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Behavior of Abu-Jir Fault Zone in Al-Thirthar Valley and near Habbaniya Lake Areas – Comparative Study Using Seismic Reflection Sections

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ABSTRACT

A comparative study of behavior of Abu-Jir fault zone in Al-Thirthar Valley and near Al-Habbaniya Lake areas has been carried out using seismic reflection sections. Interpretation of the seismic sections showed some similarities and differences in behavior of Abu-Jir Fault Zones in both areas. The seismic sections exhibit simple flower structure in the fault zone of both Al-Thirthar Valley and near Habbaniya Lake but the flower structure in later is simpler than the former. The fault zone in Al-Thirthar Valley behaves as blind fault, whereas it reaches to the Earth's surface near Habbaniya Lake. Abu-Jir Fault Zone near Habbaniya Lake is wider than that in Thirthar Valley area. Syn-rifting due to faulting and slightly thickening has begun within both areas; occur between Alan and Hartha reflectors in Thirthar area and between Alan and Dammam reflectors near Habbaniya Lake. Abu-Jir Fault Zone near Habbaniya Lake suffered to strike slip movement less than that in Thirthar Valley because it is far from the collision suture zone between Arabian plate and Turkish and Iranian plates.

Introduction

Abu-Jir Fault Zone forms an expressive linear feature across the Iraqi territory for about 600 km that is clearly visible from satellite images. This zone consists of several NW-SE trending faults that extend from Anah Graben, across the Euphrates River valley to Hit, Awasil, Abu-Jir, Shithatha, along the western side of the Euphrates River through Kerbala, Najaf and Samawa to meet Al-Batin lineament west Basrah and northwest Kuwait [1].

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Many researchers used Abu-Jir Fault Zone as a boundary between stable and unstable shelves, but they differed in determining whether the fault beyond Hit city continues northwards, following Al-Thirthar valley to meet Makhul-Hamrin range, where it dies out just south of Sinjar area [2, 3 and 4] or westward to meet Anah Grabin [1 and 5] Figure 1. Northeast passive margin of Arabian plate has suffered extension, continental rift, due to opening Neo-Tethys Ocean during Mesozoic Era [3, 4 and 6]. Many subsurface structural features have developed in central, east and north of Iraq territory [6, 7 and 8]. The irregularity in margin of the Arabian, Iranian and Turkish plates at the subduction zones with the counterclockwise of Arabian plate included wide scale strike slip movement along the older faults [9].

This work aims to compare behavior of Abu-Jir Fault zones in Al-Thirthar Valley and near Habbaniya Lake area using the available seismic sections, Figure2.

Geological Setting

Stratigraphically, many formations are exposed through the study area, wide spread Euphrates, Nfayil, Fatha and Injana formations and many deposits of Quaternary, Figure 3. Euphrates formation (Early Miocene) consists of three units. Lower Unit of basal conglomerate followed by recrystallized, fossiliferous limestone changing to coralline limestone. Middle Unit consists of alternation of hard limestone and pseudoolitic limestone. Upper Member consists of alternation of grey limestone with green marl [10]. Nfayil Formation (Middle Miocene) is widely cropped out west of Habbaniya and Razzazah Lakes but covers by thin veneer of gypcrete. It involves two members; Lower Member consists of three cycles of green marl and grey fossiliferous limestone. Upper Member consists of cyclic deposits of reddish brown claystone, siltstone and sandstone with thin limestone horizons[11].

In Al-Jazira Area Fatha Formation (Middle Miocene) includes two members; Lower Member consists of limestone – gypsum cycles and Upper member is characterized by limestone and red mudstone and claystone with some gypsum horizons[12].

Injana Formation (Late Miocene) consists of red, brown and grey claystone, siltstone and sandstone[12].

