24′ و خطى عرض 29^{o} 1.5′ - 29^{o} 5.3′. تعتبر هذه الدراسة محاولة لتجميع وتكامل الدراسات السيزمية الانكسارية الضحلة السابقة لتتبع الخامات الاقتصادية لمكون أم بجمه. وهذا المكون له خصائص فيزيائية مختلفة عن المكونات الصخرية الأخرى خاصة فى سرعة الموجات السيزمية خلالة. بجانب ذلك فان الدراسة تتعامل مع العمق و السمك وتحديد أسطح و قاع مكون ام بجمة. هناك العديد من الدراسات بداية من منطقة طلعة سليم، وادى نصيب ، وادى السيح و أخيراً دبة القرى حيث أظهرت الدراسة و جود خمس سرعات مختلفة ترتبط بخمس مكونات تبدأ برواسب الوديان و رواسب الوديان المتماسكة و مكون أبو ثورا و يليها مكون أم بجمة ثم مكون الاعدادية تحت منطقة الدراسة. و اختلفت السرعات من ٥٠٠ م/ث الى ٢٥٠٠ م/ث. و استنتج أن سرعة مكون أبو ثورا يتراوح مابين ٢٠٠٠ الى ٢٥٠٠ م/ث خاصة فى وادى السيح. بينما مكون أم بجمة تتراوح السرعة خلاله ما بين ٣٢٠٠ الى ٣٣٠٠ م/ث. و تعد سرعة الموجات السيزمية خلال مكون الاعدادية اكبر السرعات فى المنطقة المدروسة ووصلت الى حوالى ٤٧٠٠ م/ث.

ABSTRACT: *The area under study covers about 50 km^2. and is located between Long.33^{o} 19.3′ & 33^{o} 24′ and Lat. 29^{o} 1.5′ & 29^{o} 5.3′. The present study is considered as an attempt to collect and integrate the previous shallow seismic refraction studies, to follow the Um Bogma mineralized Formation. This formation has physical parameters vary from the other rock-units, specially the amplitude of the velocity of seismic waves. Besides that, the study deals with the depth and thickness as well as the determination of the top and bottom of the Um Bogma Formation. There are four studies have been done in the area under investigation started by Talet Seliem area, Wadi Nasib area, Dabit El Qerie area and finally by Wadi El Seieh area. The results show vertically five seismic velocities related to five rock-units started at the surface by wadi deposits (500 m/s), compacted sandstone deposits (upper part of Abu Thora Formation) with seismic velocity varying between 1300 &1800 m/s, lower part of Abu Thora Formation (2000 to 2500 m/s) at wadi El Seih, while Um Bogma Formation (3200–3300m/s) at wadi Haseib area and finally the Adadia Formation with the highest seismic velocity (about 4700 m/s) related to wadi Seih area.*

I- INTRODUCTION

The study depends mainly on collecting the previous seismic works in an attempt to interpret and follow up the available geologic formations related to the various elastic wave velocities and their distributions extension in the lateral and vertical directions. Figure (1) shows the topographic contour map and the locations of the studied areas distributed along the area under investigation.

II- GEOLOGY OF THE STUDY AREA.

From the previous geologic studies, the area under investigation is composed of various features of rock types with varying geological ages (Fig. 2). It starts with Precambrian rocks, which are represented by granodiorite-diorite complex. It is covered by conglomerate sandstone alternated with sandstone and siltstone (fining upward cycles) of Sarabit Elkhadim Fm., the environment is braided stream. Followed by shales in the form of two horizons of reddish color and shale green color of Abu Hamata Fm., that is rich in cupper mineralization. The environment is subtidal–tidal channel and is covered by coarse to fine grained sandstone with some thin shales. Ferruginous siltstone and gravelly sandstone of pink to brown in color form the Adadia Fm., with the environment is varied from low to moderate sinuos stream. Sarabit El Khadim, Abu Hamata, and Adadia Fms., are of Cambrian age that, covered by Um Bogma Fm as a cap in this wadi. The lower member is sandy dolostone that, covered by the middle member of marl, while some Mn ores are recorded in the lower member (Fig. 2).

Early Carboniferous age is suggested for this formation. All the previous rock units are located at the eastern side, but the other formations (e.g. EL-Hashash) which are characterized by yellowish and brownish sandstone, overlain by Um Bogma Fm. and underlain by Magharet EL Maiah Fm. It is characterized by coal seam with carboniferous shale at the base of the western side of the considered area. This coal seam is covered by Abu Zarab Fm and characterized by glass sand intercalated with multicolored siltstone.

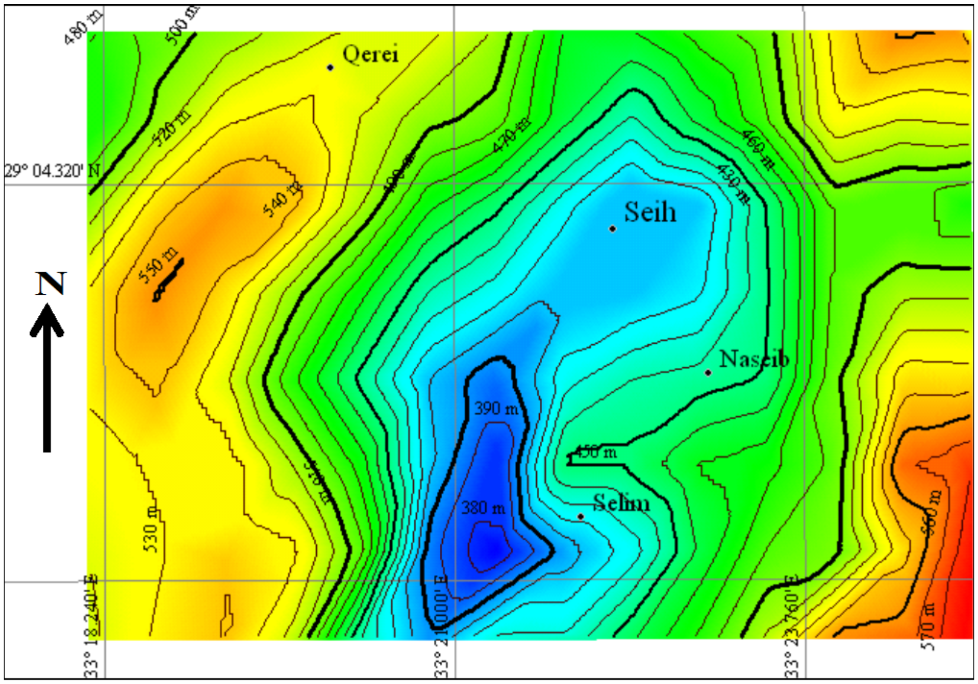

Fig. (1): The locations of the Studied areas on the topographic contour of Southwestern Sinai, Egypt. After satellite image 2001.

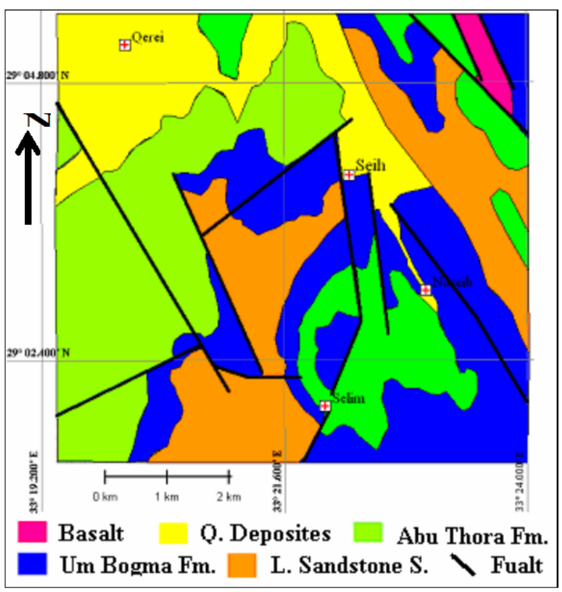

Fig. (2): Geologic map of the Study areas, Southwestern Sinai, Egypt. (After EGSMA 1994).

The last three Fms. (EL Hashash, Magharet EL Maiah and Abu Zarab) belong to delta plain, shallow marine, near shore shelf and tidal flat aeoline environment. Basaltic sill is represented in the area as a cap rock over all the previous successions. (Al Shami, 2003).

