Role of Recent Tectonics in The Activity of Wadi Shueib Landslides, NW Jordan.

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Abstract

Landslides at large scales considered as high-risk natural disasters. In West Jordan, especially, the areas near the Dead Sea Transform Fault (DSTF) are mountainous terrains and the slopes of theses steep terrain being generally unstable due to the daily seismic activity generated by the DSTF. The case of Wadi Shueib structure is that it is a several tens of kilometers long of a recently reactivated structures. The reactivation of these structures is linked to the activity of the DSTF as stress inversion from compressive to transtension-transpression along old and new fault segments. In the study area, the NE-SW tensional faults are dominant and therefore, trigger mass-wasting at different scales and styles. The history of the landslides in Wadi Shueib is inherited in the hill-size slided strata along clear sliding surfaces. In the Wadi Shueib, there are at least four large landslides and none of them is provoked by human activities. Timing and mechanism of each one of these landslides is different. In this work, we put the light on these landslides as part of the preliminary data collected from the field.

Key words: Landslides, Active tectonics, Dead Sea Transform Fault, Jordan.

Introduction

Landslides are sever catastrophes and important hazard that often linked to volcanic and earthquake hazards (*Chang et al. 2018*). The latter risk is immediate consequence of tectonic activity and they can be inferred in recent deformations. The majority of landslides associated to tectonics processes are accompanied to seismic shaking and, generally, they might occur in several mechanisms. The landslides in mountainous terrains can be inferred by geomorphic disordering the might be perturbed by surficial processes (*Chang et al. 2018*). These surficial processes are characterized in arid and semi-arid zones by weathering and in this case studying the landslides using photo-geology is viable where vegetation cover is scar.

In Jordan, the western part of the Jordanian platue is evolving in context to the activity of the Dead Sea Transform Fault (DSTF). This recent tectonics is dominated by the stress regime of the DSTF and reflected in the reactivation of old structures like the Amman Hallabat and Shueib Structures to the west of Amman (*Diabat 2009, Alawabdeh et al., 2016*).

This study present the first preliminary finding in the study area and focus on the natural and engineering slope stability. In this study we present field observation and topographic models of

four landslides in the area of Wadi Shueib. We put the light on the activity of these landslides and their possible human-life risk.

Geologic and tectonic setting

The geologic units outcropped in the study area belong to the Early and Late Cretaceous. Most of these units are Sands and Calcareous interlayered with sandy and marl units. The Early Cretaceous unit overlay the Triassic rocks in the study area forming different types of unconformities. The majority of these unconformities are angular and nonconformities. The Early Cretaceous formations are also known as Kurnub and it is entirely braded-rivers sand deposits (*Sahawneh and Attallah, 2002*). The Kurnub group in the study area is about 50 meters. The middle Cretaceous is formed by massive dolomitic limestone and is rarely outcropped in and around the study area. However, the Middle-Late Cretaceous formations are dominant. The typical formation in the study area is known as Shueib formation of Marly Limestone and it is interbeded with lower Marl Formation of Fuhais and the upper formation of Hummar Limestone. The three formations outside the study area are difficult to separated and usually symbolized by FHS. The marl in these formations contain semectites and illites in most of the layers. The top most strata in the stratigraphic sequence in the study area consist of the massive Limestone.

