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APPLICATION OF 2D HOMOGENEOUS FUNCTION METHOD TO STUDY THE SUBSURFACE GEOLOGIC SECTION IN THE NORTHWESTERN PART OF THE KHARGA OASIS AREA, WESTERN DESERT, EGYPT.

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The present study represents an application of 2D homogeneous function method to investigate the subsurface geologic section and detect depth and thickness of Nubia aquifer in the northwestern part of El-Kharga Oasis area. A simple inversion of refraction travel times (GOOGRAF software) is used for the automatic determination of 2D velocity field models, and interface structures of the subsurface geologic section in the study area. In this method the homogeneous function automatically inverts the first arrival refractions to derive a 2D velocity distribution which involves the seismic boundaries. A complex set of observed refracted traveltimes along three seismic profiles (about 1200 m length each) is used to construct refraction time field sections t(x, l) and 2D velocity field sections. Such kind of sections allows seeing complex layered structure of the subsurface section and allocation of the boundaries and the faults. Moreover, the interpreted geoseismic sections, where the interfaces between different seismic zones, faults and contact between the different blocks of rocks are traced according to their own gradient velocity range are also introduced. The resultant models were in consistent with the study objectives. They provided the required details on the delineation and mapping the geometries of the inversion boundary of the deduced five seismic zones with velocities ranging from 200 to more than 4400m/s in which the significant structural complexities where large fault blocks were interpreted. Besides, two aquifers of two different levels were also delineated. The locations of the interfaces between the seismic zones and also the two saturated zones everywhere were found to be completely compatible with knowledge about identified boundaries supplied by the nearby borehole. So, the inversion has proved very effective in confirming and imaging the accurate setting of the interfaces of the subsurface sedimentary succession including aquifers and structural complexities and providing valuable deeper information about the fault morphology.

Keywords: Seismic refraction**,** Western Desert, Kharga Oasis, Nubian aquifer.

INTRODUCTION

Seismic methods represent the most important, effective and powerful technique of geophysical prospecting. Currently, the enormous detail produced by 2D, 3D and recently 4D tomographic techniques using curved raypaths has opened up a huge reservoir engineering potential. Therefore, seismic methods became not only used for deep-seated oil exploration, but also widely applied in shallow investigations such as geological, engineering, hydrogeological, archaeological and ecological purposes (El- Haddad, 2002; Riad et.al, 2017; Abdel Gowad, 2010). At Moscow State University, a 2D tomographic inversion method of refraction traveltimes curves, i.e. the homogeneous function method, was proposed and firstly used in the 1980s (Piip, 2001). This method is based on a local approximation of the real velocity distribution by homogeneous functions of two coordinates (Piip, 2001). In this inversion the preliminary distinguishing and identification of waves on travel time curves from different interfaces are automatically performed. Whereas, for two reverse travel time curves the non-linear transformations is continuously convert the direct travel time curve to the reverse one and vice versa. Based on this theory, Piip, 2003 was designed a computer program (GOODGRAF) for processing, interpretation and construction of seismic sections from refracted wave data. This inversion is applicable to any set of travel time curves, from the minimal case of two reverse travel time curves to cases where the receivers and sources are equally spaced along the profile (Piip, 2006, Piip, et al, 2008). It can be used for the interpretation of any system of refraction travel time curves for both shallow and deep seismic, even in crustal and mantle studies (Piip, 2006).

On the other hand, the increasing need for finding new fresh water resource is required worldwide, especially in aired regions. Therefore, an exploration for groundwater aquifers is one of the most important issues in such regions. The application of this type of study is fully consistent with the major and principal governmental priorities that look for new fresh water resources to cover the prospects of development in various fields. The Egyptian government is looking forward to develop and reclaim desert lands to create new urban and agricultural environments in the desert governorates, to open more jobs and increase growth and Gross Domestic Product (GDP), through the exploitation of these vast desert areas.

