JOURNAL OF MARINE SCIENCES & ENVIRONMENTAL TECHNOLOGIES
Vol. 3, Issue No. 1 (June-2017)

ISSN: 2413-5267

Geology of Wadi Ka'am and Ka'am Dam Area, North Western of Libya

Ismail F. Shushan[1], and Mohamed Abdeljalil[2]

[1]Department of Earth & Environmental Sciences, Faculty of Science, University of El-Mergib, Khoms, Libya.
[2]Geology Department, Faculty of Science, Mansoura University, Damietta city, Egypt.
*Corresponding author: elforjismail@yahoo.com

جيولوجيا منطقة وادي كعام و سد كعام، شمال غرب ليبيا

اسماعيل الفرجاني الشوشان[1] و محمد عبدالجليل[2]

[1]قسم علوم الأرض والبيئة، كلية العلوم، جامعة المرقب، الخمس، ليبيا.
[2]قسم الجيولوجيا، كلية العلوم، جامعة المنصورة، دمياط، مصر.

Abstract

This research is an attempt to investigate the different geological features of Wadi Ka'am area located along the Mediterranean coast about 25 *km* west of Khoms city. Geomorphologic, stratigraphic, and structural investigations were carried out. The most important geomorphologic features of the study area include: the wadi Ka'am tributaries, Targhlat, and Al-chusaiha as well as other minor wadi transect of Wadi Ka'am. The wadi is characterized by steep sides due to structural effects. Wadi Ka'am is surrounded by rocky cliffs and saddle areas. The conjunction area of Wadi Ka'am tributaries forms Ka'am Lake where the Wadi Ka'am Dam was built. Terrace areas in the form of steps were formed as a result of water erosion action and may remark water level fluctuations of the lake. A number of internal lakes were formed in low laying areas due to confinement of water in the direction of discharge areas of the wadi. Sand bars (spites) were formed parallel to Wadi stream as a result of decreasing flow of water and hence deposition. Mud cracks were formed in places where muddy areas of the wadi become dried. The highly curved stream meanders of Wadi Al-Chusaiha may indicate the maturity stage of the wadi. Field observations conclude that the stratigraphic succession of the area is represented by the Triassic rocks (Abu Shaybah Formation) made up of continental horizontal-bedded sandstone intercalated with siltstone and mudstone. This is followed by Cretaceous rocks which are separated by an unconformity from the underlying Abu Shaybah sandstone. Cretaceous rocks may distinguished into two formations: the lower is Sidi As Said Formation which is distinguished into Ain Tobi Member at the base (Dolomitic Limestone) and Yefren Marl Member on the top (Marl with claystone and gypsum crystals as well as Oyster bearing horizons), and the upper Formation is Nalut Formation (Dolomitic Limestone to Dolomite with chert layers and nodules). The two Cretaceous Formations were separated by a distinct para-conformity. Structural investigation were focused on measurements of joint and fault directions in the entire area of study and may conclude that the western stratigraphic succession of Wadi Ka'am is represented by Sidi As Said Formation (Yefren Marl Member) followed up by the dolomitic Limestone of Nalut Formation, while the eastern stratigraphic succession is represented by the Triassic Abu Shaybah continental sandstones at the base followed up by the lower part of Cretaceous rocks of Ain Tobi Dolomite. This distribution may indicate the presence of a N58E- S58W directed fault (fault is thrown to NW). The prevailing direction of faults affecting the western Wadi Ka'am area is generally parallel to the prevailing extend of joints (N32W-S32E). In general, the study area is affected by two prevailing fault directions, the first which is the older and extended (N32W-S32E) where the fault is thrown toward NE and appear in the form of step fault. The second is relatively younger and represents the Wadi Ka'am

ISSN: 2413-5267

stream is directed (N58E-S58W) where the fault is thrown toward NE. As a result of structural effects, the flow direction of Wadi Ka'am is N58E.

