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ENGINEERING SITE INVESTIGATION USING 2D ELELCTRICAL RESISTIVITY TOMOGRAPHY AT THE SIKTAN PROPOSED DAM SITE AT ERBIL GOVERNORATE, IRAQI KURDISTAN REGION

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ABSTRACT

2D Electrical Resistivity Tomography (ERT) was carried out at the proposed Siktan Dam site, Erbil Governorate, NE Iraq. The aim of this study is to evaluating the geo-structural setting of the concealed bedrock along the proposed dam axis and the flanks of the proposed dam site. A comprehensive geotechnical investigation consisting of borehole drilling works and electrical resistivity data were carried out to investigate the subsurface formation. Geologically the proposed dam site is located on the Shiranish Formation consisting of dark gray claystone alternating with limestone marlstone and sandstone. Three profiles were taken by Wenner array with 48 electrodes along of each profile which equal 235m, the space between electrodes is 5m. The SYSCAL PRO instrument is used to collect resistivity data and (SYSCAL Switch) were used with 48 electrodes along one line, and which carries out an automatic switching of these electrodes for acquiring profiling data. The data were processed and interpreted by applying 2D inversions TomoLab software. The using of geophysical prospecting in geotechnical investigation is sometimes looked at as a probable rather than certain method when it comes to construct a detailed subsurface layer profiles. The correlation between borehole information and electrical resistivity ranges was done. The combination of geophysical and geotechnical data may greatly improve the quality of buildings construction in civil engineering. From the structural point of view there is no faults have been detected in this location from ERT and boreholes data as well as there is no evidence of the existence of cavities or any other risky resources. The results indicate that the proposed site is suitable for construction of the dam. Boreholes and geotechnical investigations successfully used to verify the results of the resistivity measurements results.

KEY WORDS: Geophysical, Geotechnical, Electrical resistivity, Tomography, investigation, Erbil.

INTRODUCTION

The necessity of water for our life during daily activity, using it for irrigation agricultures and industries, it becomes decrease, so it is important to management it. For that reason, dams are important to controlling it which these are usually builds on the rivers. For any dam construction, it is very important to take many surveys, like geological, geophysical, geotechnical and hydrogeological surveys, even an environmental impact assessment. To avoid any hazards or weak areas (structurally and geologically) that make a problem for the dam in the future, because the dams are construct for long periods to save water, irrigation purposes and as tourism area too.

One of the important surveys is the geophysical survey to detecting the near surface type of material or any structure like cavities, faults beneath the proposed site; also this investigation will limit the number of borehole. The advantages of geophysical techniques is reduce the cost and duration of survey, then small numbers of boreholes drilled to obtain the subsurface information and comparing it with geophysical survey information. Hence, a combined geophysical Electrical Resistivity Tomography and geotechnical (borehole drilling) investigations (GDDR, Geotechnical Internal Report, 2014) were carried out at the proposed Siktan Dam. Electrical Resistivity Tomography (ERT) is increasingly being used in environmental, engineering and hydrological

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studies, also has played an important role in addressing a wide variety of hydrogeological, environmental and geotechnical issues. The goal of geo-electrical resistivity surveys is to determine the distribution of subsurface resistivity by taking measurements of the potential difference on the ground surface. For a typical inhomogeneous subsurface, the true resistivity distribution is estimated by carrying out inversion on the observed apparent resistivity values. In environmental and engineering investigations, the subsurface geology is usually complex, subtle and multi-scale such that both lateral and vertical variations in the petrophysical properties can be very rapid. In the 2D model of interpretation, the subsurface resistivity is considered to vary both laterally and vertically along the survey line but constant in the perpendicular direction (Aizebeokhai, *et al.*, 2010).

The primary goal of the Siktan dam project and other same projects are to contribute towards reducing deficiency in the Kurdistan Region. Locally, the objectives of the project are to increase household income, enhance food security, and improve approaches to social and health infrastructure for the rural population. This study was aimed at evaluating the geo-structural setting of the concealed bedrock along the proposed dam axis and its flanks. The geotechnical investigation and electrical resistivity data were carried out to investigate the subsurface structures.

LOCATION AND GEOMORPHOLOGY OF THE STUDY AREA

Siktan Dam is located in Erbil governorate, at about 30 km south east of Shaqlawa town, near Siktan Village, on Chami Bayiz Agha River which connected to Dokan Lake. The Cham-i Bayiz Agha River flows through well-defined mountain ridges, located in NW-SE direction at the northwestern ends of the Dokan Lake. It is located within the Siktan valley which accumulating their water from the rain and the melting snow. Location of the Site investigation taken by Global Positioning system (GPS) with the coordinate: UTM time zone: X= 465115 and Y= 4009587 (Fig. 1a). The catchment area is about 63.1 Km^2 (Fig. 1b). The estimated reservoir area is 520,000 m^3. The height of the proposed dam 18.50 m; length of dam 413 m and the estimated volume is about 3,500,000 m^3 (GDDR, Geotechnical Internal Report, 2014).

Topography and geomorphologic features are affected by the competency of rocks. Rocks are either highly competent rocks occur as high ridges while relatively weak rocks form plains or hills. This is exactly the case in Siktan area. Two types of rocks are present; Limestone making the high hills which are about 500 m high at the upstream side from the proposed lake location and soft rocks making the valley and surrounding hills on the downstream side of a mean elevation of 648 m (above sea level).

GEOTECTONIC AND GEOLOGICAL CONDITIONS OF THE PROPOSED DAM SITE

The study area is located according to tectonic sub divisions of Iraq at High Folded Zone in unstable shelf (Buday and Jassim, 1987; Jassim and Goff, 2006) (Fig. 2).

At the regional scale, the site is located between the Safeen and Karmosk anticlines and exactly located near the southwest flank of Karmosk anticline (Fig. 3). Siktan dam axis is situated on the northern part of the south western limb of Karmosk anticline. Karmosk anticline is east of Mirawa anticline, with NW-SE trend and length of about 15 km. Both plunges are truncated by two blind thrust faults. The southwestern limb is steeper than the northeastern one. Bekhma Formation forms the bulk of the anticline. Safeen Mountain is trending NW-SE direction at the upstream and downstream ends of the Dam Site (Buday, 1980).