Structurally, according to locations of the seismic sections, the northern part of the study area is located within Mesopotamian Foredeep of outer platform and cut the boundary between Mesopotamian Foredeep and Low Folded Zone and the southern part cuts the boundary of Inner and Outer Platforms [5]. Surface structural features are missing but there are many subsurface extensional structures through the area [6 and 9]. Abu Jir Fault Zone is the most important subsurface structure. It formed many geomorphological features through Abu Jir vicinity such as Awasil, Al-Jabha, Al-Mudowar and Abu Jir Sag ponds [13]. The strata are almost horizontal. The slop is gentle southward through Al-Thirthar Valley [14] and is a gently sloping with a gradient of 5 m/Km towards east and northeast in Abu Jir vicinity [15].

Interpretation of Seismic Sections

Two seismic reflection sections were employed to investigate behavior of Abu-Jir Fault Zone in the study area. Reflection seismic section WT-36 crosses Al-Thirthar valley west of Makhul Anticline was used to study behavior of the fault zone in Al-Thirthar Valley, Figure 4, while the reflection seismic section AR-38 used to investigate behavior of Abu-Jir Fault Zone near Habbaniya Lake, Figure 5.

Seismic section WT-36

According to analysis of synthetic seismograms of some oil wells, six reflectors were picked, Figure 4. These reflectors include the following formation from the oldest to the youngest: Kurra chine (Late Triassic), Alan (Late Liassic), Shuaiba (Aptian), Mouddud (Albian), Hartha (Late Campanian- Early Maastrichtian) and Jeribe (Middle Miocene). Discontinuity of the good reflectors shows clear image of the main fault in the middle of the seismic section. The fault zone has width approximately 3 km measured on Hartha reflector. It consists of major fault that dips steeply toward northeast. The fault zone includes several steeply dipping normal faults that divergent upward. Two sets of minor faults dipping toward each other. The minor faults, synthetic, are dipping in a same direction of major fault while the minor faults, antithetic, dipping opposite of the major fault. Generally flower structure occurs within the seismic section in either strike slip movement or as dip-slip inversion [16 and 17]. Evidences of dip slip inversion are missing in this seismic section. Strike slip movement can be developed in either positive or negative flower structure [16 and 17]. Strike slip fault in this seismic section forms simple flower architecture. It tightly clustered fault strands that dip steeply to upward spreading fault arrays that show extensional displacements with uplifting in lower part of the major fault. Negative flower structure is formed.

Opening of the Red Sea and Gulf of Adan and the collision between Arabian and Anatolian plates develop stresses that affects to the pre-existing fault (graben strucuture) as strike slip movement that form Negative Flower Structure.

Interpretation of seismic section WT-36 shows that interval time of Shuaiba and Mauddud reflectors are variable with presence of the onlap stratigraphy features inside the main graben area, this refers to an increase in thickness of sediments, while the interval time in the shoulder areas is almost fixed. Slight thickening is occurred during extension phase of northeast passive margin of Arabian plate. Stratigraphic sequence between Alan and Hartha reflectors represent syn-rift. It continues from Late Liassic to Late Campanian- Early Maastrichtian. The interval time of Kurra chine and Alan reflectors is almost fixed and equitable both inside main graben and shoulders area. Fixed thickening of the sequence is from Alan reflector downward that represents pre-rift. According to seismic interpretation indicators and well data, this type of normal faults develops due to increase in weight (thickness) of sediments which are variety at the head of the hanging wall comparing with thickness at footwall where it almost constant and thinner [18]. Neither thickening nor faulting through the sequence from Hartha reflector upward therefore has it represented post-rift.

Seismic Section AR-38

Seismic section AR-38 is used by [13] Figure 5. It reveals five major faults. The first one (F1) is steeply dipping northeastward which has two synthetic minor faults dip northeastward and one antithetic minor fault dips southwestward. Fault (1) is suffered to strike slip movement that develop negative flower structure.

Graben structure is developed in the central of the seismic section. F2 and F3 are southwest and northeast normal faults of the graben respectively. F2 dips northeast and F3 dips southwest. Another graben is formed. F4 and F5 are southwest and northeast normal faults of the graben respectively. F4 dips northeast and F5 dips southwest. There is slight thickening between Dammam and Hartha reflectors.