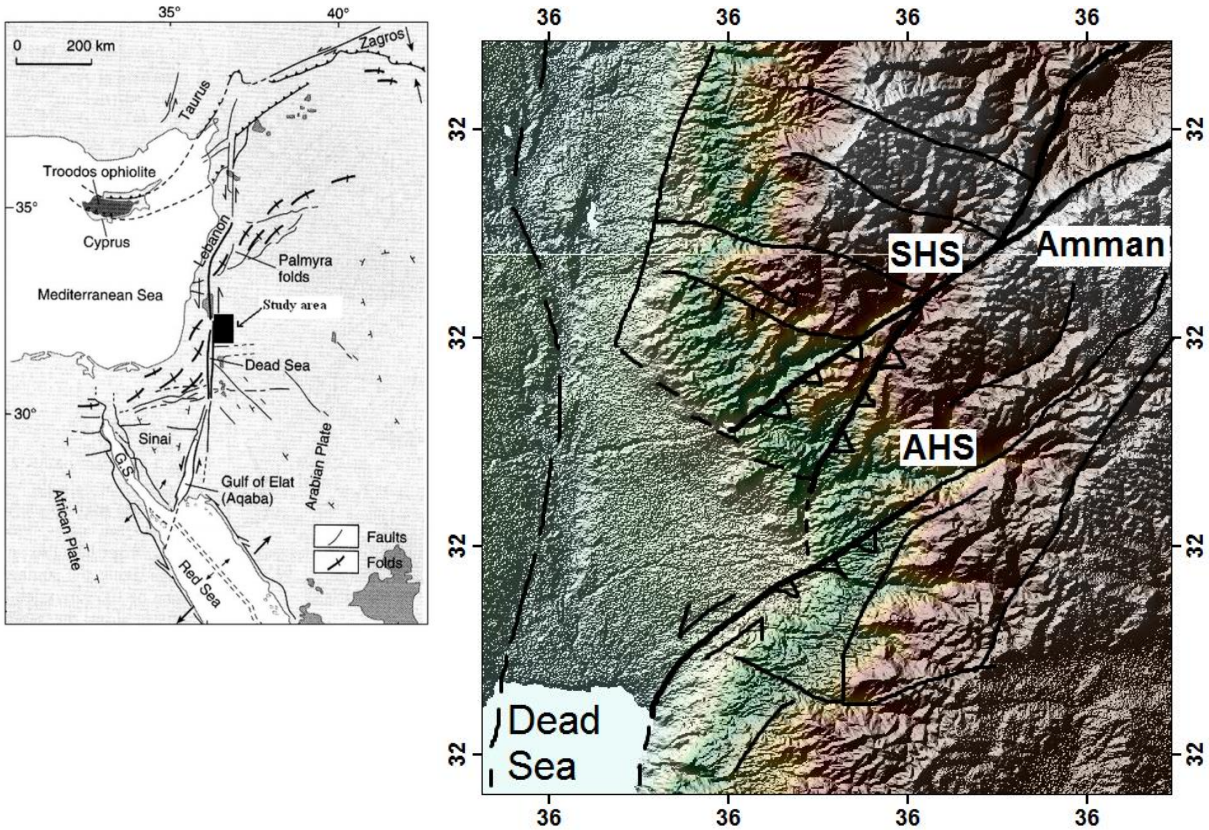

Figure 1: A) Location map of the study area after Diabat 2009. B) Structural map over hillshaded relief map generated from 20 m Digital Elevation Model.

The Tectonic setting of the study area experienced different phases of deformation (A*lAwabdeh et al., 2016*). Two phases of tectonic inversion have been identified and aged to occur through, The Late Cretaceous and the Oligocene (*Abed, 2000*).The main structure is the Shueib Structure (SHS). The SHS outcrops for about 80 km from the Southern Jordan Valley (near to the Kafrain village 40 km to the west of Amman) toward Zarqa River northern Amman (Figure 1). This structure is mainly represented by NE-SW oblique reverse fault accompanied by smaller antithetic and synthetic faults and subparallel folds (anticlines and synclines). This fault-fold system has been traditionally interpreted as inactive since the late Cretaceous. However, in a recent study AlAwabdeh, et al. (2016) proposed a Neogene reactivation of local faults related to this structure. The reactivation proposed by the latter studies is linked to the activity of the Dead Sea Transform Fault and the transtension-transfer faults in NW of the current study area.

Field Data

We present the landslides in four sites within a 6 km2 and they are named L1, L2, L3 and L4 (Figure 2). Three of these sites show landslides at major scale (L1, L2 and L3) and the forth one the slide is local and small (< 50m long). The sliding surfaces of the landslides are preserved in L1, L3 and L4 were its possible to measure the slickenside of each movement.

On the other hand, the study area is located in the reactivated zone of the Shueib structure. This reactivation provokes movement along the fault planes in the area. The fault system dominant in the study area is the NW-SE and N-S normal and normal dextral. As it is a transfer fault zone, the movement of the downthrown blocks is coherent with the present-day slides.