The proposed dam site is located on the Shiranish formation consisting of dark gray claystone alternating with limestone marlstone and sandstone (Fig. 3). The marly limestone is highly jointed and the spaces of the joints become wide due to weathering which cause a high permeability at the dam site. Shiranish Formation beds are exposed as a steep beds and continuous belts covering the entire dam site (Fig. 4). Different types of Quaternary deposits are developed in the area (Fig. 5). A recent deposit consists of recent river deposits (Pleistocene) (mainly boulders, gravel, sand, silt and clay), slope deposits (Pleistocene – Holocene) (clay, silt, gravel and boulders). These deposits are almost continuous on both sides of the dam site. They consist varies from silty clayey materials, gravel, limestone and dolostone, which are derived from the exposed formations. These deposits are poorly to

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moderately cement by calcareous, sandy and silty materials (Fig. 6).The thickness of the slope deposits ranges from less than one meter up to 20 m, but usually it is about 0.2-5 m. and alluvial deposits**:** they include deposits of flood plains, alluvial fans and river terraces. Flood plain deposits consist of a mixture of coarse grains soil (gravel and sand) plus fine grains soil (clay and silt) on the banks of the two permanent streams (Tainal and Tilie streams) where in the grain size becomes smaller when it moves away from the stream channel. These deposits are formed during periods of flooding (Buday, 1980) (Fig. 3).

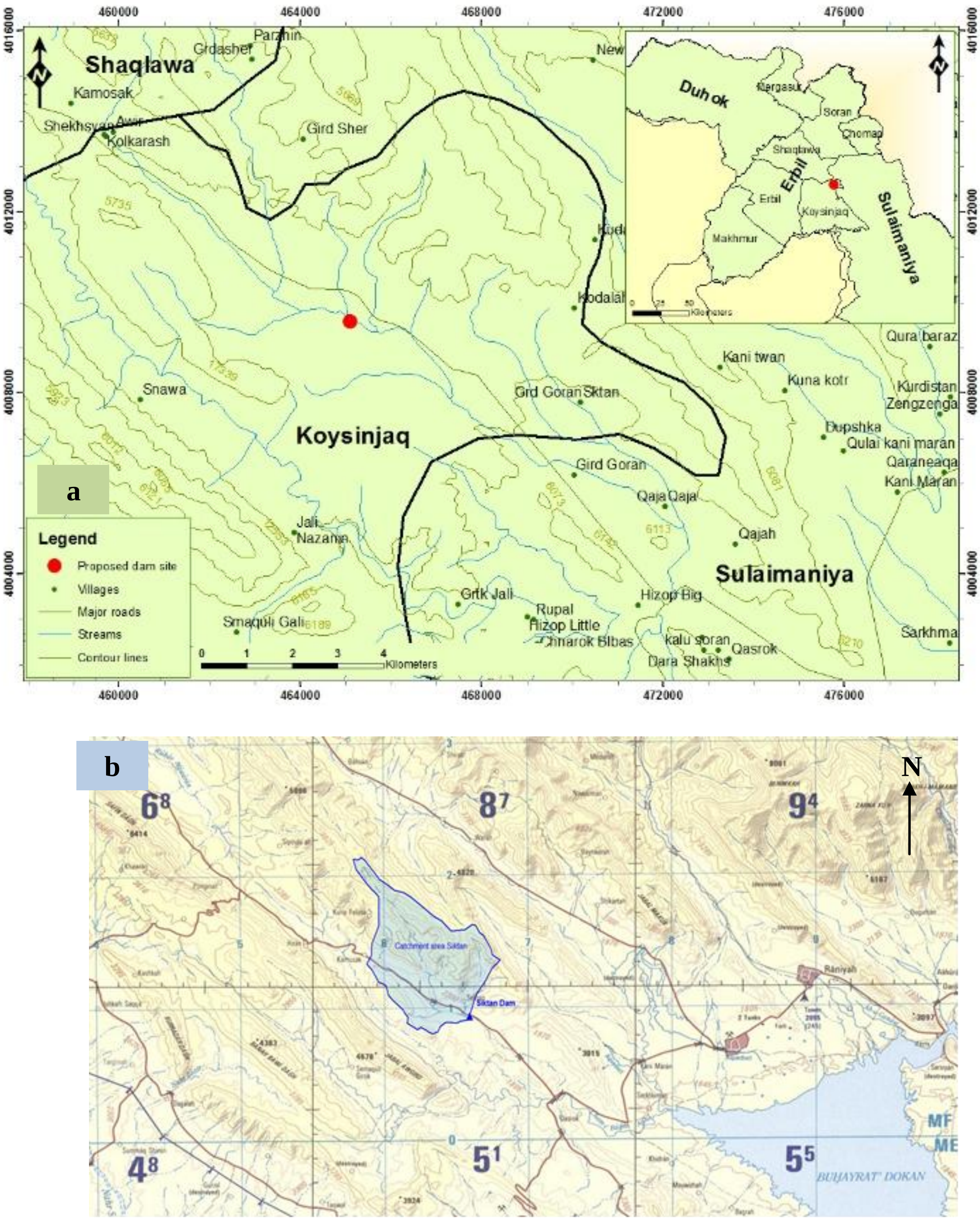

Fig. (1): a- Location map of the Proposed Dam. b- Siktan dam topography, catchment areas and reservoir (GDDR, Geotechnical Internal Report, 2014).

