

### Structural Development of Khalakan Anticline and Deposition of Dokan Conglomerate, Northeastern Iraq

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#### Introduction

Khalakan Anticline is NW – SE trending structure runs along the southwestern side of Dokan Lake in northeastern Iraq. The Cretaceous Qamchuqa forms the oldest formation that exposes and forms the core of the anticline. Kometan, Shiranish, Tanjero, Kolosh, Sinjar, Gercus, Pila Spi, Fatha and Injana are the formations that form the southwestern limb of the

#### Abstract

The research shows the relation between the structural development of Khalakan Anticline and the deposition of Dokan Conglomerate. Khalakan anticline is located in NE Iraq, within the High Folded Zone of the Iraqi Western Zagros Fold – Thrust Belt, where the southwestern limb of it represents the boundary between the High Folded and Low Folded zones. The old exposed rocks in the study area ranges from the Cretaceous Qamchuqa Formation to Late Miocene Injana Formation, where these rocks form the limbs of the anticline. The young exposed rocks represented by Dokan Conglomerate, where these rocks form erosional angular unconformity with the old formations. The study shows that the growth of Khalakan Anticline occurred in Late Miocene and developed in Late Pliocene as fold related to the back-thrust fault. The study concluded that the deposition of Dokan Conglomerate in the study area is controlled by the back-thrusting through the structural development of the anticline, consequently the pliocene rivers deposited boulders size from Pila Spi Formation on the southwestern back-limb and deposited the clay size on the northeastern limb of the anticline.

anticline deposits clearly, while the northeastern limb is covered by Dokan Conglomerate (Fig 1). Tectonically the anticline is located within the High Folded Zone of the Iraqi Western Zagros Fold – Thrust Belt, where the southwestern limb of it represents the boundary between the High Folde and Low Folded zones [1].