The Kharga Oasis is one of the most promising areas that the Egyptian government is seeking to develop and improve, to accommodate the annual population increase. So, the northwestern part of Kharga Oasis Fig (1) was chosen to investigate the subsurface geological and hydrogeological conditions. To achieve this object, seismic refraction methods was used. The aims of this study:

a. Recognizing the different subsurface sedimentary layers as possible.

b. Detecting the groundwater potentiality in the study area.

c. Identifying the structural characteristics of the subsurface sequences.

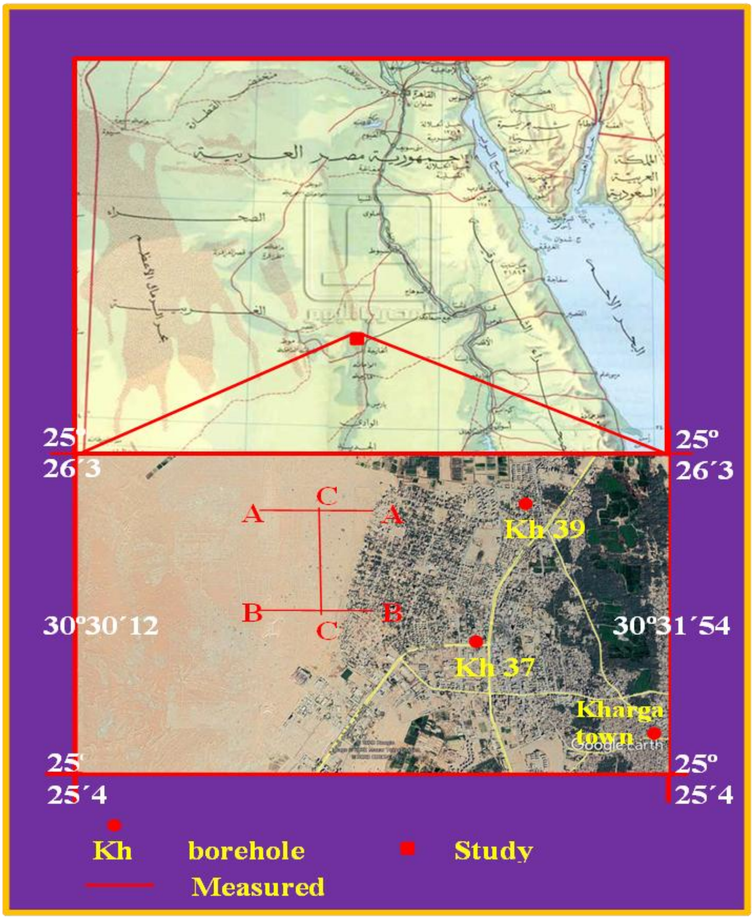

Fig (1): Location map of the study area.

GENERAL GEOLOGY

Geology of El Kharga Oasis was studied by many investigations. According to Said (1990) and Hermina (1989), Kharga Basin lies within the Western Desert of Egypt. In El Kharga Oasis the sedimentary cover unconformably overlies crystalline basement rocks exposed far to the south at Abu Bayan area. The sedimentary cover ranges in age from the Late Mesozoic to Early Cenozoic (Fig. 2).