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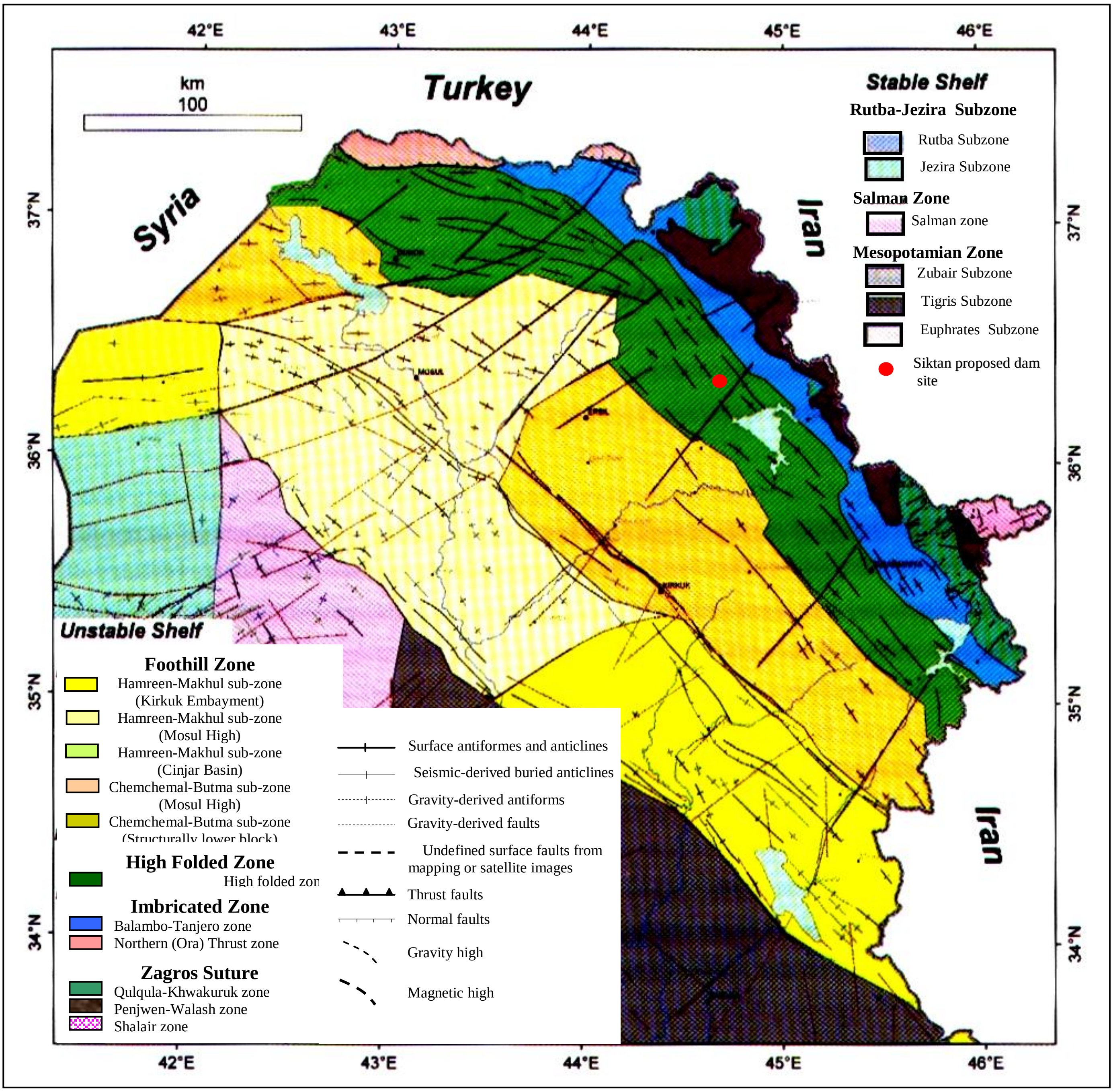

Fig. (2): Tectonic map of northern Iraq (Jassim and Goff, 2006).

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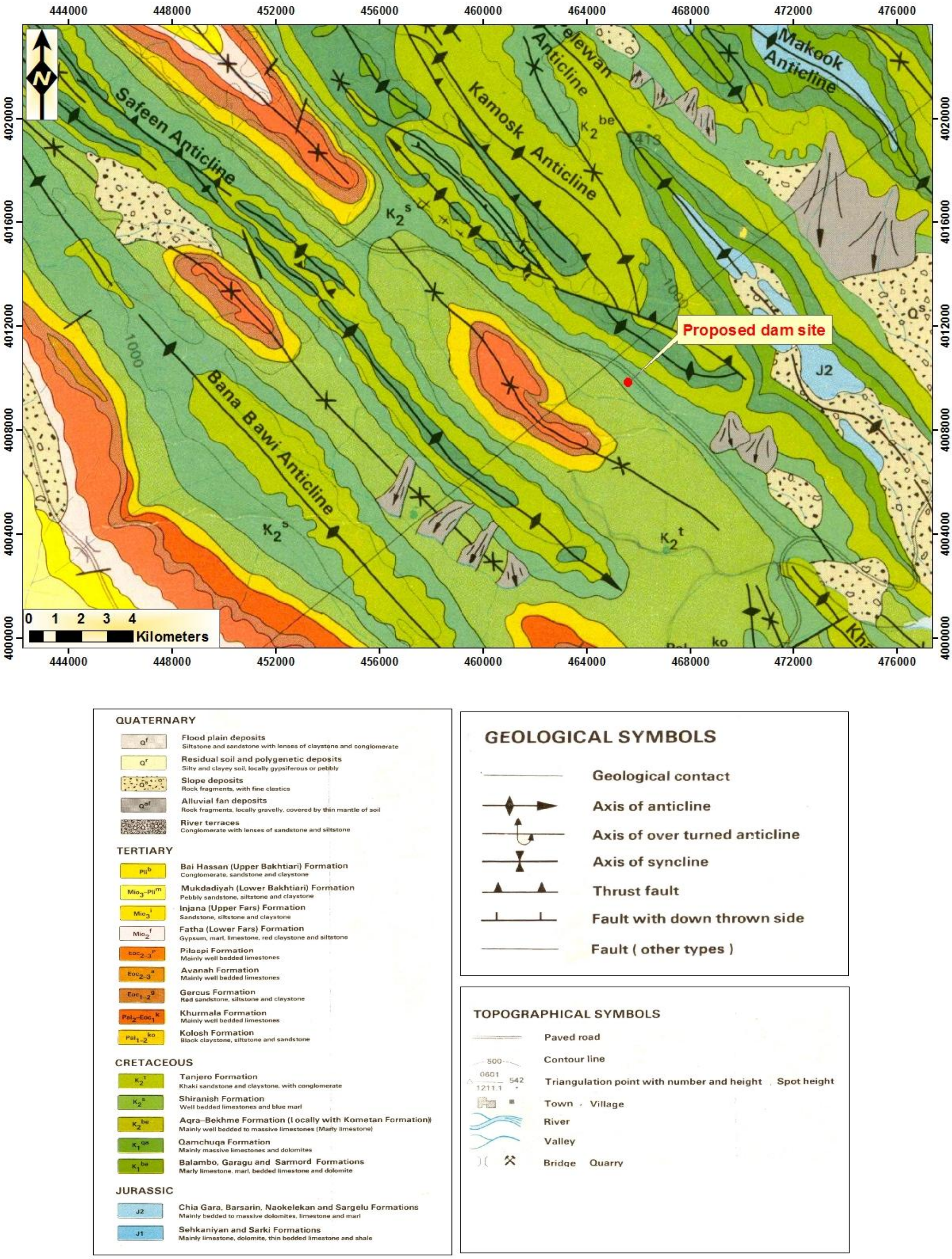