III- METHODOLOGY

Seismic method demonstrates that, it is possible to discriminate litho-units, subsurface geologic structures and different competence parameters as well. It is an approach for investigating the geologic structures of the earth's crust, based on the study of the propagation of elastic waves caused by an explosion and detectors placed in a straight line. The elastic waves caused by an impact are propagated in all directions from the point of shooting and penetrate into the crust to great depths, where they are reflected and refracted at the interfaces between the layers of rock. After reflection or refraction within the earth, the waves return back to all surfaces, where they are detected by geophones at specific distances. Determination of the travel times and distances between the source and receivers help in velocity calculations. It reflects the character of ground vibrations, the depth and shape and angle of the geologic bounders. The waves propagate with varying velocities in different geological strata (Al Shami, 2003). The contrasts between the layers velocities are large. The strata velocities increase with depth. The refraction method makes use of waves travelling parall to the boundaries between the layers, in the underlying more compacted layer, where the velocities are higher. The distances from the impact point (shot point) to the points, where the refracted waves are recorded (detecting points), as first arrivals are a function of the strata velocities and depths.

IV- FIELD SURVEYS

IV-1- Talet Selim area.

The previous geologic studies were indicated three structure liniments (F_1, F_2, & F_3) acting through the area. Two offend spreads (forward and reverse) were designed for this survey (Fig. 3). S1 forward and reverse offend spread was conducted with 6 m-distance in-between the geophones. It extends at N25°W, mainly coinciding with the main direction of the wadi cutting F_1 & F_2. It's length about 222m. S2, as a forward and reverse offend spread, was conducted with 3m in-between the geophones, and extends N50°E, mainly at right angle with the main direction of the area and with 95m length. This seismic line (S2) intersects the first one S1. Several shoots were applied at every position on both sides of the spread to enhance the signals to noise ratio. In addition, filters were applied, such as band path filter and knotch.

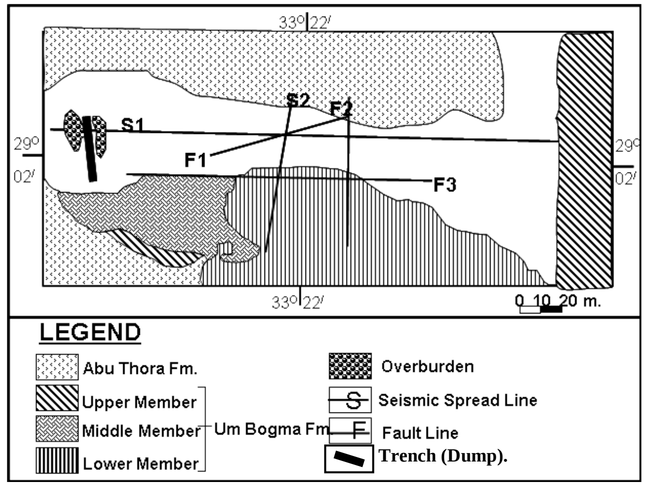

Fig. (3): The locations of seismic profiles in Talet Seliem area, Southwestern Sinai, Egypt.

The two seismic profiles S1 and S2 (Fig.4) revealed that, the first wadi deposits layer has an average velocity of about 550m/s, with a depth varies from 0 to 6m. While the second wadi deposits layer ranges in depth between 6m and 42m. The thickness of this layer increases towards the northern side; meanwhile it reaches its minimum at the western part of the area. The (23m) thickness is recorded at the other side of the shooting spread S1. The layer has a velocity range from 1500 to 1600 m/sec. This layer is interpreted geologically as cataclastic layer of interbedded beds of shale, clay, marl...etc. The third layer of sandstones has a velocity varies from 1900 to 2000m/sec., according to Nigm, et. al.,(2001).

IV-2- Wadi Nasib area.

The survey was conducted according to the results of the various geophysical studies such as the magnetic which reflect the directions of structure framework takes place along the area and vertical electric sounding which illustrated the variation of resistevity of different rock units as well as the previous topographic and geologic information. There are seven spread seismic lines. Three of them are perpendicular to Wadi-Nasib, while four seismic profiles traverse through the wadi, as shown in Fig. (5). The length of all spread seismic profile is about 400m, along 24 geophones, with distances in-between of about 15m, to cover a large area and to reach greater depth. About seven shots are located along every profile, two of them in the forward, two in the reverse and three in the central part of the profile (Fig. 5).

Many processing's steps were done to analyse the various velocities of the expected geoseismic layers. Besides, the depths of the various geoseismic layers,

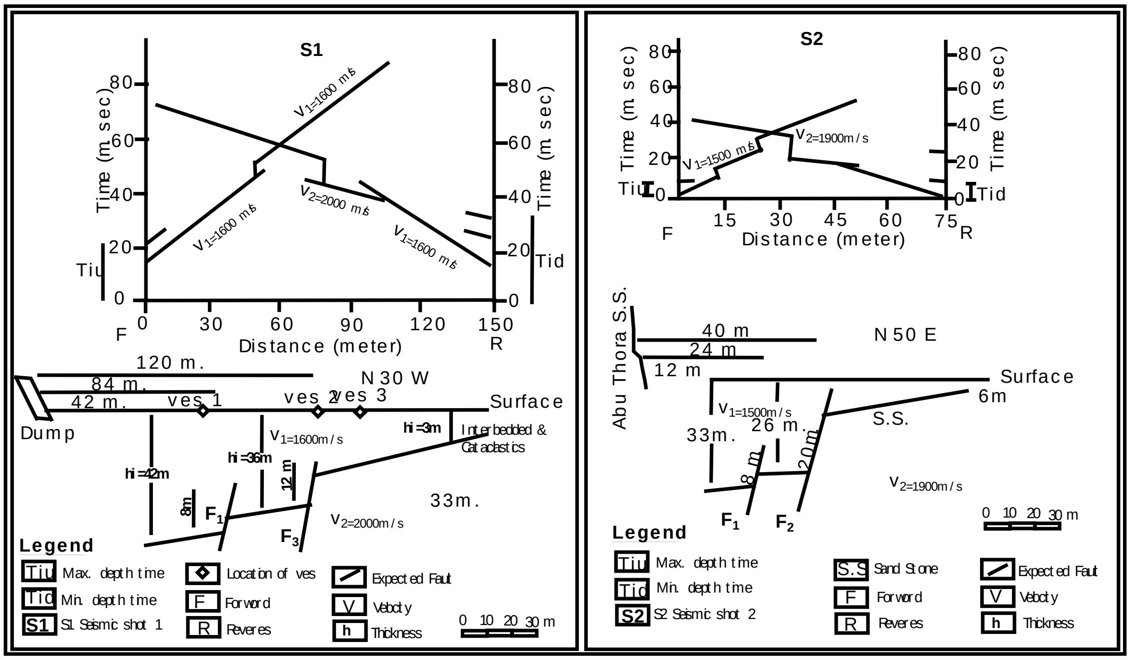

Fig.(4): Geo-seismic cross section in S1&S2 in Talet Seliem area, Southwestern Sinai, Egypt. (After Nigm, 2001).

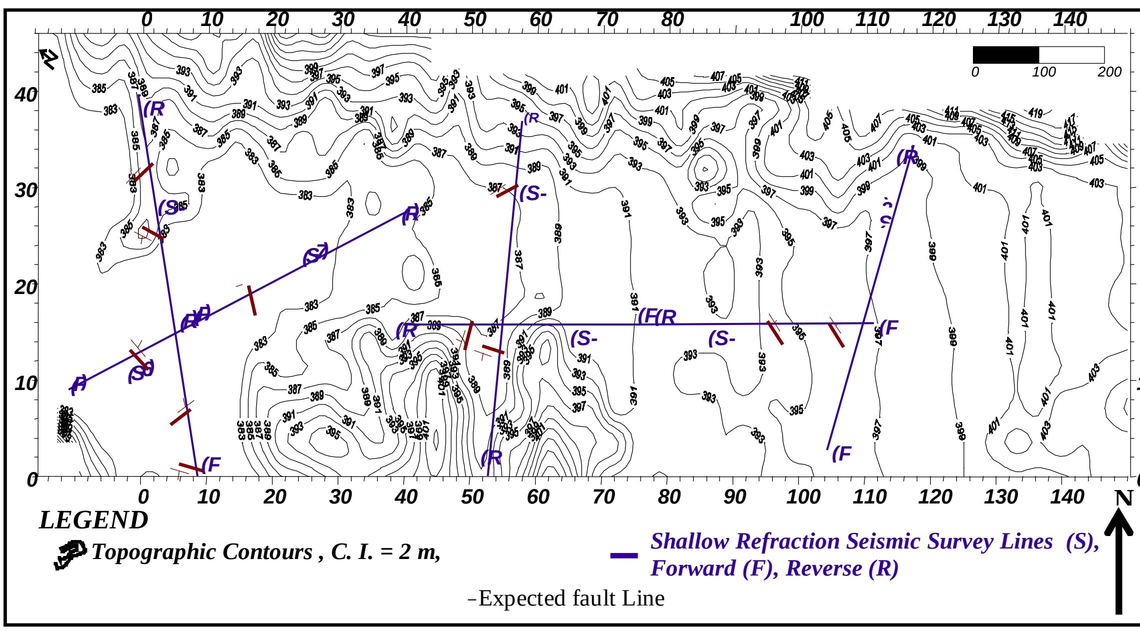

Fig. (5): Locations of seismic profiles at W.Nasib area, Southwestern Sinai, Egypt.