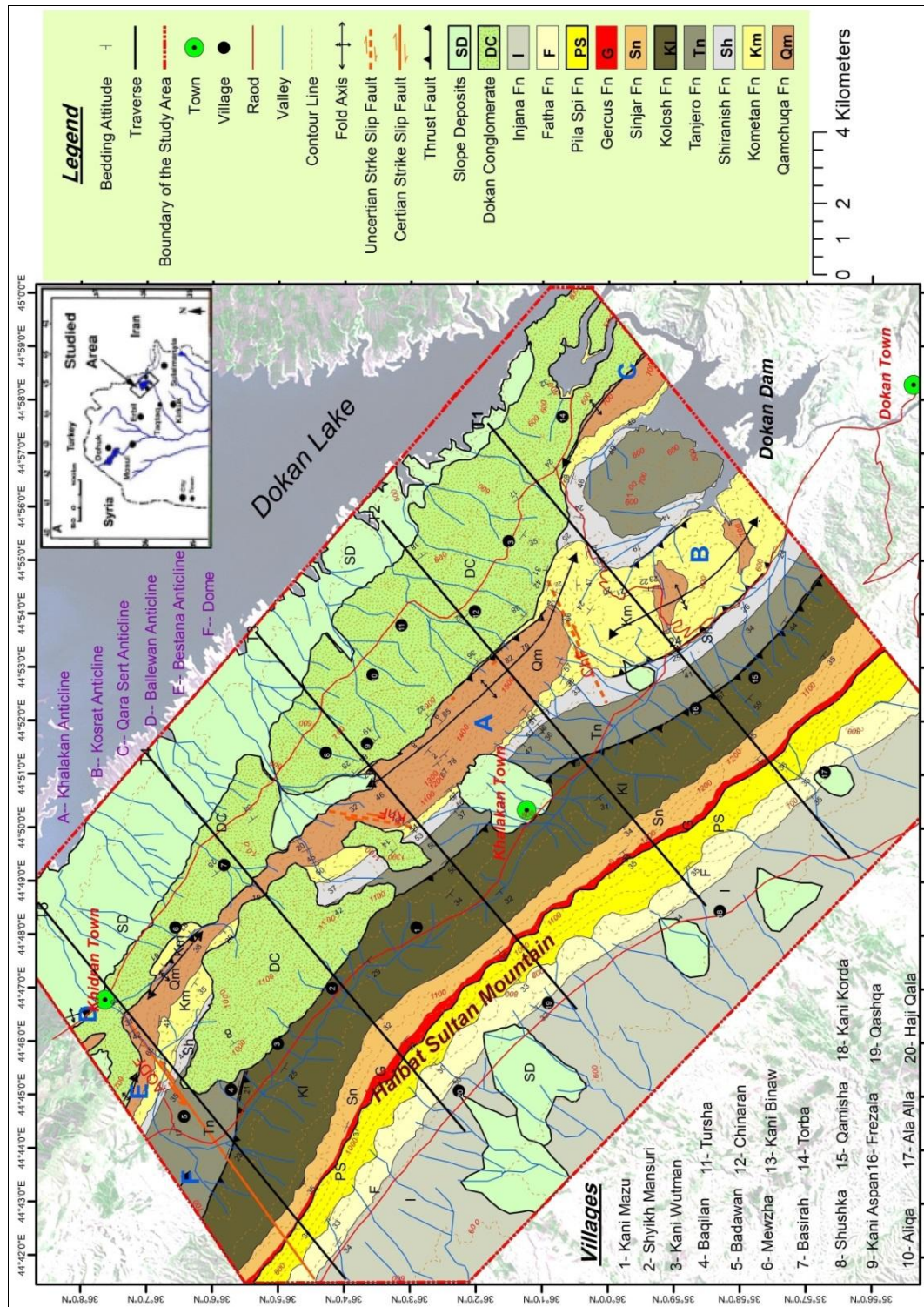


Fig 1: Geographic location and the geological map of the study area

**Folding Age of Khalakan Anticline**

The age of the folded strata and their relationships determine the folding age of the fold, where [2] referred that main folding in northeastern Iraq started during Middle Miocene-Pliocene and consequently the youngest geological unit of the Late Miocene-Pliocene Bakhtiari Group (Muqdadia and Bai Hassan formations) affected by the folding. In the study area, Kometan, Shiranish, Tanjero, Kolosh, Sinjar, Gercus and Pila Spi, Fatha and Injana formations form the

southwestern limb of the anticline while Dokan Conglomerate lies above them with erosional angular unconformity (Fig. 2).

[3] considered Dokan Conglomerate as Early Tertiary river terraces deposited horizontally on older dipping cretaceous strata and both were deformed later during the later post-Miocene folding. Thereafter, [4] supposed it as equivalent to the Late Pliocene Bai Hassan Formation because it involves boulders of Pila Spi Formation, while [5] referred that the deposition

of it is connected by the structural development of Khalakan Anticline. According to this study, Khalakan Anticline formed in the Late Miocene and

developed during the Pliocene, therefore the Injana Formation is affected by the folding while Dokan Conglomerate is affected by the development.

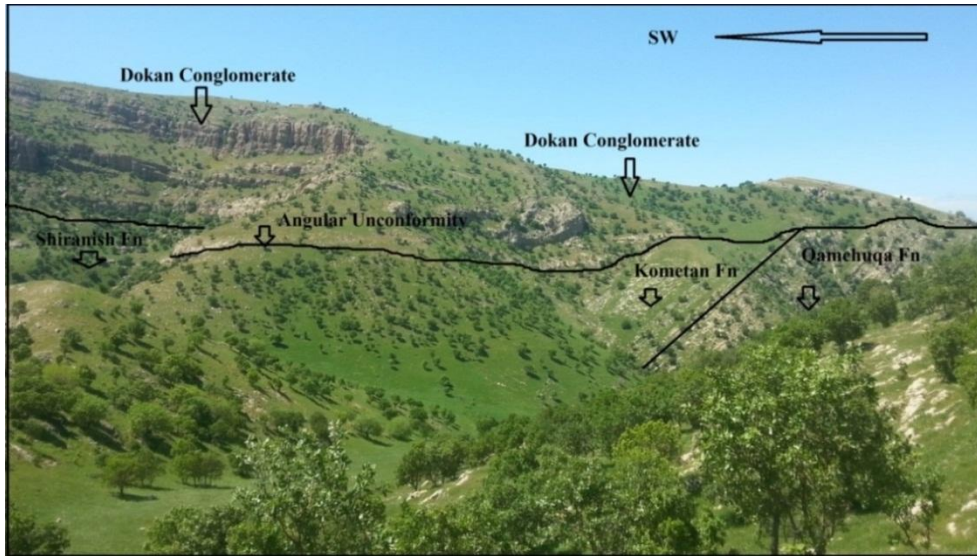


Fig. 2: Dokan Conglomerate above the southwestern limb of Khalakan Anticline with erosional angular unconformity

**Structural Development of Khalakan Anticline**

According to [6-8] and [9], the development of folds in Zagros Fold Thrust Belt was detected by some geomorphic criteria, such as drainage network and water and wind gabs. The water and wind gabs are the strongest indicator of the lateral development of folds

[6]. When a fold grows laterally, the tributaries (streams) that flow in two flanks track toward the growth direction instead the following in steepest topographic gradient (perpendicularly to the fold axis), and there are at least two wind or water gaps formed by the same stream (Fig. 3).