Fig. (3): Geological map of the study area (Sissakian, 1997).

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Fig. (4): Fractured (marl limestone) of the Shiransh fm. at siktan dam site.

Fig. (5): Quaternary and Recent deposits.

Fig. (6): Slope deposits at dam site.

MATERIALS AND METHODS

2D electrical resistivity tomography

Electrical resistivity method is one of the important near surface geophysical methods especially for shallow investigations like engineering, environmental and archaeological studies. In the last decade, there has been great progress in computerized data acquisition systems and 2D and 3D inversion software for DC resistivity measurements. Resistivity tomography or imaging is now widely employed in environmental investigation and civil engineering (i.e. Van et al. 1991; Dahlin 1996; Olayinka and Yaramanci 1999; Chambers et al. 1999). As is well known, the quality of the observed data or noise contamination mainly affects the resolution and reliability of the technique and it depends on all aspects of the fieldwork (Zhou and Dahlin, 2003). Using of two dimensional electrical resistivity imaging as a tool in the field, this increase the data collection with a short time and a good data quality then the reality of subsurface information. Two-dimensional (2D) resistivity surveys are usually carried out using large numbers of electrodes connected to multi-core cables. For a system with limited number of electrodes, the area covered by the survey can be extended along the survey line using the roll-along technique (Dahlin and Bernstone, 1997). The resistivity of the 2D model is assumed to vary

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both vertically and laterally along the survey line but constant in the direction perpendicular to the survey line. Electrical Resistivity Tomography (imaging) give a picture of the subsurface resistivity distribution. To convert the resistivity picture into a geological picture, some knowledge of typical resistivity values for different types of subsurface materials and the geology of the area surveyed is important. To apply the imaging technique successfully, great attention must be paid to controlling the observed data quality in fieldwork and data processing, and any possibilities of minimizing the effects from all kinds of error sources must be taken. For this reason it is important to investigate the properties of the data observation errors and understand their effects on the imaging results (Zhou and Dahlin, 2003).

DATA ACQUISITION AND INSTRUMENTS

The field survey was done to get enough subsurface information in the study area to deciding the dam construction by 2D electrical resistivity tomography. Three profiles were taken by Wenner array with 48 electrodes along of each profile which equal 235m, the space between electrodes is 5m. The depth of the investigation is assumed to be 40 - 50 m, being a fraction (1/5-1/6) of the total length of the profile. The SYSCAL PRO instrument belong to Incorporated Research Institutions for Seismology (IRIS)-made is used to collect resistivity data and (SYSCAL Switch) were used with 48 electrodes along one line, and which carries out an automatic switching of these electrodes for acquiring profiling data.

The first profile is semi-parallel to the dam axis which is directed from north to the south direction (N-S). The second profile is perpendicular to the dam axis which is directed from northwest to the southeast (NW-SE) and the third profile is located at the right abutment which is nearly parallel to the profile 2 as shown in (Figs. 7&8). The 2D resistivity profile on the left abutment didn't take because there wasn't an efficient place because of human activity (playground and a lot of houses of Siktan village) to take a profile; to make a good resistivity tomography survey must be far away from the noisy sources.

ERT RESULTS

After the data were acquired at the field, they are representing the apparent resistivity which could not depend on them to interpret them to the geology. It needs the software to convert the apparent resistivity to true resistivity by using computer software which called TomoLab software to make a resistivity model section or inversion section which shows as a colored image, each color represents a specific geological material according to the preliminary information.

