



Tikrit Journal of Pure Science

ISSN: 1813 – 1662 (Print) --- E-ISSN: 2415 – 1726 (Online)

Journal Homepage: <https://tipsj.org/>



Tectonic Indications for Faulting Within the Southeastern Plunge of Kosrat Anticline, Northeastern Iraq

Ayyed Hussein Ward  

Department of Applied Geology, College of Sciences, University of Tikrit, Tikrit, Iraq

Received: 17 Dec. 2024 Received in revised forum: 6 Jun. 2025 Accepted: 15 Jun. 2025

Final Proof Reading: 20 Oct. 2025 Available online: 25 Oct. 2025

ABSTRACT

This study deals with the faulting in Southeastern plunge of Kosrat Anticline that located within the High Folded Zone of the Iraqi Western Zagros Fold-Thrust Belt. The research focused on the normal faults facing each other's within the southeastern part of Kosrat Anticline. The field data included attitude's fault planes with their striations (slickenlines). The results showed that Kosrat Anticline is a part of shear zone for dextral (N-S trending) strike slip fault, where this zone related the presence of anticlines (Kosrat, Qara Sard and Sara) as folds related thrust facing each other's. By comparison between the results of this study with the previous studies, it can be said that the growth of the NE-SW normal faults facing each other's started from north in synchronous with the starting for the dextral movement of Little Zab Fault and established to presence of Dokan Depression as well as the obstruction for the growth of Kosrat Anticline if compared with Sara (Surdash) Anticline.

Keywords: Normal fault, Strike slip, Anticline, Dextral Movement, Dokan area

Name: Ayyed Hussein Ward

E-mail: ayedwarid@tu.edu.iq



©2025 THIS IS AN OPEN ACCESS ARTICLE UNDER THE CC BY LICENSE
<http://creativecommons.org/licenses/by/4.0/>

المدلولات التكتونية للتصدع ضمن الغاطس الجنوبي الشرقي من طية كوسرت المحدبة، شمال شرقي العراق

عايد حسين ورد

قسم علوم الارض التطبيقية، كلية العلوم، جامعة تكريت، تكريت، العراق

الملخص

تناول هذا البحث التصدع في طية كوسرت المحدبة التي تقع ضمن نطاق الطيات العالية لحزام زاغروس الغربي العراقي. ركز البحث على الصدوع الاعتيادية ضمن الجزء الجنوبي الشرقي لطية كوسرت المحدبة. تضمنت البيانات الحقلية وضعية مستويات الصدوع المكتشفة مع تخطيطاتها (حزوز الصفاح). اظهرت النتائج ان الجزء الجنوبي الشرقي من طية كوسرت المحدبة هو جزء من نطاق قصي لصدع مضربي يميني باتجاه شمال - جنوب. حيث يتطلب هذا النطاق وجود طيات محدبة (كوسرت، سارا وقره سرد) كطيات متعلقة بصدوع زحف متقابلة الميل مع بعضها. ومن خلال تلك النتائج والربط مع الدراسات السابقة، يمكن القول بان نمو الصدوع الاعتيادية متقابلة الميل بدأ من الشمال مع بداية الحركة اليمينية لصدع الزاب الصغير المضربي مما ادى الى تكوين منخفض دوكان واستمر باتجاه الجنوب وتسبب في إعاقة تطور نمو طية كوسرت إذا ما قورنت مع تطور طية سارا (سورداش) المحدبة،

INTRODUCTION

According to Fig. 1, the study area is located within Fold-Thrust Belt and tectonically it is active (1).
the High Folded Zone of the Iraqi Western Zagros