Comparison of Abu-Jir fault zone

There are similarities and differences between the behaviors of the fault zone in area of Al-Thirthar Valley and near Habbaniya Lake areas. The characteristics of the fault zone may be summarized as;

• Abu Jir Fault Zone in seismic section AR-38 reaches to earth's surface, cutting Dammam reflector, whereas in seismic section WT-36 behaves as blind fault

• Width of the fault zone in Al-Thirthar Valley less than the width in near Habbaniya. It has 3Km and 8Km respectively.

• Simple flower structure is appeared on the fault zone of both areas that means strike slip movement is occurred upon pre-existing normal faults. The seismic sections show the fault zone in Al-Thirthar Valley is subjected to strike slip movement perfectly while less movement taken place near Habbaniya Lake.

• Syn-rifting due to faulting and thickening is begun through the fault zone in both areas that takes place between Alan reflector (Late Liassic) and Dammam reflector (Middle-Late Miocene) near Habbaniya Lake and between Alan reflector and Hartha reflector (Late Campanian-Early Maastrichtian) in Thirthar valley. During this span time the northeast margin of Arabian plate undergoes to extension or rifting lead to formation of the fault zone.

Discussion

Seismic reflection surveying is the most widely used and well-known geophysical technique of subsurface geological structures. Good reflectors are picked in seismic sections WT-36 and AR-38. The discontinuity of the reflectors reveals good image of Abu-Jir Fault Zone. The fault is developed by the extension of northeast passive margin of Arabian plate during Mesozoic Era. Northeastward counterclockwise movement of the Arabian plate due to the opening of Red Sea and Gulf of Aden and the collision between the Arabian and Turkish or Anatolian plates generate southward stresses. The stresses develop the strike slip movement. Seismic section WT-36 shows that the pre-existing fault, graben structure, is suffered to strike slip movement perfectly because it near to the collide suture of above two plates. Seismic section AR-38 is far away from the suture therefore less affected by strike slip movement than the former. The Fault Zone in Al-Thirthar valley is reached to Hartha reflector (Late Campanian-Early Maastrichtian) Figure 4. It is continues inactive from Maastrichtian upward. Seismic section AR-38 reveals Abu Jir Fault Zone cuts all stratigraphic sequence of the basin. The Seismic sections AR-50 and AR-22, in area near Habbaniya Lake, appear Abu Jir Fault Zone reaches to earth’s surface [19]. Abu Jir Fault Zone sometime appears on the earth’s surface especially in area west of Al-Razzazah Lake [4 and6] and very clear in view of digital images between Najaf and Hit cities. Many geological features related to faulting along Abu Jir fault Zone are showed by optical viewing of aerial photograph or satellite image. Sag ponds, pressure ridge and many water springs are extended westward. Abu Jir Fault Zone is suffered to another phase of extension, especially in Abu Jir vicinity, due to the tilt of Mesopotamian sequence Figure 6. Rapid subsidence of Mesopotamian Foredeep is acted during middle and late Miocene [4]. It generated high tension or new phase of extension in axis of flexure where Abu Jir Fault Zone is present especially through area of Hit city southeastward. The stresses continue during Tertiary period, therefore Abu Jir Fault Zone in Abu Jir vicinity continues active, crosses the younger formations and wider than the fault in Al-Thirthar valley.

[1] mentioned that the seismic reflection sections of Al-Thirthar valley show Abu Jir Fault Zone is missing but it runs westward and meet Anah Graben to construct Anah-Abu Jir Fault System. This research reveals there is a fault in Al-Thirthar valley not only in seismic section WT-36 but also in WTM-26, north Thirthar Lake directly, [20] but the geometry and

kinematic of this fault is unlike that in Abu Jir Fault Zone near Habbaniya Lake. Correlation between seismic section AR-38 and seismic sections of Anah Graben that used by (1 and 6) appears similarity of geometry and tectonically timing relationship between them. Present of sulfate water springs between Hit and Anah such as Albaghdadi and Haqlan water springs another indicator that Abu Jir Fault Zone runs westward coincide with [1 and 6].

