Morphotectonic study of lower Zab River using remote sensing techniques (North Iraq)

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Abstract

Lower Zab River flows from the mountainous region that adjacent for the Iranian border and continues to reach waters of the Tigris River in the Fat ha area, the study area is located at the semi-final of the river from the structure of the Bai Hassan and to its inflow in the Tigris River.

The satellite data captured by satellites (Land sat) by (TM) (thematic mapper) and using several channels confirmed the presence of different river steps levels, as well as what looks like previous trace of the river, especially at the place of cutting the river to south Qara Chauq structure, and linking the study field current with the data space was reached the previous trace of the river, which is the current trace of the river, a distance of 10 kilometers. in addition to the foregoing, it has been in the study account meander function of river and measure the amount of wide the current valley of the river, becoming evidence of activity tectonic modern region which led to a change in the riverbed to more than once.

Introduction

The lower Zab River Comes from Mountain Highlands that separated between Iraq and Iran, and cuts the river in his way several geological structures until confluence with the Tigris river, it has been observed from different satellite data that photograph of the study area that the lower Zab River cut a set of structures that is from the antecedent river, but the presence of a trace of several stages of river steps and the presence of a previous possible trace in the area that different current of the river area, especially when the river cuts the Bai Hassan and southern Kara Chauq structures, that encourage doing of the current study.

Morfotectonic considered one of the important entrances for the Neotectonic studies, that dealing with the newest structural features resulting in the Earth’s crust and its activity throughout its history tectonic extended since the end of the Tertiary (Neogene) or in the first half of the Quaternary (Vicente, et al., 1996; Bloom, 1998) and it can be the earth movements extended since the Miocene to the recent, that it are important in the forming the Morfotectonic elements of any region (Zhiming, 1993)), which included the probability of the antecedent of the river, and a Sinuosity index and the amount of width of the valley, depending on linking satellite data and study field.
Location of the study area

The current study area, located 240 kilometers north of the Baghdad, Iraq, along the lines 35° 50'–35° 05' north and 43° 45'–44° 45' east and to the eastern side of the Tigris River, as shown in Figure (1).

Figure (1) shows the location of the study area.
Geological study area

Tectonically, the current study area lies in folded zone, where the Quaternary depositions is exposed on the surface, which consists of gravel and boulders (Mukdadiya and Bai Hassan Formations) In addition to recent depositions. While exposed in the core of Bai Hassan and Kara Chauq structures the Miocene formations (Tertiary age), which consists of evaporate rocks and limestone and marl within Fatha Formation and with sandstone and clay within Injana Formation, Figure (2).

Plate (1) shows the geological study area

Surface geology of the study area

Geologically, current study area distinguished in sedimentary cover, which influenced by late Alpine orogeny, where sedimentary rocks exposed are extended from the lower Miocene to the recent, where outcrops geological formations (from oldest to newest) Fatha, Injana, Mukdadiya, Bai Hassan, in addition to, Quaternary and recent depositions.

Below is a description of surface geological formations in the study area:

❖ Fat ha Formation

Mention naming lower Fars on this formation for the first time in Iran by Busk and Mayo, 1918: in Bellen et al., 1959. they considered the stratigraphy units rock after it
was divided into a series of layers of several researchers such as Pilgrim 1908; in al-Jubouri, 1999. and later replaced this name in Iraq, was chosen a typical section became known as Fatha Formation.

Cited Kitchin in an unpublished report (In Bellen et al., 1959) divided the rocks of this formation in Kirkuk area into the following units: Upper Red Beds, Seepage Beds, Saliferous Beds, Transition Beds, consists of a succession depositional cycles consist of evaporates, limestone, silt. the age of formation has been proven in middle Miocene (Serravallian), this formation is considered one of the important formations in the east of the Tigris River region.

❖ **Injana Formation**

This formation is called previously Upper Fars, where consists of different sizes and type, starting from the claystone, siltstone and sandstone, the age of formation back to upper Miocene - lower Pleistocene (Buday, 1980). He mentioned Hussein, 2009; That the Injana Formation consist of sandstone of different sizes with successive claystone in the sedimentary cycles repeated with increasing thickness of the claystone layers in the upper part of the formation as well as a secondary gypsum deposits in various formation layers.

❖ **Mukdadiya Formation**

Previously this formation is called lower Bakhtaran, where consists of pebble Sandstone which are fragile, successive and overlapping with thin layers of siltstone and claystone, the formation age is Pliocene, (Bellen et al.,1959).

We have noted Al-Rawi et al.,1992; that the lower contact boundary of the formation with the Fatha Formation compatible and gradual, and determined the appearance of the first sandstone layer carriers of the pebble. The lower contact boundary of formation with the Bai Hassan formation is also compatible and determined when the first layer appearance of Massive Conglomerate.

❖ **Bai Hassan Formation**

The Bai Hassan Formation consists of coarse conglomerates weak cohesion and successive with sandstone and siltstone, the age of formation back to Late Pliocene. Pointed Albanna, 2002; the stratigraphy variation of the Mukdadiya Formation to the Bai Hassan Formation is very fast and determined by the appearance of coarse conglomerates layer, and this variation is a contact boundary between them.