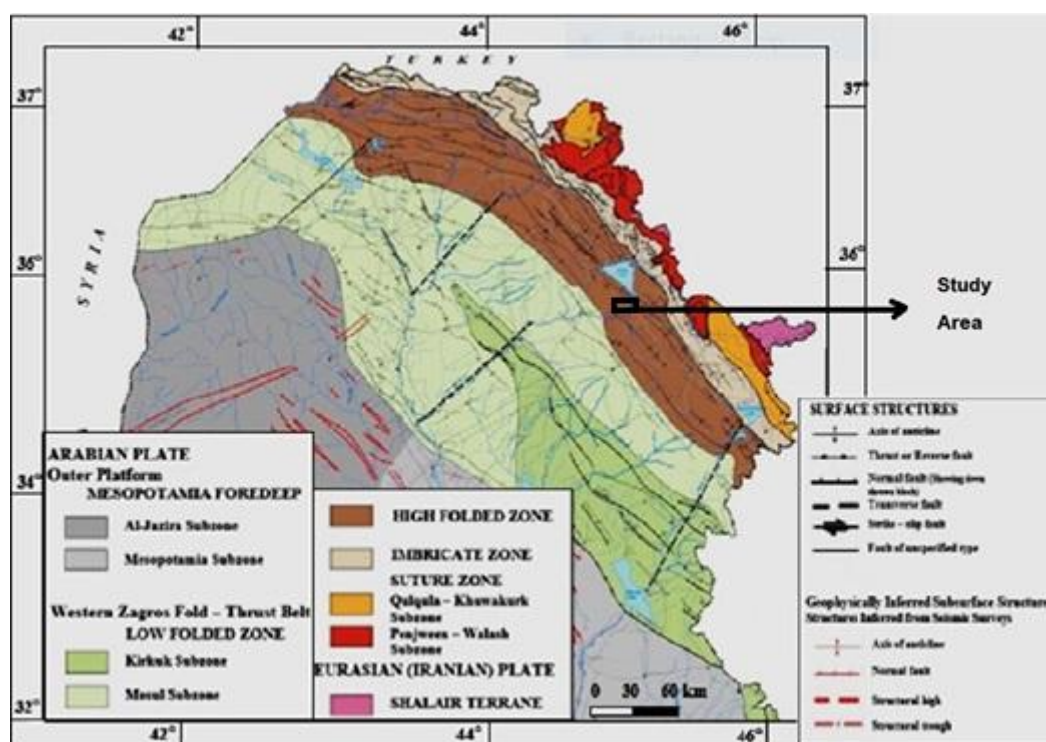


Fig.1: Tectonic location of the study area (2).

According to (3,4), the exposed rocks that seen in Kosrat Anticline are ranged from Cretaceous to Late Pliocene, and represented by Qamchuqa, Kometan, Shiranish, Tanjero, Kolosh, Khurmala, Gercus, Pila

Spi, Fatha, Injana formations and Dokan Conglomerate as equivalent to Bai Hasan Formation respectively (Fig. 2).

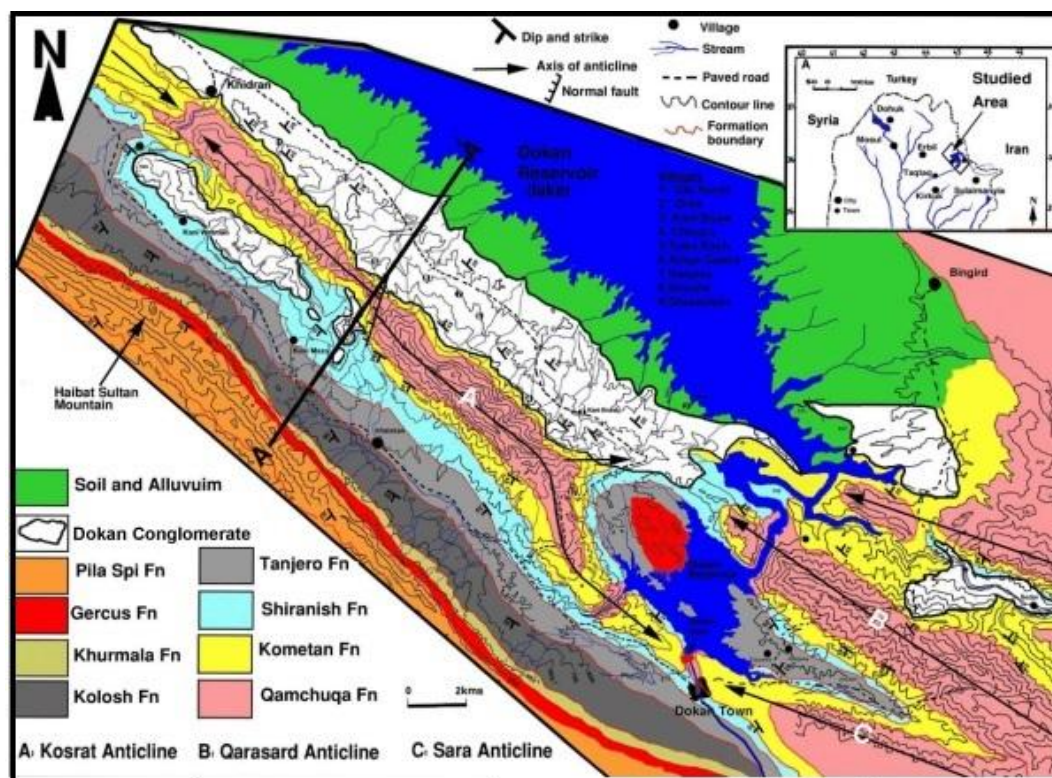


Fig. 2: Geological map of Kosrat Anticline and the adjacent anticlines within Dokan area (3).

Generally, the deformation of Zagros Fold Thrust Belt occurred as result for NE – SW tectonic compressive stress, and it controlled by the movement of NW-SE trending thrusts and conjugated (NS, NE-SW trending) strike slip faults (Fig. 3). The thrust faults caused the growth of NW-

SE trending for folds, while the conjugated strike slip faults caused obstructing and ending for these folds (5). These conjugated strike slip faults were selected in the Iraqi Zagros Fold Thrust Belt by several researchers, such as (6-11).

