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

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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
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.
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:
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 Ka'am 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.](image)

![Figure 4. The hilly areas surrounding the Wadi.](image)

![Figure 5. The highly curved meanders of wadi stream.](image)
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.](image)

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.](image)

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).
3.1.5. Sandbars and Spits

This 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 sandbar at the discharge area.

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.

Figure 10. Accumulation of sediments in the form of sandbar at the discharge area of the wadi stream.
3.1.6. Types of Drainage Basins

Satellite 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.](image)

3.2. Stratigraphy of Study Area

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

3.2.1. Triassic Rocks

It is 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
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)

<table>
<thead>
<tr>
<th>Description</th>
<th>Thickness meters</th>
<th>Member</th>
<th>Formation</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravels and boulders</td>
<td>-</td>
<td></td>
<td>Recent Valley Deposits</td>
<td>Quaternary</td>
</tr>
<tr>
<td>Coastal- calcareous sandstones</td>
<td>10-20</td>
<td></td>
<td>Eolian Deposits</td>
<td></td>
</tr>
<tr>
<td>Eolian materials intercalated with gravels and silica grains as well as rare calcareous shells.</td>
<td>10</td>
<td></td>
<td>Eolian-Marine Deposits</td>
<td></td>
</tr>
<tr>
<td>Clay, sandy limestone associated with salts and gypsum crystals</td>
<td>1-3</td>
<td></td>
<td>Sabkha Deposits</td>
<td></td>
</tr>
<tr>
<td>Calcarenite with sporadic siltstone lenses</td>
<td>30-40</td>
<td></td>
<td>Qarqaresh</td>
<td></td>
</tr>
<tr>
<td>Silstone, conglomeratic sandstone with calcareous and gypsiferous shells</td>
<td>15</td>
<td></td>
<td>Jefara</td>
<td></td>
</tr>
<tr>
<td>Consolidated &amp; looses gravel, intercalations of calcareous shells.</td>
<td>25</td>
<td></td>
<td>Qasar Al-Haj</td>
<td></td>
</tr>
<tr>
<td>Clay, sandy-calcarenite, conglomerate, marly-limestone, limestone</td>
<td>100</td>
<td></td>
<td>Alkhoms</td>
<td>Miocene</td>
</tr>
<tr>
<td>Dolomitic limestone to dolomite with chert nodules</td>
<td>200</td>
<td></td>
<td>Nalut</td>
<td>Late-Cretaceous</td>
</tr>
<tr>
<td>Marl. Claystone + gypsum crystals</td>
<td>380</td>
<td>Yefern Marl</td>
<td>Sidi Assed</td>
<td></td>
</tr>
<tr>
<td>Dolomitic limestone to dolomite + quartz and quartzite interbeds</td>
<td>30-45</td>
<td>Ain Tobi</td>
<td>Abu Shybah</td>
<td>Trias ssc</td>
</tr>
<tr>
<td>Sandstone &amp; mudstone, inter-bedded with calcareous beds and conglomerate</td>
<td>160-150</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 lacks the presence of good preserved fossils (Figure 14).

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

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

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
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.
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.
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 Targhat and Wadi Al-chusaiha and other minor wadi distributors. 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.
(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