❖ **Quaternary deposits and Recent Sediments**

Quaternary deposits consist of flood lowlands deposits and sand deposits and old river terraces deposits of the Tigris River, that river terraces depositions consistence a belt form around the riverbed of Tigris River and consist of gravel and sand with secondary gypsum with silt and clay, and high permeability. Featuring beds outcrop (exposure) on two sides of Tigris River and In some valleys side some sedimentary
structures such as Cross bedding, linear bedding and lens forms of clay or silts beds within gravel beds.

Spread in the study area the recent deposits and Quaternary deposits represented friable deposits and fluvial deposits of different lithology properties of clays and sands in addition to the presence of evaporate rocks (gypsum).

The aim of study

The aim of the study is access for evidence supports idea of recent tectonic activity in the area, that lead to a change of riverbed more than once.

The antecedent trace of river

From note the river stage, especially that the existence of the southern Kara Chauq structure and southeastern plunge (which is locally called Karabotic fold) shows that it consists of three stages, namely: -

Phase I: located just 7 kilometers starting from the river and on the southeastern plunge top (Karabotic Fold) and the rate of height (883) meters above sea level.

Phase II: located on (4) kilometers from the stage river and lie right of the river also and at the rate of height 361 meters above sea level.

Phase III: that is a last stage, it is consist of stage strip within the current of the river valley.

Geological report has pointed (GR49, 1929) to the first and second stage that it consists of Gravel deposits. Therefore, we assumed that these gravel deposits are a remnant Mukdadiya and Bai Hassan Formations and this means having the Injana Formation at the bottom of the gravel deposits. But these deposits found sitting on the Fatha Formation and on the other hand, the average thickness of the Injana Formation in these areas is reached to 650 meters.

If we accept what was mentioned in that report. In this case, the rise in these deposits in the columns form is very high, but in fact, according to field observations in this study show almost compatible contour line elevation topography in the area with not differ by only a few meters, and this means that this is a terraced deposits other than deposits Muqdadiyah and Bai Hassan formations. This means that a terraced is depositions and not erosion.

That the terraced third stage and scattered here and there on the edge of the river also is a depositional terraces in most places and reached to several meters thickness. Also that some of the terraced this stage consist of outcrop of carbonate rocks, especially when the river cut core Krabotic Fold and that they appear in this outcrop.

The depositional terraces stages, that contain a few dipping (2 degrees) with the river level. The all terraced river that exists in the area of type unpaired terraces, not existence terraces Stages River on both sides of the river are facing.

The existence of terraced stages river in far areas more than 4 kilometers right of the river can be explained based on the captured region data satellite picked up in (1975) and scale (1: 500 000 ), plate (2), which applies to the plate (1) by where we note the trace impossible for lower Zab river, which was its watercourse before and beginning of the uplifting and folding operations in the area, which led to the taking away of the river toward the southeast and gradually be compatible with the increase in uplifting operations and folding arrived to his current condition.
Plate (2) shows the data satellite (panchromatic image) for study area

The previous imposable trace of river is now called the Wadi alfedha and notes of data satellite the existence of drainage patterns long this valley, but the striking absence, it has not existed any terraced river around this valley because of its coverage of recent sediments, but the AAPG explorer, 1984 pointed out in a structural contour map of the area, and derived from data satellite to the fact that this valley is a fault rushes with lower Zab fault before cohesion with the Tigris River fault. Then, with continuous uplifting, folding and unbalanced growth and unequal operations in the region have led to a rise in the northwestern part of the most southeastern part, that leading to creeping river slowly to the current location and stabilize it because of the fault size is big and ease of drilling in this area, Figure (2).

Figure (2) show the past trace impossible of lower Zab River.
Generally, any possibilities were true; they indicate the existence of tectonic activity in the area. It has led to the uplifting and forming the structures in that area and thus river make a way into refer to these structures in an attempt to maintain its direction. And that the existence of recent terraced stages means that tectonic activity continuing to till now.

**Sinuosity index of river**

He explained (schumm, 1981) that the instability and disturbance river in all operation river, concluded from the river system for this river. So, Therefore, we studied the sinuosity index of the river, it has been divided river long into units, according sinuosity portion of the river all at once, and then measure the actual distance of the river sinuosity from the side and another side, measuring the same distance if it was assumed that the river was straight in this Section, and by dividing the first to the second it can be extracted the sinuosity index.

\[
\text{Sinuosity index} = \frac{\text{The actual length of the river at a certain area}}{\text{The length of the river if it is straight}}
\]

The area bounded to study sinuosity index was the same area to study the width of the valley (next paragraph) before Bia Hassan structure until after the Southern Qara Chauq structure. It can be seen subdivisions sinuosity index as according to (shumm, 1977) and as they are in the table (1).

Table (1) shows sinuosity index as according to (shumm, 1977).