***Keywords**: Wadi Ka'am, Wadi Ka'am Dam, Khoms, NW Libya.*

الملخص

تم في هذه الدراسة التحقيق من السمات الجيولوجية المختلفة لمنطقة وادي كعام الواقعة على طول ساحل البحر الأبيض المتوسط على بعد حوالي 25 كم غرب مدينة الخمس. وأجريت الدراسات الجيومورفولوجية، الطبقية، والهيكلية. ومن أهم ملامح الجيومورفولوجيا في منطقة الدراسة: روافد وادي كعام، وترغلات، والشيحة، فضلا عن غيرها من الوديان الصغيرة الأخرى في وادي كعام. يتميز الوادي بجوانب شديدة الانحدار بسبب الآثار الهيكلية. ويحيط بوادي كعام المنحدرات الصخرية والمناطق السرجية. وتشكل المنطقة المشتركة لروافد وادي كعام بحيرة كعام حيث تم بناء سد وادي كعام. تم تشكيل مناطق مصطبة في شكل خطوات نتيجة لتحات المياه حيث يلاحظ تقلب مستوى المياه في البحيرة. كما تم تشكل عدد من البحيرات الداخلية في المناطق المنخفضة بسبب حصر المياه في اتجاه مناطق التفريغ في الوادي. كما تشكلت أعمدة رملية موازية لتيار الوادي نتيجة لانخفاض تدفق المياه وبالتالي حدوث الترسيب، بالإضافة لتشكل شقوق الطين في أماكن المناطق الموحلة والتي جفت في الوادي. وتشير مسارات الدفق المنحنية لوادي الشيحة إلى مرحلة تكون الوادي. أشارت النتائج الميدانية إلى أن التعاقب الطبقي للمنطقة تمثلها الصخور الترياسية (تكوين أبوشيبة) المكونة من الحجر الرملي القاري الأفقي المسطح مع الأحجار الكلسية والأحجار الطينية يلي ذلك صخور العصر الطباشيري التي يفصلها الحجر الرملي لأبوشيبة الكامن بشكل غير متوافق. الصخور الطباشيرية تميزت في تشكيلين: السفلي تكوين سيدي الصيد، والتي يتميز في عضو عين توبي كأساس (الحجر الجيري الدولوميتي) وعضو مارل يفرن بالأعلى (مارل مع بلورات الحجر الجيري والجبس فضلا عن المحار بهيئة افقية)، والتشكيل العلوي هو تكوين نالوت (الحجر الجيري الدولوميتي إلى الدولوميت بشكل طبقات وعقيدات). التكوينات الطباشيرية منفصلة بشكل بارز وشبه متطابقة. وقد ركز التحقيق الهيكلي على قياس اتجاهات الاتصال والتصدع في منطقة الدراسة بأكملها، ويمكن أن نستنتج أن التعاقب الطبقي غربي وادي كعام يمثلها تكوين سيدي الصيد (عضو مارل يفرن)، يليها الحجر الجيري الدولوميتي لتكوين نالوت، في حين أن التعاقب الطبقي شرقي الوادي يمثلها الحجر الرملي القاري الترياسي لأبو شيبة في القاعدة يليها نحو الأعلى بالجزء السفلي صخور العصر الطباشيري دولومبت عين توبي. قد يشير هذا التوزيع إلى وجود تصدع باتجاهN58E-S58W (التصدع باتجاه الشمال الغربي). إن التوجه السائد للتصدعات التي تؤثر في منطقة غرب وادي كعام تتوافق بشكل عام مع امتداد المفاصل السائد (N32W-S32E). وبشكل عام، تتأثر منطقة الدراسة باثنين من اتجاهات الصدع السائدة، الأولى وهي الاقدم وممتدة (N32W-S32E) حيث تمدد نحو الشمال الغربي وتظهر في شكل صدع خطوة. والثاني أصغر سنا نسبيا ويتمثل باتجاه تيار وادي كعام (N58E-S58W) حيث يتجه باتجاه السمال الشرقي. ونتيجة للآثار الهيكلية، فإن اتجاه تدفق وادي كعام هو N58E.

الكلمات الدالة: وادي كعام، سد وادي كعام، الخمس، شمال غرب ليبيا.

1. Introduction

Ka'am dam (also is called Khaam Dam) was constructed in January 1974 within Ka'am Region (the so called Cinyps in Greek), which is located about 25 *km* west of distant from Khoms City to the east (Figure 1). The conjunction of Wadi Al-Cusaiha and Wadi Targhlat forms Wadi Ka'am and Ka'am Lake in front of Ka'am Dam (Figure 2). Wadi Ka'am Dam is made of soil established on the gravely and sandy strata of the wadi (NWC, 2007).

The present study aims to investigate the different geomorphologic, stratigraphic and structural features of Wadi Ka'am area.

ISSN: 2413-5267

Figure 1. Location of the study area, (Google map, 2017).

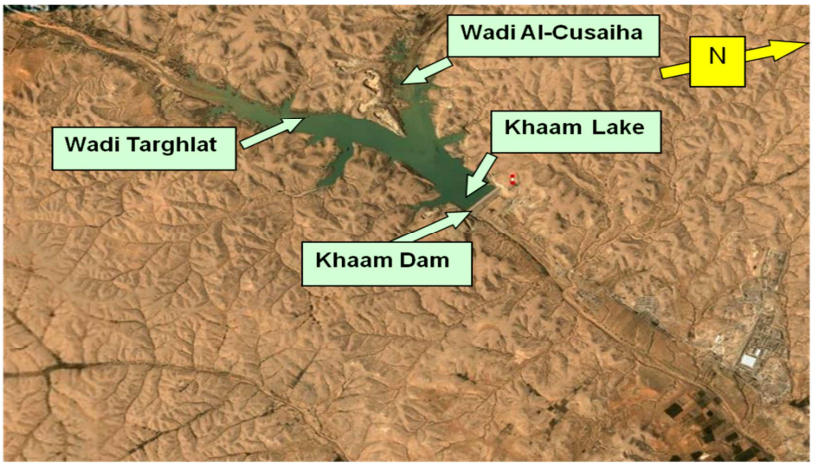

Figure 2. Satellite image showing Ka'am Lake in front of Ka'am Dam, (Google map, 2017).