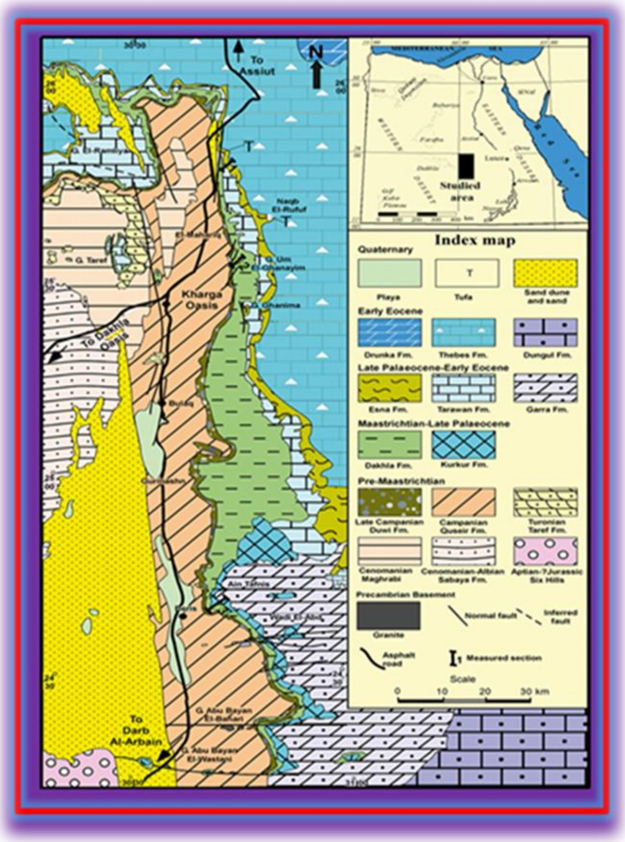

Fig (2): Geologic map of El-Kharga Oasis area. (Simplified after the Geological map of Egypt, 1987, Conoco coral project).

The study area is located to the northwest of El Kharga town and is a part of almost features plain with nearly flat weathered claystone outcrops covered by a veneer of recent sands. The geologic setting of the study area is in the context of El Kharga depression and its surrounding environs. The stratigraphic sequence encountered in surface and drill –holes is represented downward by about 50m thick siltstone, claystone and sandstone layers belonging to Campanian Quseir Formation (Hermina, 1989) overlaying fluviomarine- continental sandstones of the Nubia Group Fig. (2).

The structural style of the Kharga Oasis area is characteristic for stable shelf tectonics. The stratigraphic sequence is represented by more or less Cretacous Paleocene horizontal strata with a general very gentle dip ranging between 2º and 4º northward. Faults and to a lesser extend, large-scale folds are easily detected on the surface map of the study area. Several workers (e.g. Yossef et al, 1982; El Younsey, 1984; Abd El all, 1982; and Hermina, 1989) recognized that block movements in the basement have yielded the surface structural make-up of the Kharga area. Several trends of various faults in different areas, affect the Kharga area. One of the most predominantly fault trends is that extending N-S and control the main topographic features in and outside the Kharga depression. Faults belonging to this N-S trend reach in length up to 40Km., of which is the Taref –Teir fault that effects El Kharga Town area and extends to the north and south with vertical dislocation about 200m.

SEISMIC DATA ACQUISITION, PROCESSING AND INTERPRETATION

Shallow seismic refraction measurements were performed in the study area along three profiles, AA, BB, and CC, each has about 1200m length, Fig (1). Two of these profiles (AA and BB) have a parallel (E-W) extension while, the third one has a perpendicular (N-S) direction and intersect both of them in their middle. Refraction data were collected in P-wave mode twice (direct and reverse shooting) using the 12-channels signal enhancement seismograph (model EG& GES-1225) manufactured by Geometrics. Heavy weight dropper with changing weights was used to generate the seismic energy (El-Haddad,2003). The direct and reversed seismic events were picked from 14 Hz vertical geophones oriented vertically to the seismic line at 20 m interval.

Interpretation of the collected seismic data was done using 2D inversion algorithm (GODOGRAF software). This algorithm is based on a local approximation of the real velocity distribution by homogeneous functions of two coordinates (Piip, 2001; Piip and El-Haddad 2008). In this inversion the preliminary distinguishing and identification of waves on travel time curves from different interfaces are automatically performed. Whereas, for two reverse travel time curves the non-linear transformations continuously convert the direct travel time curve to the reverse one and vice versa (Piip, 2001; Piip and El-Haddad 2008). The output of this algorithm was presented as a 2D velocity field models. These models are displayed as a field of velocity contour lines with a constant interval (Fig.3).