<table>
<thead>
<tr>
<th>sinuosity index value</th>
<th>Straight</th>
<th>sinuous</th>
<th>zigzag shape of river</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.05 &gt; 1.05 - 1.5</td>
<td>1.5 &lt;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It can be seen sinuosity index of the lower Zab river from table (2) and comparing these values with the table (1) shows that the lower Zab River limited within the river curved (sinuous). (But in high sinuous when a cut of the structures, as well as in the middle of the area that limited between the Bia Hassan and southern Qara Chauq structures) to low sinuous in other areas of the river. Figure(3).

Note this figure is also the river from the type curve and sinuate increasing when a cut of the structures due to the choice weakness areas, whether due to the presence of fault or fractures or because of brittle lithology that are easy to drill component Gorge and continues into this stream does not change it.

The continuation of river to change its stream until stability within the groove and drill into it, the evidence of tectonic activity in the region. Strong note is increasing the level sinuosity index of river value also in the area between Bai Hassan and the southern Qara Chauq structures. At first glance, this case may raise some questions that there may be exist another structure may be subsurface structure and thus when growth affects the sinuosity of the river. But the survey field for the region illustrated the cause of this sinuosity due to the existing factory and quarrying of stones from the Muqdadiyah and Bai Hassan Formations, in addition to recent deposits that leading human-induced into a sinuosity index of river as required by the quarries and locations and washing operations gravel extracted.

It also the seismic studies supported (studies carried out by the North Oil Company\Geological Department, 1989.1992) absence of other subsurface structure in this area,
as well as the direction of drainage pattern zones that leads him from the Bai Hassan and Southern Qara Chauq structures.

Mentioned Adams, 1980; that a sinuosity index of river is affected by the degree of slope of the valley or riverbed. When comparing the a sinuosity index of the river of the lower Zab river with longitudinal section and the amount of gradient him , we find that the slope of the valley of the river factor has no important connection with a sinuosity index of river, this gives further evidence that the slope of the river is in depended mainly on lithological area and not on the tectonics activities of the area.

As mentioned (Al-Daghastani and Al-Daghastani, 1996) that the surface valleys respond to the growth of folds and changes, structural and tectonic in the area through behavioral Valley Study (Abrat Alsagera) when a cut the Ashkift structure northwestern Iraq, as increasing a sinuosity index of this valley to reach more than 1.5 when the cut structure axis.

He also mentioned (Al-Daghastani and Salih, 1993) responded Khazar River that drill Aqra structure and other structures in the north of Iraq because of the growth of these structures in later (the river from antecedent type) as a result of the Arabian plate move toward the north and northeast and colliding with an Iranian plate , The lower Zab River resembles almost all rivers and valleys of northern Iraq, in terms of increasing the sinuosity when a cut the structures , on the other hand, that river the oldest from the structures that is cut.

Increasing sinuosity index of this river gives strong evidence of tectonic activity in the area , leading to the uplifting of geological structures slowly and thus increasing the sinuosity index of the river when a cut of these structures , and he drilling his own groove continues to flow in it .

The current width of the river valley

It has been studied the current width of the river valley of the study area starting from the areas before Bia Hassan structure and ending with a distance estimated at 4 kilometers after the Southern Qara Chauq structure, depending on data satellite, plate (1), for the clarity of the state in which more accurately than using other topographical maps. The study by reading the width of the valley each centimeter (1,000 meters) which was (27) read are shown in Table (2), note that the choice of the limits of width riverbed then it has been in depended on extensions flood flat, we note from the table that the value width of the valley decrease when entering the river to the geological structures (Bai Hassan, the southern Qara Chauq structures) component incised valley which is drilled area by the river during structure growth. And this is explained in Figure 3. it can be seen as a large, width valley in the areas before and after the structure.

When comparing the values width of valley with sinuosity index, we find in this comparison kind of compatibility, since the small- width of the valley places offset high sinuosity index , except for the area between Bai Hassan and the southern Qara Chauq structures. Sinuosity index refers to a high value while the width valley value refers to a large value too. This study of width valley gives another indication that the sinuosity index in the intermediate region is not related in any way to the phenomenon of tectonic there.

So we conclude short to the width valley whenever he was small (this gets at the river cut in the structures) demonstrates the phenomenon of tectonics , and the tectonic
activity in the region, the rise of structures towards the top, either when the valley is
wide that indicate the area has not a structure.

CONCLUSIONS
Through the current study of the Morphotectonic was reached:
1. Existence previous trace river is located after the Bai Hassan structure about of
10 kilometers west of the current location.

2. The existence of river terraces, that formed three phases due to the region's
exposure to intense tectonic activity and through away the first phase of the
terraced to the distance (7) kilometers from the terraced third phase.

3. high sinuosity index river at cut its different structures, which indicates the
existence of tectonic activity and the Morphotectonic phenomenon continuous till
now.

4. The difference in width of the river valley and reflow the narrow Gorge when the
river make penetration into the various structures and reviewed in the flat areas,
and also indicates the presence of tectonic activity and the Morphotectonic
phenomenon continuous till now.

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