Table (1): Summarize the velocities, thicknesses and depths for the geoseismic layers of W. Nasib. (NMA, 2001).

Shoot No.	Layer 1	Layer 2	Layer 3	Layer 4
Thickness Range	3 To 10 m.	4 To 32 m.	23 To 49 m.	Um Bogma
Velocity Range	0.45 To 0.81 Km/s	1.6 To 2.3 Km/s	3.1 To 3.8 Km/s	4.1 To 4.9 Km/s
Depth Range	0 To 21 m.	-1To 16 m.	-50 To 8m.	-70 To –7 m.

according to their velocities and arrival times are calculated under every geophones at a fixed distance from the source (NMA, 2001).

After drawing the travel time-distance curves the different velocities are calculated from slopes of (T-D) relationships. The interpretation of the time- distance plots in Wadi Nasib area used a technique for delineating subsurface geologic successions and the prevailing structures. This technique named the generalized reciprocal method. Depth calculation utilizing the generalized reciprocal method (GRM) is not inherently ambiguous, because this method is not a function of the conditions occurred beneath the geophones. This work has been carried out to delineate the different geoseismic layers, from refraction seismic measurement as illustrated in table (1).

The main results and conclusion, arrived through the ground geophysical techniques of Wadi Nasib area are corroborated with the available geological information are summarized in the following:

The distribution of seismic velocities in the successive layers indicate the presence of wadi deposits (0.45–0.81 Km/s), compacted sandstone or upper pat of Abu Thora Fm. (1.6–2.3 Km/s), lower part of Abu Thora Fm. (3.1–3.8 Km/s) and Um Bogma Fm. (4.1–4.9 Km/s). The first geoseismic layer ranges in thickness between 3 and 10 m. The second one has a thickness varies from 4 to 32 m. The third layer ranges in thickness between 23 and 49 m. the average depths of the various layers ranging between 21 and 0 m., 16 and 1 m., 8 and –50m. and –7 and –70 m., respectively. Structurally, the mapped area is dominated by a number of faults trending in the N-S and E-W directions, which indicates good matching with the subsurface geological and geophysical information (NMA, 2001).

IV-3- Wadi Al Seih area.

Eighteen compressional (P-wave) seismic refraction profiles were conducted in Wadi Al Seih area. The distribution of Quaternary wadi deposits over a large portion of the central proposed site prohibits the conduction of any seismic work at the northern and southern parts of the study area. The profiles are ranging in length between 120 and 1080 meters. All the refraction-shooting layouts, such as end offset shoting, split shoting, and reversed shotings are represented by the obtained data. Each profile can, therefore, be interpreted using more than one inversion technique (Yosef, 2006).

Layouts of 24-geophones on the seismic spreads illustrate inter-geophone spacings ranging between 5 and 15 meters, while the distance between the shot and the first geophone spacing is half the geophone spacing used in the present study.

The section of this area has five layers; first layer has a compressional wave velocity of 650 meter/second and a thickness of less than 4m. This layer is considered as un-consolidated wadi deposits. The second layer has a compressional wave velocity varying from 1400 to 1600 meter/second and a thickness ranges between 8 and 10 m. This layer is considered as consolidated wadi deposits. The third layer has a compressional wave velocity varying from 2800 to 3200 meter/second and a thickness reached to 35 m in the eastern part and attauned 25m in the western part. This layer is considered as Abu Thora Formation, which is divided recently from top to bottom into Abu Zarab Formation, Magaret El Maiah Formation and El Hashash Formation and is composed mainly of sandstone. The fourth layer has a compressional wave velocity ranges between 4500 and 5000 meter/second with a thickness of 18 to 20 m. This layer is considered as Um Bogma Formation the main target of this study, which is composted mainly of compacted dolostone intercalated with marl and siltstone. The depth of Um Bogma Formation increases in the eastern direction to attain 64 m and decreases in western direction to reach 54 m. The last layer has a compressional wave velocity of more than 5000 meter/second and the depth of this layer is more than 64m.

IV-4- Dabit El Qerie area.

The survey was conducted in order to locate the upper boundary of Um Bogma Formation and to determine its seismic velocity. Twenty-four geophones of 5 m interval and 9 shots were established in every profile. The profiles were pre-selected according to the results of magnetic survey and were taken in the parts of low relief. About 16 seismic profiles were surveyed, as shown in Figure (6), with length varying from 120 to 240m, to cover all the area.

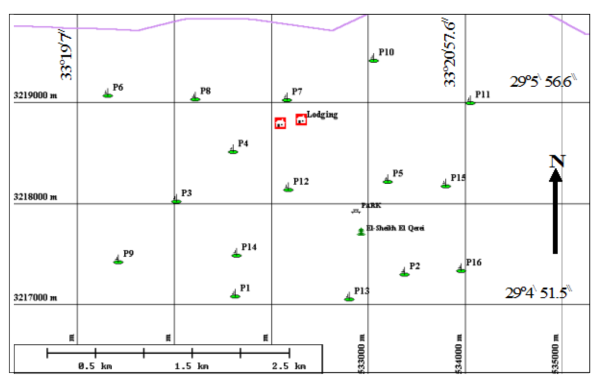

Fig. (6): Locations of seismic profiles at Dabit El Qerei area, Southwestern Sinai, Egypt.

Area	X (UTM)	Y (UTM)	wd	cwd	ath	umb	ada	l1	L2	l3
T.S	535701.97	3211734.12	550.0	1500.00	2000.00	*	*	2.00	28.00	30.00
W.N	537318.81	3213585.83	500.0	1800.00	2300.00	3300.00	4100.00	5.00	20.00	25.00
W.S	536096.07	3215428.50	600.0	1500.00	2500.00	3200.00	4700.00	10.00	27.00	19.00
D.Q	532500.00	3217500.00	500.0	1300.00	2000.00	3200.00	3500.00	2.00	18.00	25.00

T.S	Talet Seliem	W.N	Wadi Nasib	W.S	W.El Seieh	D.Q	Dabit El Qerie
wd	Wadi Deposits	cwd	Compact W. Dep.	ath	Abu Thora	umb	Um Bogma
ada	Adadia	l1	layer 1 Thickness	l2	layer 2 Thickness	l3	layer 3 Thickness

According to the interpretation of the seismic refraction survey, the upper boundary of Um Bogma Formation was obtained in some localities with velocity that, eccede 3000 m/sec (which could be related to the dolostone) that may have the ability to be mineral potentialities and in other case that less than 3000 m/sec, which could be related to claystone and silty dolostone (Amin, 2005).

V- GEOSEISMIC INTERPRETATION

Three different refracting interfaces can be identified in the area of study. These refractors are interpreted from top to bottom as Mid-Quaternary deposits, top Abu Thora Formation, and top Um Bogma Formations, respectively. In some profiles, the upper boundary of the Lower Sandstone Series can be detected. This is because Um Bogma Formation is not too thick and the velocity contrast is high. As illustrated in the next table, the average velocities of these rock units are as follow:- The Quaternary deposits have seismic velocity of 500m/s, Abu Thora Formation has average seismic velocity of 1300m/s, the velocity of Um Bogma Formation is 2000-3300m/s and the average velocity of the Lower Sandstone Series is 3500m/s.

Fig. (7) shows the velocity distribution of the first layer of wadi deposits across the area. The velocity varies from 550m/s at Talet Selim to 490m/s at W. Nasib to 590m at wadi El Seih and 510m at Dabit El Qerie area. These differences indicate that, the sediments in the Wadi Deposits are more looser at Talet seliem than the sediments in Wadi El Seih that has the highest velocity of the Wadi Deposits layer.

The distribution of the velocity of the second layer (Fig. 8) exhibits the increase of compaction towards the eastern side of the mapped area especially at Wadi Nasib, which reveals more velocity of this formation (about 1850 m/s).

The velocity map of the third rock unit of Abu Thora Formation, (Fig. 9), reflects that, the velocity ranges between 2000 and 2400m/s. The high velocity located at El Seih area means that, this formation is compacted higher than the other areas.

The mapped velocity in Fig.(10) shows that, the fourth rock unit Um Bogma Formation has the highest velocity at Wadi Nasib area at the central eastern part of the study area, while Dabit El Qerei area which is located at the western corner of the under area indicated the lowest velocity in the area. Meanwhile, the Talet Seliem does not cover by the seismic data.

The last velocity map of Adadia Formation (Fig. 11) reflects that, the highest velocity is concentrated at the central part of the mapped area at Wadi El Seih, which indicates highly compacted Adadia Formation. While, Wadi Nasib reveals moderate velocity. On the other hand, Dabit El Qerei area exhibits the lowest velocity than the other two parts.