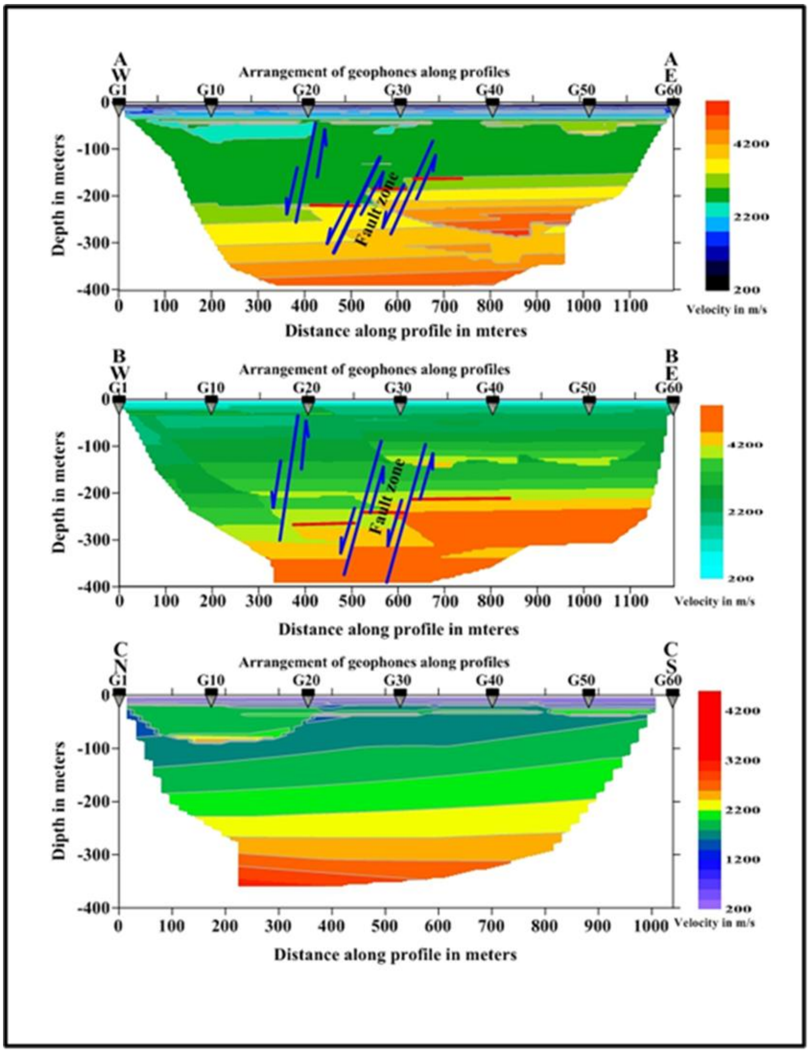

Fig (3): Seismic velocity field sections along AA, BB, and CC profiles.

RESULTS AND DISCUSSION

Constructed 2D seismic velocity of sections along the three profiles A-A, B-B and C-C (Figs.3) show that;

- The velocities of the primary seismic waves along the three profiles increase with depth and its Varity ranges from less than 1400 to more than 4200m/s.

- This range of the seismic velocity can be divided into seismic zones, each can identified by extended boundaries and maintaining the values of the velocity gradient and velocity interval from top to bottom.

- Accordingly, five seismic zones were resolved along AA profile while, but only four appeared along BB and CC profiles. These zones which may represent layers or strata are covered by thin surface layer (1 to 7m thick) of weathered shale and loose sand.

- Some lateral variations in the seismic wave velocities can be detected at the second, the third, and the fourth seismic zones along AA and BB profiles. These lateral variations may represent fault zones, and/or lenses (Behera et al., 2002, Demanet et al., 2001, Holker et al., 2002, Greenhalgh and Zhou 2002, Mackenzie et al., 2002 and, Riad et al, 2017).

Geological interpretation of the seismic zones was done based essentially on correlating the detected velocities with published velocity tables (e.g. Gurvich, 1973 and Redpath, 1973) aided by subsurface information from nearest drill holes and previous geophysical studies (Abd El-all, 1982; Senosy, et al, 1999 and El-Haddad, 2003). Constructed geoseismic sections along the three profiles A-A, B-B and C-C are presented in Figures (4). Accordingly, the proposed subsurface lithologic sequence along these seismic sections can be summarized in the following:

- The uppermost zone which has velocity ranges from 1400 to 2400 m/s, interpreted as shale intercalated by shale, mudstone, and siltstone of Quseir Formation. The thickness of this layer varies from 35 to more than 50m in some places.