2. Methodology

The present study is based on field observations and measurements as well as documentation of the different geological features in the area. Satellites images were used to detect types of drainage basins in Wadi Ka'am and Ka'am Dam area. Correlation between rock succession outcrops is necessary to set up the structural relationships of the rock units and hence the entire of the study area.

3. Results and Discussion

3.1. Geomorphology

Based on field observations, Wadi Ka'am area is characterized by the following geomorphologic features:

ISSN: 2413-5267

3.1.1. Wadi Ka'am Tributaries

This include Wadi Al-Cusaiha and Wadi Targhlat and other minor tributaries. Field observations show that, Wadi Al-Cusaiha and Wadi Targhlat transport water as well as sediments to Wadi Kaa'm stream with other minor wadi tributaries (Figure 3). The wadi tributaries appear with very steep sides due to structural effects within the region. Wadi Ka'am is surrounded by rocky cliffs and hilly areas (Figure 4), where it erodes its stream as a result of the hydraulic action of water. The highly curved meanders of wadi stream may indicate the mature stage of the wadi (Figure 5).

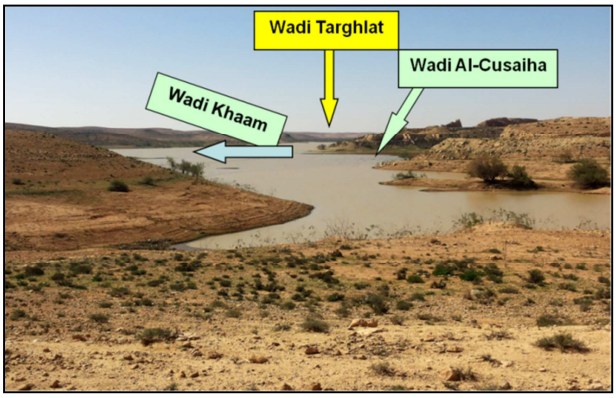

Figure 3. The conjunction of Wadi Al-Cusaiha and Wadi Targhlat with Wadi Ka'am.

Figure 4. The hilly areas surrounding the Wadi.

Figure 5. The highly curved meanders of wadi stream.

ISSN: 2413-5267

3.1.2. The Artificial Ka'am Lake

It is located in the front of Ka'am Dam and where water is accumulated in conjunction area of the wadi Al-Cusaiha, wadi Targhlat and wadi Ka'am (Figure 6).

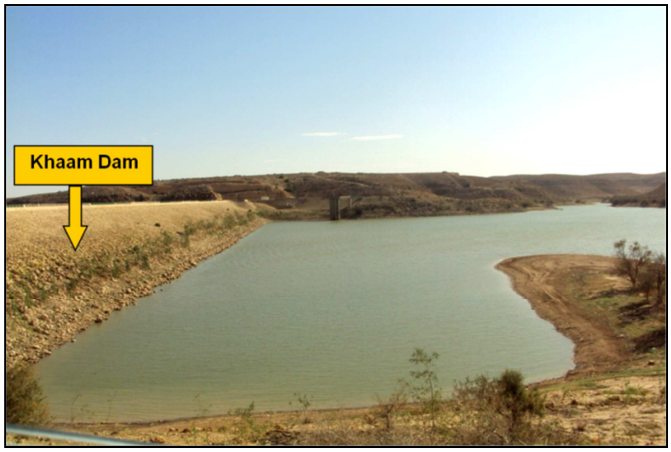

Figure 6. Showing the Formation of Ka'am Lake in front of Ka'am Dam.

3.1.3. Terrace

Extended along the sides of Ka'am lake as a result of fluctuations of water level, the terrace appear in the form of steps which indicate the different water levels that the lake reached (Howard *et al.*, 1968). Figure (7) represents a step terrace along the sides of the Ka'am lake.

Figure 7. Formation of step terrace along the sides of the lake due to fluctuations of water level in the lake.

3.1.4. Internal Lakes or Ponds

It is formed as a result of water entrapment in low laying areas as water moves towards the Ka'am Dam (Figure 8); most likely called ponds for their smaller sizes than lakes (Mitsch and Gosselink, 2007). Mud Cracks formed due to dryness of muddy areas (Figure 9).

ISSN: 2413-5267

Figure 8. Formation of small bodies of water (ponds) in the low-lying areas in wadi Ka'am.