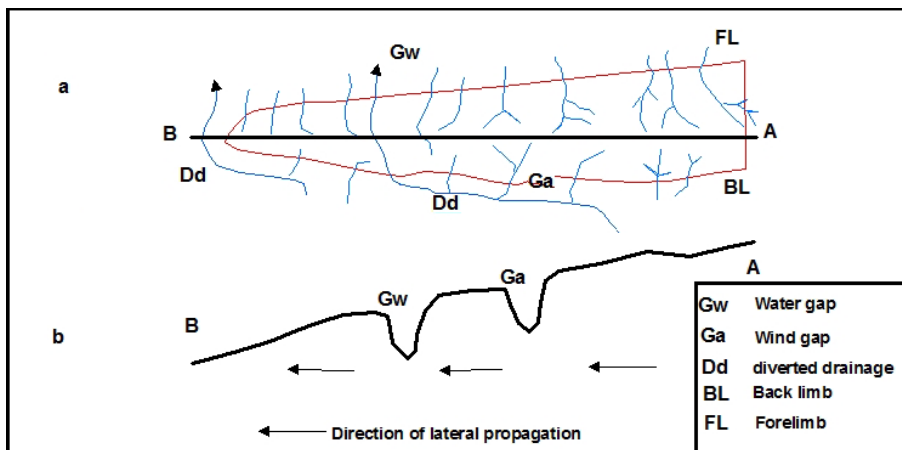


Fig. 3: Idealized diagram shows the tectonic geomorphology of a fold that is propagating laterally [6]

By comparison between the drainage pattern of the streams for the study area in figure 1 with figure 3, it can be seen that the lateral development of Khalakan Anticline is from southeastern to northwestern direction, consequently two wind gaps were formed in south of Basarah and Mewzha villages respectively

while one water gap formed in south of Khidran Town (Fig. 4, 5 and 6 respectively). Also it can be seen that the higher topographic backlimb is represented by the southwestern limb of Khalakan Anticline while the lower topographic forelimb of the anticline is represented by the northeastern limb.



