



## Neotectonics of Al-Thirthar, Al-Habbaniya , Al-Razzazah Depressions, Central Iraq, by using Remote Sensing Data.

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### Abstract

The object of this research is to reveal the neotectonics of Al-Thirthar, Al-Habbaniya, and Al-Razzazah depressions by using remote sensing data. The age of the exposed rocks ranges from Early Miocene to Holocene. The depressions represent the west margin of the Mesopotamia Zone along its boundary with Al-Salman Zone. The lineament map contains three major groups of lineaments. Two of them are trending east-west and northeast-southwest parallel to the transversal fault systems of Iraq territory. The third group is trending northwest-southeast. The lineament groups reveal the tectonic and structural effects to the extension and the shape of the depressions. The intersection of the lineaments divided the area into small fragments which contribute to develop the depressions. Some of geomorphological landforms reveal that the neotectonics of depression area are relatively weak.

**Keywords:** genesis, depression, enhancement, lineaments, elevation model.

نيوتكتونك منخفضة الترتار والحبانية والرزازة, وسط العراق, باستخدام بيانات التحسس النائي

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### المستخلص:

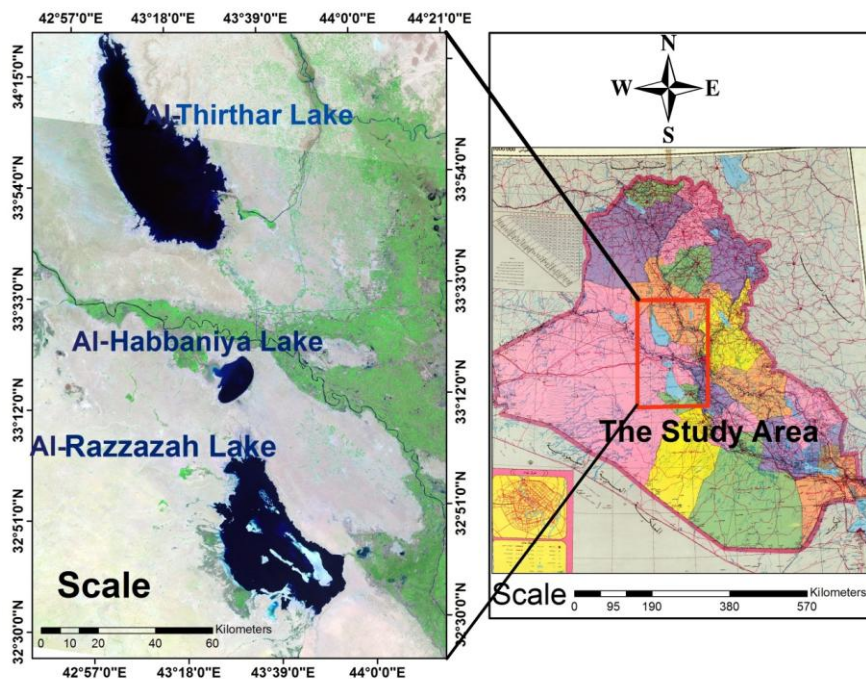
يهدف البحث الى دراسة التكتونية الحديثة لمنخفضات الترتار والحبانية والرزازة من خلال معطيات التحسس النائي. تقع منخفضات الترتار والحبانية والرزازة وسط العراق الى الغرب من نهر دجلة. عمر الصخور المكتشفة تتراوح بين المايوسين الأسفل والهولوسين. تمثل المنخفضات الثلاثة الحافة الغربية لنطاق ما بين النهرين على الحدود مع نطاق السلطان. أن خارطة المظاهر الخطية تحوي ثلاثة مجاميع رئيسية من الاستطاليات. اثنان منها تتجه شرق-غرب وشمال شرق-جنوب غرب موازية الى أنظمة الفوالق المستعرضة في العراق اما المجموعة الثالثة فتتجه شمال غرب-جنوب شرق. أن ظهور هذه الاستطاليات موازية الى الفوالق الرئيسية تعكس التأثير التكتوني والتركيبي على امتداد وشكل المنخفضات. أن تواجد الاستطاليات في اتجاهات مختلفة عملت على تقطيع صخور المنخفضات وساهمت في تطوير تلك المنخفضات. عكست بعض الاشكال الجيومورفولوجية الحديثة ان النشاط التكتوني الحديث كان ضعيف نسبيا.