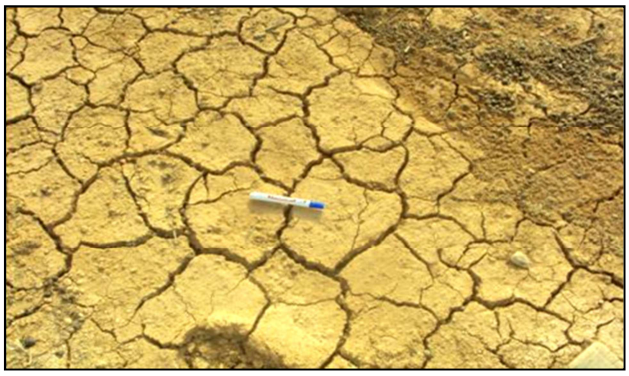

Figure 9. Mud Cracks Formed due to dryness of muddy areas.

3.1.5. Sandbars and Spits

This is may form when the flow of water in wadi stream becomes reduced, deposition takes place and spits or bars may form parallel to wadi stream. However, Bars are typically found in the slowest moving, shallowest parts of rivers and streams (Strahler, and Strahler, 1996). Figure (10) represents an accumulation of sediments in the form of sand bar at the discharge area.

Figure 10. Accumulation of sediments in the form of sandbar at the discharge area of the wadi stream.

ISSN: 2413-5267

3.1.6. Types of Drainage Basins

Satellites images were detected to represent the types of drainage basins of Wadi Ka'am area. The drainage basins are represented mainly by dendritic (Figure 11a), trellised, and rectangular patterns as shown in Figure (11).

Dendritic drainage patterns develop where the river channel follows the slope of the terrain. They form in V-shaped valleys and as a result, the rock types must be impervious and non-porous (Lambert, 1998; and Pidwirny, 2006). Trellis drainage is characteristic of folded mountains while rectangular drainage develops on rocks that are of approximately uniform resistance to erosion, but which have two directions of joining at approximately right angles (Ritter, 2006).

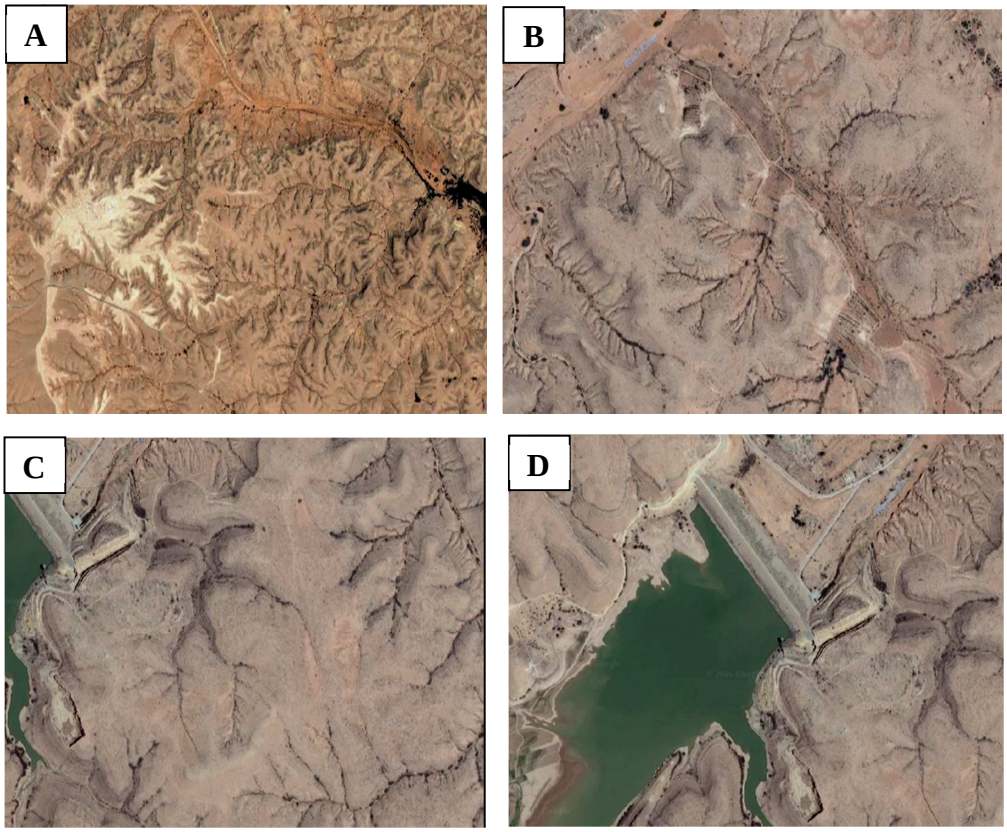

Figure 11. Types of drainage basins in Wadi Ka'am and Ka'am Dam area detected from satellite images. (a): Dendritic, (b, c, d): Trellised and Rectangular.