The next three maps (Figs. 12, 13 & 14) show the thickness variations of the first three layers. as follow:

The first map (Fig. 12) indicates that, the thickness of the first layer is ranging between 2.5 to 9.5m in which the maximum thickness is located at Wadi El Seih area and the minimum thickness at Dabit El Qerei area (Fig.13) reflects the Compact.

The thickness of Abu Thora Formation is about 28m at Talet Seliem and 19m at Debit El Qerei and Wadi Nasib locations (Fig.14). The third layer has a maximum thickness at Talet Seliem area of about 29m, while such thickness decreases toward the northeastern corner of the mapped area reaching to about 17m at Wadi El Seih area.

Figure (15) shows the interpreted geoseismic cross-section of the various studied areas. The x axis reflects the elevation of the surface and subsurface by meter, while the Y axis shows the surface distance.

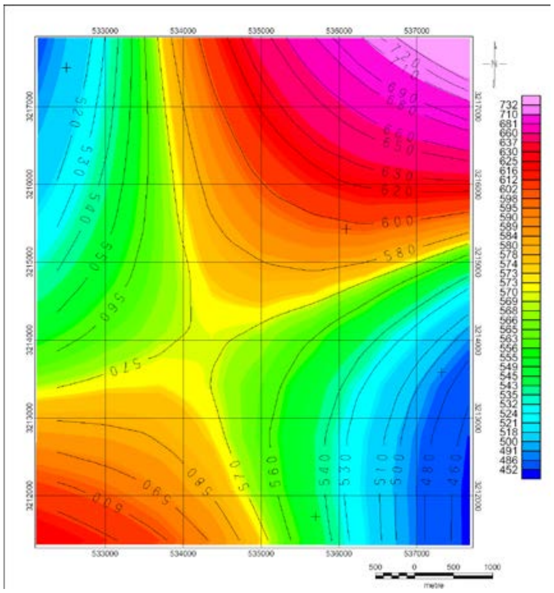

Fig. (7):Lateral velocity distribution of the surface wadi deposits.

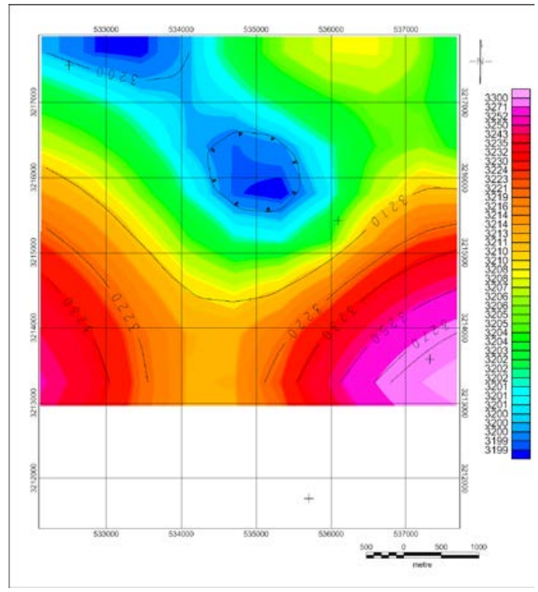

Fig. (9):Lateral velocity distribution of Abu Thora Fm.

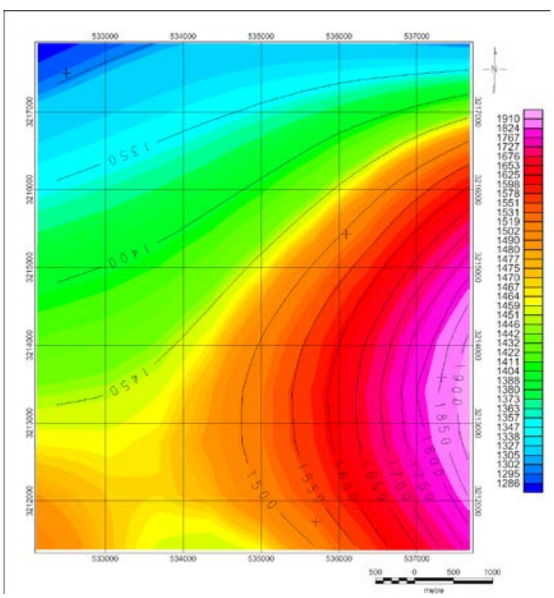

Fig. (8):Lateral velocity distribution, of the compacted wadi deposits.

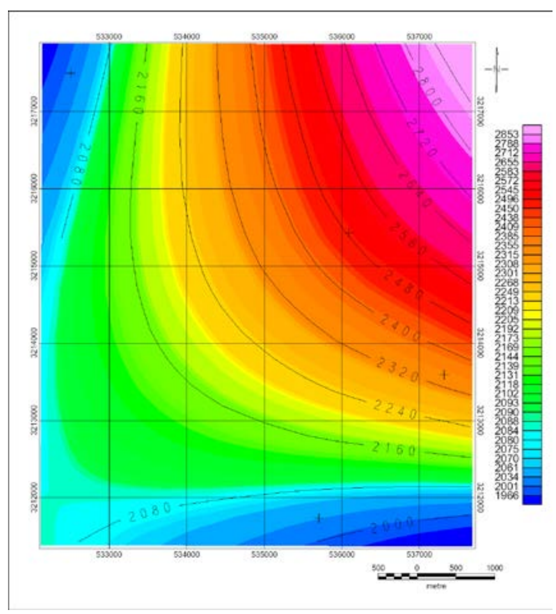

Fig. (10):Lateral velocity distribution of Um Bogma Fm.

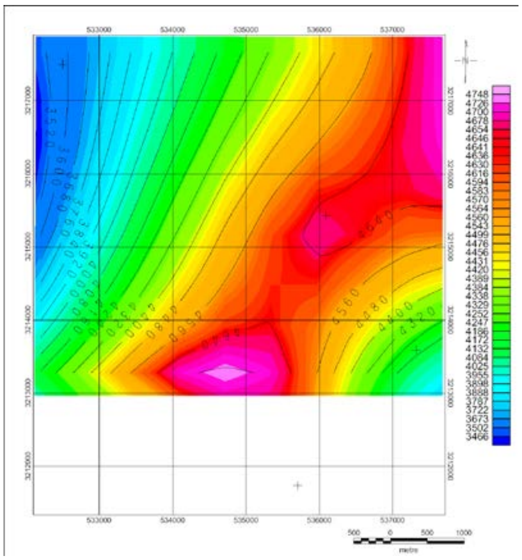

Fig. (11):Lateral velocity distribution of Adadia Fm.

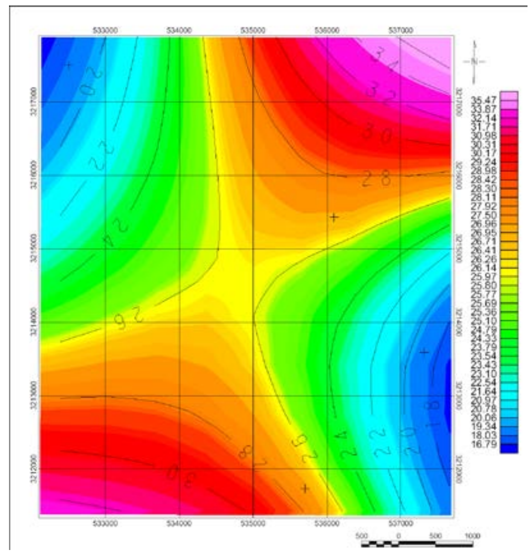

Fig. (13):Lateral thickness distribution of compacted wadi deposits.

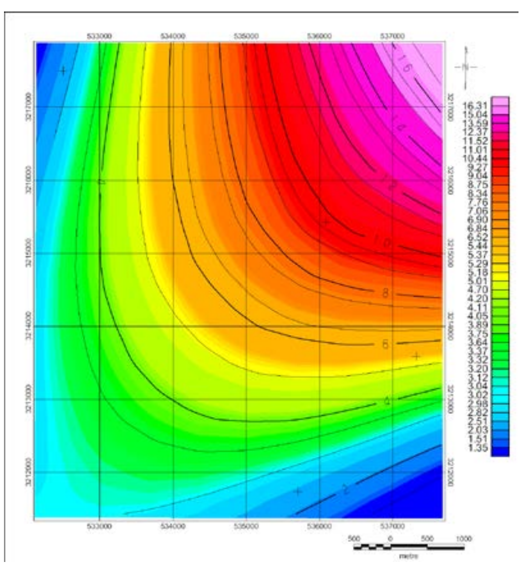

Fig. (12):Lateral thickness distribution of wadi deposits.