Conclusions

The Fault Zone in area of Al-Thirthar Valley and near Habbaniya Lake is developed due to extension of northeast margin during time span from Late Liassic to Early Maastrichtian in Thirthar valley and continues to Middle-Late Miocene near Habbaniya Lake. Opening the Red Sea and Gulf of Aden and collide between Arabian and Turkish plates are generated southward stresses affected to Abu Jir fault Zone as strike slip movement. The stresses are reduced southward.

Other phases of extension are taken place during Middle Miocene upward because of tilt of Mesopotamian sequence. The phases of extension are acted to Abu Jir Fault Zone in area near Habbaniya Lake. The fault is reactive and reaching to earth's surface, therefore it leaves some geological features that related to faulting and very clear in view of digital image between Najaf and Hit.

Abu Jir Fault Zone in area near Habbaniya Lake is reaching to earth's surface, the width is 8 km and consisting of many major faults, whereas in Al-Thirthar Valley it is blind fault, the width is 3 km and consisting of one major fault. This reflects the fault near Habbaniya Lake is more active in comparison with Thirthar Valley. On other hand the area west of Hit is consisting many sulfate water springs such as Albaghdadi and Haqlan water springs, come from deep aquifers, therefore the authors believe Abu Jir Fault Zone beyond Hit runs westward to meet Anah graben concordant with [1 and 6].

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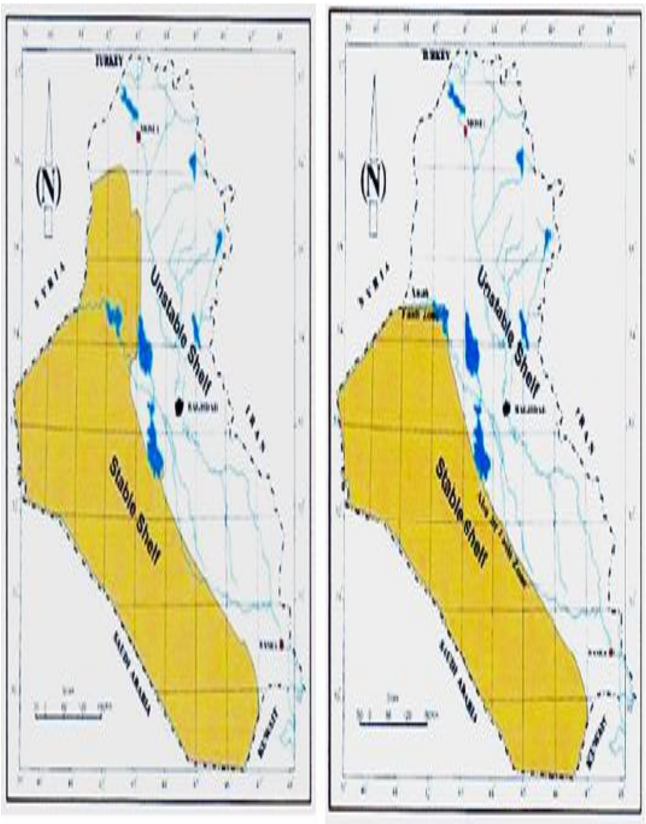

Figure (1) The boundary between stable and unstable shelves of Iraqi territory. Left depend on [2] right depend on [1 and 5].