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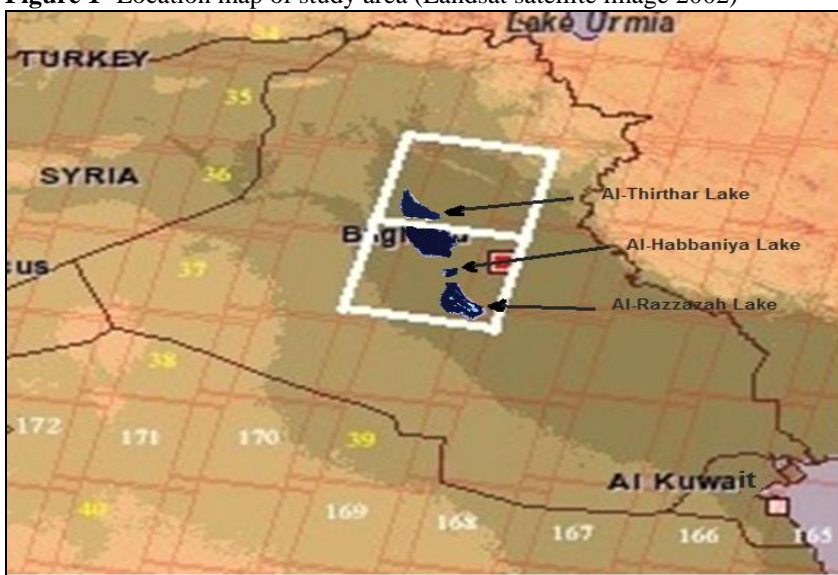
**Introduction**

Al-Thirthar, Al-Habbaniya and Al-Razzazah depressions are located in the middle of Iraq, west of Tigris River figure-1. The three depressions became lakes after connecting by net of channels during them and with Tigris and Euphrates Rivers. Two scenes of Landsat satellite Enhanced Thematic Mapper (Landsat-7 ETM) images 169-36 and 169-37 are used to cover the study area figure-2 and table-1-. Several softwares such as ERDAS IMAGING version 9.2, ArcGIS version 9.3 and Rock Ware v. 1.5 were used to get data about lineament map of the selected area and determine the modern geological features as indications of neotectonics of the three depressions.

Spatial resolution of Landsat-7 ETM is 30 m for all multispectral bands except panchromatic and band 6 (thermal). Panchromatic band has spatial resolution of 15 m. Merging bands are done by ERDAS software between panchromatic band and each multispectral band to increase the spatial resolution of the bands from 30 m to 15 m. Several enhancement processes e.g. histogram equalization and high pass filter were applied to the scenes. High resolution enhanced satellite imagery allows the lineaments and geological features to appear clearly.[1]



**Figure 1-** Location map of study area (Landsat satellite image 2002)



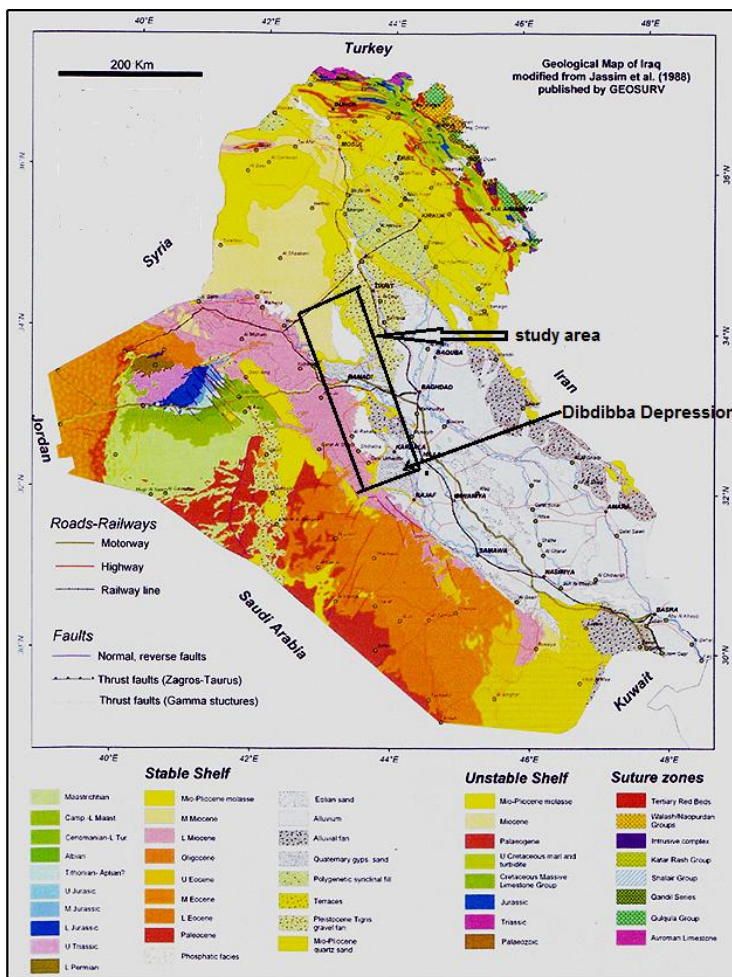
**Figure 2-** Landsat-7 image 169-36 and 169-37 were used for study area