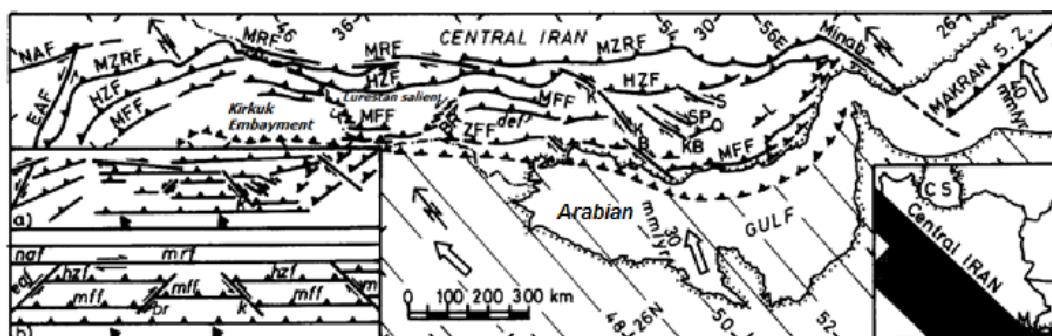


Fig. 3: Map view of Zagros Fold-Thrust Belt shows the controlling of NW-SE thrust and conjugated (NS, NE-SW trending) strike slip faults in the deformation and the folds growth (5).

The conjugated strike slip faults are also called Riedel shear faults, where the bisect of these faults is represented by the major compressive tectonic stress (σ_1) that cause the shortening and finally the deformation. The Riedel shear faults are classified into two types, synthetic (R) and antithetic (R') faults, where the slip of the synthetic (R) fault is right – lateral (dextral) and the slip of the antithetic (R') fault is left – lateral (sinistral). The synthetic

fault has more active in comparison with the antithetic fault because the strike of it is nearly parallel to shortening direction. Finally, the map view will be showing several tectonic landforms within the shear zone, represented by folds related thrust faults facing each other (thrusts and back thrusts) and normal faults facing each other (Fig. 4. a and b).

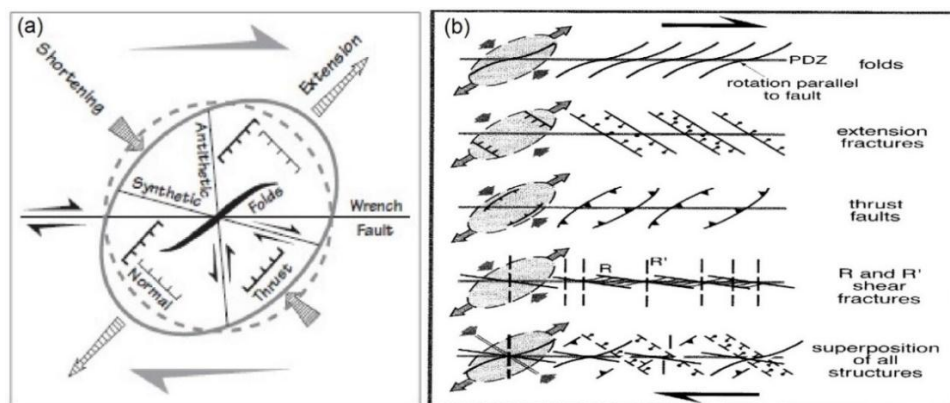


Fig. 4: (a) tectonic landforms associated with dextral strike-slip (wrench) fault zone in a map view⁽¹²⁾, (b) Folds, extension (normal) and thrust faults, Riedel shears and conjugate shears form at predictable angles with respect to the principal displacement zone (PDZ)⁽¹³⁾.

Before the building of Dokan Dam, the topographical map of Dokan Depression showed that Little Zab River runs proximally from North to South and most probably it represents surface trace of N-S fault⁽¹⁰⁾. The growth of folds for High Folded Zone is controlling by thrusts facing each other (thrust and back thrust) and shows more development in comparison with the folds of low folded zone; therefore, the fold related NE dipping fault (thrust) can be shows Foreland vergency (steep dipping of SW limb) while the fold related SW dipping fault (back thrust) can be shows suture vergency (steep dipping of NE-limb)⁽¹⁴⁾.

Sara (Surdash) and Kosrat anticlines are folds related thrust faults^(15, 16) respectively, while Qara Sard Anticline related back thrust fault⁽¹⁷⁾. By fractures analysis, Kosrat anticline showed NE-SW and N-S tectonic compressive stress⁽¹⁸⁾. Depending on the distribution of the geological outcrop surrounded the depression,⁽¹⁹⁾ suggested several

normal faults facing each other that have NE - SW strikes (perpendicular on fold axes).

