Surface analysis and critical review of the Darbandikhan (Khanaqin) fault, Kurdistan Region, Northeast Iraq

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Abstract

The Iraqi Zagros Mountain Belt has been deformed intensely by colliding of Arabian and Iranian plates and the resulted deformation, on all scales, have been analysed in the previous studies, including folding and faulting. One of these deformations is the Darbandikhan (or Khanaqin) fault which has nearly N20E tends. According to the previous studies, it extends for about 200kms in the eastern Iraq and nearly coincides with Sirwan (or Diala) river. It is indicated on the maps and described by many authors previously either as traverse strike slip fault or as deep normal fault. Moreover than that, some geologists have attributed many tertiary stratigraphic and sedimentologic variations to the movement of the blocks of this fault. In the present study, the field data and stereonets are used to analyse the surface structural and stratigraphical expression of the fault. For this purpose, the Darbandikan Gorge (or town) and its surrounding areas are survey for classification of the deformational and stratigraphical and sedimentologic difference (on the both side of the fault) that may be associated with this fault on the surface. In the present study, neither traverse strike slip nor normal fault are recorded in the Darbandikhan gorge and surrounding areas. Moreover, no stratigraphic differences (facies changes) are recorded on both left and right sides of the assumed fault. The recorded deformation is lateral thrust fault that strikes nearly N20W. The strikes of the fault are not coinciding with the previously indicated Darbandikhan (Khanaqin) fault which is assumed to strikes nearly N20E. In this study the stress components ($\sigma 1$, σ_2, and σ_3) are clarified with the origin of the shortening that are associated with the thrust and strike slip faults.

Keywords: lateral thrust, oblique strike slip fault, Pila Spi Formation, Zagros Main thrust, Darbandikhan town, Sirwan fault, Khanaqin fault.

Introduction

The area is located at 55 km to the southeast of Sulaimani city and includes the area around Darbabdikhan town on the both right (western) and left (eastern) sides of the Sirwan River (upstream of Diala River). Recently, the area has subjected to intense field and seismic survey for oil exploration and two deep well are drilled but oil has not found till now. The area is part of the Sirwan valley which collects runoff from most parts of northeast of Kurdistan region into Darbandikhan lake (Fig.1). The Sirwan river valley has broad bottom with gentle sides and classified as Consequent River which meets with many subsequent tributaries. The largest tributaries are Dewan, Dara Duwena and Zhalla Naw streams which are descending toward the Sirwan River from Qaradagh and Barkal (northern part of Tuny Baba) and Zimako areas respectively. In the studied area, Sirwan River has highly meandering course which controlled by local structure, lithology and coarse accumulation of alluvial fan sediments.

Most areas of the valley consist of local plains which are hilly and mostly sloping gently toward the Diala River. These plains are mainly covered by sporadic small and large blocks of limestone of Pila Spi Formation and Oligocene Rocks such as the area around Darbandikhan town. Other parts of the areas are covered by badlands which are consisted of numerous small valleys and canyons which are deep and steep sided. These bad lands occur on the areas that are covered (consists) of conglomerate and red clay stone of Upper and Lower Bakhtiari Formations. The best examples of these bad lands are the area that is known as of Tuny Baba and the streams of this areas are called locally "Khir" in Kurdish which indicating to accumulation of coarse spherical gravels on the stream beds.

The main mountain of the area is Zimnako, Golan and Sagrma which are located at the north, west and southwest of the Darbandikan Dam (Fig.1). The lateral thrusts are exposed directed along the downstream of the latter dam especially at left side of the Diala River where the six locations are found where slickensides are found. The aim of this study is to surface analysis and critical review of the Darbandikhan (Khanaqin) fault which is assumed, in the geological literature of the Iraq, ass the main geological deformation in the northeastern Iraq. The analysis includes structural and stratigraphical differentiation on both sides of the fault (Fig.2).

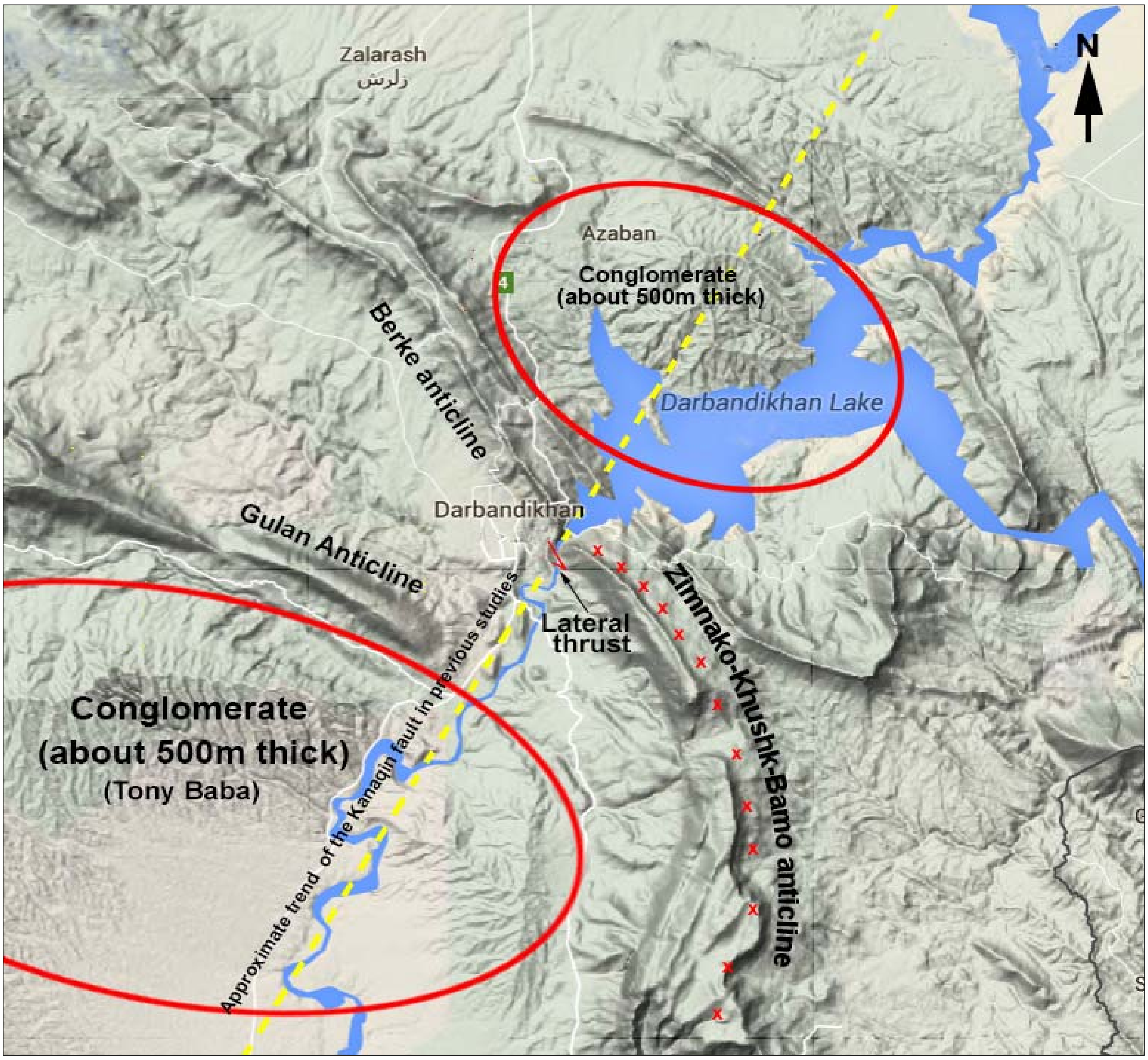

Fig. (1): Topographic map of the area around Darbandikhan town shows the two lateral thrusts and bending of the anticlines around the conglomerate successions (indicated by x letters)