- The second layer is characterized by velocity range (2400 – 3000 m/s). This layer is interpreted as the upper water-saturated fluviomarine-continental sandstone of the Nubia Group (upper Aquifer). The depth to this layer is found at different depths ranging from 50 to 120m and has average thickness about 100m.

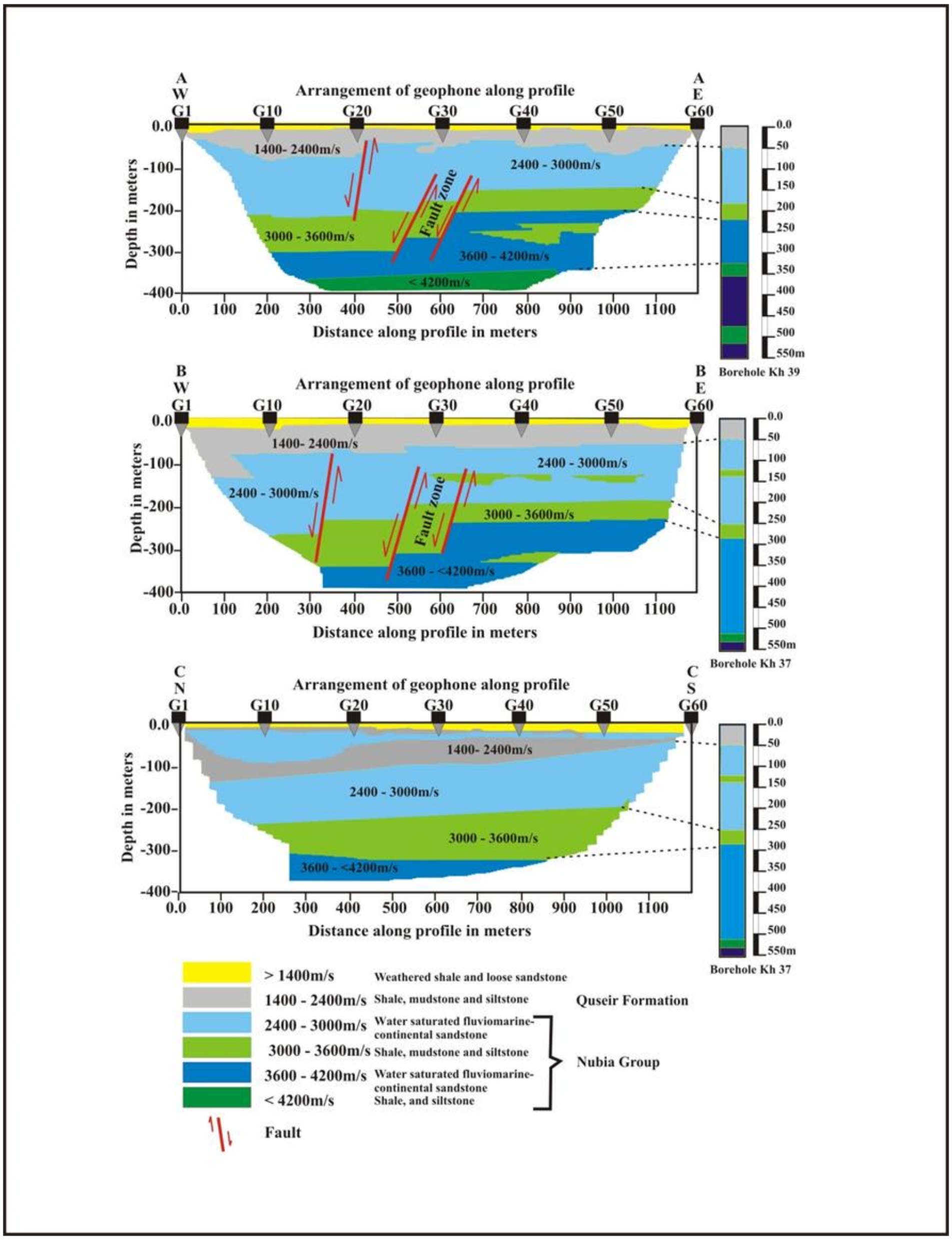

Fig (4): Geoseismic cross section along AA, BB, and CC profiles.