Fig. 4: Wind gap in south of Basirah Village

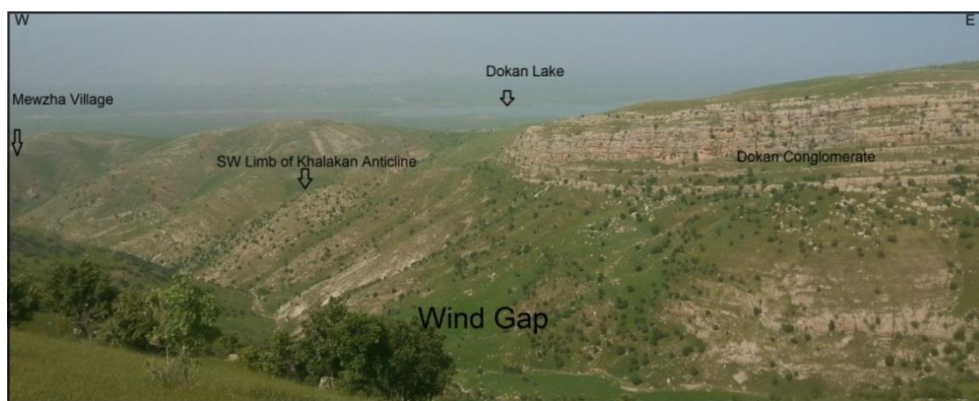


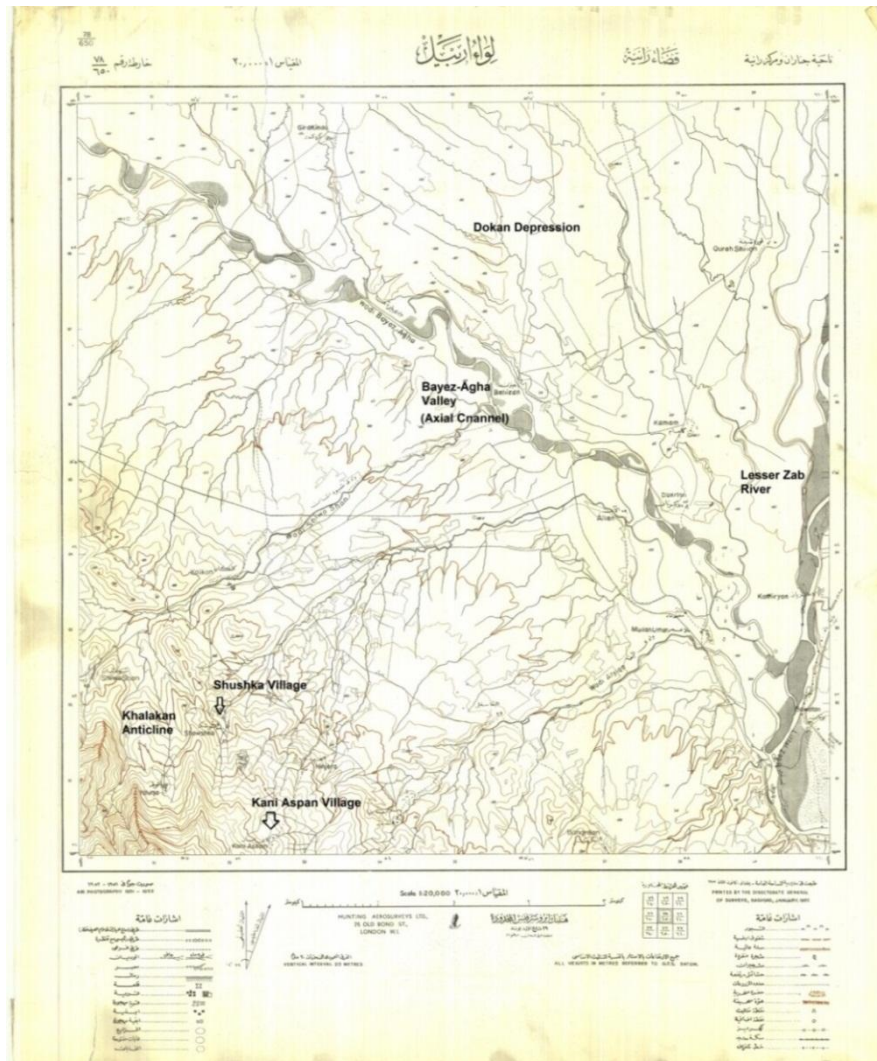
Fig. 5: Wind gap in south of Mewzha Village



Fig. 6: Water gap in south of Khidran Town

Moreover, 1957 topographic map of Chinaran Ranya shows that the streams in Khalakan Anticline area flow to northeastern and pour in Payez-Agha Valley, where the valley represents axial channel pours in

Lesser Zab River before the building of Dokan Dam and using Dokan Depression as water reservoir (Fig.7).



**Fig. 7: 1957 topographic map of Chinaran Ranya shows that the streams in the study area flow to northeastern and pour in Payez-Agha Valley [10]**

**Thrusting and Alluvial Fans Relationship**

According to [11], folds in thrust-fold belts are attributed to the thrust faults. [12] modeled the relationship between the thrusting and the depositin of alluvial fans at 0.9 m. yr. and at 1.9 m. yr. (Fig. 8.a and b) where the thrust fault moves the hanging wall (back-limb) in high level and leads to the presence

sediments as transversal alluvial fans as well as the presence of axial channel in the lower level (forelimb). Consequently the alluvial fans that deposited on the higher level is caorse grain and involves gravel while the alluvial fans that deposited on the lower level is fine grain and involves mud (Fig. 9).