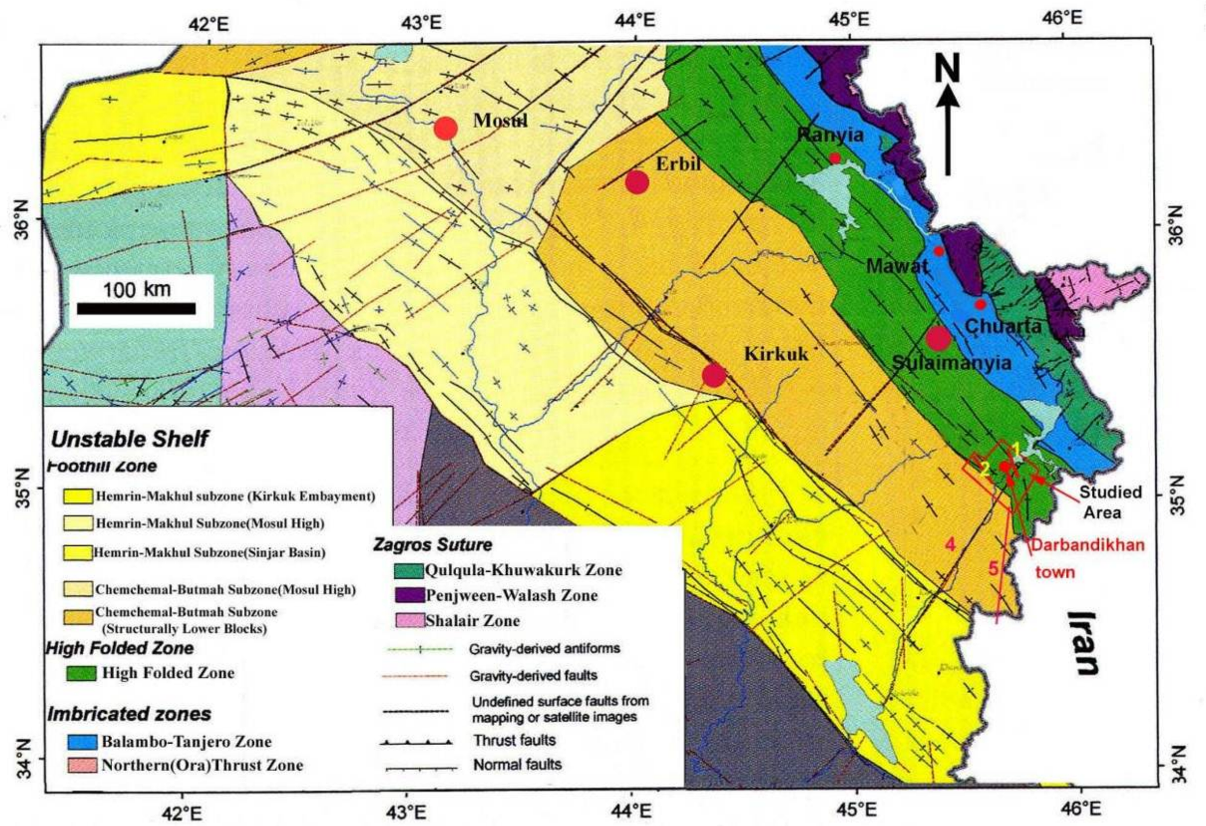

Fig. 2: Tectonic subdivision of the northern Iraq by Jassim and Goff (2006)[1] on which the studied area is shown with, 1, 2 and 3: three fault of the present study, 4: Unclassified fault of Jassim and Goff (2006) [1] 5: strike slip fault of Ibrahim (2009) [2] and Lawa et al. (2013) [3].

Method of the study

Data collection is depended on the field survey around the Darbandikhan town where there are extensive outcrop of the Tertiary rocks on the both side the assumed Khanaqin fault. During survey the lithology, boundary, deformational features and facies changes of stratigraphic units, on the both sides of the fault, are inspected by hand lenses and eyes. The inspections are recorded and compared with the findings of previous studies. The fault data, strike, dip and displacements are measured using geological compass. The method of Richard W. Allmendinger is used for analysis of the data for indication of the paleostress using FaultKinWin 1.2.2 Program, 2001.

The stereographical representation of the data is depended on software that plots the faults and the striations and calculates the attitude of (σ1, σ2 and σ3) and indicates the direction of the footwall and hanging wall movement by arrows. The paleostress which resulted from mesolateral thrust and reverse faults are compared with that of the main Zagros thrust fault to see angular relation between them.

Stratigraphic expressions on the both sides of the Khanaqin

The stratigraphy of the exposed formations is important for checking of the stratigraphic expressions of the Khanaqin fault in the area which may be expressed in difference in facies, lithology and their thickness (Fig.3). The present expressions are compared with those concluded in many previous studies such as Lawa (2004) [4], Ghafur (2012) [5] and Lawa and Ghafur (2015) [6] whom attributed many facies change and stratigraphic characteristics to the Khanaqin fault.

Kolosh Formation (Paleocene)

The formation consists of black to grey marl, sandstone and thin beds of conglomerate and its thickness reaches about

400m. It is exposed in the core of the anticline such as Sagrma, Kalosh and both Zmnako and Birke and Bamo. Due to the softness, it is intensely deformed by upwards flow and accumulation in the cores of the above anticlines. The softness has motivated sliding of many blocks of the Sinjar Formation on Kolosh Formation along the northwestern limbs of the above anticlines. Due to the sliding, the formation has rolling and hummocky surface. These slides are discussed in detail by Karim and Ali (2004) [7] and Ali (2005) [8] directly to the north of the studied area. The lithology of this formation is nearly same on the both side of the Khanaqin (Darbandikhan) fault as seen near Kasti and Sartak villages on the right side and the left side of the fault respectively. At these two localities the contact between Sinjar and Kolosh Formations are gradational and there are several lenses of conglomerate inside Kolosh Formation blow the contact.

Sinjar Formation (Late Paleo cene-Early Eocene)

This formation consists of about 40 meters of grey to milky massive detrital and biogenic limestone. It has gradational contact with both Kolosh and Gercus Formations. In the studied area, it only exposed in the cores of the Sagrma and Berki anticlines. Its main fossil content is nummulites, alveolina, discosyclina, coral and green algae with pelecypods and gastropods. On the both side of the Khanaqin fault, the formation is relatively thin which has about 10-30 m thick and the limestones occasionally associated with conglomerates.

Gercus Formation

In this study, the thickness of this formation is variable from place to another; the maximum thickness is located near the Darbandikhan dam which reaches more than 200m such as near Merede village. It is composed of red claystone, sandstone and lenses of conglomerate. Its boundary is gradational with underlying Sinjar Formation while it is unconformable with the overlying Pila Spi Formation as there is a bed of conglomerate between the two formations which about 3 meters thick and described by Ameen (2006) [9]. The formation is nearly similar on both side of the fault and it rapidly change to dolomitic limestone and marly limestone of the Khurmala Formation which is described by Karim (1997) [10].

Pila Spi Formation

This formation is directly related to the studied faults in the studied area and its thickness is about 70 meters. It composed of chalky and dolomitic limestone. In the studied area, according to Khanaqa (2012) [11], its lithology contains (in some intervals) intraclasts, bioclasts, alage, coral and broyzoa. On the both sides of the Khanaqin fault, the formation is lithologically different as on the left side it is thicker and contains more fossils as compared to the right side. On the later side the formation inter-fingers with Avanah Formation.This indicates more open and deeper environment of the formation on the eastern side than the western (right side).

Oligocene Rocks

In the studied area, The Oligocene rock successions are described in detail for the first time by Babashekh (2000) [12], Kharajiany (2008) [13],and Ghafor et al. (2014) [14]. Khanaqa et al. (2009) [15] have extended the outcrops (or basin) limit of these successions into inside High Folded Zone. This extension is more than 15km northward as compared to that indicated by Dunnington (1958) [16] and Lawa et al. (2013) [3] (Fig.4).