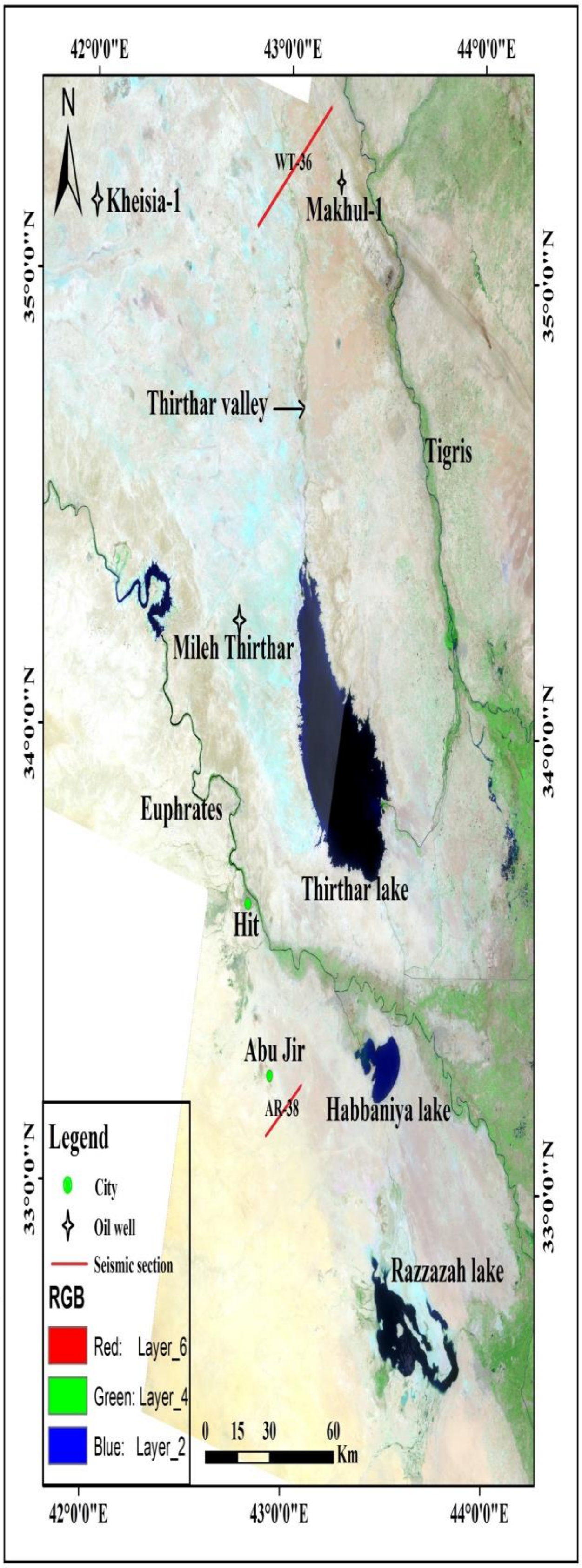

Figure (2) Location map of study area.