- The third seismic zone with velocity (3000-3600 m/s) is suggested as silty sandy claystone layer of the Nubia group with average thickness about 40m.

- The forth seismic zone is interpreted as the lower water-saturated sandstone layer of the Nubia Group (lower Aquifer). It has velocity ranges from 3600 to 4200m/sec and depth varies between 200 t0 300m.

- The fifth seismic zone with velocity more than 4200 m/s is suggested to be shale layer.

The interpreted geoseismic cross-sections show good correlation with the drilled near surface succession. Lithologic contrasts between the upper layers of Quseir formation and those of the underlying Nubia Group, is obviously detected along the three constructed cross-sections. The upper layer of shale, claystone, and siltstone of Quseir formation are mainly flat layers showing slight variation in thickness and gentle warping corresponding to weak ductile deformation. In contrast, the lower layers of the Nubia Group display brittle deformation in the form of predominance of fault and fault zone dislocations especially in AA and BB sections, but not present on C-C section. This is in agreement with the predominance a fault trend in the area, which extends parallel to the N-S Teir-Taref major fault of the Kharga. The detected faults in the geoseismic section are minor faults developed as an echo of the major faults. The C-C geoseismic section extends parallel to the strike of faults, so no faults dislocations are detected.

CONCLUSIONS

The resultant 2D velocity field models and Geoseismic sections of the study area were introduced. Analysis of the field can be summarized as follows:

(i) Five seismic zones were resolved along AA profile while, only four of them are appeared along BB and CC profiles;

(ii) Lithologic contrasts between the upper layers of Quseir Formation and those of the underlying Nubia Group, is obviously detected along the three constructed cross-sections;

(iii) Quseir Formation are mainly flat layers showing slight variation in the thickness and gentle warping corresponding to weak ductile deformation;

(iv) Nubia Group display brittle deformation in the form of predominance of fault and fault zone dislocations especially in AA and BB sections; and

(v) Two aquifers are detected in the study area at depths about (50-120 m) and (200-300 m).

Thus, the 2D homogeneous function method is successful in meeting the survey objectives. The resultant satisfactory models were found to be completely compatible with knowledge supplied by the borehole and the collected information.

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تطبيق طريقة المعادله المتجانسه فى بعدين لدراسة القطاع الجيولوجي التحت سطحي في الجزء الشمالي الغربي من منطقة الواحات الخارجه ، الصحراء الغربية ، مصر

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تقدم الدراسه الحاليه تطبيقا لاستخدام طريقة الدالة المتجانسة ثنائية الأبعاد لدراسه القطاع الجيولوجي التحت سطحي في الجزء الشمالي الغربي من منطقة الواحات الخارجة . و قد تمت القياسات السيزميه للموجات الطوليه الانكساريه على طول ثلاث بروفيلات طول كل منهم ١٢٠٠ متر تقريبا يمتد اثنان منهما فى اتجاه شرق –غرب بينما يمتد البروفيل الثالث فى الاتجاه العمودى (شمال – جنوب). وقد تم معالجه البيانات المقاسة في صورة منحنيات لأزمنة أول وصول للموجات السيزمية المنكسرة باستخدام برنامج طوموجرافى متقدم (جادوجراف) الذى يعتمد فى الاساس على نظريه المعادله المتجانسه فى بعدين للتقدير التلقائى للنماذج السرعيه للموجات السيزمية المنكسرة المتغيره راسيا و افقيا وتحديد التراكيب المختلفه المحتمله للقطاع الجيولوجى التحت سطحى. وقد اظهرت القطاعات السرعيه ثنائية الأبعاد المستنتجه لاقصى عمق تم الوصول اليه على طول البروفيلات الثلاثه لمنطقه الدراسه و الذى يقدر بحوالى ٤٠٠ متر ان القطاع التحت سطحى غير متجانس راسيا و افقيا. و بناءا على التدرج السرعي تم تقسيم القطاعات راسيا الى خمسه نطاقات سرعيه تظهر جميعها على طول القطاع الاول (AA) بينما يظهر منها اربعه نطاقات فقط على طول