Lithologically, it consists of hard massive milky limestone which contains red spots and lamina. The succession is used for decoration stone and crashed for using as aggregate with white cement. It is located between Pila Spi and Lower Fars Formation and contains at least two limestone or polygenetic conglomerates. On the both side of the Khanaqin fault, the formation is relatively thin which has about 10-30 m thick. Lawa and Ghafur (2015) [6] concluded that the Khanaqin Basement Fault splits the studied area (Low Folded Zone of Northeast Iraq) into two parts and leads to developing of two different depositional sequences with different thicknesses on each side of the fault. They added that most probably on the left bank, Oligocene facies show similarity to Asmari group of Lorestan zone rather than Kirkuk Group. However, the present study has compared between the study of Karim et al. (2012) [15] and Ghafor et al. (2014) [14] and has not found such difference in facies and sequence across the fault.

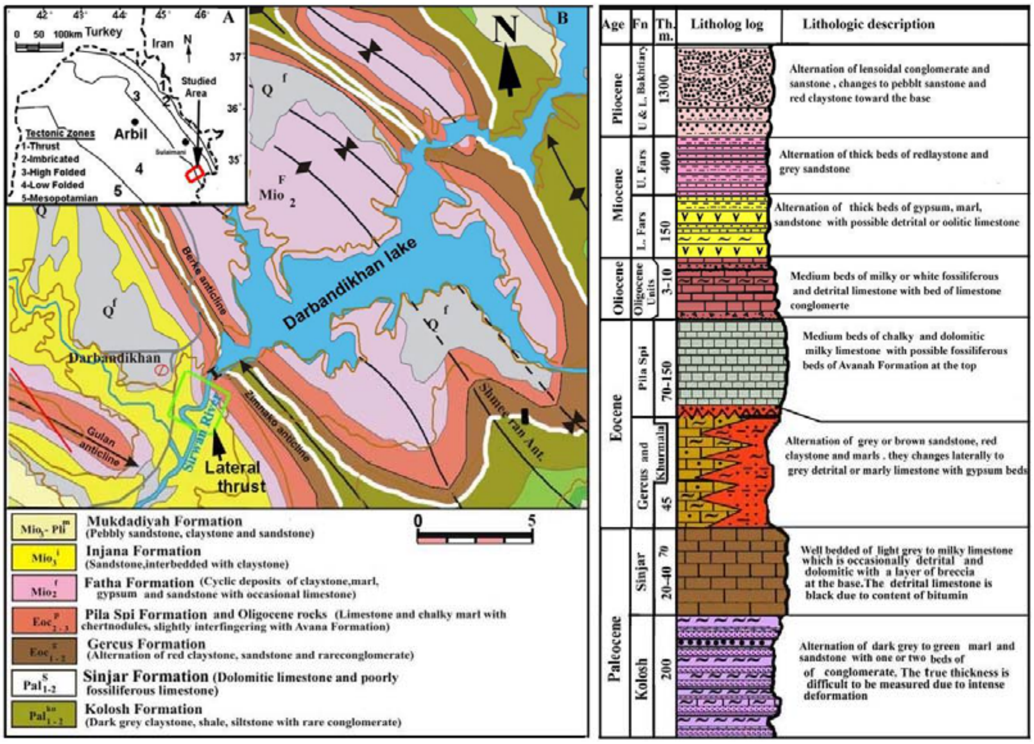

Fig. 3: Geological map Sissakian (2000) [17] and stratigraphical column of the studied area. It can be seen that there is expression of the lateral thrust (see the green square) at the south of Darbandikan dam on the right side of the Sirwan River

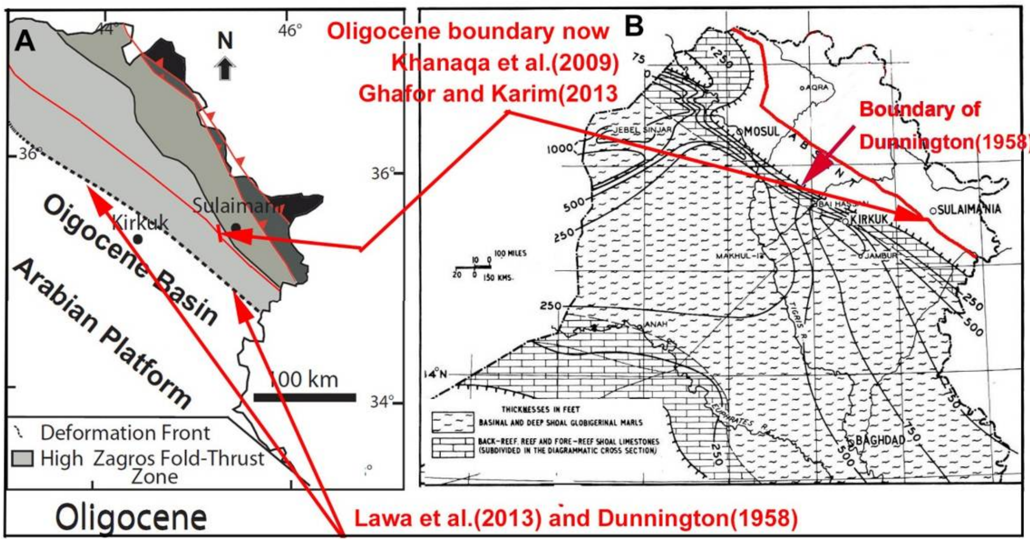

Fig. 4: The same extend of Oligocene basin (or outcrops) is indicated by Lawa et al (2013) [3] (A) and Dunnington(1958) [16] (B) in the Low Folded Zone while Khanaqa et al. (2009) [18] and Ghafor et al (2014) [14] have transferred the extension inside the High Folded Zone (Red lines in the A and B).

Fatha (Lower Fars) Formation

The studied area represents the peripheral areas (areas of the on lapping on the paleoslope) for both Lower Fars and Oligocene succession where the formation mainly consists of red claystone, gypsum, sandstone and limestone. Its thickness is about 20-70 meters and its lower boundary is unconformable with the Oligocene succession and Upper boundary is gradational with Upper Fars Formation. In the present study no lithological and structural difference is observed on the eastern and western sides of the fault as appear in the sections at the east of Horeen and west Banikhelan villages respectively.

Result

In this section, the results of the field and office works are shown graphically, defined accurately and analyzed by stereonets.

Darbandikan (Khanaqin) Fault

Previously, many authors have indicated and mapped as Khanaqin strike-slip fault by Ibrahim (2009) [2] or as Khanaqin longitudinal fault by Al-Qayim et al. (2012) [19], or as normal transversal fault by Lawa (2004) [4] or as a north south trending dextral strike-slip fault by Lawa et al. (2013) [3] (Fig.5). Recently, Lawa and Ghafur (2015) [6] called it Khanaqin Basement fault and according to former authors, it has north- south trends. Jassim and Goff (2006) [1] named it Sirwan Fault which geographically coincides with the Sirwan River (Fig.6). Aqrawi et al. (2010, p.27) [20] called it Sirwan lineament. Lawa (2004, p.227) [3] had drawn a fault that nearly coincides with Sirwan River and called it "Halabja-Amij transversal fault". He mentioned that by this fault the Bamo area (left side of the Khanaqin fault) had been uplifted to terrestrial land during Early Eocene while the right side was covered by shallow sea (Fig.6B). Buday and Jassim (1987) [21] had shown a fault that is passed from south of Baghdad to Khanaqin town but it don't elongate to Darbandikhan town (or dam).