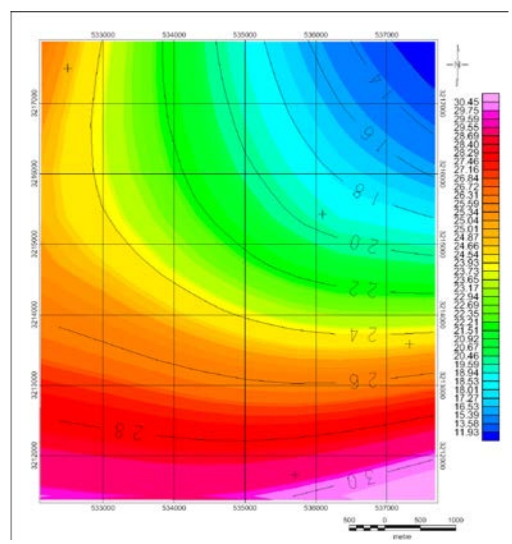

Fig. (14):Lateral thickness distribution of Abu Thora Fm.

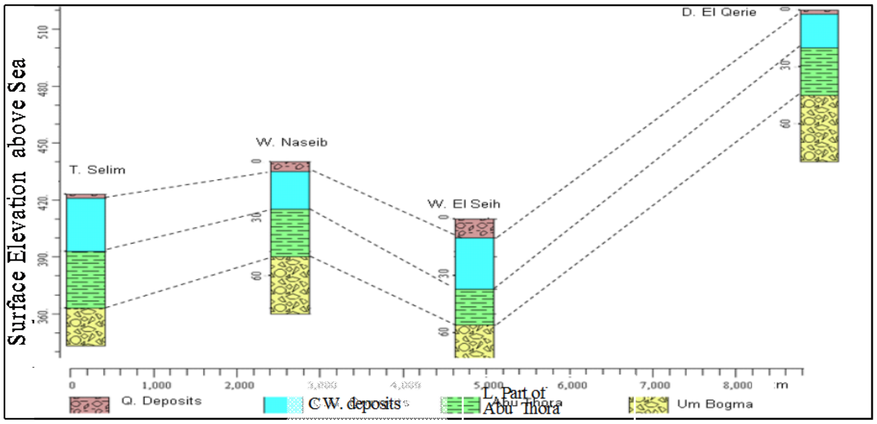

Fig. (15):Interpreted geoseismic cross-section through the studied areas, Southwestern Sinai, Egypt.

The correlation among the studied areas indicate that, the Wadi Deposits vary from one meter to about 10 meter, followed by the Compacted Wadi Deposits or (the upper part of Abu Thora Fm.) with a thickness ranging between 18 and 26m. The third layer covers the lower part of Abu Thora, which varies in thickness from 19 to 30 m. Um Bogma Fm. that located under the aforementioned succession, is shown in Fig. (15). It is found at about 60 m from the surface of the investigated areas.

CONCLUSION

Shallow seismic refraction method is considere as a powerful tool for geophysical shallow mineral, lithological and structural explorations. The integration among the shallow seismic refraction studies across Talet Seliem, Wadi Nasib, Dabit El Qerie and Wadi El Seieh areas led to the deduction of five seismic velocities starting by 500m/s, that is mainly related to Wadi Deposits, about 1500m/s associated with Compacted Wadi deposits or the upper part of Abu Thora Formation. The lower part of Abu Thora Formation is closely related to 2000-2500m/s. On the other hand, Um Bogma Formation (Mineralized horizon) has a seismic velocity varies from 3200 to 300m/s. Finally, the Adadia Formation seismic velocity is more than 4700m/s. The interpreted geosismic cross-section indicates the lateral extension of the studied areas to about 8000m, starting from Talet Seliem to Dabit El Qerie, while the surface elevation from the sea level is ranging from 410m at Wadi El Seieh, to 520m at Dabit El Qerie. The author believes that, the Compacted Wadi Deposits velocity may be considered as the Upper part of Abu Thora Formation. The thickness of the first layer (Wadi Deposits) from 2 to 10m, the Compacted Wadi deposits or upper part of Abu Thora Formation is varied from 18 to 28m and the Lower part of Abu Thora Formation has a thickness ranging between 19 and 30m. So the depth of the top surface of Um Bogma Formation is located between 45 and 56m.

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CONSTRUCTION OF STRUCTURAL AND BASEMENT TECTONIC FRAMEWORK OF DABBET EL QERAI AREA, SOUTHWESTERN SINAI, EGYPT, USING GROUND MAGNETIC DATA

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بناء الوضع التركيبي وتكتونية القاعدة لمنطقة دبة القرى جنوب غرب سيناء – مصر بإستخدام بيانات المغناطيسية الأرضية

الخلاصة: تغطى منطقة الدراسة حوالى ١٦كم٢ وتقع بين خطى عرض ٤/ ٢٩° إلى ٧ / ٢٩° شمالا، وخطى طول ١٧/ ٣٣° إلى ٢٢/ ٣٣° شرقا وتتعامل الدراسة مع بيانات المسح المغناطيسى الأرضى لمنطقة دبة القرى جنوب غرب سيناء – مصر. تتابع المسح المغناطيسى وأوضح شكل التركيب المغناطيسى الضحل والعميق وشكل صخور القاعدة ونوع الحركات التكتونية التى أثرت على منطقة الدراسة وتم تصحيح بيانات المسح المغناطيسى الأرضى المأخوذة ورسم الخرائط المغناطيسية للمركبة الكلية للمجال المغناطيسى باستخدام تقنية التحليل الترددى وذلك لتلاشى تأثير المغناطيسية المتبقية والتى تعمل على تغمية الشاذات المغناطيسية المختلفة. كما تم إستخدام تقنية معامل التحليل الطيفى لتحديد النطاقات بين المركبات المغناطيسية الضحلة عند عمق ٦٠ مترا والعميقة عند عمق ١٥٠ مترا . و أدى التكامل بين كل الخرائط المستنتجة وتفسيرها إلى إنشاء خريطة الحركات التكتونية التى أثرت على منطقة الدراسة، وأظهرت وجود ثلاثة نطاقات تمتد فى إتجاه شرق شمال شرق: النطاق الأول والذى يقع فى الشمال الغربى للمنطقة الممسوحة و يعتبر ككتلة مرميه إلى أسفل، والجزء الأكبر والذى يحتل المنطقة الوسطى يمثل رميه عليا ويظهر الشاذات ذات المجال المغناطيسى الضحل. فى حين أن النطاق الثالث والذى يمثل الجزء الجنوبى الشرقى للمنطقة يمثل رمية سفلية تظهر مجالاً مغناطيسياً عميقاً. وقد تم إختيار ثلاث بروفيلات لعمل النمذجة التحتسطحية وعكست هذه البروفيلات شكل وعمق الطبقات الرسوبية بداية من الحقبة الرابعة (الرملية) وحتى الصخور القاعدية، مؤكدة بنتائج المسح الجيوكهربى والجيوسيزمي.

ABSTRACT: *The investigation site covers an area of about 16 km^2 between Latitudes 29^0 4$'$ & 29^0 7$'$N and Longitudes 33^0 17$'$& 33^0 22$'$E. This study deals with the ground magnetic survey data of Dabbet El Qerai area, southwestern Sinai, Egypt. A systematic magnetic survey was conducted to estimate the shallow and deep magnetic structures as well as the basement relief, and to determine the tectonic framework that takes-place through out the studied area. The collected magnetic data was corrected and mapped as a total magnetic intensity field (TMI) map. Analytical signal technique was applied to remove the effects of remnant magnetization which acts as a mask for the different magnetic anomalies, The radially power spectral technique was applied to delineate the effective bands that were conducted to assist discrimination between the shallow near surface (residual at average depth of about 60 m) and deep seated (regional at average depth of about 150 m) anomalies. Consequently, all these maps were combined and interpreted in terms of the basement structural framework of the area. The area of Dabbet El Qerai proved to be composed of three major tectonic zones all of which are oriented in the ENE direction. The first zone is located at the northwestern side of the studied area as downthrown blocks, a huge part occupying the central part of the area is inform of an uplifted basement which is associated with shallow magnetic anomalies, while the third zone is located at the southern part of the area, shown as downthrown blocks. Three magnetic profiles were used for modeling in the area; these profiles reflect the shape and depth of the sedimentary section from Quaternary sands, to the basement bed rock, confirming the previous geoelectric and shallow seismic investigation results.*

INTRODUCTION

Previous geologic studies indicate that the area under investigation includes some basaltic flows that spread in the central part. This basaltic flow is associated with remnant magnetic field which covers the whole sedimentary succession.

The total magnetic field of this area has been previously reduced to the magnetic pole (RTP) and separated into regional and residual magnetic components (Amin, 2005). The result of such treatment could reveal the existence of remnant magnetic field which distorted the results. Therefore the author tried to treat the original data by the analytical signal technique which does not assume the absence of remnant magnetization.