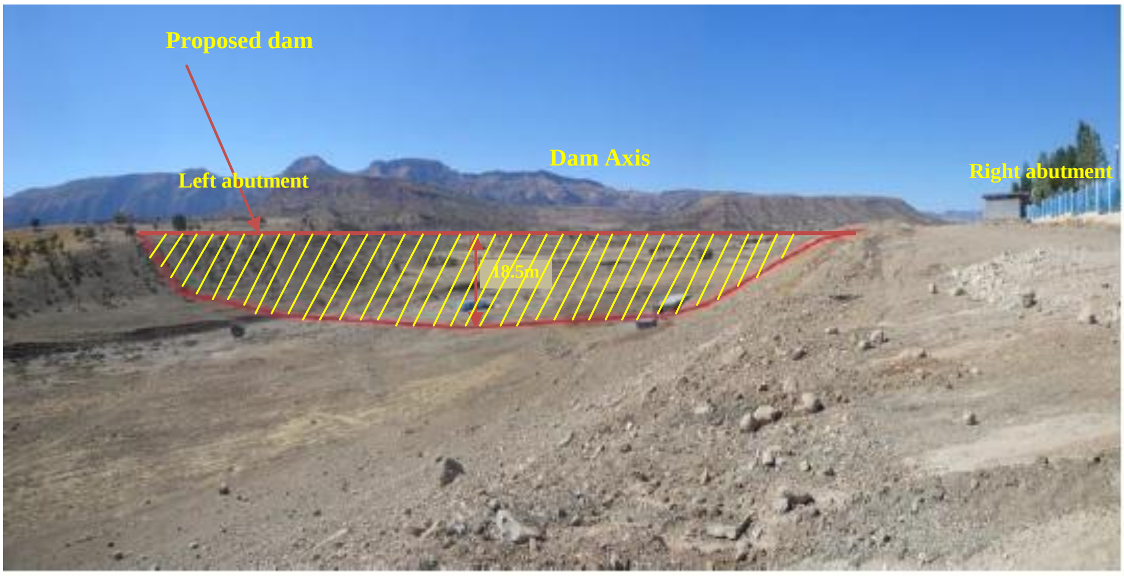

Fig. (7): Siktan proposed dam axis.

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Fig. (8): Satellite Image showing the 2D electrical resistivity profiles and location of the boreholes at Siktan proposed dam.

Profile- 1 (Dam axis)

This first profile is parallel to the dam axis which is directed from southwest to the northeast direction. This profile is perpendicular to the strike, at the coordination (X = 465115 and 465128; Y = 4009587 and 4009831 UTM). In this profile four layers were recognized. The first layer represents the alluvial deposits of Quaternary sediments which composed of variety types of clastic sediments like gravel, sand and clay with resistivity value ranges (10-100 Ohm.m). The thickness of this layer is about (2-6m), in the center of the valley the thickness about 2m and in the left abutment about 6m. The second layer represents the blue marl of Upper part of Shiranish Formation; its resistivity value ranges (15-45 Ohm.m) with thickness about (10-12m). The third layer represents the marly limestone of which is the main component of Lower part of Shiranish Formation with resistivity value ranges (55-75 Ohm.m). Within this layer another layer occurs nearly at the center of the profile with high resistivity value ranges (85-130 Ohm.m), its represents stratified limestone. The last layer which is appear in the right abutment has the resistivity value ranges (10-20 Ohm.m) with thickness about (20m), this layer represents the weather and fractured marly limestone of Shiranish formation (Fig. 9).

Profile- 2 (perpendicular to the dam axis)

This profile is perpendicular to the dam axis which extends from upstream to the downstream and nearly parallel to the strike of layers which is taken in the valley with the coordination (X = 465227 and 465004; Y = 4009674 and 4009742 UTM). This profile is composed of three layers. The first one is the results of weathered rocks of mountains which represents alluvial deposits. They are boulder, gravel and sand with resistivity ranges (70-310 Ohm.m).The thickness of this layer is about (2-5m). The second layer is composed of blue marl bed of Shiranish Formation with resistivity value ranges (25-30 Ohm.m), its thickness about (20m). The third layer is composed of marly limestone of Shiranish Formation with resistivity (55 Ohm.m) (Fig. 10).

Profile 3 (right abutment)

This profile is located on the right abutment and it’s parallel to the profile 2 which is perpendicular to the dam axis, at the coordination (X = 465062 and 465280; Y = 4009512 and 4009489 UTM). Three layers were recognized. The first layer represents the recent deposits which composed of gravel, sand and clay with resistivity

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value (30-35 Ohm.m). The thickness of this layer is about (4- 9m) this layer located at downstream of the profile. The Second layer represents the silty clay with resistivity value (9-15 Ohm.m). The thickness of this layer is about (6-8m) this layer located at upstream of the profile and this location is cultivated area. Third layer composed of weathered and fractured marly limestone of Shiranish Formation with resistivity value (20-25 Ohm.m). Also, with a lens of blue marl which is located at downstream with resistivity value (15 Ohm.m) (Fig. 11).

DISCUSSION

It is a great opportunity to verify the geophysical modeling results by correlation them with the actual geological conditions. It is emphasized that the subsurface layers nature were found at the exact or vicinity location indicated by the geophysical measurements and its characteristics were in agreement with the determined 2D electrical resistivity tomography (ERT) profiles.

Available five boreholes lithology data presented here which were drilled at proposed dam site (GDDR, 2014). Table 1 shows boreholes location and depth. Fig. 8 shows Geological/geotechnical profile of the study site based on borehole data.

Comparative data analyses of borehole log data and 2D resistivity tomography profiles accomplish the objective. Comparison of the ERT profile (P1) and borehole lithology of (BH4 and BH5) indicate that there is good agreement (Fig. 12). The profile up to 50 m depth with resistivity value ranges (10-100 Ohm.m) has been observed gives a representation the first layer represents the alluvial deposits of Quaternary sediments which composed of variety types of clastic sediments like gravel, sand and clay. This layer is encountered between (2-6 m) the second layer is encountered between (10-12m), this layer represents the blue marl of Shiranish Formation, and its resistivity value ranges (15-45 Ohm.m). The third layer with resistivity value ranges (55-75 Ohm.m) represents the marly limestone of which is the main component of Shiranish Formation. Within this layer another layer occurs nearly at the center of the profile with high resistivity value ranges (85-130 Ohm.m) represent stratified limestone. The last layer which is appear in the right abutment its resistivity value ranges (10-20 Ohm.m) with thickness about (20m) this layer represents the weather and fractured marly limestone of Shiranish formation.

Comparison of the ERT profile (P2) and borehole lithology of (BH3) (Fig. 12) showed that the first layer has a high resistivity ranges (70–310 Ohm.m), it is weathered rocks of mountains which represent alluvial deposits. They are boulder, gravel and sand up to 5 m depth. Further below the underlying the second layer is composed of blue marl bed of Shiranish Formation with resistivity value ranges (25-30 Ohm.m), up to 25 m depth. The third layer is composed of marly limestone of Shiranish Formation with resistivity (55 Ohm.m).