FIELD DATA AND METHODOLOGY

This study selected several faults (stations) within the southeastern part of Kosrat Anticline and recorded the attitudes of these faults (as dip direction / dip amount) with the attitudes of the rakes of faults, as well as the location of these faults. T and P axes method (Anderson method) was used to determine the fault type in this. This method assumes that the surface of each fault represents the level of maximum shear-stress, and the movement striations on it are parallel to that stress⁽²⁰⁾. This means that the maximum (σ_1) and minimum (σ_3) stress axes guess the pressure axes P and T respectively, located at an angle of 45 on either side of the striation in the plane containing the striation and perpendicular to the fault plane. The axis of the medium (σ_2) stress remains within the fault plane and perpendicular to the plane that includes the two previous stress axes study (Fig. 5).

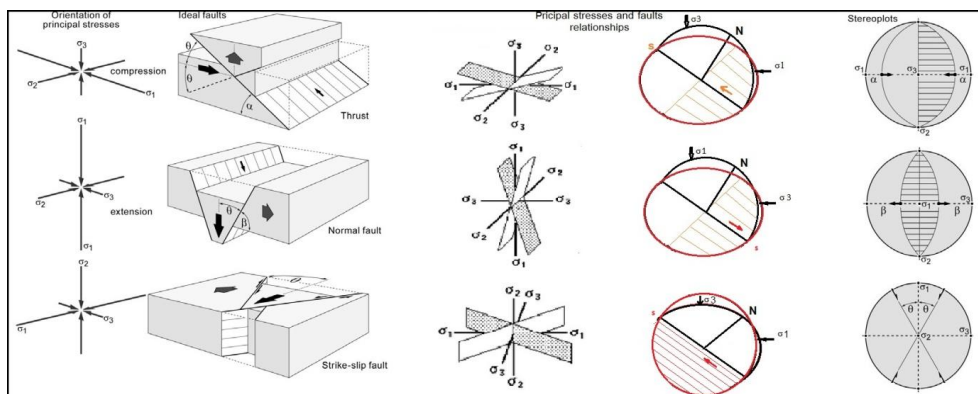


Fig.5: The relationship between the conjugated faults and the principal stresses, according to T and P axes method of Anderson

Through the figure 5, it can be seen that the maximum stress (σ_1 or P) and the minimum stress (σ_3 or T) are located within vertical ideal plane perpendicular to the fault planes. The location of the point P in the normal fault is closer to the center of the stereo plot than the point T, while the location of the point T in the thrust fault is closer to the center of the stereo plot than the point P. In the strike slip fault, location of the P and T points are near the circumference of the stereo plot.

Stereo Win Software was used to analyze and show the faulting types by the stereographic projection for the selected faults.

RESULTS AND DISCUSSION

According to T and P axes method and the figures obtained by using the Stereo Win software, the research showed the following results: -

Station 1: The station showed fault scarp within Kometan Formation, at location E: $44^{\circ} 55' 26''$ and N: $35^{\circ} 57' 29''$. The fault plane recorded 142/71 as dip direction/ dip amount. The attitude of striations recorded 070/41 as trend and rake. The stereographic projection showed normal slip, where the p is closer to the center of the stereo plot than the point T (Station 1 in fig. 6).

Station 2: The station showed fault cut the contact between Shiranish and Kometan formations at location E: $44^{\circ} 55' 50''$ and N: $35^{\circ} 57' 24''$. The fault plane recorded 316/67 as dip direction/ dip amount. The attitudes of the striations within the fault plane recorded 337/65 as trend and rake. The

stereographic projection showed normal slip, where the p is closer to the center of the stereo plot than the point T (Station 2 in fig.6).

Station 3: The station showed fault within Shiranish Formation at location E: $44^{\circ} 57' 03''$ and N: $35^{\circ} 56' 48''$. The fault plane recorded 275/78 as dip direction/ dip amount. The attitudes of the striations within the fault plane recorded 004/05 as trend and rake. The stereographic projection showed dextral strike slip, where the location of the p and T points are near the circumference of the stereo plot (Station 3 in fig. 6).

Station 4: The station showed fault cut the contact between Shiranish and Kometan formations at location E: $44^{\circ} 57' 16''$ and N: $35^{\circ} 56' 40''$. the fault plane recorded 317/73 as dip direction/ dip amount. The attitudes of the striations within the fault plane recorded 353/69 as trend / rake. The stereographic projection showed normal slip, where the point P is closer to the center of the stereo plot than the point T (Station 4 in fig.6).

Station 5: The station showed fault cut the contact between Shiranish and Kometan formations at location E: $44^{\circ} 57' 18''$ and N: $35^{\circ} 56' 39''$. the fault plane recorded 133/70 as dip direction/ dip amount. The attitudes of the striations within the fault plane recorded 082/60 as trend / rake. The stereographic projection showed normal slip, where the point P is closer to the center of the stereo plot than the point T (Station 5 in fig.7).