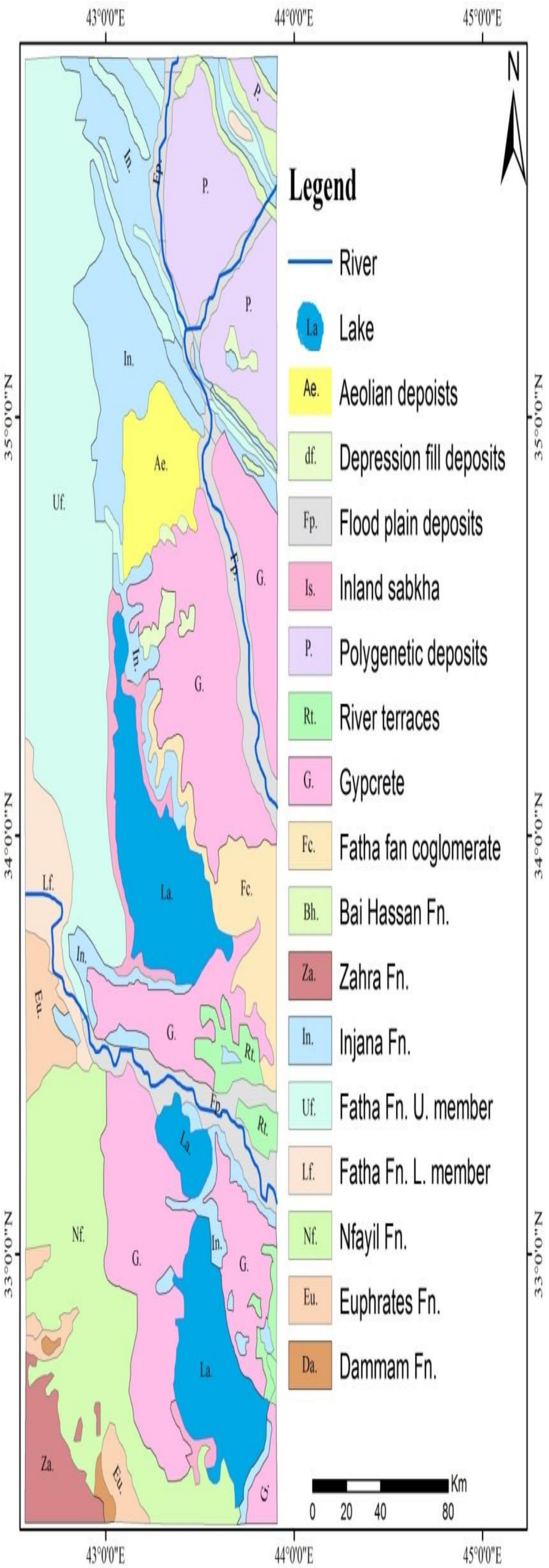

Figure (3) Geological map of study area [modified from 21].

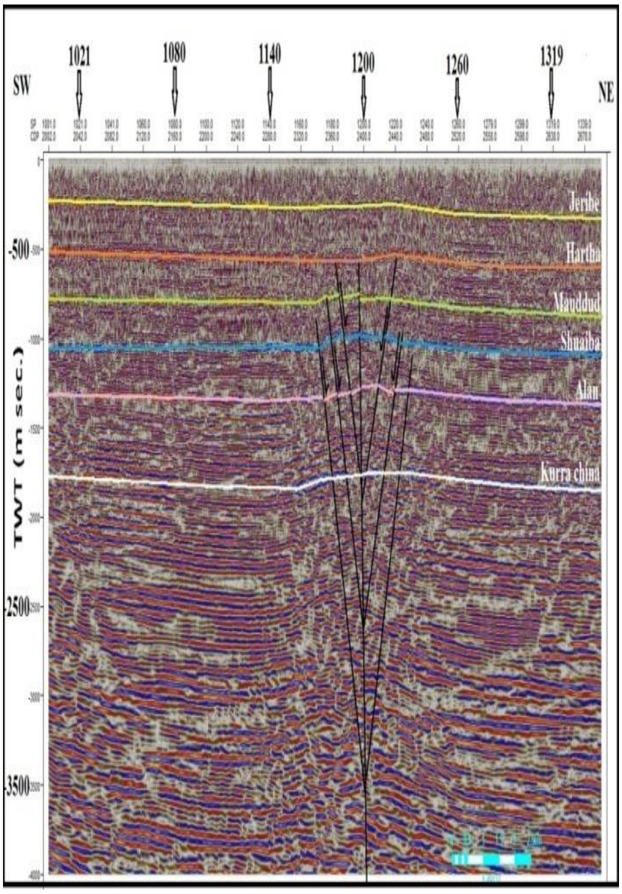

Figure (4) Seismic reflection section WT-36 in Al-Thirthar valley.