Also the ERT profile (P3) correlated with the borehole lithology (BH1) (Fig. 12). In the ERT profile the high resistivity ranges values (30-35 Ohm.m) indicated presence of top soil, clay sand within gravel and boulder (Recent deposits) up to 9m depth. The underlying second layer is silty clay resistivity value (9-15 Ohm.m) up to the depth of 18 m. Third layer with resistivity value ranges (20-25 Ohm.m) composed of fractured marly limestone with a lens of blue marl with resistivity value (15 Ohm.m) belongs to Shiranish Formation. Groundwater level was determined at all boreholes but in different depth as shown in (Table 1).

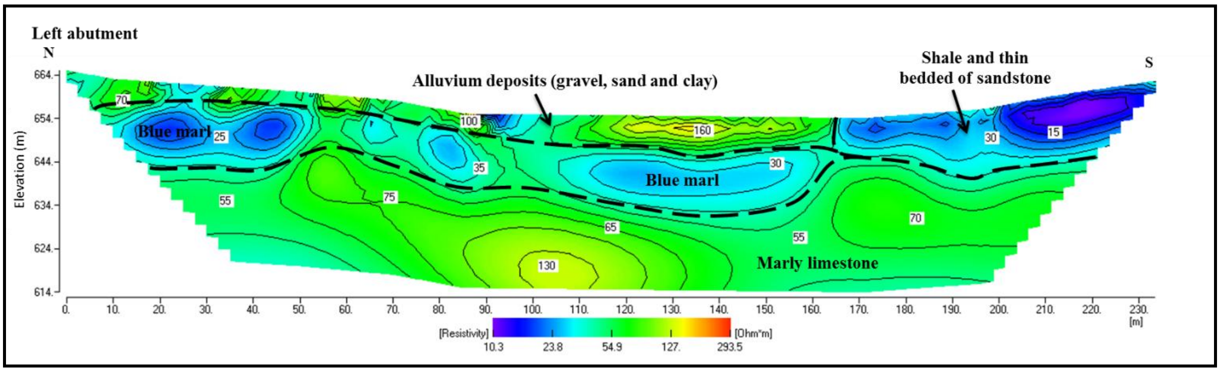

Fig. (9): Inverse resistivity model along profile 1 which is parallel to the proposed dam axis.

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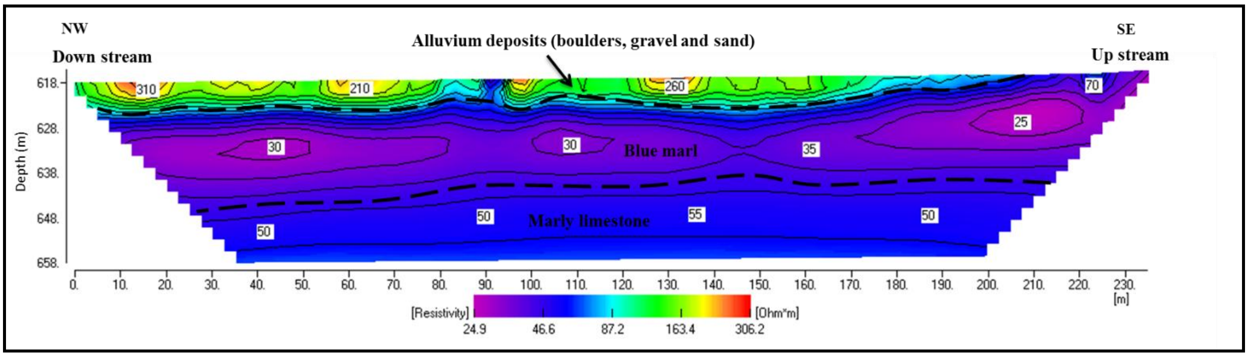

Fig. (10): Inverse resistivity model along profile 2 which is perpendicular to the proposed dam axis.

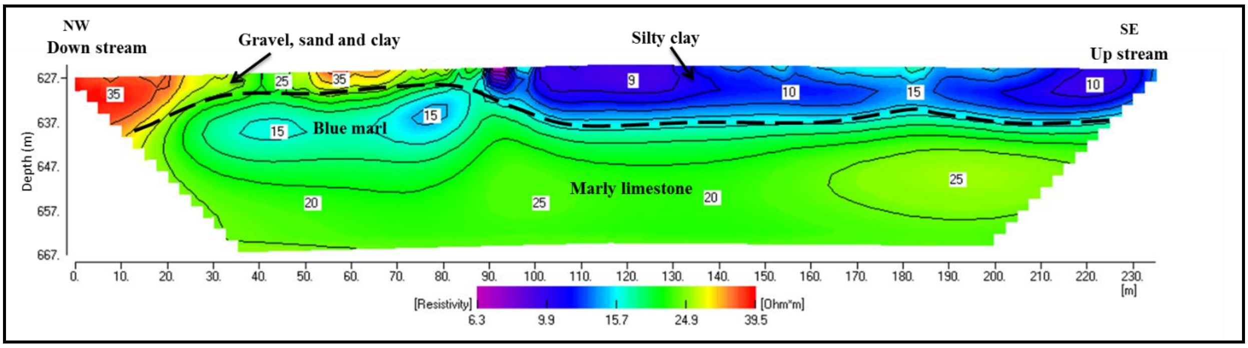

Fig. (11): Inverse resistivity model along profile 3.