**Table 1-** Data of Landsat ETM images.

Locations	ETM Data			
	Path	Raw	Acq. date	Producer
WRS-2	169	036	16-04-2000	Earth sat
WRS-2	169	037	11-07-2002	Earth sat

**Stratigraphy**

The age of the exposed rocks is range from Early Miocene to Holocene. Generally, the oldest rocks crop out in the west of three lakes, in which Euphrates Formation (Early Miocene) exposes in west bank of both Al-Habbaniya and Al-Razzazah Lakes. Al-Fatha Formation (Middle Miocene) appears in the west bank of Al-Thirthar Lake. Injana Formation (Late Miocene) exposes in north, south and east area of both Al-Thirthar and Al-Razzazah Lakes. Outcrops of Injana Formation show as patches within gypcrete. These outcrops spread in the area south of Al-Thirthar Lake and east of Al-Razzazah Lake. The formation extends as a narrow strip along east bank of Al-Habbaniya Lake. Dibdibba Formation (Pliocene – Pleistocene) exists in Dibdibba Depression. The depression appears as triangle shape in geological map of Iraq figure-3 . Quaternary sediments in this area include Al-Fatha fan conglomerate (Pleistocene) deposited in east area of Al-Thirthar Lake also exist as a strip separates Injana Formation from Al-Fatha Alluvial Fan (Early-Middle Pleistocene). However, gypcrete layer (Holocene) spreads south of Al-Thirthar Lake and along east side of both Al-Habbaniya and Al-Razzazah Lakes [1].

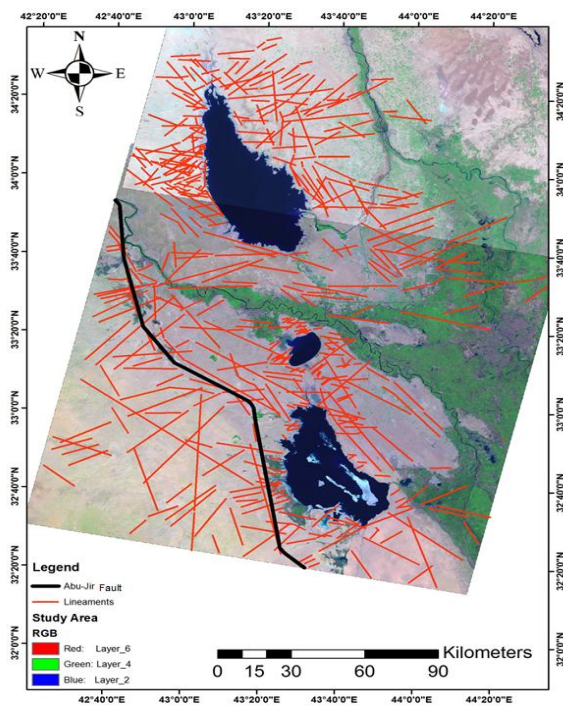


**Figure 3-** Geological map of Iraq (After GEOSURV in 1)

**Lineaments**

Lineaments are straight or gentle curving features on earth’s surface that are commonly expressed topographically as ridges, depressions, or aligned depressions. Structural analyses are conducted on regional scale, to provide a comprehensive look at the fault extent, lineaments and other structural features. Geological features are typically large (kilometric scale) and applications therefore require small-scale imagery to cover the extent of the element of the interest [2]. There are many processes in which lineaments can be drawn as map such as color composite, principle component and others or by use kernels 5x5, 7x7 or 9x9 , but kernel 3x3 can delineates lineaments and detects any variation within digital image because of the size of features in the images.

Two scenes of Landsat-7 imagery are used by ArcGIS Software to generate lineament map of study area figure-4 with check of some lineaments in field work Plates 1. Histogram and the statistics of the map are done figure-5. It is very difficult to detect structural features in an area where vegetation cover is dense. Lineaments are drawn by many scales (zooming) applied to show local lineaments where zoom increases, versus reducing the zoom regional lineaments will be extracting clearly such as Abu-Jir fault system that appear west of Al-Razzazah lake.



**Figure 4-** Lineaments appear on images of study area



**Plate 1-** Lineament feature northwest Al-Thirthar depression

The histogram illustrates the short lineaments less than 1 km is more frequency than other lineaments. They are concentric in surrounding area of the three lakes figure-5.