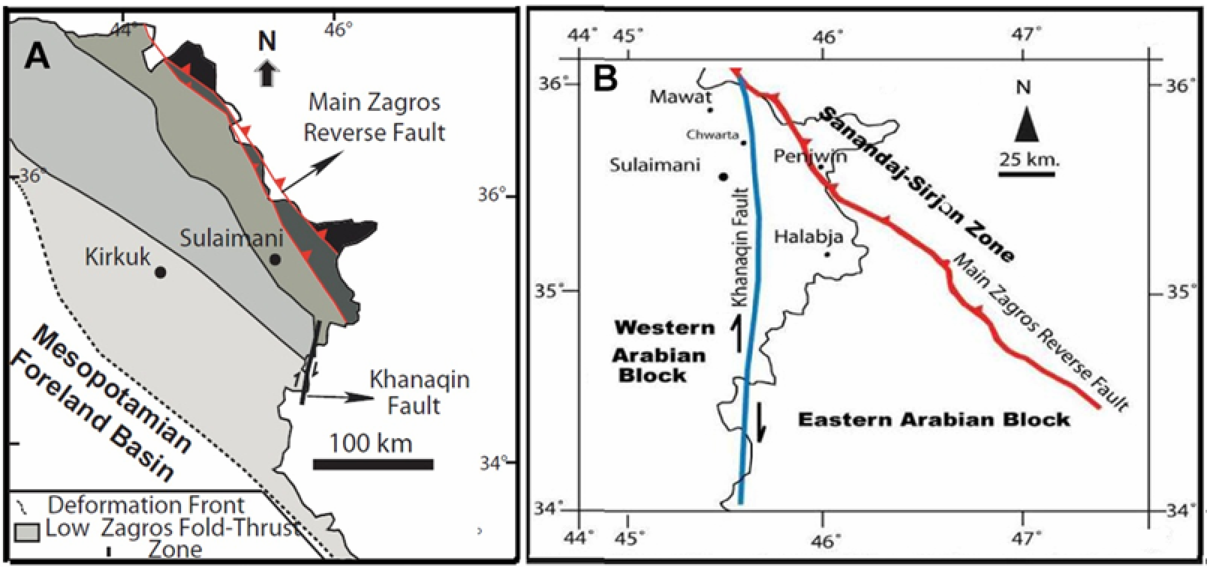

Fig. 5: Location of the Khanaqin fault, A) Lawa et al (2013) [3] and B) Ibrahim (2009) [2]

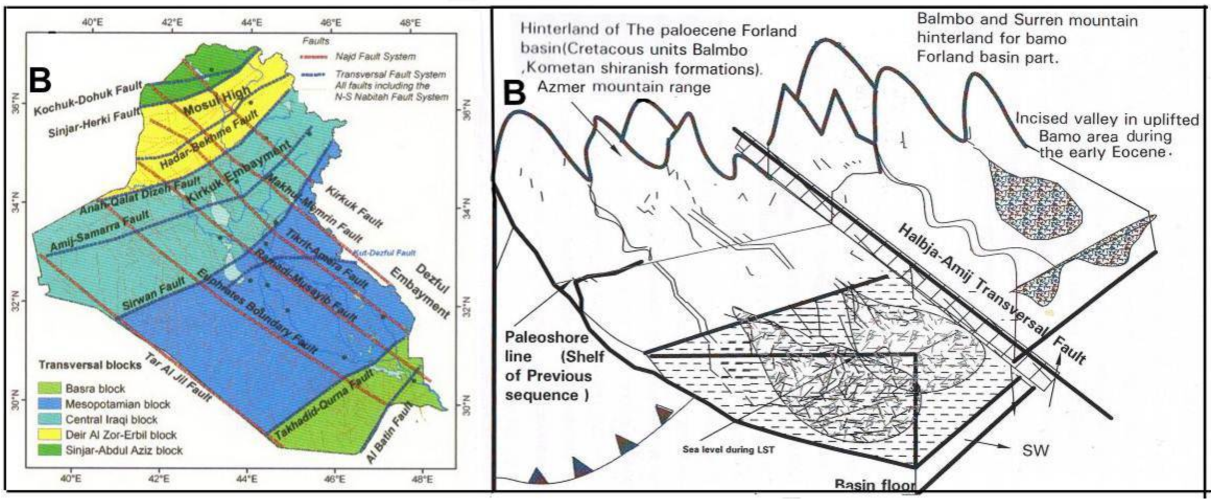

Fig. 6: Sirwan Fault, A) by Jassim and Goff (2006) [1] and B) depostional model of Paleocene Foreland basin that affected by deep Halabja-Amil transversal fault (Same location of Khanaqin fault) and uplifted Bamo area (Zhalla section) Lawa (2004, p.227) [4].

Darbandikhan lateral thrust

In the present study, in spite of extensive fieldwork, the expression that coincides with Khanaqin fault is not found. But the recorded structure is a lateral thrust which has attitude of 335/ 22 and opposites those of latter fault. The thrust has clear expression on the surface which represented by southeastward shifting and overlapping of the Zimnako anticline directly to the south of the location of Darbandikhan dam (Fig.1, 2 and 3).

Now the latter anticline is dissected by Sirwan River by which a narrow gorge is shaped in which the Sirwan River is flowing and lateral thrust occur (Fig.7A). Another expression, which is related to the lateral thrust, is the common occurrence of slikensides and polished surface along mesofaults which exist inside both Pila Spi Formation and Oligocene succession on the left (eastern) side of the Sirwan River directly at the downstream of Darbandikhan dam (Fig. 7B and 8).

The paleostress analysis for the above mesofaults indicates that there is a compressive stress states in the direction NW- SE parallel to sub parallel to the axes of the major folds in the area. The minor fold in the figure (7B) below shows this direction of stress because its axis is in the direction NE-SW therefore the maximum stress direction ($\sigma 1$) tentatively is normal to fold axial surface in the direction NW- SE.

Another expression of the thrust which hast not relation with Khanaqin fault is occurrence of a small and open anticline that has an axis with attitude of 057/ 10 which is nearly normal to the axis of the Zminako anticline (main anticline in the area).This anticline is formed most possibly due thrust fault and can be related to fault bend fault (Fig.9B).

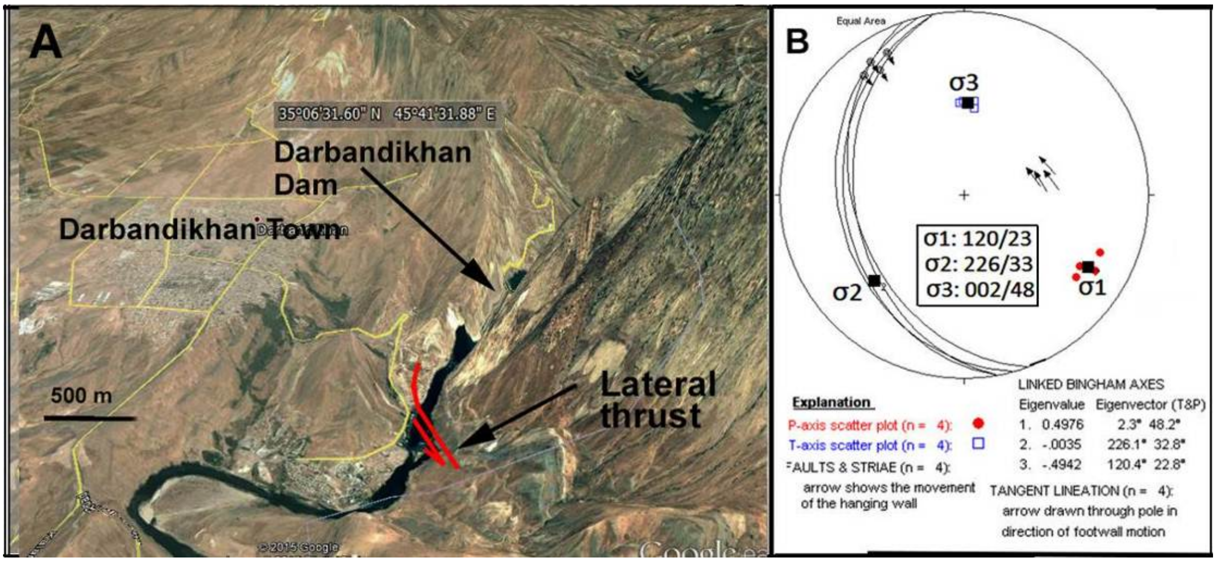

Fig. 7 A: a Google earth image show a lateral thrust in the Darbandikan gorge. **B)** The paleostress analysis for the striations along the red line which indicates that there is a compressive stress states in the direction NW- SE parallel to sub parallel to the axes of the major folds in the area.