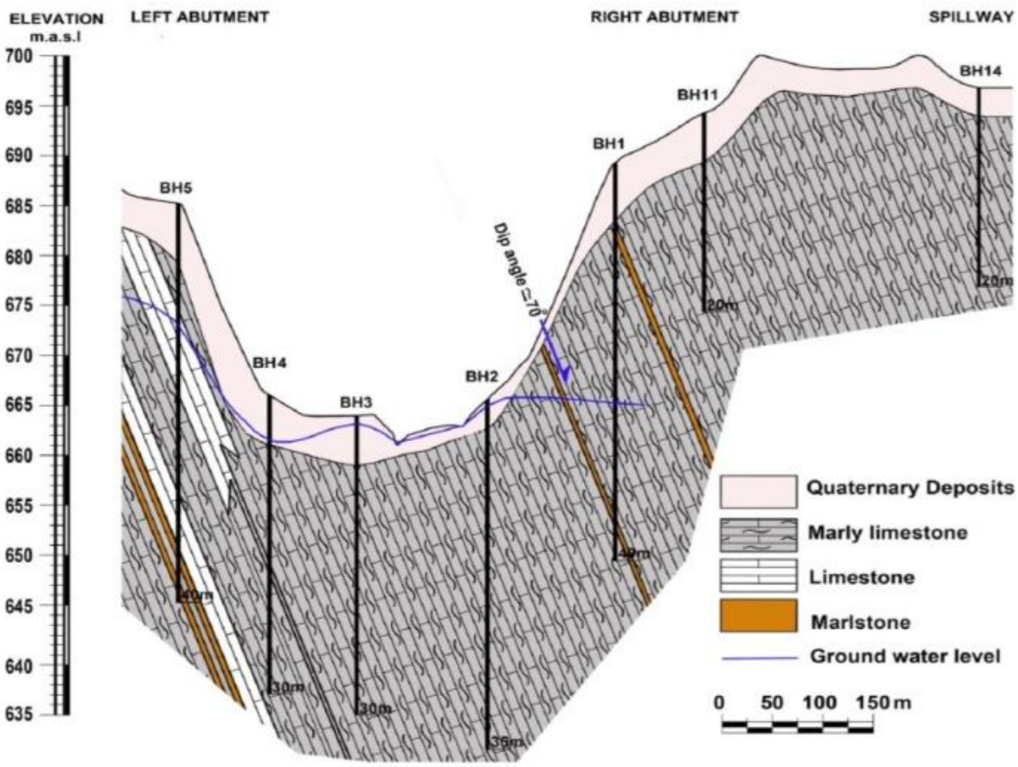

Fig. (12): Geological cross section along Dam axis (GDDR, Geotechnical Internal Report, 2014).

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Table (1): Boreholes location, coordination and depth (GDDR, 2014) "G. L.:Ground level, G. W. L.: Groundwater level"

BH No	Location	East	North	depth	G. L. m a.s.l	G.W. L m.a.s.l
1	Right Abutment	465043	400954	40m	690.2	665.2
2	Dam axis, valley	465063	400963	35m	665.5	665.0
3	Dam axis, valley	465089	400970	30m	665.2	663.2
4	Dam axis, valley	465111	400976	30m	666.0	661.5
5	Left Abutment	465138	400982	40m	685.1	673.1

CONCLUSIONS

The ERT result was constrained using drilled boreholes covering the area up to forty meters. Depth to bedrock layer obtained from boreholes compared with depth inferred from ERT profiles, the comparison confirmed variation in subsurface structures and depth. This further reinforces the ERT method for using in the investigation as a good complement for geotechnical site investigation. The depth of penetration of resistivity survey sometimes far more than that of boreholes drilling carried out during geotechnical investigation. Furthermore a wide lateral coverage was observed for the resistivity tomography as against point observation by geotechnical method. This provides better image of the subsurface and provides opportunity for better engineering design for the foundation of structure in the study area.

The top surface layer shows low to high resistivity ranging from 10 Ohm.m to more than 310 Ohm.m, it is composed mainly of coarse materials such as boulder and gravel, while in some location fine soft materials such as silty clay has been appeared. The thickness of the recent sediments is ranging from 2 to 9 m. The layer with low resistivity value ranges (15-45 Ohm.m) represents the blue marl belong to Shiranish Formation with thickness about (10-12m) in Profile 1 and 20m in profile 2. The layer of moderate resistivity values ranges from 55-75 Ohm.m represents the marly limestone of which is the main component of Shiranish Formation in profiles 1, 2 and 3. Within these layers another layer occurs nearly at the center of the profile with high resistivity values ranges from 85 Ohm.m to 130 Ohm.m its represents stratified limestone in profile 1. The layer which is appear in the right abutment have resistivity values ranges (10-25 Ohm.m) with thickness about (20m) in profile 1, also this layer is appeared in the third profile, this layer represents the weather and fractured marly limestone of Shiranish formation.

From the structural point of view there is no faults have been detected in this location from ERT and boreholes data as well as there is no evidence of the existence of cavities and there are no any risky sources. As a result, the site is considered suitable for construction of dam.

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ڤەکولین دەربارەی جهی ئەندازەیی ب بەکارهینانا توموگرافیا بەرگریا کە هرەبایی دوو ئاراستەیی لە جهی پیشنیارکری بۆ بەنداڤا سکتان ل پاریزگەها هەولیر، هەریما کوردستنتا عیراقی