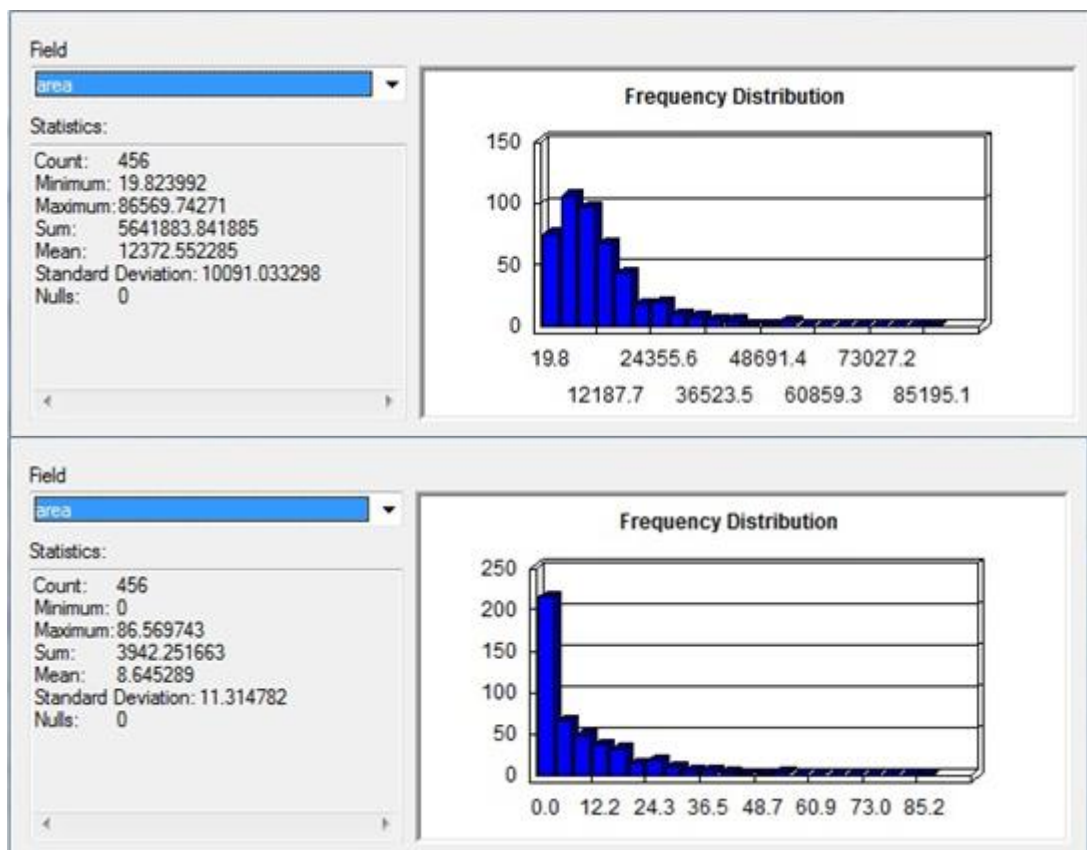


Figure 5- Histogram and statistics of the lineament map (A) in meters (B) in kilometers

### Lineament Analysis

Many authors such as [2- 4] used different techniques to recognize and analyze the linear features on satellite images. They are very useful tools for tectonic studies especially when combined with geophysical and field data.

Rose diagram is drawn for lineaments of the study area by using Rock-ware version 15 software figure-6.

The figure shows two groups of major lineaments trend in two different directions. The first group of lineaments trends east-west approximately perpendicular to the axis of three lake extents. The second group generally trends N60°E-S60°W approximate perpendicular to the most geological structures in unstable shelf of Iraqi territory.

The lineaments of both groups east-west and northeast-southwest are parallel to east-west and northeast-southwest Transversal Fault Systems of the tectonic zones of Iraq according to (1) figure-7. It is interesting to note where the cover rocks are in contact with basement, fracture pattern from the basement can be seen superimposed and passing into the cover rocks.

Major topographic lineaments are often clearly related to structures and rocks as mapped on the Earth's surface, and increasingly, to postulate subsurface fractures [2].