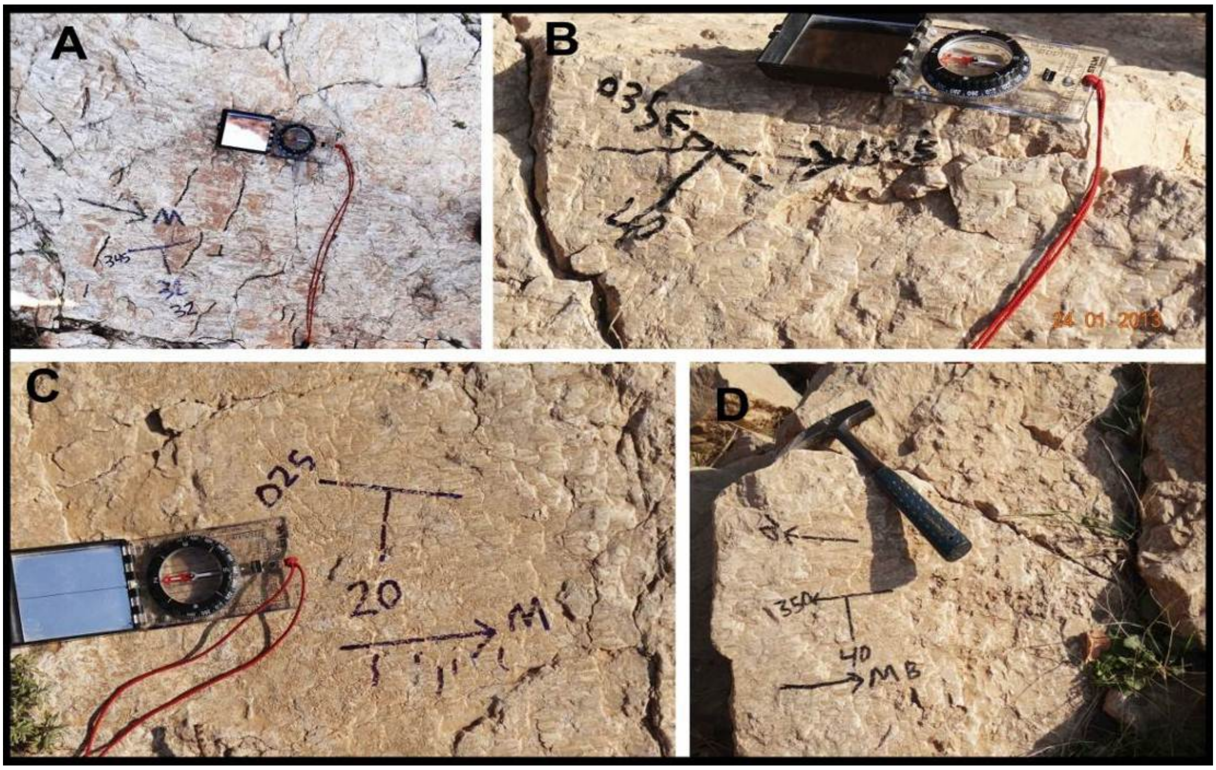

Fig. 8: Attitude of striations on several stations of lateral thrust in the Darbandikhan gorge at 400 m down-stream of the dam on the left side of the Dilla River. The compass needle indicates north.

Age of anticline growth in the studied area

The field observation showed that the growth of the anticlines, in the studied area, is aged Pliocene. This is according to the extensive deposition of the coarse (gravel and boulder) conglomerates of the Upper Bakhtiari at south of the anticlines which proves that the they are not grown (existed) during latter age. The transportation hydro-dynamic of these conglomerates needs rela-tively steep slope to move the gravel and boulders across the present location of present anticlines from north to south during pre-Pliocene ages. If the anticline existed (grown) before Pliocene, the gravels could not by pass the anticlines. The paleocurrent direction of these conglomerate aids the above judgement as its direction is toward south and southwest which cut across the anticlines. The synclines are wider than the anticlines such as the Qaradagh and Azaban synclines. The map of Sissakian (2000) [17] shows clearly this wideness of the syncline which may be attributed to the deposition of thick succession (more than 500 m) of conglomerate in the studied area which preserved the synclines from tightening and anticlines from widening.

Bending of the anticline around conglomerate bodies

At the south and north of the studied area, there are thick successions of conglomerate of the Upper Bakhtiari Formation. These successions are about 500 thick and consist of polygenetic gravel conglomerate and their outcrops are nearly circular or oval in shape (Fig.1). On the geological map and Google earth, it can be seen that the anticlines generally bend around the conglomerate.

The conglomerate successions exist as two outcrops, the northern and southern ones are called Azaban and Tony Baba outcrops respectively. The surface area of these outcrops has several kilometers square in surface area. The conglomerate successions are deposited as the subsiding basin which filled with alluvial fan sediments during Early Pliocene before growth of the anticline. Later when the folds had been grown, the conglomerates had been shaped as a part of the synclines. The conglomerate is hard, heavy and resistive to deformation, therefor it is located inside the synclines while the anticlines are located outside of the conglomerates and bend around them. The most prominent feature is the southward shift bend around them Zimnako-Khushk-Bamo anticline (Fig.1). This bending is similar to bending of pipes when confined between hard moving arms (Fig.1A).

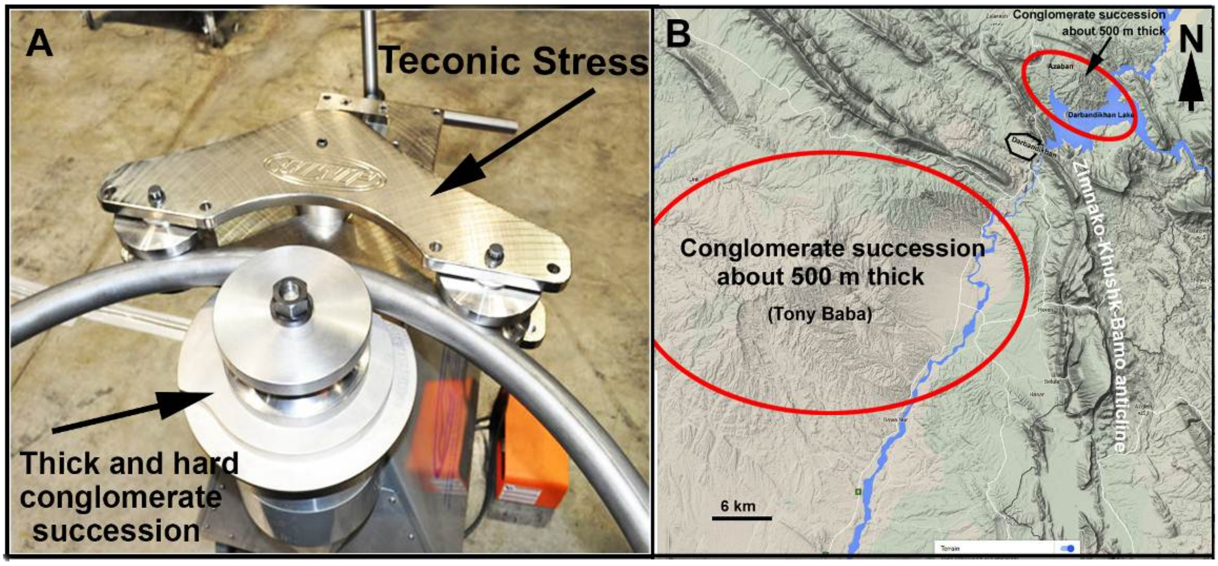

Fig. 9 A: bending of pipes by confining (enclosing) between stronger moving arms (stress), B) the southward bending of the limestone succession (Zimnako-Khushk-Bamo anticline) between hard and strong conglomerates is compared to the bending of the pipe in the left photo.

Discussion

Darbandikhan fault

There is not agreement and field data about Darbandikhan fault, the graphical model that drawn for the Darbandikhan area by Lawa (2004) [3], indirectly shows that the fault is normal fault since he had mentioned that the left bank of the Sirwan river (Bamo area) was uplifted during Early Eocene. While Lawa et al. (2013. P.91) [3] and Ibrahim (2009) [2] has assigned it as a north south trending dextral strike-slip fault (Fig.1)and he had mentioned the below paragraph about the Khanaqin fault " *a north south trending dextral strike-slip fault, separates the Kirkuk Embayment from Lurestan. This fault may have had a major influence on the stratigraphic and tectonic evolution of these two provinces and may partly be responsible for this abrupt change in the propagation rate of the deformation front*".