3.2. Stratigraphy of Study Area

The stratigraphic succession of the of study area (Table 1) has been presented by Mann (1975) as follows:

3.2.1. Triassic Rocks

It represented by Abu Shaybah Formation, made up of continental fine-grained, white to pale-cream, medium to thick, flat-bedded sandstone inter-bedded with thin to medium bedding

ISSN: 2413-5267

silty-mudstones. Sandstones found with coarse quartz grains (coarser than sand grains) are characteristic for Abu Shaybah Formation (Figure 12).

Table 1. The stratigraphic succession of Khoms and adjacent areas (Mann, 1975)

Description	Thickness meters	Member	Formation	Age
Gravels and boulders	-		Recent Valley Deposits	Quaternary
Coastal- calcareous sandstones	10-20		Eolian Deposits	
Eolian materials intercalated with gravels and silica grains as will as rare calcarous shells.	10		Eolian- Marine Deposits	
Clay, sandy limestone associated with salts and gypsum crystals	1-3		Sabkha Deposits	
Calcarenite with sporadic siltstone lenses	30-40		Qarqaresh	
Siltstone, conglomeratic sandstone with calcareous and gypsiferous shells	15		Jefara	
Consolidated & looes gravel, inter-calations of calcareous shells.	25		Qasar Al-Haj	
Clay, sandy-calcarenite, conglomer-ate, marly-limestone, limestone	100		Alkhoms	Mio-cene
Dolomitic limestone to dolomite with chert nodules	200		Nalut	Late-Cret-ceous
Marl. Claystone + gypsum crystals	380	Yefern Marl	Sidi Assed	
Dolomitic limestone to dolomite + quartz annd quartzite interbbeds	30-45	Ain Tobi		
Sandstone & mudstone, inter-bedded with calcareous beds and conglomerate	160-150		Abu Shybah	Tria -ssic

ISSN: 2413-5267

Figure 12. Abu Shaybah Sandstone (Triassic), *Note the flat bedding*.

3.2.2. Cretaceous Rocks

It is located above the Triassic Abu Shaybah Sandstone and separated by unconformity. Cretaceous is represented by Sidi As Said Formation (lower) and Nalut Formation (upper). In general, Sidi As Said Formation is divided into two members: the lower is Ain Tobi Member and the upper is Yefren Member. Ain Tobi Member is generally dolomitic limestone to dolomite while Yefren Member is made up of Marl and limestone inter-beddings with Oyster fossils in some places as represented in Figures (13, 14, and 15). Nalut Formation is the upper part of Cretaceous and is separated by the lower Sidi As Said Formation by a distinct unconformity and is represented by dolomitic limestone to dolomite with chert nodules. Generally, Nalut Formation lakes the presence of god preserved fossils (Figure 14).

Figure 13. The dolomitic-limestone to dolomite of Ain Tobi Member (the lower part of Sidi As Said Formation)

ISSN: 2413-5267

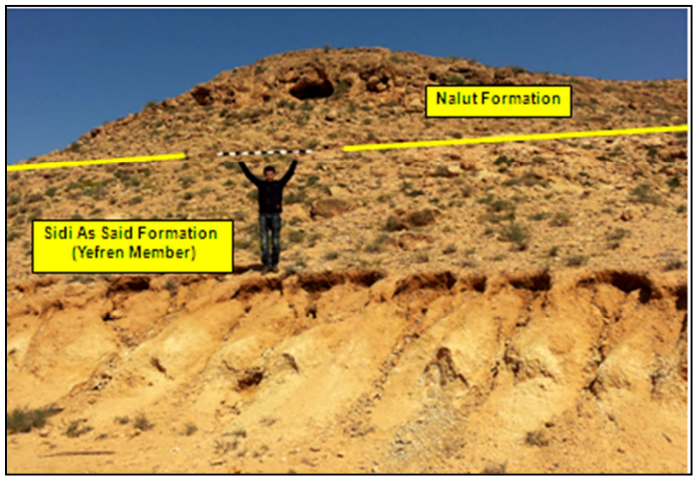

Figure 14. The upper part of Sidi As Said Formation Followed by Nalut Formation, *Note the contact*.

Figure 15. The Oyster fossils-bearing horizon of Yefren Member.

3.3. The Structural Features

A geological survey in the area of study is needed in order to understand the overall image of different structural features which included field measurements of joint and fault directions as well as the recognition of relative movement and correlation of rock successions along Wadi Ka'am sides (eastern & western parts) (Figure 16).