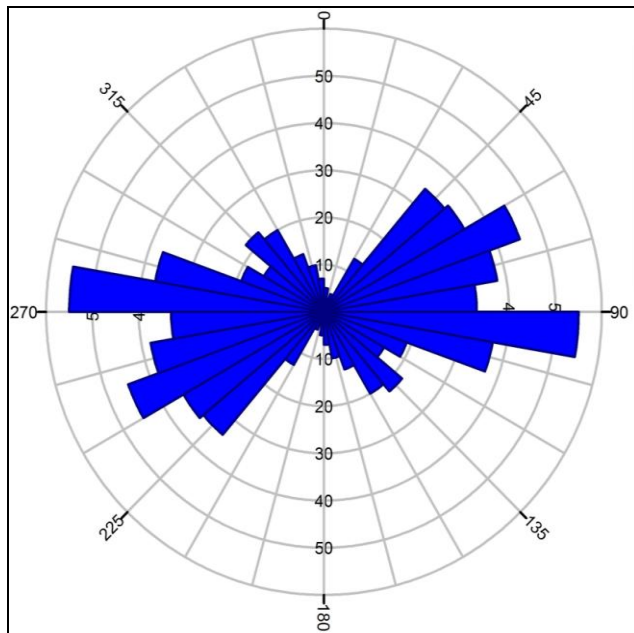


Figure 6- Rose diagram of lineament map of study area

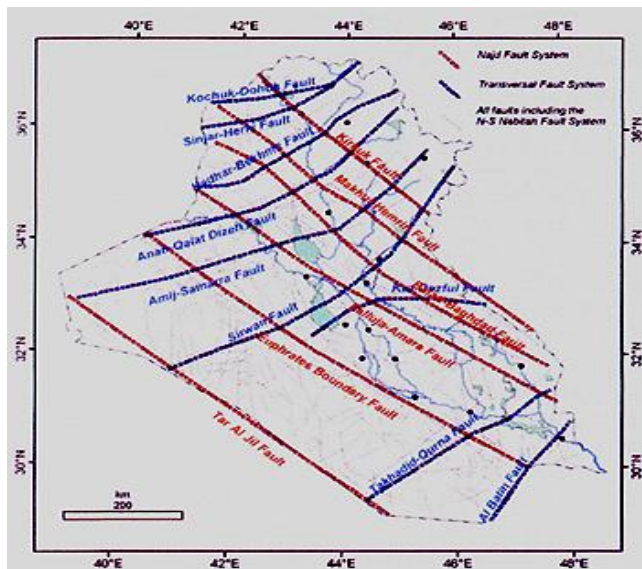


Figure 7- Tectonic zones of Iraqi territory (After 1)

The Transversal Fault System in central of Iraq was reactivated from Late Jurassic time onward. Some faults of these systems underwent sinistral strike slip movement in Quaternary time; at least 2 km of horizontal displacement is occurred along the Anah- Qalat dizeh Fault at Al-Fatha in the last few million years. Many foothill zone anticlines are segmented into separate domes and their fold axes are bent at the intersection with the transversal faults [1]. figure-7 shows that both Al-Thirthar and Al-Razzazah lakes are pyriform, and the axis of each one deflects to the east in the south half of them. The deflection of the axis may be due to sinistral movement of Amij-Samarra and Sirwan transversal faults that pass beneath Al-Thirthar and Al-Habbaniya Lakes respectively. Generally these lineaments play important role in changing the shapes of the Al-Thirthar and Al-Razzazah Lakes.

Third group of lineaments trends N30°W figure-6. It is parallel to subsurface normal faults spreading in extensional zone. They have northwest trending (5 and 6). The lineaments dense in the eastern bank of the three lakes figure-4 and intersect the two major lineaments. The intersection makes small blocks and more intensity deformed region that effect strongly to the formation of the lakes. [1] referred that Al-Thirthar, Al- Habbaniya , Al-Razzazah and Bahr Al Najaf depressions may be

tectonically, controlled by the NW-SE trending Euphrates Boundary Fault and N-S trending Thirthar fault line.

NW-SE Fault System was reactivated during Jurassic to Quaternary [1]. Also extension in upper part of study area succession is due to tilt of Mesopotamia sequence. Axis of the tilt or flexure develops along the boundary between Mesopotamia zone and Salman Monocline where the three depressions are located.

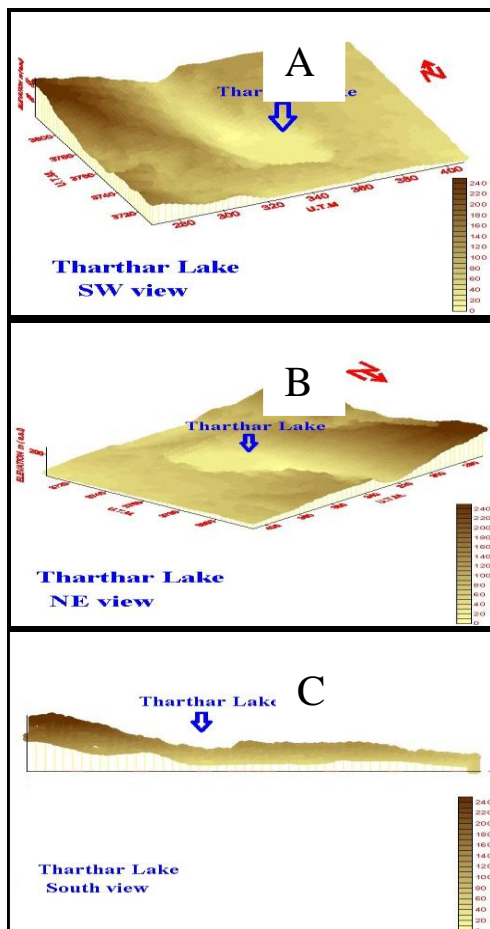
Finally, not all lineaments develop from initial fractures in the basement. Some of the lineaments, especially the ones which are parallel to the axes of the depressions, represent fractures or joints in the sediment cover as a result of tectonic activities of Tertiary and Neotectonics.