Sissaskian et al. (2014) [22] mentioned that Sirwan River almost coincides with the supposed deep seated fault Sirwan Fault and added that clear indication can be seen on the total magnetic field map which confirms the supposed deep seated fault while not clear in the Bouguer gravity map.

From the above citations (in the present section and 1-3) it is appear that there is neither agreement about the location nor about the type of the fault even by same author. Another thing is that no published data available about the expression of this fault on the surface. In this regard, Jassim et al (1975) [23] have mapped the area around the Darbandikhan town in detail but they didn't found the expression of the Khanaqin fault. They found a normal fault that strikes parallel to the axes of the anticlines in the area (Fig.10A) and cut normally the Khanaqin fault. Moreover than that, the present lateral thrust fault is not related to the Darbandikhan Fault (Khanaqin fault) neither in type nor in direction. Therefore, the Khanaqin fault must be re-studied in the subsurface to prove its existence or absence. The sedimentological and stratigraphical fault expression is not observed during Campanian–Pliocene in the studied area by the present authors.

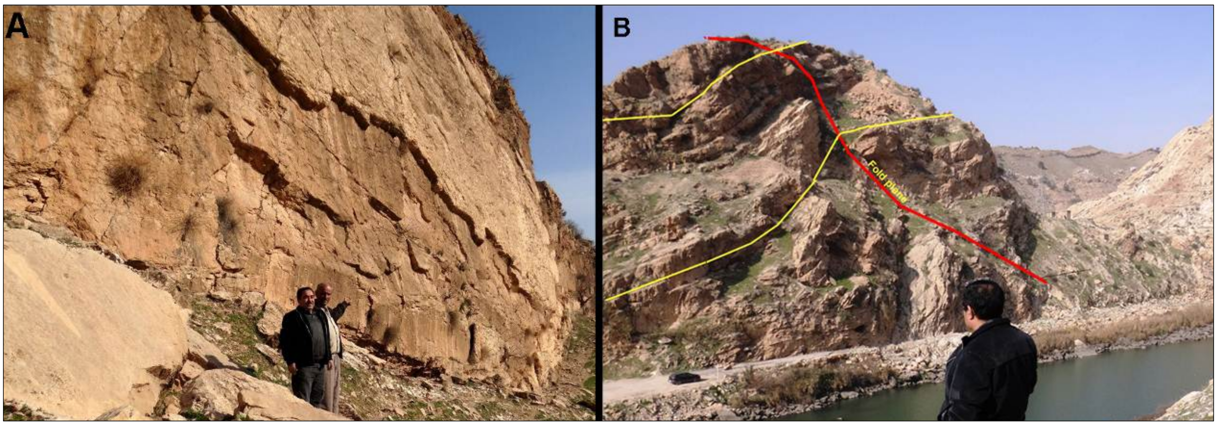

Fig. 10: Normal fault scarp that strikes parallel to the axes of the anticlines and recorded by Jassim et al. (1975) at 2km north of Darbandikhan town.

The type of the sediments, facies changes and the stratigraphic succession of the formations such as Shiranish, Tanjero, Kolosh, Sinjar, Gercus, Pila Spi, Lower Fars, Upper Fars and Upper Bakhtiari Formations in addition to Oligocene rocks show no any difference on both side of Khanaqin fault as observed by the present authors. Even there is no agreement about which side was uplifted since there are opposite conclusions by two groups of publications, the first on is that of Lawa (2004) [3] and the second is that of Ghafur (2012) [5] and Lawa and Ghafur (2015) [6]. On the basses of stratigraphic evidence, in the first one has showed that the left side of the fault (Bamo and Belula sections) are uplifted (Fig.6B)

Lawa (2004) [4] has attributed some facies change on right and left side of the Sirwan River to the Khanaqin fault that uplifted left side. He added that on the left side (Bamo area), more conglomerate was deposited than the right side. Ghafur (2012) [5] has concluded that Khanaqin Basement Fault cut across her study area into two parts and leads to developing two different depositional sequences with different thickness in each side of the fault. She added (in the p.261) that the activity of the fault (Khanaqin fault) resulted in thinner shallower Kirkuk Group Formations on the western (right side) side than on the eastern side. She further showed by diagram (p.257) that the left side had uplifted during Early Oligocene by which sedimentation had been stopped.

Lawa and Ghafur (2015) [6] have stated that Khanaqin Basement Fault splits their studied area (the area around Darbandikhan town) into two parts by which two different depositional sequences were developed with different thicknesses on each side of the fault. They added that on the left bank, Oligocene facies show (most probably) similarity to Asmari group of Lorestan zone rather than Kirkuk Group. But Karim et al. (2012[24]) has showed well development of the Oligocene on the Sharwal Dira (Sharwadir) anticline on the left (eastern) side of the Khanaqin fault. The facies and lithology is nearly similar to Oligocene of Kirkuk area including the right side of the Kanaqin fault. The present authors think that conclusions and opposite citations of Lawa (2004) [4]; Law and Ghafur (2015) [5] based on comparison of sections that are not in the same tectonic position in the basin during Eocene or Oligocene. Two sections can be compared when they both have same distance from basin depocenter or have same tectonic position. The fence diagram that is drawn for the areas on the right and left side of the Khanadin fault during Tertiary does not show any stratigraphic expression of the later fault (Fig. 11 and 12).

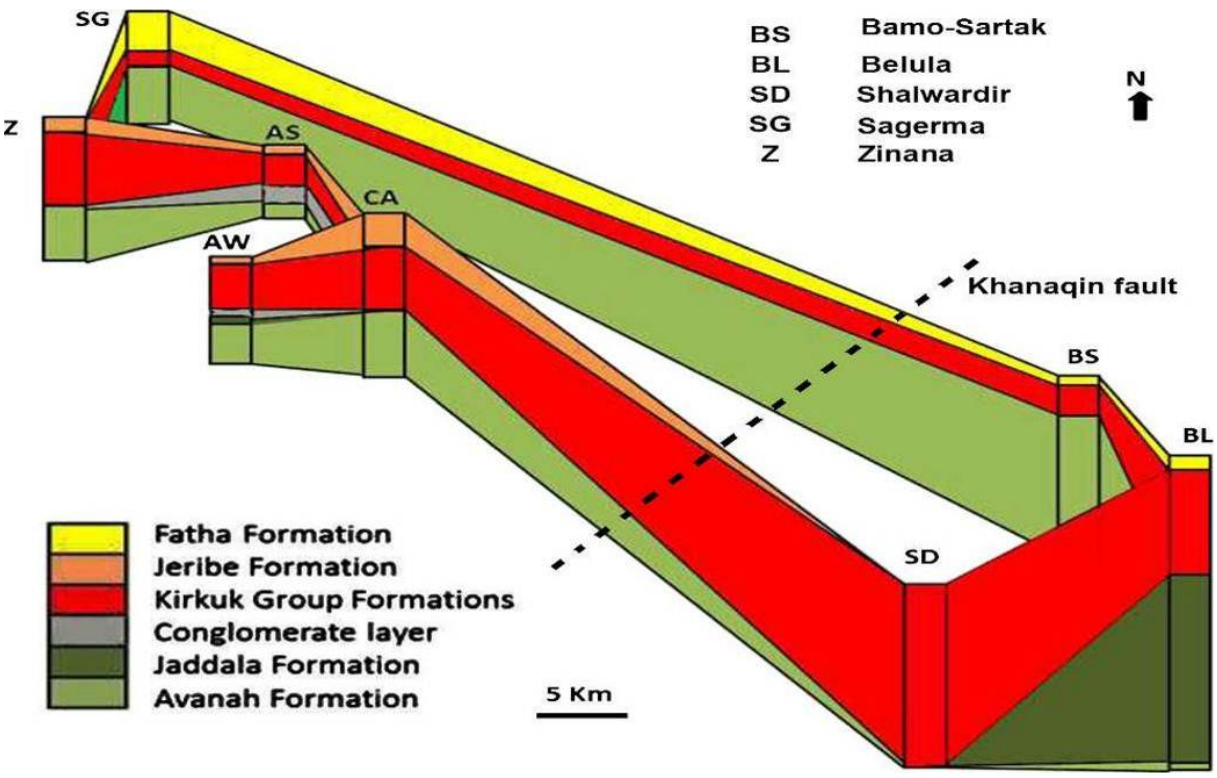

Fig. 11: Fence diagram by Ghafur (2012) [5] and Lawa and Ghafur (2015) [6] shows facies changes across the Khanaqin fault (the dashed line which is indicated in the present study)

Fig. 12: Two erosional surface at the base of the conglomerate of Gercus Formation on the right (A) and left (B) side of the claimed Khanaqin fault. It can be seen that the conglomerate is nearly has same grain size and underlying rocks are limestone and marl which has nearly same depth of deposition but with different turbidity.