پوختە

توموگرافیا بەرگریا کەهرەبایی دوو ئاراستەیی **(ERT)** هاتەکرن ل جهی کو هاتیە پیشنیارکرن بۆ ئاڤاکرنا بەنداڤا سکتان، ل پاریزگەها هەولیر، باکووری عیراقی. ئامانجا ڤی لیکولینەڤی بو نرخاندنا چینیت کەڤریین ڤەشارتی لە دریژاهیا تەوەریت پیشنیارکری بو بەنداڤی و هەردوولاییت جهی پیشنیارکری ل سەر چارچوڤەیا جیولوجیك. لیکولینەڤەکا جیوتەکنیکی یا گشتیانە هاتەکرن کو پیکدیت ل لیکولینا بیراو کومکرنا داتایان بو ڤەکولین دەربارەی پیکهاتیین ئەردی. ژ ئالیی جیولوجی ڤە جهی پیشنیار کری بۆ بەنداڤی دکەڤیتە سەر پیکهاتەیا شیرانیش کو پیك دهیت ل کەڤری تەڤنی رەنگ خولی دویف ئیك دگەل کەڤری کسلی مارلستون و کەڤری خیزی. سی پرۆفایلان هاتە وەرگرتن ب بەکارهینانا ریزبوونی ڤینەر دگەل **48** جەمسەران ب دریژاهیا یەك هیل ل هەر پروفایلەکی کو ئیکسانە **(235م)**، دوراتیيا ناڤبەرا جەمسەران **5** مەترە. ئامیری سیسکال هاتە کارهینان بۆ کۆمکرنا داتا بەرگری کارەبایی و سیسکال سویتش هاتەکارهینان دگەل **48** جەمسەران ب دریژاهیا ئیك هیل، وئەواراەدبیت بگوهرینا سەربخو بۆڤان جەمسەران بۆ دەستڤەهینانا داتاییت پرۆفایلی. داتا هاتنە ژارەسەرکرن و شرۆڤە کرن ب بکارهینانا پرۆگرامی تۆمۆلابی پیچەوانەییا دوو ئاراستەیی. بەکارهینانا جیۆفیزیك دناڤ لیکۆلینیت جیوتەکنیکی هندەك دەما ب ریگەکا کاراتر ل ریگا سەرەکی دهیتە هەژمارتن بۆ چیکرنا پرۆفایلان بۆ چینیت ئەردی. دڤی لیکۆلینی دا پرۆسیجەری هەڤپەیوەندیا زانیاریت بیرا ژ بۆ بەرگریی کەهرەبایی هاتەکرن. کۆمکرنا داتایین جیۆفیزیکی و جیۆتەکنیکی دبیتە ئەگەری باش کرنا کوالیتیا ئاڤتهیان ئەندازەیا شارستانی. ل دویف ئەنجامین دەستڤەهات ل **(ERT)** دەربارەی پیکهاتیین ئەردی چ لیکترازان دژی جهی دانینەو هەروەها ل داتایین بیراژی چ بەلگە نینە بۆشاییان ژ بن ئەردی هەبن و چ سەرچاوەیین مەترسیدار نینە. ئەنجامیت دەستڤەهاتی ئەڤ چەندە دسەلمینیت کۆ ئو جهی هاتە پیشنیارکرن باشە کۆ تیدا بەنداڤی بیتە ئاڤاکرن. نها لیدانا بیراو ڤەکولینیت جیوتەکنیکی ب شیوەیەکی سەرکەفتی هابکارهینان بۆ پشت راستبوون ژ ئەنجامین پیڤانا بەرگریی. ب ڤی چەندی بۆمە ئاشکردبیت کۆ ئەندازەیا جیۆفیزیکی دشیت چارەسەریا ب دەست ڤەبینیتۆ دیارکرنا پیکهاتەیین بن ئەردی.

التحريات الهندسية الموقعية باستخدام المقاومة الكهربائية التصويرية ثنائية الابعاد فى موقع سد سكتان المقترح في محافظة اربيل، اقليم كردستان العراق

الخلاصة

تم إجراء المقاومة الكهربائية التصويرية المقطعية **(ERT)** ثنائية الابعاد **(2D)** في موقع سد سكتان المقترح ، محافظة أربيل، شمال العراق. والهدف من هذه الدراسة هو تقييم الإطار الجيولوجي التركيبي

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للأساس المخفي على طول محور واكتاف موقع السد المقترح. تم إجراء تحري جيوتقني كامل والتى تتضمن أعمال حفر التنقيبية وبيانات المقاومة الكهربائية لمعرفة التركيبة الجيولوجية تحت سطح الأرض. موقع السد المقترح من ناحية الجيولوجية يقع على التكوين شيرانيش **(Shiranish formation)** والتى يتالف من الطين الرمادي الداكن بالتناوب مع الحجر الجيري مارلستون والحجر الرملي. تم أخذ ثلاث مسارات بتقنية وينر وباستخدام **48** قطب على طول المسارات الثلاث **(**بطول كلي **235**م**)** وبمسافة **5**م بين الأقطاب الكهربائية للحصول على بيانات المقطع العرضى . تم استخدام جهاز سيسكال برو**(SYSCAL PRO)** لجمع بيانات المقاومة و **(**سيسكال سويتش**)(SYSCAL Switch)** مع **48** قطب على طول كل مسار ، والتي تقوم بتحويل تلقائي لهذه الأقطاب للحصول على بيانات المقطعية ثنائية الابعاد. تمت معالجة البيانات وتفسيرها من خلال تطبيق برنامج تومولاب **(TomoLab software)** الانعكاسية ثنائية الابعاد **(2D)**. وفي بعض الأحيان ينظر إلى استخدام التنقيب الجيوفيزيائي في التحريات الجيوتقنية على أنه طريقة محتملة بدلا من طريقة مؤكدة عندما يتعلق الأمر ببناء ملامح مفصلة للطبقة تحت السطحية. في هذه الدراسة، تم إجراء مضاهاة و ارتباط معلومات الحفرة التنقيبية مع نطاقات المقاومة الكهربائية . إن الجمع بين البيانات الجيوفيزيائية والجيوتقنية قد يحسن كثيرا من جودة بناء المشاريع في الهندسة المدنية. من الناحية التركيبية لم يتم الكشف عن وجود أي فوالق او تكهفات او مناطق ضعف في هذا الموقع من **(ERT)** ومن بيانات الحفر التقيبية وليس هناك أي مصادر محفوفة بالمخاطر فى الموقع. ونتيجة لذلك، يعتبر الموقع مناسبا لبناء السد. واستخدمت التحريات الجيوتقنية ووالحفرة التنقيبية بنجاح للتحقق من نتائج قياسات المقاومة. ويتبين أن الجيوفيزياء الهندسية قادرة على توفير حلول لتحديد ماموجود تحت سطح الأرض ويمكن الاعتماد عليها للحصول التركيبة الجيولوجية لتحت سطح الارض.