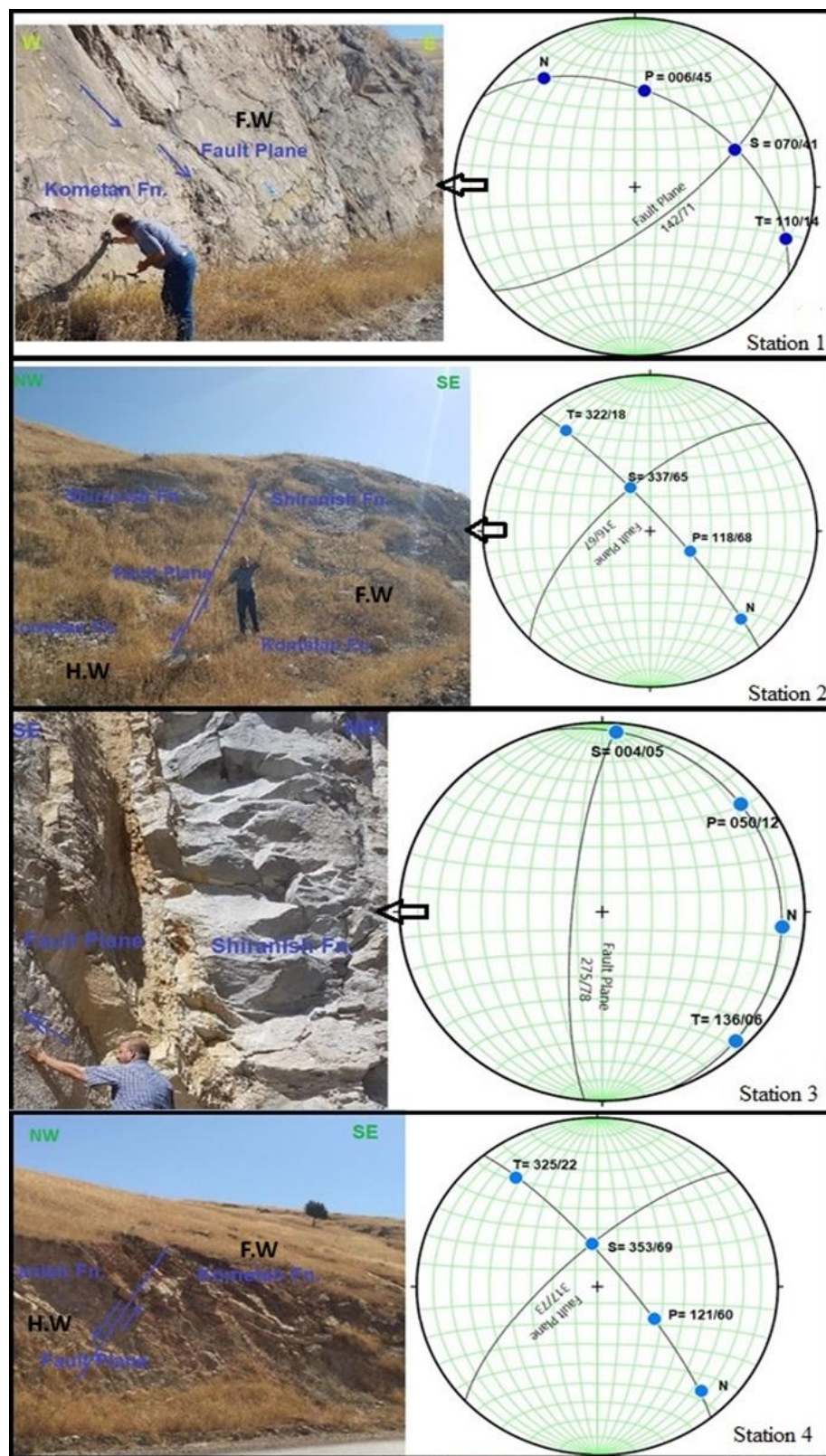


Fig. 6: Shows results of stations (1-4)