#### Digital Elevation Model (DEM):

Digital elevation models are commonly built using data collected by remote sensing technique but they may also be built from land surveying. DEMs are the most common basis for digitally-produced relief maps, drainage modeling, land-use studies and geological applications. They are very useful where two optical images are acquired with different angles [7].

The Digital Elevation Models of three lakes are generated. They involve interpolating contour maps, which are produced by direct surveying of the land surface, aerial photographs and surveying central points. Surfer Software version 8 is used to show the study area in three dimensions. Figures are made in variant views. They are produced by grid, that is formed by data derive their values X, Y and Z from topographic map of 1: 100,000, where (X, Y) are coordinates in UTM system and Z the elevation.

After getting the values X, Y, and Z. data were input in surfer software. Gridding is made according to density of the data. Denser data gives accurate results. 3D figures draw custom-made the user by contour interval, coloring or others. Finally exaggeration to elevation is made to explain the topography of the depression area and surrounding figures-8, 9 and 10 .



**Figure 8-** Digital elevation model of Al-Thirthar area (A) Southwest view (B) Northeast view and (C) South view

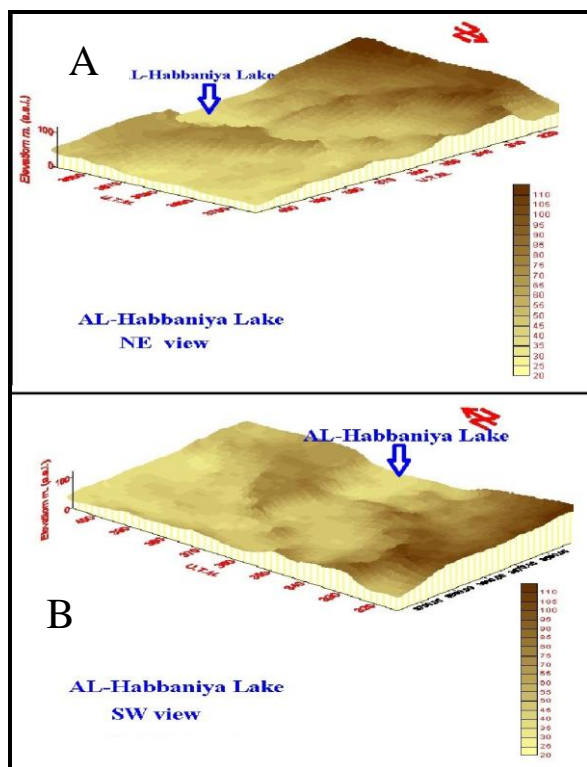


Figure 9- Digital elevation model of Al-Habbaniya area (A) Northeast view (B) Southwest view

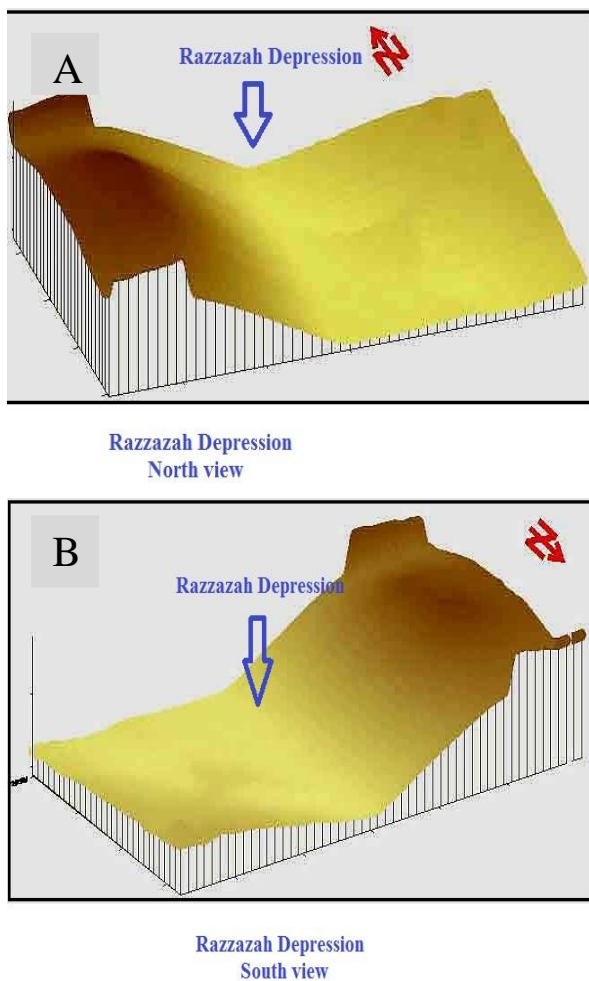


Figure 10- Digital elevation model of Al-Razzazah area (A) North view (B) South view