The sections of the Bamo area was closer than Qaradagh area to foreland (source area) which means that was more closer to proximal area than those located to east and southeast of Darbandikhan town. The equivalent section Zhalla section (inside Sartak Bamo valley) is located more northward than that assigned by Lawa (2004) [4]. It is most possibly located North of Mirade village not Kashty village as assumed by the latter author. Connectedly, Karim (2004) [25] has clearly discussed the equivalent sections of Tanjero Formation inside the basin of Maastrichtian. He mentioned that the depocenter was not coinciding with the axes of present anticlines. He added that the depocenter of the basin was shifting 25 degree more northward away from the axes of the present anticlines. What had mentioned by the latter author is proved by Barzinjy (2005) [26] for both Paleocene and Eocene basin. In the present study it is found that near the boundary of Gercus and Sinjar formation, there are erosional surface on the right and left side of the assumed fault which proves that Khanaqin fault has not affected the sedimentation on left side (Fig.12) which means that there is no sedimentary or stratigraphic expression of the Khanaqin fault.

From the above definitions and detail documentation, two facts are appeared about the two faults. The first one is that one of the faults is a lateral thrust faults and the other one not know if it is normal or strike slip fault. The second fact is that the plane (direction of displacement) of thrust faults has the direction of about N 20 W. This direction is not coinciding with previously indicated Darbandikhan area (Khanaqin fault). The interesting thing is that in Mawat area, Karim and Sulaiman (2012) [27] had recorded and discussed in detail several lateral thrusts which have same direction of displacements of the present ones. This means that in Iraqi Kurdistan, especially south eastern part, the lateral thrust (with displacement of N20W) is regional not local. The question is "what are the factors that made the lateral thrust have same direction of displacement in two lengthily separated areas of different tectonic zones?" The displacements of the lateral thrusts and Main Zagros Thrust are about 340 and 40 degrees respectively.

The causes and origins of these lateral thrust require answering of three questions, the first one is what is relation of these lateral thrusts with Main Zagros Thrust Fault. The second, what is the effect of Khanaqin, if exist, on the lateral thrusts. The first one, relation of these thrusts with Main Zagros Thrust, is discussed in detail by Karim and Sulaiman (2012) [27] who indicated the lateral thrusts in Mawat area are possibly related to lateral ramps that are associated with Main Zagros Thrust faults. But in the present studied area there is no thrust fault therefore the relation with Main Zagros Thrust is weak. The second question cannot be answered without detail deep seismic survey of the studied area; this is because both stratigraphy and structure have not showed any evidence for existence of the Khanaqin fault.

Causes of Darbandikhan lateral thrust

It worthy to mention that both the present lateral thrust and those of Mawat area are associated with more than 400 m thick and massive successions of conglomerate of Upper Bakhtiari and Tanjero Formations respectively. It is possible that lateral thrusts are more or less resulted from the competency of the conglomerate which are resistive to deformation and transfer the stress to surrounding other rocks. The stress state with northwest–southeast trend is another possibility which was cited by many authors such Al-Fadhli et al. (1979[28] and 1980) [29]. These authors had studied polyphase deformation and superimposed folding in Piramagrun and Said Sadiq areas. They had indicated the compressional tectonic phase with a trend of northwest-southeast. Al-Jumaily (2004) [30] and Al-Hakari (2011) [31] studied tectonic investigation of the brittle failure structures and paleostress analysis in northern Iraq and they concluded a compressive tectonic stress in the direction NW-SE.

The best reasoning, for the Darbandikhan lateral thrust is not known exactly, but the bending of the Zimnako-Khushk-Bamo anticline southward and around Tony Baba conglomerate has exerted compression force on the inner side of the bending (inner arc or southwestern limb). The compression most possibly resulted from shortening and then laterally thrusting of the southwestern limb of the Zimnako-Khushk-Bamo anticline. This is similar to the faulting of a core of an anticline due to accommodation of the shorting of the inner layer. In this connection, thrust (or reverse) fault of the Kolosh Formation (from outside of study area) is exampled for inner arc faulting (Fig.12) which similar to the lateral thrust of the Darbandikhan thrust.

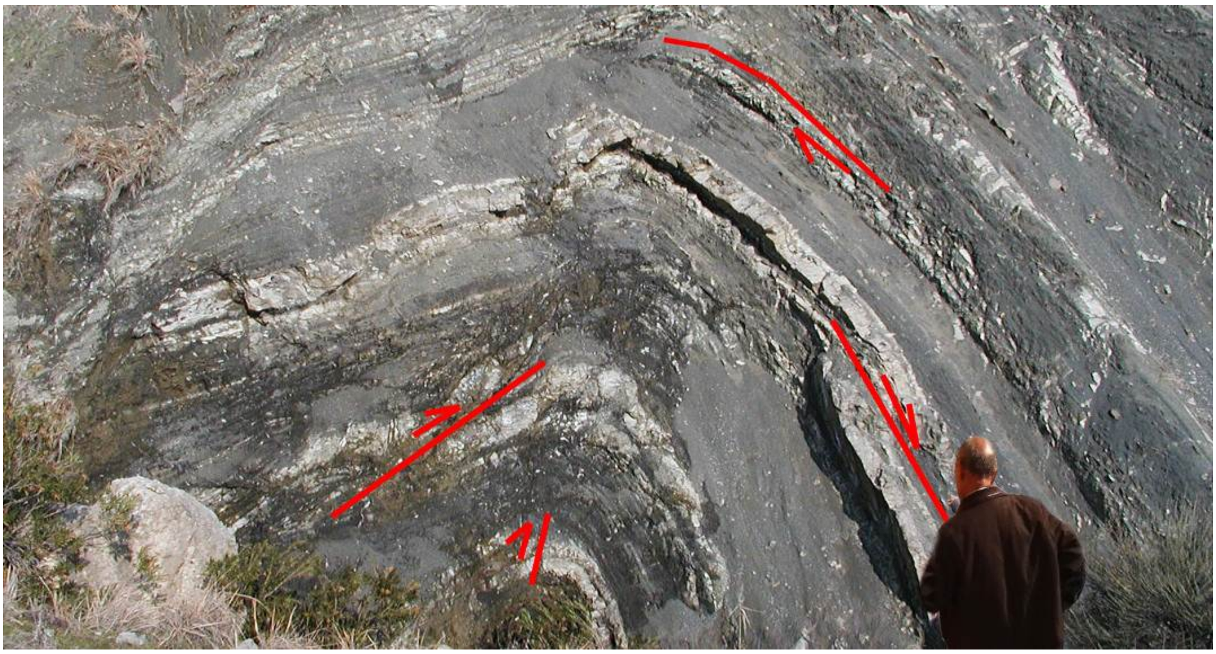

Fig. 13: Inner arc(layer) faulting of Kolosh Formation (outside of the studied area) is exampled for reasoning lateral thrust in Darbandikhan.