The discovery of uranium mineralization in the Paleozoic sedimentary rocks at southwestern Sinai area increases the economic potential and future development of this area Fig. 1. It is known that the Paleozoic sedimentary rocks in southwestern Sinai overlie unconformably the basement rocks with undulated surfaces. They are separated from the Pre-Cenomanian rocks in many localities by basaltic sheet. These sedimentary rocks are exposed mainly in Um Bogma area and its surroundings, EGSMA (1994).

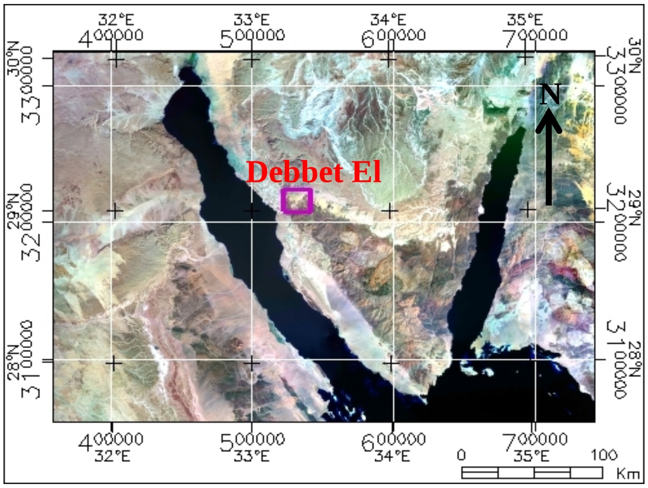

Fig. (1): Location map of Debbet El Qerai area, south-western Sinai, Egypt. (After GLCF 2004)

Geological outline of Dabbet El Qerai area

The area can easily be classified as Precambrian basement rocks and sedimentary cover started from Cambro-Ordovician to Permo-Triassic and Recent deposits (Kora, 1984) as shown in table 1**.**

Figure 2 reflects the surface geology of Debbet El Qerai area, which is covered mainly by Quaternary deposits represented by lose sand and the rest of the area covered by Abu Thora fm. formed from sandstone rocks, with a very small spots of basaltic flows that overlies the Abu Thora formation.

Magnetic survey

The survey was carried in order to locate any magnetic ore body that could be associated within the Um Bogma Formation and to determine the depth, shape, and the surface of the basement beneath Debbet El Qerai area.

A Proton-precession magnetometer was used in the survey that generates a measurement of the total magnetic field intensity. This magnetometer is a sensitive instrument (0.05nT), used to map spatial variations in the Earth's magnetic field.

The survey was conducted for the study area in a grid pattern perpendicular to the expected structure found in the area with station interval of 20 m and line interval of 80m parallel to the north-south direction. Another fixed PMG-1 was set on Auto mode in order to measure the total magnetic intensity field every 30 second as a base station in order to correct for the diurnal variation.

Table (1): General lithostratigraphy of the Paleozoic succession in Um Bogma area, southwestern Sinai, after Kora (1984).

Age	Formation	Lithology	Environment
Permo-Triassic	Qiseb	Red beds: sandstone and mudstone	Fluviatille
	Basalt	Basaltic sill and lava flows	
Carboniferous	Abu Thora	Glass sand member Kaolinitic claystone member	Fluviatille, swamp to Coastal marine
	Um Bogma	Sandy dolostone Marly dolostone Pink dolostone (Mn-Fe ore)	Shallow open marine
Cambro-Ordovician	Adadia	Cross bedded sandstone	Fluviatille
	Nasib	Thin bedded silty sandstone	Intertidal- deltaic
	Abu Hamata	Shale and siltstone	Shallow marine
	Sarabit El Khadim	Pebbly sandstone	Intertidal- Fluviatile
Precambrian Basement		Igneous and metamorphic rocks	

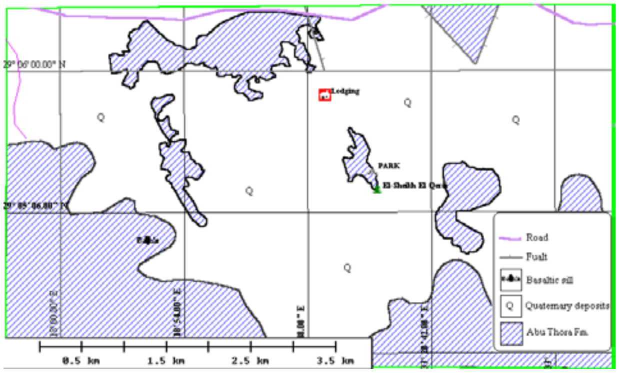

Fig. (2): Geologic map of Debbet El Qerai area, southwest Sinai, modified from EGSMA (1994).

Magnetic Interpretation

After applying all corrections related to the ground magnetic survey the total magnetic intensity contour map was drawn as shown in Fig. 3.

The previous geologic information indicated that the area under investigation includes a basaltic flow covering Abu Thora Formation, therefore the RTP map is not considered a good tool because the possibility of existence of the remnant magnetization that could mask the magnetic anomalies and distort the real magnetic source reading. The best filter in this case is the analytical signal technique which could be considered the best tool for this purpose because it dose not depend on the inclination, declination and magnetization polarity. The analytical signal map shown in figure 4 reflects the area that can be easily divided into three zones according to the magnetic character. It also shows fluctuation of positive and negative magnetic sources which indicate that the belt is affected by the basaltic flow.

The analytical signal technique is affected mainly by the magnetic source independent of being negative or positive amplitude. As well as the anomalies are located directly over the magnetic source reading especially in the low latitudes areas. The value of the analytical signal is defined as the square root of the square sum of the vertical and the two horizontal derivatives of the magnetic field (Macleod et al. 2000).

The power spectrum of an anomaly is calculated for the mean value of the Fourier transformation (Cianciara and Marcak, 1977) by averaging over circle and an anticipated spectrum value is determined. The plotted two dimensional power spectrum curve is shown in figure 5. The log amplitude against the frequency in cycle/km, shows the major contribution of the magnetic anomalies as coming from two sets of sources at two interfaces. The white noise is coming from wave number higher than log A0=0 cycle/meter. The first segment lies at low frequency (long wave length regional), with steep slope in power at wave number range from 0 to 0.65 c/km coming from sources which are deep with estimated depth as H1= 150 m. The second segment is located at wave number (short wave length "residual") ranges from 0.65 to 2.65 c/km which is due to relative shallow sources with estimated depth at H2 = 60 m (Fig. 5).

Qualitative Interpretation of Magnetic Data

Analytical signal, Regional, and Residual magnetic maps Figs. 5, 6 & 7 reflect that Dabbet El Qerei area is a composed of three major zones (A, B and C) of ENE direction as shown in figure 8.

The first zone (A): is located at the northwestern part of the area of Debbet El Qerai north of fault F_8 and extends from the center of the western part and ending in the upper east corner of the studied area. It has a broad contour shape that reflects low frequency that can be interpreted as basement than the adjacent zone (B) to its south. This zone (A) can be easily considered as a downthrown block of a major fault (F_1) that intersects the area in the ENE - WSW direction.

The second zone (B): is located at the central part of the studied area trending from the southwestern part towards the middle of the eastern part. This zone is bounded by a system of faults that made it as an up-thrown block from the other two northern and southern zones of downthrown nature since it is magnetically of higher frequency than its adjacent zone (A) and zone (C). It is also intersected by a system of northerly oriented faults that trends toward NW and NNE, thus creating uplifted and downthrown blocks across the three zones of the studied area.

This part; zone (B); includes a great number of high frequency magnetic anomalies in comparison with the other two parts as shown in Figs. 6 & 7. These high frequency anomalies of alternating positive and negative amplitudes are interpreted to be due to intra-sedimentary intrusive body within Abu Thora Formation. It is to be noted that these high frequency magnetic anomalies are limited to zone (B) of uplifted nature Fig. 8.

The third Zone (C): occupies a small part at the southeastern corner of the studied area. This zone reflects low gradient and broad contour lines with relatively low intensity with the adjacent zone (B). In addition, it can be considered as a downthrown block of the bounded fault system that separates it from zone (B). It has low frequencies in the residual component map and the value of the negative contour lines increases towards the southeast direction.