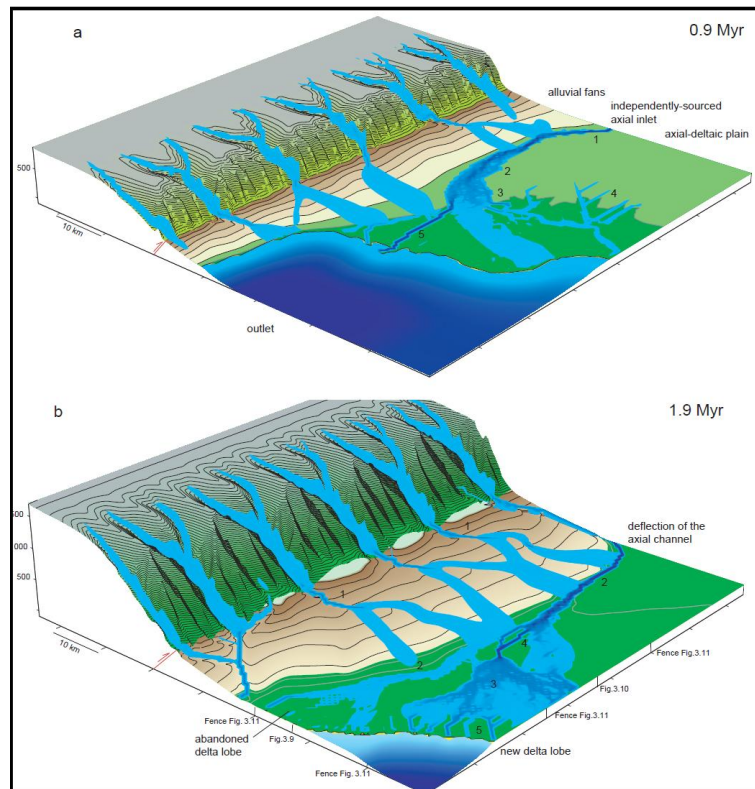


Fig. 8: Two models show the relationship between thrusting and deposition of alluvial fans. (a) at 0.9 m. yr. (b) at 1.9 m. yr. [12]

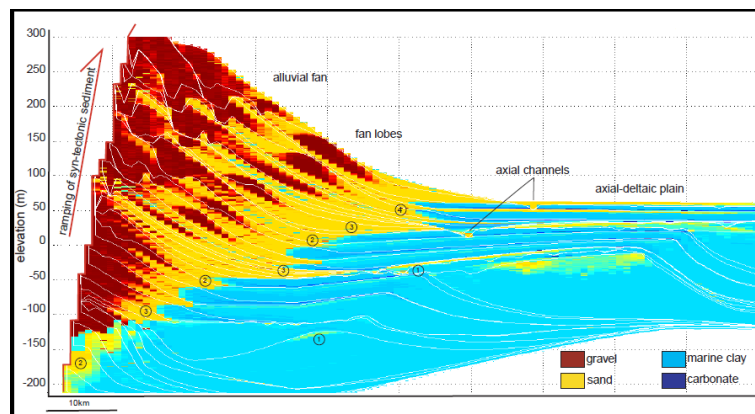
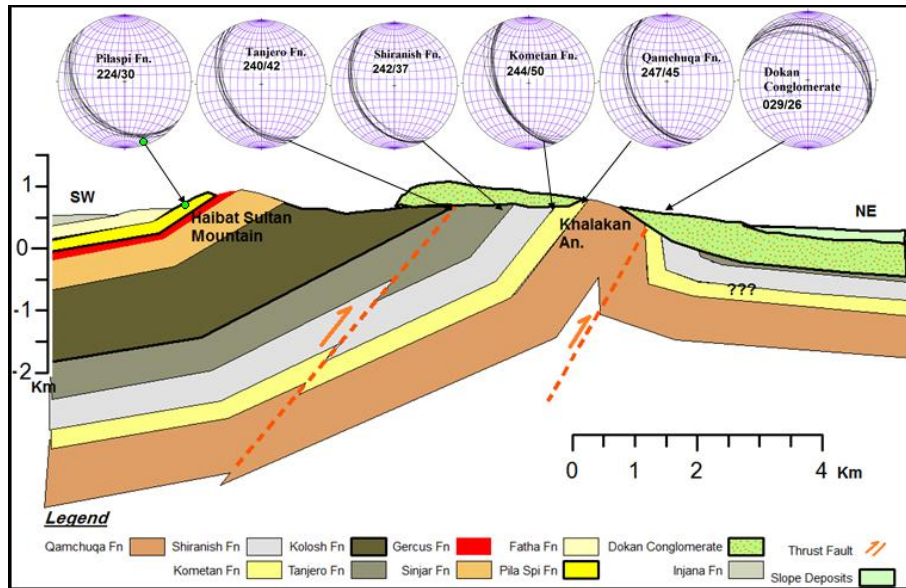