Conclusions

This paper has the following conclusion

1- In previous studies there is no agreement about location, name and type of Khanaqin or Darbandikhan (or Sirwan) fault.
2- Structural, sedimentary and stratigraphical surface expressions of Darbandikhan fault are not found. What is found is lateral thrust not normal or strike slip fault as indicated previously.
3- Around Darbandikhan town lateral thrusts are found that have 90 degrees of difference in direction with of Darbandikhan (Khanaqin) fault.
4- The lateral thrust fault is generated due to bending of the Zimnako-Khusk-Bamo anticline.

Reference

1. Jassim, S. Z. 9and Goff, J. C. 2006. *Geology of Iraq*. Dolin, Prague and Moravian Museun, Berno. 341p.
2. Ibrahim, A. O. 2009. *Tectonic style and evolution of the NW segment of the Zagros Fold – Thrust Belt, Sulaimani Governorate, Kurdistan Region, NE Iraq*. Unpublished Ph. D. Thesis, University of Sulaimani, College of Science, p. 187.
3. Lawa, F. A., Koyi, H. and Ibrahim, A. 2013. Tectono-stratigraphic evolution of the NW segment of the Zagros Fold – Thrust Belt, Kurdistan, NE Iraq. *Journal of Petroleum Geology*, v. 36, no.1, p.75-96.
4. Lawa, F. A. 2004. *Sequence stratigraphic analysis of the middle Paleocene –Middle Eocene in the Sulaimani District (Kurdistan Region)*. Unpublished Ph.D. Thesis, University of Sulaimani.
5. Ghafur, A. A. 2012. *Sedimentology and reservoir characteristics of the Oligocene-Early Miocene carbonates (Kirkuk Group) of southern Kurdistan*. unpublished PhD Thesis, School of Earth and Ocean Sciences, Cardiff University.p.200.
6. Lawa, F. A. A, and Ghafur, A. A. 2015. Sequence stratigraphy and biostratigraphy of the prolific late Eocene, Oligocene and early Miocene carbonates from Zagros fold-thrust belt in Kurdistan region. *Arab J Geosci*, DOI 10.1007/s12517-015-1817-4.
7. Karim, K. H and Ali S. S. 2004. Origin of dislocated limestone blocks, on the slope side of Baranan (Zirgoez) Homocline: A key to the development to western part of Sharazoor plain. *KAJ*, V. 3, no.1, p.46-60.
8. Ali S. S. 2005. Effect of slide masses on ground water occurrence in some areas of Sharazoor plain /NE Iraq. *Water Resources and Environmental Problems in Karst –Proceedings of International Association of Hydrogeologist. International conference, Karst (CVIJIĆ)*.
9. Ameen, B. M. 2006. Sequence Stratigraphy of Gercus Formation Sequence Stratigraphy of Gercus Formation (Middle Eocene) in Sulaimaniya area, NE-Iraq. *Iraqi Journal of Earth Science*, v.6, No.2, p.23-32.
10. Karim K. H. 1997. Stratigraphy of Sartaq-Bamo Area, Northeastern Iraq, Journal of Iraqi Geological Society, http://kurdistan-geology.com/?p=384.
11. Khanaqa, P. A. 2012. Interpretation of new facies in the Pila Spi Formation (Middle – Upper Eocene), Sulaimanyia Area, Ne Iraq. *Iraqi Journal of Geology and Mining*, issued by GEOSURV, V.7, no.3,p. 33-45.
12. Babashekh, S. M. R. 2000. *Hydrogeochemistry of caves and springs in Sangaw- Chamchamal area in NE-Iraq*. Unpublished M.Sc Thesis, College of Science, Baghdad University. p.150.
13. Kharajiany, S. O. A. 2008. *Sedimentary facies of Oligocene rock units in Ashdagh mountain-Sangaw District-Kurdistan Region*. Uunpublished MSc. Thesis . University of Sulaimani. Sulaimani. P. 106.
14. Ghafor I M , Karim K. H. and Sissakian V. 2014. Published BY: *Arabian Journal of Geosciences*, 2014, v 7, no. 9, p. 3599-3610.
15. Karim K. H., Khanaqa, P.A., Ismail, K. I. and Sissakian V. 2012. Facies analysis of the Oligocene succession on the Sharwaldir anticline, NE of the Kalar Town, NE-Iraq. *Iraqi Bulletin of Geology and Mining*, Vol.8, No.2. pp.1-19.
16. Dunnington, H. V. 1958. Generation, migration and dissipation of oil in Northern Iraq. *Arabian Gulf, Geology and productivity*. AAPG Foreign Reprint Series, no. 2.
17. Sissakian, V.K. 2000. *Geological Map of Iraq, scale 1:1000000*, 3rd edit., GEOSURV, Baghdad.

18. Khanaqa, P. A., Sissakian V. S., Karim, K. H. Karim, S. A. 2009. Lithostratigraphic study of a Late Oligocene-Early Miocene succession, south of Sulaimaniyah, NE-Iraq. *Iraqi Bulletin of Geology and mining*, Vol.5, No.2, p.41-57.
19. Al-Qayim, B., Omer, A. and Koyi, H. 2012. Tectonostratigraphic overview of the Zagros Suture Zone, Kurdistan Region, Northeast Iraq. *GeoArabia*, V. 17, No. 4, p.109-156.
20. Aqrawi, A. A. M., Goff, J. C., Horbury, A. D and Sadooni, F. N. 2010. The Petroleum Geology of Iraq. *Scientific Press*, p. 424.
21. Buday, T. and Jassim, S. Z., 1987. The Regional geology of Iraq: Tectonism Magmatism, and Metamorphism. In: M. J. Abbas and Jassim, S. Z (Eds), *GEOSURV*, Baghdad, Iraq, p 445.
22. Sissakian, V.K., Al-Ansari, N. and Knutsson, S. 2014. Origin of Some Transversal Linear Features of NE-SW Trend in Iraq, and Their Geological Characters. *Natural Science*, V.6, p. 996-1011.
23. Jassim, S. Z., Al-Shaibani, S. I, Q. and Ajina, T. M. l 975. Possible Middle Eocene block movements in the Darbandikhan area, Northern Iraq. *Geol. Soc. Iraq*. Special Issue, p. 139-145.
24. Karim K. H., Khanaqa, P. A., Ismail, K. I. and Sissakian V. 2012. Facies analysis of the Oligocene succession on the Sharwaldir anticline, NE of the Kalar Town, NE-Iraq. *Iraqi Bulletin of Geology and Mining*, V. l.8, no. 2. p. 1-19.
25. Karim, K.H. 2004. *Basin analysis of Tanjero Formation in Sulaimaniya area, NE-Iraq*. Unpublished Ph.D. Thesis, University of Sulaimani University, p. 135.
26. Barzinjy, S. T. M. 2005. *Stratigraphy and basin analysis of Red Bed Series from northeastern Iraq-Kurdistan Region*. Unpublished Ph.D. thesis, University of Sulaimani University, p. 159.
27. Karim, K. H. and. Solaiman S. H. 2012. Origin of lateral thrust in Mawat Area, Kurdistan, NE-Iraq. *First International Conference on Petroleum and Mineral Resources, Koyia University, Koyia Town*, WIT Press, p.183-195.
28. AL-Fadhli, I., Janardan Rao, Y., Oweiss, G. and Takla, M. A. 1980. Superimposed Folding in Sayed-Sadek area, near the Zagros suture zone, Iraq. *Geoviews*, V. 3, no. 111, p. 126-148.
29. AL-Fadhli, I., Janardan Rao, Y., Oweiss, G. and Khalil, M. 1979. Polyphase deformation in apart of Zagros, Sulaimaniyah district, NE Iraq. *J. Indian Academy of Geoscience*. V. 22, p. 1-31.
30. AL-Jumaily, I. S. I. 2004. *Tectonic investigation of the brittle failure structures in the Foreland Folds Belt. Northern Iraq*. Unpub. Ph.D. thesis, University of Mosul, Iraq, (in Arabic).
31. AL-Hakari, S. H. S. 2011. *Geometric Analysis and Structural Evolution of NW Sulaimani Area, Kurdistan Region, Iraq*. Unpub. Ph.D. thesis, University of Sulaimani, Kurdistan region, Iraq. P. 240.