### Analysis of Digital Elevation Models

Digital elevation model of Al-Thirthar area figure 8 shows that the slope of the surround area is toward the axis of the depression. The slope in the west bank is gradual toward the depression. It has low gradient. Gradient is very low in the east bank of the Al-Thirthar depression. Steep cliff east rim can be noted figure-8c . It represents the conglomerate of Al-Fatha Alluvial Fan.

Existence of the Quaternary deposit in the east bank and absent in the west bank (8) reflects that the east bank of the Al-Thirthar depression is low area after Al-Fatha Alluvial Fan deposition, that took place due to subsidence of Mesopotamia basin during Tertiary time. Rapid subsidence during Middle and Late Miocene was in the Mesopotamia basin (2). This subsidence of the sequence generates tensile stress in area of Al-Thirthar depression as well as in area of Al-Habbaniya and Al-Razzazah Lakes.

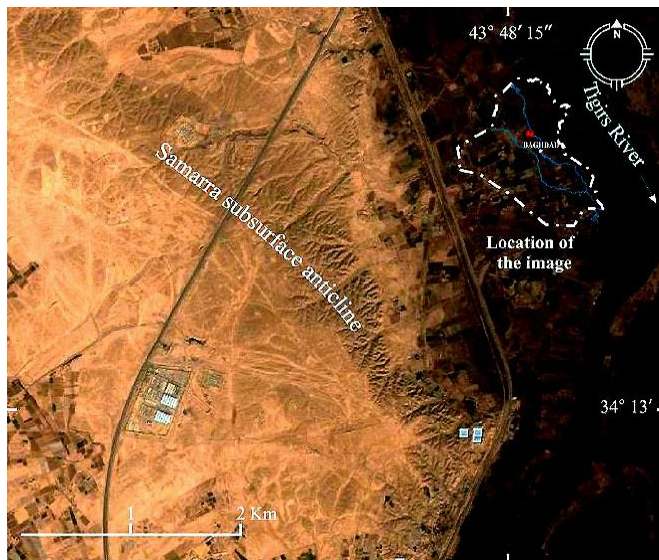
Al-Habbaniya depression is small. Distinct variation in gradient is not observed. Generally, the west and east banks have the same elevation. They have gentle slope toward depression. Hills, plateaus and ridges can be observed in the digital elevation model of Al-Habbaniya area figure-9.

Digital elevation model of Al-Razzazah depression shows elevated west bank relative to the east bank. The west bank has small steep ridge. Gradient in the west bank is greater than the east one. Abu-Jir fault system passes beside the west rim of Al-Razzazah depression, and may affect on the west bank of the depression figure-10.

### Geomorphologic Landforms as Neotectonic Indicators:

Many indicators are observed in surrounding areas of the three lakes. These indicators may represent neotectonic activities.