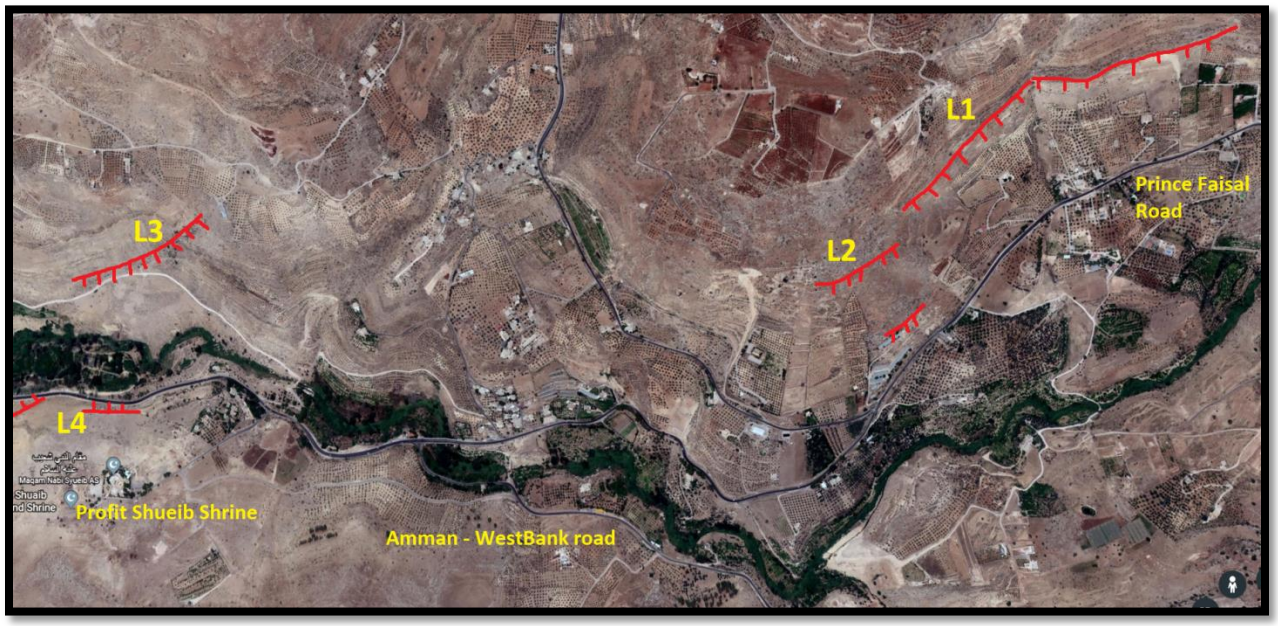

Figure (2): Aerial Photograph of the study area showing the location of the slides. (Google Earth image

Location L1

This is the biggest slide in the study area and part of the slided strata are in metastable phase. It extends for about 500 m and the scarp is very clear. The landslide occurred on a major fault plane striking N-S (Figure 3).

Location L2

This site is active and frequent to have slide. Two different phases of sliding are clear and can be identified in the topographic profiles (Figure 3). The last time of sliding of this site was on 2001. Major tensional and opened fractures can be observed in the field.

Figure (3) Field Photograph of the L1 and L2 site.

Location 3

In this site, a whole hill is downslided along fault plane. The direction of the slides is NW-SE and is concordan to the transfer zone of the SHS associated normal fault systems (Figure 4). As shown in the figure, the slides strata are rotated along the sliding surface indicating sliding over ductial surface. This surfaces belongs to the Marl layers of the Shueib formation that contains clay minerals.

Figure (4): Field photo of the site L3.

Location 4

This location lies on the Main Road connecting Amman and Salt with Jordanian-Palestinan border. From the observation and the type of slide occurring in the site, the most probable mechanism of this slide is the road cut. Some mitgational precautions are already been taken like the gabions and the metal nets (Figure 5). However, the landslides are frequent and associated with heavy rain events seasonally.

Figure (5): Field photo of the L4 Location.

Discussion and Conclusions

This study presented field observations of active landslides in Wadi Shueib, West Jordan. The landslides in location L1, L2 and, L3 are natural slides provoked by clear discontinuities. However, the slide location (L4) is active due slope instability caused by the non-engineered road cut. In the L1 and L3 no evidence of recent slides is reported. However the last activity in the slide L2 was 18 years ago by general creep of debris and no rock slide were documented.

The nature of the sliding surfaces and the orientation of these movements are concordant with the reactivated faults in the area. Taking in account the present-day active stress field and the seismogenic faults in the area, the movements along these faults enhance the chance of landslides and promote future events.

The case of L4 emphasizes the situation of the non-engineered road cut and the associated mass-movements. The actual mitigation processes the government follows do not face the demand yielded from the landslides on the main road and yearly road closes are expected.

This study is a preliminary report of the field investigation of the landslides in Wadi Shueib. The current status of the landslides in four location vary between very active to non-active slides and

more data analysis, in particular spatial and geotechnical analyses, are needed to fully evaluate the risk and mitigation plan in the study area.

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