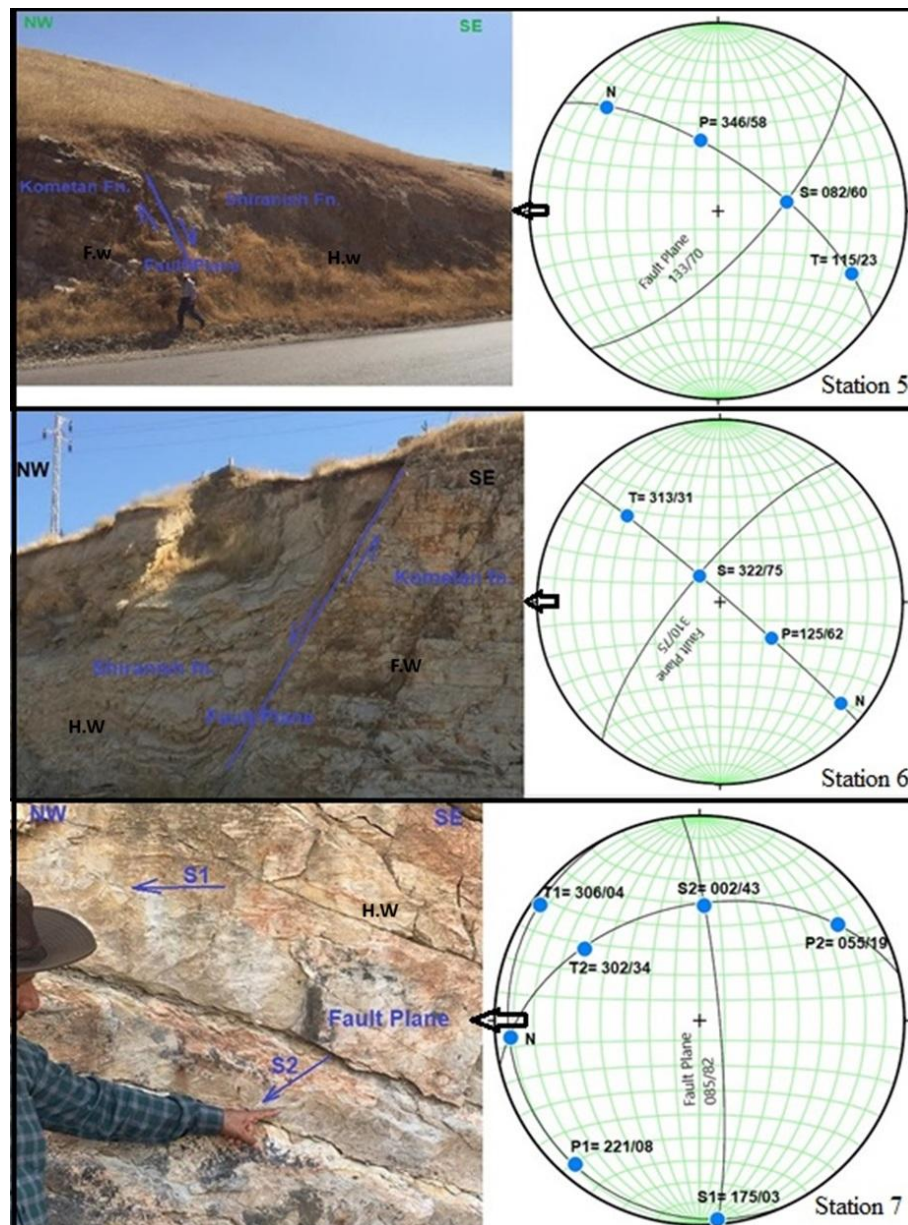


Fig. 7: Shows results of stations (5-7)

Station 6: The station showed fault cut the contact between Shiranish and Komatan formations at location E: $44^{\circ} 57' 25''$ and N: $35^{\circ} 56' 34''$. The fault plane recorded 310/75 as dip direction/ dip amount. The attitudes of the striations within the fault plane recorded 322/75 as trend / rake. The stereographic projection showed t slip, where the point P is closer to the center of the stereo plot than the point T (Station 6 in fig.7).

Station 7: The station showed fault within Komatan Formation at location E: $44^{\circ} 57' 26''$ N: $35^{\circ} 56' 33''$. The fault plane recorded 085/82 as dip direction/ dip amount. This station has some specialization

because it is located near the Little Zab River and it show two directions striations for fault plane of hanging wall, the attitudes of the striations within the fault plane recorded 175/03 with 002/43 as trend / rake. The stereographic projection showed dextral strike slip and thrust slip respectively. Where the location of P1 and T1 points are near the circumference of the stereo plot as result of strike slip fault, and the point T2 is closer to the center of the stereo plot than the point P2 as result of thrust fault analysis (Station 7 in fig.7).

The results showed that the stations 1-6 involve NE – SW (perpendicular to the fold axes of anticlines)

normal faults facing each other's, while stations 3 and 7 showed proximally N-S dextral strike slip faults. As well as the N-S dextral strike slip movement of station 7, the station showed thrust movement for the east block as hanging wall. That means Kosrat Anticline area in west of little Zab River submitted to obstruction by normal faults facing each other if compared with Sara Anticline area in the east, and that interpreters the present of Kometan Formation as core of Kosrat Anticline if compared with Sara Anticline that shows presence of Qamchuqa Formation as core (Fig.2).