ISSN: 2413-5267

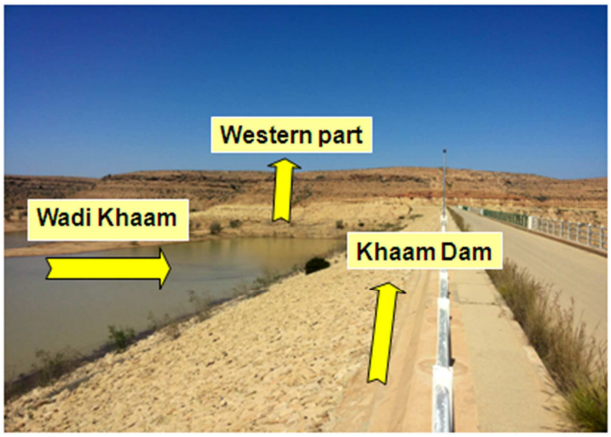

Figure 16. Wadi Ka'am Area.

Actually, a fracture is any separation in a geologic formation, such as a joint or a fault that divides the rock into two or more pieces. A fracture will sometimes form a deep fissure or crevice in the rock. Fractures are commonly caused by stress exceeding the rock strength, causing the rock to lose cohesion along its weakest plane (Park, 2005). Correlation of rock successions on both sides of Wadi Ka'am concluded that the western Wadi Ka'am rock succession is represented by Sidi As Said Formation (Yefern Marl Member) followed-up by the dolomitic limestone of Nalut Formation, while the eastern part of the wadi is represented by sandstones of Abu Shaybah Formation at the base followed-up by dolomites of Ain Tobi Member (the upper part of Sidi As Said Formation) as shown in Figures (17 and 18). The mentioned distribution of rock successions may indicate the presence of a S58W-N58E directed fault in the area with fault thrown to NW direction (Figure 19).

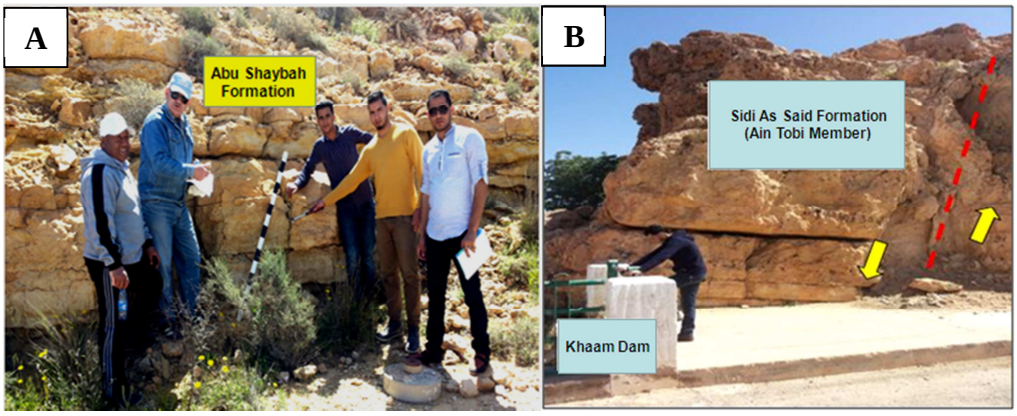

Figure 17. The eastern rock succession of Wadi Ka'am.
A) Abu Shybah Sandstone at the base, and
B) Ain Tobi Member (Sidi As Said Formation) on top.

Joint and fracture directions in western Wadi Ka'am area were measured and represented in Figure (20). A joint may have been created by either strict movement of a rock

ISSN: 2413-5267

layer or body perpendicular to the fracture or by varying degrees of lateral displacement parallel to the surface (plane) of the fracture that remains "invisible" at the scale of observation (Mandl, 2005; and Davis *et al.*, 2012). The major trend of these fractures and joints is NW-SE. Field observations conclude that the presence of these joints and fractures within the area of study produced a number of minor wadi streams that supply water to Wadi Ka'am and may extend in the direction of the major trend of joint and fracture direction and exactly (N32E-S32W).

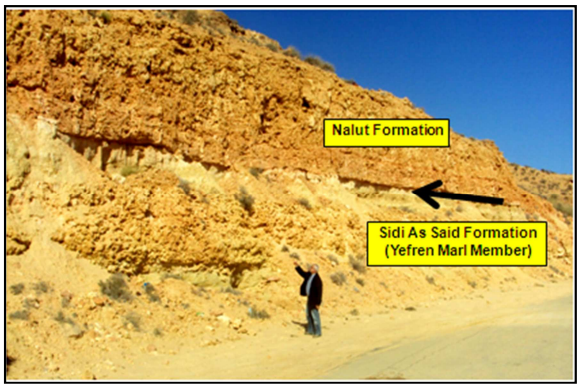

Figure 18. The western rock succession of Wadi Ka'am

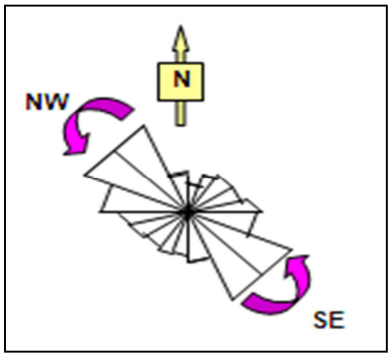

Figure 19. Representation of joint directions. Note the NW-SE major trend.