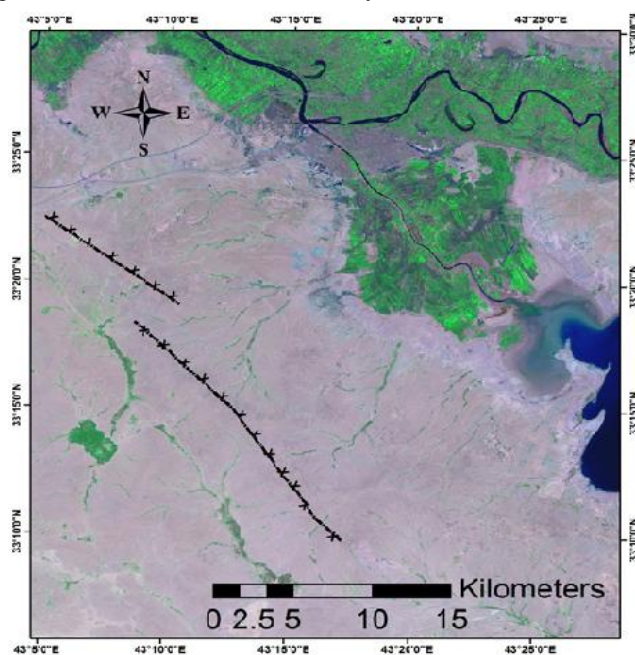
- 1- Recent tectonic activities of several buried structures including folds and faults are recorded through their effects upon the Quaternary stratigraphy and present geomorphologic landforms. They represent abandoned river channels and topographic expression of some active subsurface anticlines (9) figure-11. Rolling topography in the north part of Mesopotamian plain, east of Al-Thirthar Lake, indicates subsurface anticlines that are still rising up such as Balad, Samarra, Tikrit and Baiji Anticlines (10).
- 2- Systematic conjugate joints in limestone of Al-Fatha Formation (Middle Miocene) in the Northwest margin of Al-Thirthar Lake are good indications for tectonic activities after this time Plate 2.
- 3- Abu-Jir fault zone system passes through the west margin of Al-Razzazah Lake. It appears as zone, very clear in the satellite image, and still active nowadays.
- 4- Al-Thirthar Lake is deep depression bordered in east side by cliff of conglomerate layer of Al-Fatha Alluvial Fan (Pleistocene). That is made by subsidence of east bank of Al-Thirthar Lake.
- 5- Lineament map of study area figure-4 shows few systematic groups of lineaments. Some of these lineaments, especially the short northeast ones, may represent tension or release joints in sediment cover, that developed as a result of mentioned above tensile stress during Pliocene – Early quaternary.
- 6- Local drainage divide lines are developed along crest of subsurface structure figure-12 . It is located west Al-Habbaniya Lake and perhaps represents active subsurface anticline or nose. (Al-Sakeni, 1986) (11) referred to a developed active subsurface structure named Nafata-Awasil structure extends from south Hit to east of Al-Habbaniya Lake in NW-SE direction. It is found by geophysical surveys (seismic, gravity and magnetic). They are done by foreign oil companies and drilled many oil wells in it. The area of local drainage divide line was developed as a response to active Nafata-Awasil structure.
- 7- There are three stages of migration eastward of the Tigris River due to the uplifting of the subsurface structure and neotectonics figure-13. The first stage is during Pleistocene, the second stage is during Holocene and the last stage at the present time (12). The location of the migration is in the east of Al-Thirthar Lake.



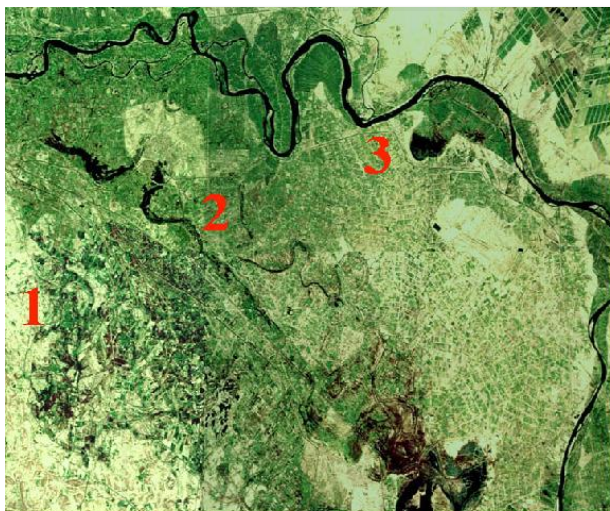
**Figure 11-** Active Samarra subsurface anticline, east of Al-Thirthar Lake (Enhanced from 9)



**Plate 2-** Limestone of Al-Fatha Formation northwest margin of Al-Thirthar lake. Systematic conjugate joints good indication for tectonic activity.



**Figure 12-** Satellite image shows the drainage divide developed along crest of subsurface structure



**Figure 13-** Migration of the Tigris River is eastward in three stages. A good indication of neotectonics east of the Al-Thirthar depression. (After12).

### Conclusions

1. There are three groups of lineaments. The first group is trending east-west perpendicular to the extensional structures beneath the three depressions. The second group is trending N60°E-S60°W perpendicular to the most of the normal faults in the extensional zone. The third group is trending N30°W parallel to the most of the normal faults in Extensional Zone.
2. There are dense lineament features in area surround the depressions. Some of them are parallel to the depressions and the others are perpendicular to them. The intersection of the lineaments divided the area into small fragments which contribute to develop the depressions.
3. The three major groups of lineaments are parallel to the major fault systems of Iraq territory that reveal that the tectonic and structural effects play important role in controlling to the extension and shape of the depressions.
4. The important phenomenon of the neotectonics is the deflection of the axes of Al-Thirthar and Al-Razzazah depressions from north-south direction to the northwest-southeast.
5. Presence of some of geomorphological landforms reveals that the neotectonics of area of depressions are relatively weak.

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