The general tectonic compressive stress direction that caused the deformation in Zagros Fold Thrust

Belt is NE-SW, therefore the folds in northeastern Iraq have NW-SE axes. By compression with figure 4, the strike of Little Zab Fault nearly parallel to general tectonic compressive stress (Synthetic fault in figure 4). Finally, the movement of the N-S dextral strike slip fault within Dokan area established to the growth of folds (Kosrat, Qara Serd and Surdash) related thrusts facing each other (thrusts and back thrusts) as positive tectonic landforms associated with dextral strike slip fault, in addition to the growth of Dokan Depression (lake) as negative tectonic landforms associated with dextral strike slip fault in Dokan Area (Fig. 8).

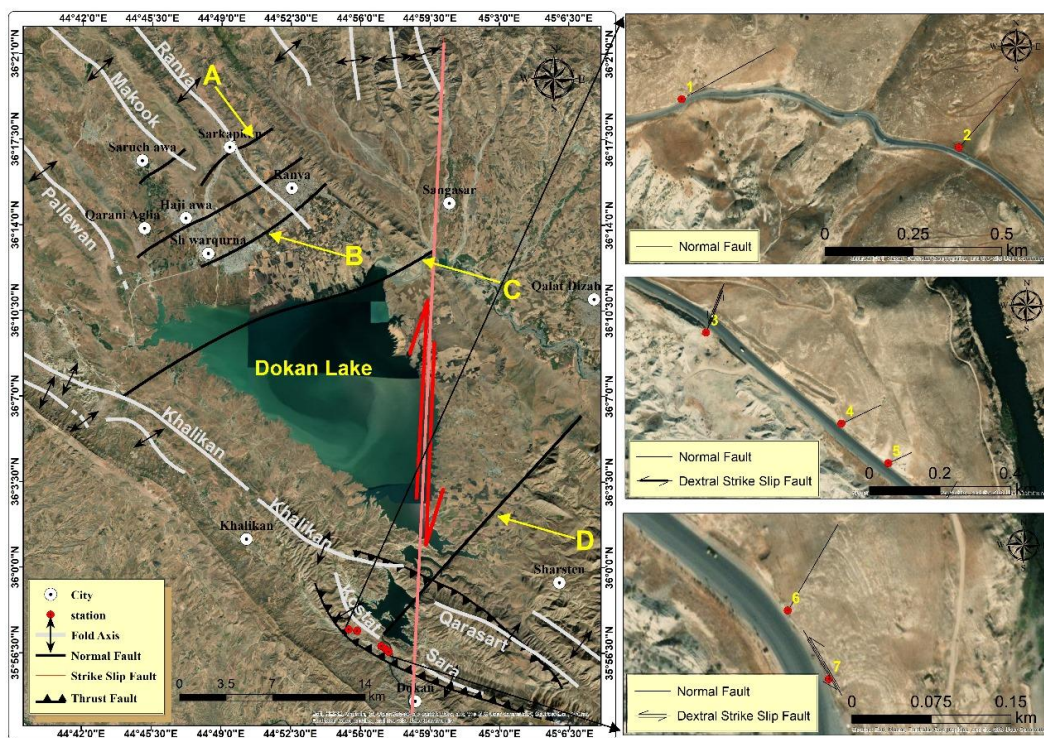


Fig. 8: Satellite image shows tectonic landforms associated with N-S strike slip fault in Dokan Area (After (16, 17, 19).

CONCLUSIONS

- 1- Dokan Area is located within shear zone of N-S dextral strike slip fault.
- 2- Little Zab River represents surface trace for N-S Dextral strike slip fault within High Folded Zone.
- 3- The dextral movement of the strike slip fault in Dokan Area established to the growth of Sara (Surdash) with Kosrat anticlines as folds related

thrust faults and established to the growth of Qara Serd Anticline as fold related back thrust fault.

- 4- The normal faults facing each other of the south east part for Kosrat Anticline represent part from large faulting system, this system established to Dokan Depression as pull apart basin (tectonic land form) associated with the N-S dextral strike slip fault in Dokan area.

5- The presence of the normal faults facing each other's in the south east part of Kosrat Anticline led to obstruction for the fold growth if compared with Sara (Surdash) Anticline.

Conflict of interests: declared no conflicting interests.

Sources of funding: No specific grant from a public, private, or nonprofit organization was obtained for this research.