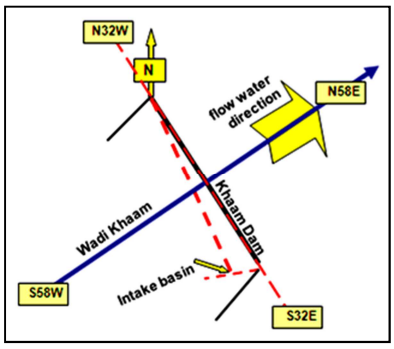

Figure 20. Wadi Ka'am field measurements representation. Note: 1) the main flow direction of Wadi Ka'am toward N58E (yellow-colored arrow) parallel to the fault direction S58W-N58E, 2) the construction of Ka'am Dam perpendicular to Wadi Ka'am stream, and 3) the extension of minor wadi streams in the direction N32W-S32E.

ISSN: 2413-5267

Generally, the structural investigations within the area of study confirms the presence of two main fault directions, the first which is older and is in the form of steps (step fault) with N32W-S32E direction and fault thrown to NE. The second which is relatively younger representing Wadi Ka'am stream with N58E-S58W direction and fault thrown to NW as shown in Figures (20-23).

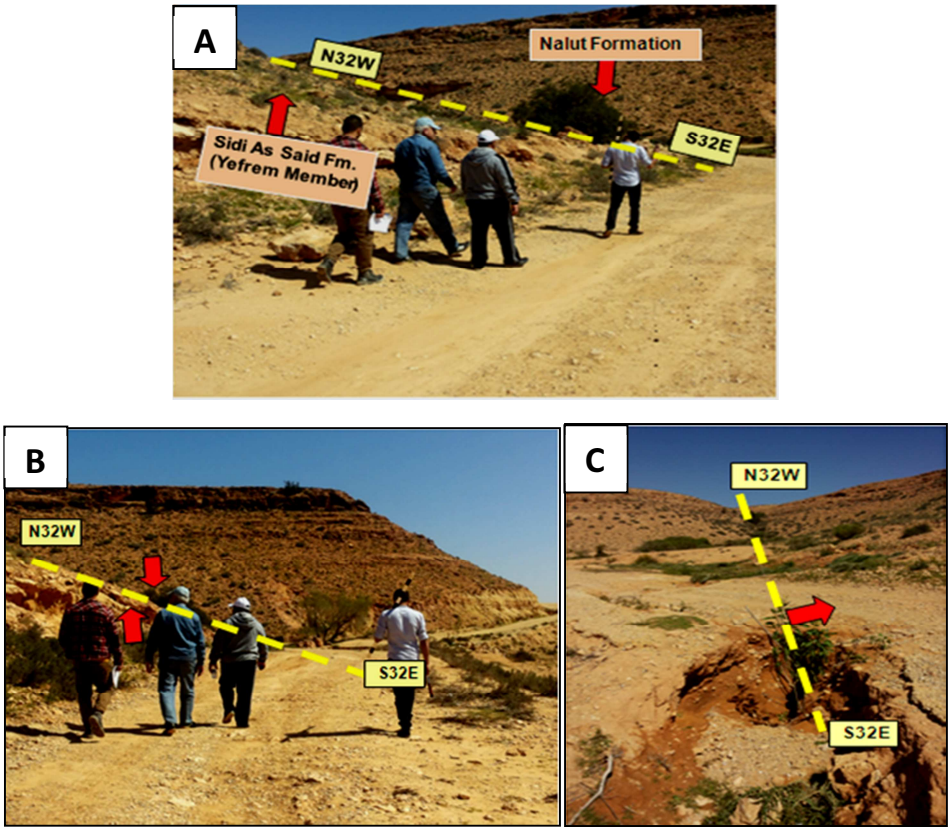

Figure 21. Faults exist in the western Wadi Ka'am that cuts the western rock -succession.
A) The downward movement of Nalut Formation, relative to Sidi As Said Formation
B, C) The downward movement of Nalut Formation, relative to Sidi As Said Formation.

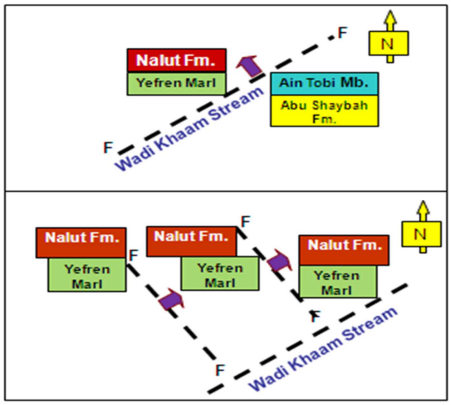

Figure 22. Block-diagram showing the different faults appeared in Wadi Ka'am area. Note the presence of two fault directions.