Fig. 9: Stratigraphic cross section shows the distribution of the transversal alluvial fans controlled by thrusting [12]

**Khalakan Anticline and Dokan Conglomerate Relationship**

Folds in northeastern Iraq are related to the thrust faults and have southwestern forelimb, except some anticlines in the High Folded Zone that related to back-thrust faults and have northeastern forelimb [13]. Dokan Conglomerate is alluvial fans deposited in fresh water environment above Khalakan Anticline, the outcrop of Dokan Conglomerate above the

southwestern limb of the anticline is called Kani Wutman while the outcrop above the northeastern limb is called Khalakan [4]. According to this study, the geological cross section appeared that Dokan Conglomerate lies horizontally above the southwestern back-limb of Khalakan Anticline and lies with NE dipping above the northeastern forelimb of the anticline (figure 10).



**Fig. 10: Geological cross section drawn from the traverse no. 4 of figure 1, shows the relationship between Khalakan Anticline and Dokan Conglomerate**

According to this study, Dokan Conglomerate above the southwestern limb of Khalakan Anticline (Kani Wutman outcrop) involves boulders and above the northeastern limb (Khalakan outcrop) involves thick beds of clay (Fig. 11 and 12 respectively). According to [4], Boulders of Kani Wutman outcrop derived from Pila Spi Formation. When compared between Fig. (8 and 9) and Fig. (10, 11 and 12), it can be seen that Dokan Conglomerate in the study area was deposited as transversal alluvial fans and controlled by

back-thrust fault related Khalakan anticline, consequently Kani Wutman outcrop involved boulders while Khalakan Outcrop involves clay. Dokan Conglomerate lies on the southwestern limb of Khalakan Anticline that involves Late Miocene Injana Formation (Figure 10) and lies on the northeastern limb with northeastern dipping (Fig. 12), therefore the deposition of Dokan Conglomerate can be adopted in Late Pliocene (equivalent to Bai Hassan Formation in Taq Taq area).



**Fig. 11: Kani Wutman outcrop of Dokan Conglomerate shows cobble and boulder sizes of clasts**

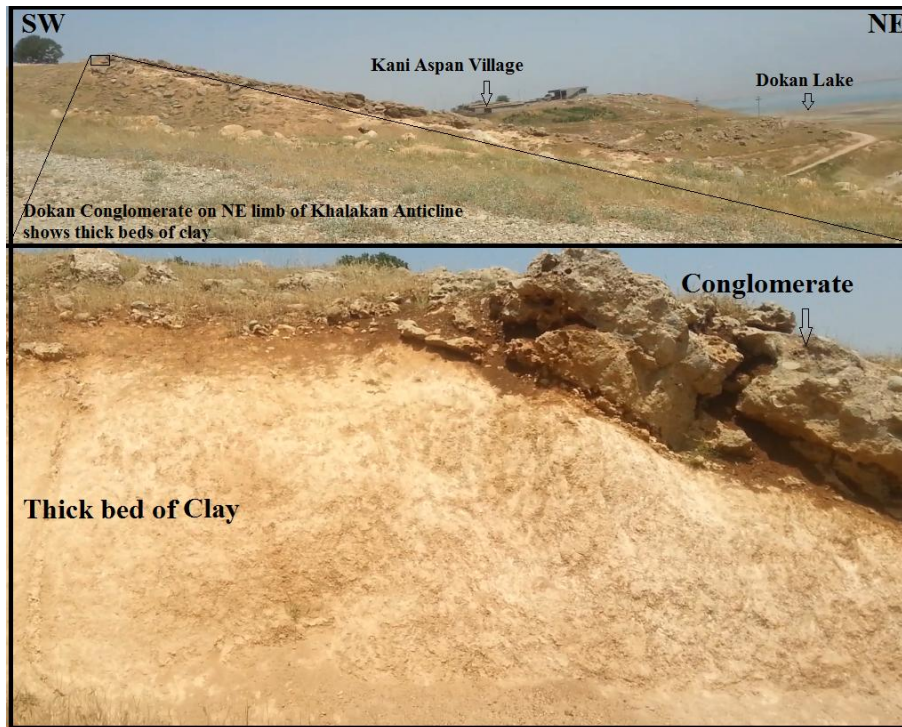


Fig. 12: Khalakan outcrop of Dokan Conglomerate shows clay size of clasts with northeastern dipping (near Kani Aspan Village)