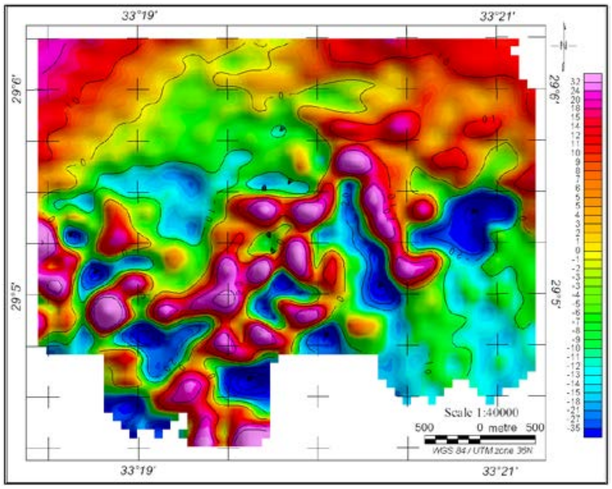

Fig. (3): Colored contour map of total intensity magnetic field of Debbet El Qerai area, southwestern Sinai

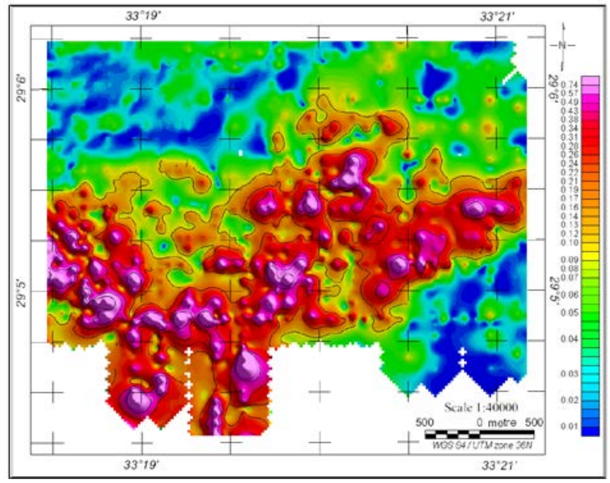

Fig. (4): Colored contour map of Anylatical signal of Debbet El Qerai area, southwestern Sinai.

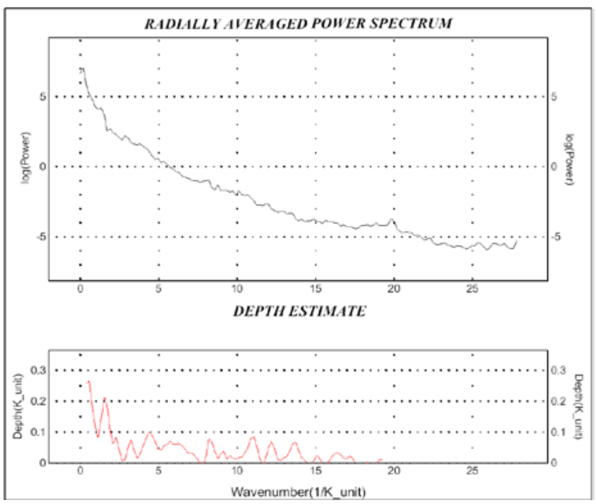

Fig. (5): Power spectrum curve and the estimated depth of the magnetic components in Debbet El Qerai area, southwestern Sinai.

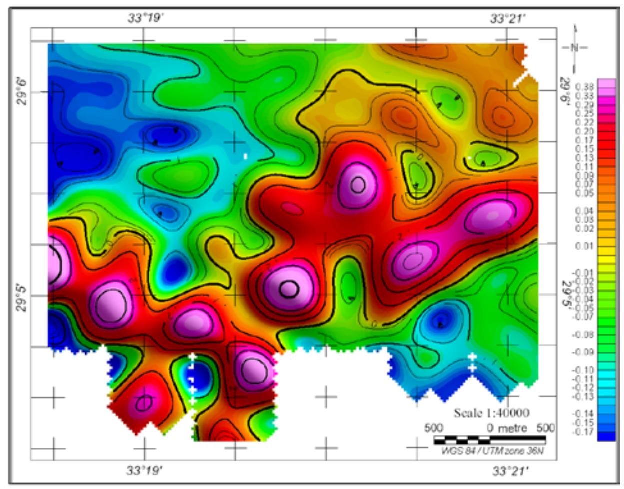

Fig. (6): Colored contour map of regional magnetic component map of Debbet El Qerai area, southwestern Sinai.

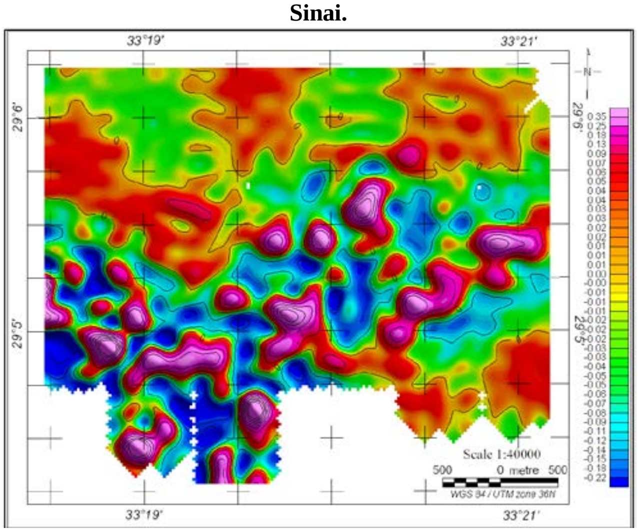

Fig.(7): Colored contour map of residual magnetic component map of Debbet El Qerai area, southwestern Sinai.

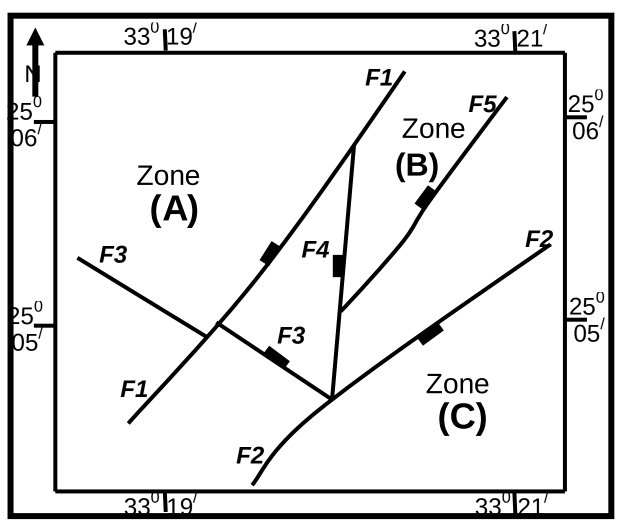

Fig.(8): Interpreted magnetic basement tectonic map of Debbet El Qerai area, southwestern Sinai.

This zone is bounded from the SE by a series of NE trending faults; F_{11} and F_{12}; with downthrown nature to the SE.

Close examination of the Analytical signal, regional and residual magnetic maps, Figs. 4, 6 & 7, shows different magnetic anomalies that vary in amplitude and frequency. These variations can be interpreted as differences in structure or composition of the magnetic source of these anomalies. As mentioned before, zone (B) suggests a shallow source for them and hence is thought to be due to intrusive bodies within the sedimentary section of Abu Thora Formation. The magnetic anomalies associated with the Analytical signal and regional maps, Figs. 4 & 7, with different zones A, and C suggest the association of these anomalies with another source other than that associated with zone (B) of the residual magnetic map Fig. 6 and is definitely of relatively deeper source. Accordingly, it is logic to assume that such broad magnetic anomalies in the NW and NE corner of the area as shown in analytical signal and regional maps, Figs. 4 & 7, are associated with the down fault of basement rocks in the studied area Fig. 8. Such anomalies do reflect variations in the composition as well as the structure of the basement rocks, and in particular the depth to its top. The variation in depth to the top of the different basement blocks is directly related to faulting.

Both the Analytical signal and regional magnetic maps, Figs. 4 & 7, show the interpreted boundaries separating zone A, B and C, Fig. 8, are of structural origin. It is very evident that the magnetic character north of the boundary separating zones (A and B); F_1; is definitely and completely different from that mapped within zone (B), south of it. The same phenomenon at the boundary separating zones (B) and (C) especially at the SE corner of the studied area (F_2), is mapped in Fig. 8. The orientation of these two major boundaries (F_1, F_2) separating zones (A) and (B) in the north and zone (B) and (C) in the south, Fig. 8, suggests a Late Cretaceous age for such structural elements. Simply because the ENE orientation of structural elements is very characteristic to the Syrian Arc system of Late Cretaceous age, which is very well expressed in the subsurface of the Western Desert of Egypt and on the surface of North Sinai.

Analytical signal and regional magnetic maps, Figs. 4 & 7, show readily another set of fault system of northerly direction. Fault F_3 is trending in NW direction Fig. 8, (Suez trend), some others are of NNE Aqaba trend (F_4, F_3 & F_5). These faults were mapped using the different rules and signatures of mapping faults from magnetic data. Some of these rules used in mapping this set of northerly oriented faults are listed below:

1- At contacts between two different frequencies.

2- At contact between two different magnetic gradients; steep and gentle gradients; which reflect the shallower and deeper blocks respectively.