القطاعين الثانى (BB) و الثالث (CC) تغطى هذة النطاقات طبقه يترواح سمكها ما بين متر واحد الى سبعه امتار تقريبا و بناءاعلى المشاهدة الحقليه فان هذة الطبقه مكونه من الطفله و الرمال المفككه (weathered shale and loose sand) . وقد تم تحويل النطاقات السرعيه للقطاعات المستنتجه من الدراسه الى قطاعات جيولوجيه توضح التتابع الصخري التحت سطحى و ذلك بالاستعانه بالجداول المنشوره للسرعات المميزه للسحن الصخريه المختلفه المتواجدة على اعماق متباينه وكذلك بيانات التتابع الصخري التحت سطحى المسجله من الابار القريبه وقد اظهرت الدراسه ان التتابع الصخري التحت سطحى المستنتج هو كالتالى :

١- الطبقه العلويه و التى تنحصر سرعه سريان الموجات السيزميه الطوليه خلالها مابين ١٤٠٠ الى ٢٤٠٠ متر لكل ثانيه قد تم تفسيرها على انها مكون القصير الذى يتكون من تتابعات من الطفله و الحجر الطينى و سمك هذة الطبقه يتراوح ما بين ٣٥ الى ٥٠ متر.

٢- الطبقا الثانيه تتميز بنطاق السرعة (٢٤٠٠ - ٣٠٠٠ م / ث). وقد تم تفسيرها على أنها الخران الجوفى العلوي للحجر الرملبى النوبى و التى تم العثور علىها على أعماق مختلفة تتراوح بين ٥٠ إلى ١٢٠ متر ويبلغ متوسط سمكها حوالي ١٠٠ م.

٣- الطبقه الثالثه تمثل خليط من الحجر الرملى الطينى و الغرين و التى تعتبر العضو الثانى من الحجر الرملى التوبى و تتميز بنطاق سرعات ما بين ٣٠٠٠ الى ٣٦٠٠ متر لكل ثانيه و تتواجد فى القطاع بسمك ٤٠ متر تقريبا.

٤- الطبقه الرابعه و التى تتميز بسرعات تتراوح بين ٣٦٠٠ الى ٤٢٠٠ متر لكل ثانيه تمثل الخران الجوفى العميق للحجر الرملى النوبى الذى يظهر فى القطاعات الثلاثه على اعماق تتراوح بين ٢٠٠ الى ٣٠٠ متر.

٥- الطبقه الاخيرة تظهر فقط فى القطاع الاول (AA) فقط على عمق اكثر من ٣٠٠ متر و تمثل طبقه الطفله من مجموعه الحجر الرملى النوبى.

٦- اظهر القطاعين الاول و الثانى (AA , BB) و اللذان يمتدان من الشرق الى الغرب و تحديدا فى المنتصف نطاق فالق ذات ازاحة راسيه ناحيه الشرق و فالق اخر ات ازاحة راسيه بسيطة فى نفس الاتجاه. و بمقارنه اماكن تواجد الفالق و النطاق فى القطاعين يمكن استنتاج الاتجاه العام للتفلق و هو اتجاه شمال - جنوب و هو الاتجاه العام للفوالق فى منطقه الخارجة (Taref major fault).

بمقارنه القطاعات الجيولوجيه المستنتجة من هذة الدراسه مع تلك البيانات التى تم تجميعها من الابار القريبه بالاضافه الى الدرسات السابقه التى تمت على منطقه الدراسه اتضح ان هناك توافق كبير حيث وجد تقارب كبير بين سمك الطبقات و الاعماق المقدرة فى الحالتين. هذة النتائج تؤكد نجاح طريقه المعادله المتجانسه و برنامج التفسير المبنى عليها (جادوجراف) فى تحقيق الهدف من الدراسه.