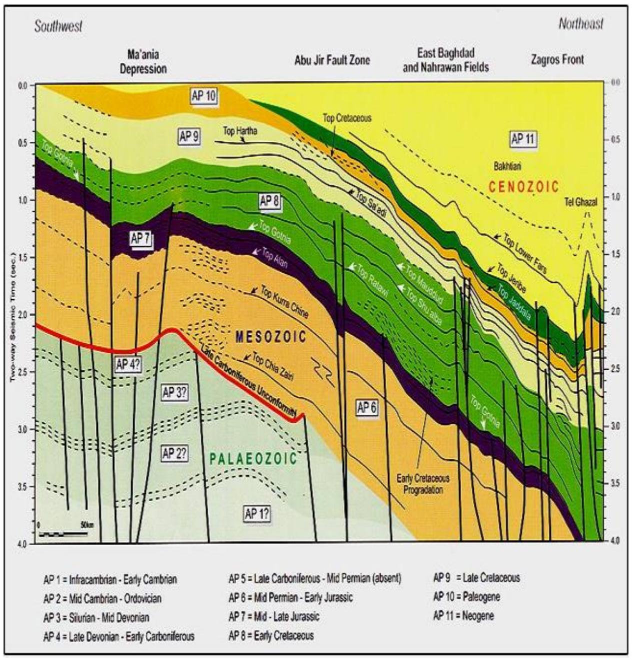

Figure (5) Seismic reflection section AR-38 in Abu Jir area [after 13].

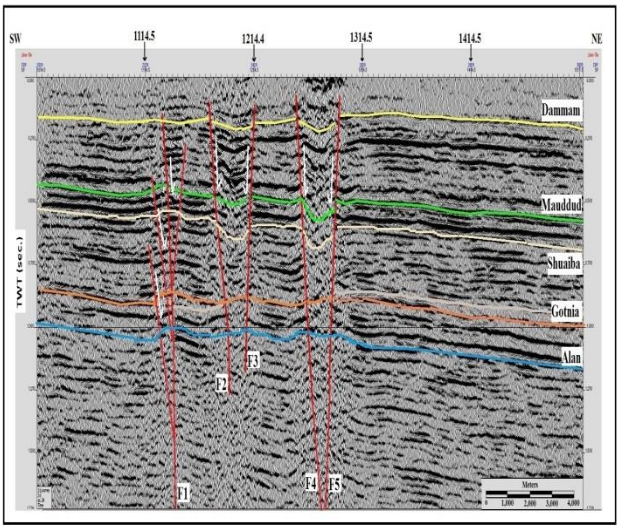

Figure (6) Two way time regional seismic derived from seismic reflection extended from west to east of Iraq [after 22].

سلوك نطاق فالق ابو جير في وادي الثرثار وقرب بحيرة الحبانية, دراسة مقارنة باستخدام المقاطع الزلزالية الانعكاسية

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الخلاصة

دراسة مقارنة سلوك فالق ابو جير في وادي الثرثار وقرب بحيرة الحبانية انجزت باستخدام المقاطع الزلزالية الانعكاسية المتوفرة. تفسير المقاطع يظهر وجود تشابهات واختلافات في السلوك بين المنطقتين. المقاطع تظهر تراكيب زهرية بسيطة لنطاق الفالق في كل من وادي الثرثار وقرب بحيرة الحبانية ولكن هذا التركيب اقل تطور قرب بحيرة الحبانية. فالق ابو جير في وادي الثرثار تحت سطحي بينما قرب بحيرة الحبانية يصل الى سطح الارض مخلفا بعض الظواهر الجيولوجية مثل sag ponds و pressure ridges. نطاق فالق ابو جير قرب بحيرة الحبانية اكثر عرضا مما عليه في وادي الثرثار. زيادة بسيطة في سمك الطبقات الصخرية المرافق للتصدع الطبيعي قد وجد في المنطقتي بين عاكسي علان والهارفه في وادي الثرثار وبين عاكسي علان والدمام قرب الحبانية. نطاق فالق ابو جير قرب بحيرة الحبانية اقل تأثير بالحركة المضربية مقارنتا بوادي الثرثار لان المنطقة الاخيرة اقرب لحزام التصادم بين الصفيحتين العربية والتركية.