3- Sharp bends in magnetic contour lines, especially if it is 90^o range.

4- Difference in magnetic intensity along a contact or line.

5- Relative positioning of similar magnetic anomalies in size and amplitude suggest a fault with horizontal displacement only rather than vertical displacement as F_7.

The northerly oriented mapped faults F_4 & F_5, Fig. 8 are more expressed in zone (B) rather than zones (A) and (C). This may be related to the fact that source of magnetic anomalies is shallower in zone (B) as compared with the other two zones (A) and (C). A major Fault of NW (F_3) and another set of ENE trending faults F_1 and F_2, Fig. 8, were also mapped using a fore mentioned rules. The different signs of relative vertical or horizontal displacement are expressed on this fault (F_3), as deduced from the relative difference in magnetic character along such faults, using the above-mentioned rules.

It is to be noted that the set of northerly oriented faults F_4: F_5, Fig. 8, is suggested to be of Oligo-Miocene age since they represent and are parallel to the two complementary shear fractures; the Suez and Aqaba fault trends of typical Oligo-Miocene age. Moreover, it is to be noted that the relative frequency of magnetic anomalies associated with interpreted basement blocks reflects the relative depth to its surface as for example the magnetic anomalies associated with uplifted basement block east of the interpreted fault F_3 that seems to be shallower than the uplifted basement block east of the interpreted basement fault F_2.

Magnetic Models

Three modeled profiles were designed to cover the various magnetic zones as mentioned in Fig 9, to determine the depth, structure and extended basement rocks. They are selected across the position of vertical electric sounding points. This integration between the magnetic and vertical electrical sounding helps to determine the sedimentary succession over the basement rocks. The information of the sedimentary layers was taken from the VESs such as depth and extension, while the matching between the observed and calculated magnetic curves can reflect the surface of the basement rocks beside the structure that takes place across the position of the different VES's and their elevation above the sea level, as well as the depth for the various sedimentary layers.

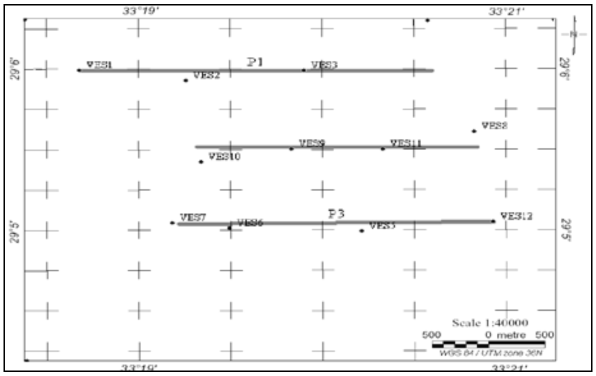

Fig. (9): selected three magnetic models map of Debbet El Qerai area, southwestern Sinai.

The first model located in the northern portion of the mapped area in E-W direction passing across VES 1, 2, 3 and 4 as shown in Fig. 10. This model was associated with zone (A). It reflects the occurrence of basement rock which has a magnetic susceptibility about $5*10^{-5}$ as mentioned from the previous geologic study that granite rocks which have magnetic susceptibility varying between 10^{-3} and 10^{-5} k/s. Otherwise, the sedimentary cover has a non magnetic susceptibility against the basement rocks. The thickness of sedimentary cover was derived from the analysis of the VES's (according to apparent resistivity) which could easily differentiate between the sedimentary cover and the basement rocks. This sedimentary cover extends to about 160 m. the surface of the basement as shown in model 1 Fig. 10 shows that the variation in depth is ranging from 390 to 360 m (about 30 m.) with a gentle slope from the west to east in the direction of the gulf of Suez and Red sea. There is a good agreement between the results of VES's and magnetic model Fig. 10 to determine the surface relief of the basement rocks.

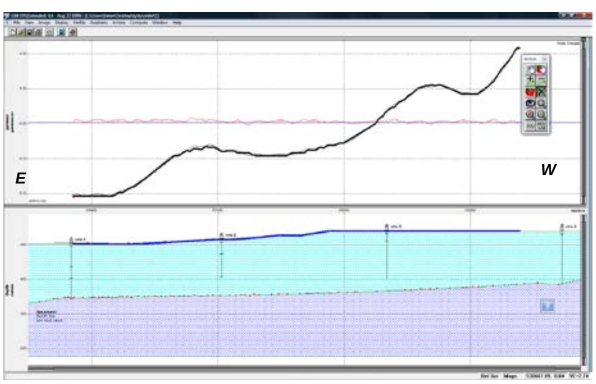

Fig. (10): Shows the first Magnetic model and the interpreted sedimentary formation and basement surface

The second model reflects the intersection of the VES's 10, 9, 11 and 12 as shown in Fig. 11 and is passing in the central part of the studied area (zone B). The topographic profile passing through this model is varying from 480 to about 490 m above sea level. The basement surface under this model shows two relatively high peaks reaching about 100m from the ground surface of the area, while the maximum depth reaches about 150m from the topographic relief. This model reflects the occurrence of some basaltic sheet and also the presence of basaltic neck under the highly magnetic peak. This basaltic rocks has a magnetic susceptibility that reach about $2000*10^{-5}$. It spreads between the sedimentary layer in the lenses form extend laterally in the east west direction and varying in thickness from 1 to 10 m. The third model in the southern part of zone (B) as mentioned from figure 9. It reflects two peaks the first one reaches about 0.5 gammas, while the other reaches about 0.2 gammas.

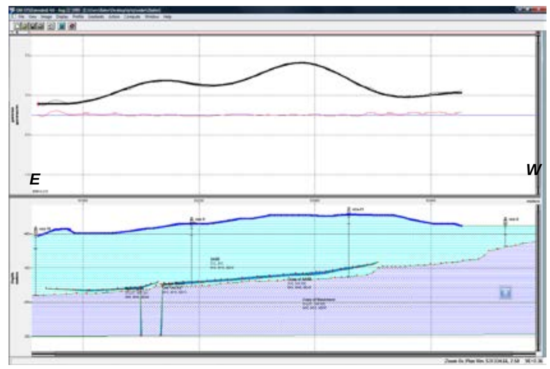

Fig. (11): Shows the second Magnetic model and the interpreted sedimentary formation and basement surface

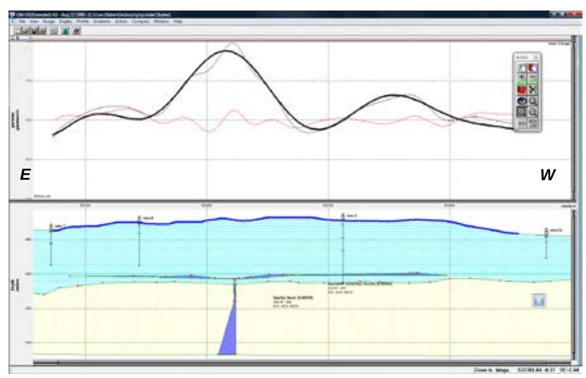

Fig. (12): Shows the third Magnetic model and the interpreted sedimentary formation and basement surface

The first magnetic peak reflects the basaltic neck and the basaltic flow, beside the surface of the basement rocks which lie under the sedimentary succession at depth of about 150 and 160m, which is mainly matched with the VES's interpretation. This variation may be structurally controlled or due to the difference in the basement relief under this profile.

The examination of the three models passing through the area indicates the depth of the basement rocks relief that rang between 120 to 160 m under the ground surface.

There is a good agreement between the magnetic model and the VES's results according to (Amin, 2005). Also it gives a good idea about the basalt sills which are located at the central part of the studied area and mainly associated with the zone B as shown in the all magnetic maps.

CONCLUSION

The magnetic tool is considered to be a powerful tool to determine the basement rocks composition and depth which is covered by a sedimentary succession that include the various rock types especially Um Bogma Formation. The analytical signal technique is considered the best filter method to discover the causative magnetic bodies regard less of the inclination, declination or magnetic polarity. So it is the suitable tool to discover the remnant magnetic rocks (Basaltic flow) which is located in the central portion of the area under investigation. The study shows that the area can be easily divided into three magnetic zones. The NW and SE belts are similar in behavior; while the central belt is varying in magnetic character than the previous belts. The structure framework took place across the area reflects the effect of the ENE, NW and NNE trends acting as the most prevailing direction cutting the area under study. Three magnetic models were constructed to indicate the subsurface configuration through the integration between the regional magnetic component and the results of previous VES,s in the area. The top surface of the basement rocks was tilted toward the Gulf of Suez. The depth to the basement surface varies from 120 to 160m. from the ground surface. The close examination of the three magnetic models passing through the area reflect that the basement rocks in the central profile is shallower than the other two profiles. The two models (2 & 3) indicate the effect of many basaltic necks beside occurrence of basaltic flow or basaltic lenses.

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