REFERENCES

1. Sissakian VK, Al-Ansari N, Abdullah LHJG, Engineering G. Neotectonic activity using geomorphological features in the Iraqi Kurdistan region. 2020;38(5):4889-904. <http://dx.doi.org/10.1007/10706-020-01334-1>.
2. Doski JAJJoES. Active tectonics along the Sheladiz seismogenic fault in the Western Zagros fold-thrust belt, Kurdistan, Northern Iraq. 2021;110(2):595-608. <http://dx.doi.org/10.1007/s00531-020-01973-y>.
3. Karim KH, Taha ZAJBoG, Mining. ORIGIN OF CONGLOMERATIC LIMESTONE" DOKAN CONGLOMERATE" IN DOKAN AREA, KURDISTAN REGION, NE IRAQ. 2012;8(3):15-24. <https://ibgm-iq.org/ibgm/index.php/ibgm/article/view/203/197>.
4. Ward AH, Al-Kubaisi MSJTJoPS. Geometry of Khalakan Anticline, Northeastern Iraq. 2018;23(2):95-106. <http://dx.doi.org/10.25130/tjps.23.2018.034>
5. Berberian MJT. Master "blind" thrust faults hidden under the Zagros folds: active basement tectonics and surface morphotectonics. 1995;241(3-4):193-224. [https://doi.org/10.1016/0040-1951\(94\)00185-C](https://doi.org/10.1016/0040-1951(94)00185-C).
6. Abdullah LH, Al Daghashani HS, Bety AKSJH. Evaluation of neotectonic activity using watershed geomorphic analysis: A case study in the west of Dokan Lake, Kurdistan Region, Iraq. 2023;9(2). <https://doi.org/10.1016/j.heliyon.2023.e13187>.
7. Al-Attar ZT, Othman AA, Al-Hakari SHS, Obaid AK, Salar SG, Liesenberg VJEES. A neotectonic statistical assessment through watershed geomorphic analysis: a case study in the Greater Zab River Basin, Turkey–Iraq. 2022;81(13):355. <https://doi.org/10.1007/s12665-022-10478-7>
8. Ghafur AA, Sissakian VK, Al-Ansari N, Omer HO, Abdulhaq HAJRiGS. Tectonic development of northeastern part of the Arabian Plate: Examples from Pirmam and Bana Bawi anticlines in the Kurdistan region of north Iraq. 2023;14:100054. <https://doi.org/10.1016/j.ringps.2023.100054>.
9. Sissakian VK, Abdullah LH, Ghafur AJJoAES. Tectonic framework of Iraq. A critical review and discussion. 2024;276:106342. <https://doi.org/10.1016/j.jseae.2024.106342>
10. Ward AH, Al-Kubaisi MSJTJoPS. Structural development of Khalakan anticline and deposition of Dokan conglomerate, northeastern Iraq. 2018;23(3):87-96. <https://doi.org/10.25130/tjps.v23i3.504>
11. Koshnaw RI, Stockli DF, Horton BK, Teixell A, Barber DE, Kendall JJT. Late Miocene deformation kinematics along the NW Zagros fold-thrust belt, Kurdistan region of Iraq: Constraints from apatite (U-Th)/He thermochronometry and balanced cross sections. 2020;39(12):e2019TC005865. <https://doi.org/10.1029/2019TC005865>
12. Bull WB. Tectonic geomorphology of mountains: a new approach to paleoseismology: John Wiley & Sons; 2008.
13. Burbank DW, Anderson RS. Tectonic geomorphology. EEGS 1720 South Bellaire, Suite 110, Denver, CO 80222-4303, USA; 2013.
14. Ward AH, Fahmi TM, Khalaf HSJTJoPS. Variation of the Anticlines Vergency in the Iraqi Zagros Folds Belt and Its Tectonic Indications. 2020;25(2):64-70. <https://doi.org/10.25130/tjps.v25i2.237>
15. Hussien SA, Al-Kubaisi MS, Hamasur GAJJoS. Impact of Geological Structures on Rock

- Slope Stability in The NW Nose (Plunge) of Surdash Anticline, Sulaimaniya/NE Iraq. 2020:550-66. <https://doi.org/10.24996/tjs.2020.61.3.11>
16. Al-Kubaisi MS, Barno JMJAJoG. Fold geometry and kinematics of inversion tectonics for Kosrat anticline, northeastern Iraq. 2015;8:9469-80. <https://doi.org/10.1007/s12517-015-1864-x>.
17. Al-khatony S, Al-Azzawi N, Lawa FJINJoES. Structural and tectonic study of Qara Sard anticline and Choplagh syncline, from Sulaimaniya area, Kurdistan region, Northeastern Iraq. 2019;19(1):39.0-58.0. <https://doi.org/10.33899/earth.2019.170270>.
18. Al-Hakari SHSJZS-PA. Paleostress analysis from brittle failure and minor structures in Dokan Area, Kurdistan Region, NE of Iraq. 2016;1(8):283-310. <https://doi.org/10.17656/jzs.10522>
19. Sissakian VK, Al-Musawi HA, Al-Ansari N, Knutsson SJJoES, Engineering G. The origin and genesis of the Dokan conglomerate, NE Iraq. 2016;6(3):1-15.
20. Radaideh OM, Mosar JJT. Cenozoic Tectonic Deformation Along the Pontarlier Strike-Slip Fault Zone (Swiss and French Jura Fold-and-Thrust Belt): Insights From Paleostress and Geomorphic Analyses. 2021;40(5):e2021TC006758. <https://doi.org/10.1029/2021TC006758>