ISSN: 2413-5267

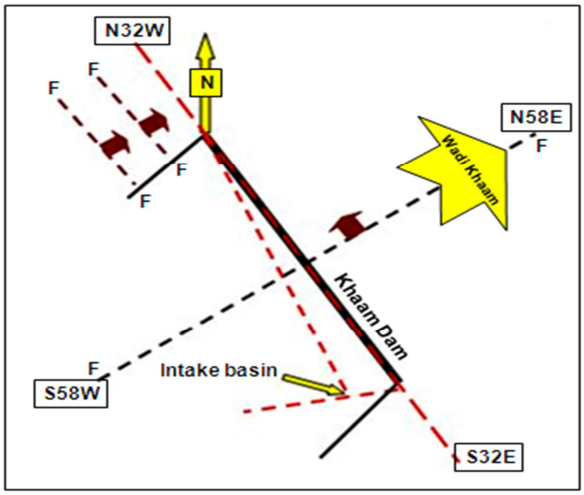

Figure 23. Presentation of faults in Wadi Ka'am area. Two fault directions existed, one in the form of steps (step fault) that thrown to NE, and the other takes N58E direction through which the Wadi Ka'am flows.

4. Conclusion

The geomorphologic features of the study area are represented mainly by Wadi Ka'am, Wadi Targhlat and Wadi Al-chusaiha and other minor wadi distributers. The highly steep sides of wadi streams may indicate the effect of such structural events that took place within the study area. Cliffs, saddles and terraces surround Wadi Ka'am stream may denote the erosion action events by water that flow in the wadi. Deposition of spits or bars parallel to wadi stream could take place when the flows of water in wadi stream become reduced. Small bodies of water could form in low-laying basin area of the wadi stream most likely in the form of small ponds. Dendritic, trellised and rectangular systems are the most important drainage patterns that characterize the Wadi Ka'am area which also reflex the nature of the rocks existed within the drainage basin of the wadi.

Based on the stratigraphic scheme of Khoms area made by Mann (1975), the following rock succession is recognized: Triassic rocks: represented by Abu Shaybah Formation which mainly made-up of sandstone-claystone with calcareous beds and conglomerate. This is followed by Cretaceous rocks and is separated from Triassic by an unconformity. Cretaceous is distinguished into Sidi As Said Formation (divided to Ain Tibi Member -Limestone mostly dolomitic at the base and Yefrin Member -Marl with Limestone on the top) and Nalut Formation which is the upper and consisting of dolomitic limestone with chert nodules. Oyster bearing horizon is observed to separate Sidi As Said Formation from Nalut Formation.

Joint and fracture directions measurements done in western Wadi Ka'am area showed their major trend to be directed into NW-SE. Field observations show that, the presence of these joints and fractures within the area of study produced a number of minor wadi streams

ISSN: 2413-5267

(distributaries) that supply water to Wadi Ka'am and may extend precisely towards N32E-S32W. Generally, structural investigations within the area of study confirms the presence of two main fault directions, the first which is older and is in the form of steps (step fault) with N32W-S32E direction and has fault thrown to NE. The second which is relatively younger representing Wadi Ka'am stream with N58E-S58W direction and fault thrown to NW.

References

Davis G.H., Reynolds S.J., and Kluth C. (2012). *Structural Geology of Rocks and Regions*, 3rd ed., John Wiley and Sons, Inc., New york, USA.

Google Map (2017). https://maps.google.com/.

Howard A.D., Fairbridge R.W., and Quinn J.H. (1968). *Terraces, fluvial—Introduction*. Ed. R.W. Fairbridge, The Encyclopedia of Geomorphology: Encyclopedia of Earth Science Series, vol. 3. Reinhold. Book Corporation. New York, USA.

Lambert D. (1998). *The Field Guide to Geology*. Checkmark Books, USA.

Mandl G. (2005). *Rock Joints: The Mechanical Genesis*. Springer-Verlag, Heidelberg, Germany.

Mann K. (1975). *Geological Map of Libya: Sheet Alkhums*, Nr. 133-14 Explanatory Booklet, Ind. Res. Cent., Tripoli, Libya.

National Water Cooperation (NWC) (2007). Annual Report.

Ritter ME. (2006). T*he Physical Environment: An Introduction to Physical Geography*. Available Online at: [http://www.earthonlinemedia.com/ebooks/tpe_3e/title_page.html].

Park R.G. (2005). *Foundation of Structural Geology*. (Reprint of the 1997 Chapman and Hall edition) Rutledge, Abingdon, England.

Pidwirny M. (2006). *The Drainage Basin Concept, Fundamentals of Physical Geography*, 2nd ed., Available Online at: [http://www.physicalgeography.net/fundamentals/contents.html].

Strahler A., and Strahler A. (1996). *Introducing Physical Geography*. John Wiley & Sons Inc., USA.

Mitsch and Gosselink (2007). *Wetlands*. John Wiley & Sons, USA.