**Pliocene-current and Rock Source of Dokan Conglomerate**

By comparison between the clasts of Dokan Conglomerate in the study area and Bai Hassan Formation in Taq Taq area (south of the study area), Dokan Conglomerate consists of limestone derived from Cretaceous Qamchuqa Formation in mainly while Bai Hassan Formation contains only rare

igneous clasts. This contrast attributed to that the study area located more close to mountain range at time of deposition while Taq Taq Area located in far from mountain range [4]. The Pliocene-current in the High Folded Zone transported the sediments of Dokan Conglomerate by axial rivers from east or west areas, and transported the sediments of Bai Hassan from the Thrust Zone to Erbil and Sulaimani areas (Fig. 13).

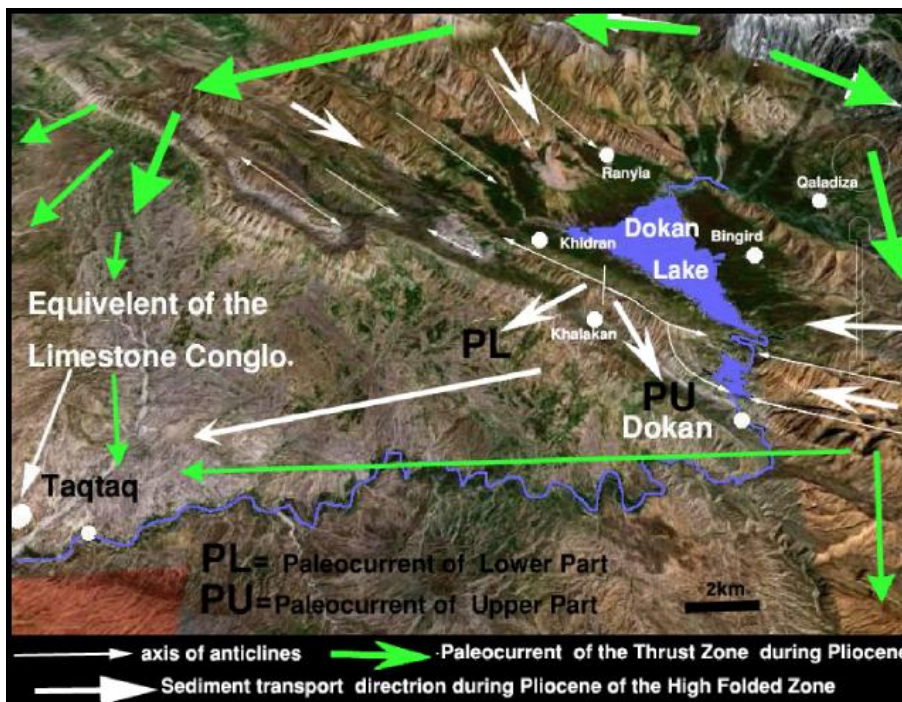


Fig. 13: Google Earth Image shows the direction of Pliocene-current, as interpretation to way the Dokan Conglomerate mainly consist of limestone clasts, while Bai Hassan consist of polygenic clasts [4]



Despite Dokan Conglomerate derived from Qamchuqa Formation in mainly, Kani Wutman outcrop involves boulders of Pila Spi Formation [4]. Qamchuqa Formation exposes and forms the core of large number of anticlines in the High Folded Zone [1], while Pila Spi Formation is exposed in several anticlines (as Safeen, Bina Bawi, Shakrook and Harir anticlines) [14]. In addition to Haibat Sultan Mountain (Fig. 10), Pila Spi Formation exposes in the two limbs of Safeen Anticline and appears more erosion in comparison

with Shakrook and Harir anticline [8]. The exposure of Pila Spi in Haibat Sultan Mountain and Safeen Anticline are good indication to that the boulders of Kani Wutman outcrop was transported from the west and northwestern areas, where the Pliocene rivers flowed in channels parallel to the fold axes of anticlines (Fig. 14), and diverted at Kani Wutman Village to cross the fold axis of Khalakan Anticline and pour in Payez Agh Valley.

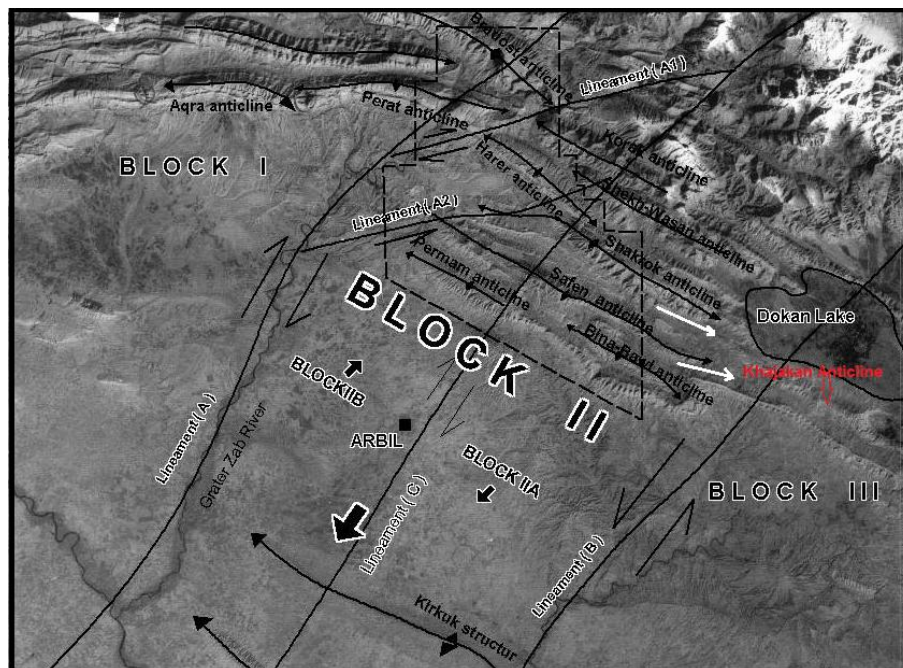


Figure 14: Aerial image shows several anticlines in the west and northwestern of Khalakan Anticline (After14), and Pliocene current direction (white arrow) (After 4).

### Conclusions

1- The folding of Khalakan Anticline started in Late Miocene and developed in Late Pliocene as fold related by back-thrust fault, therefore the higher topographic backlimb is located in southwest direction while the lower topographic forelimb is located in the northeastern direction.

2- The deposition of Dokan Conglomerate above Khalakan Anticline is controlled by the back-thrusting through the Pliocene structural development of the anticline, consequently the rivers deposited boulders

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size from Pila Spi Formation on the southwestern back-limb and deposited the clay size on the northeastern limb of the anticline

3- The study confirm that Dokan Conglomerate deposited above Khalakan Anticline as equivalent to Late Pliocene Bai Hassin Formation, where Dokan Conglomerate have erosional angular unconformity with the southwestern limb of Khalakan Anticline that involves Late Miocene Injana Formation, moreover it is influenced by the folding events that represents structural development of Khalakan Anticline.

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## التطور التركيبي لطية خلكان المحدبة وترسيب مدملكات دوكان، شمال شرقي العراق

منال شاكر الكبيسي ، عايد حسين ورد

قسم علم الارض ، كلية العلوم ، جامعة بغداد ، بغداد ، العراق

### الملخص

يوضح البحث العلاقة بين التطور التركيبي لطية خلكان وترسيب مدملكات دوكان. تقع طية خلكان في شمال شرقي العراق، ضمن نطاق الطيات العالية لحزام طي وتصدع زاكروس الغربية العراقية حيث جناحها الجنوبي الغربي يمثل الحد بين نطاقي الطيات العالية والطيات الواطئة. الصخور القديمة المنكشفة في منطقة الدراسة تتدرج من تكوين قمجوقة الكريتاسي الى تكوين انجانة البلايوسيني المتأخر، حيث تكون هذه الصخور اجنحة الطية. الصخور المنكشفة الحديثة متمثلة بمدملكات دوكان، حيث تكون هذه الصخور سطح تعروي زاوي مع الصخور القديمة. أظهرت الدراسة ان نمو طية خلكان حدث في المايوسين المتأخر وتطور في البلايوسين المتأخر كطية متعلقة بصدع عكسي. استنتجت الدراسة ان ترسيب مدملكات دوكان مسيطر عليه بالتصدع العكسي خلال التطور التركيبي للطية، وبناءا على رسبت الانهار البلايوسينية حجم جلاميد من تكوين بلاسي على الجناح الجنوبي الغربي ورسبت حجم طين على الجناح الشمالي الشرقي للطية.