Investigating the slip-rate of an unexplored segment of the Doruneh Fault in central Iran: the Doruneh - south Torud Playa segment

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ABSTRACT

A significant portion of the Doruneh fault length in central Iran has remained completely unknown due to its location within the aeolian and evaporitic sediments of the central Iran. The geological maps also show the fault trace in most central Iran as a dashed inferred fault line. Since the fault is among the largest strike-slip faults with a reverse component and numerous human societies have grown around it, its paleoseismologocal studies are of great importance. According to aerial photos, satellite images and geological maps of the fault in Central Iran, we first identified the strike of the fault and then extracted the fault geometry in the field by digging two trenches on the late Quaternary deposits displaced by the fault. We have also sampled different layers to estimate the fault slip rate in central Iran, which is in the process of measuring Optically Stimulated Luminescence (OSL) signals. The result of these samples will help us to identify the fault slip rate as well as the late Quaternary climate change in Central Iran.

Keywords: Doruneh fault, Slip rate, Torud, OSL

INTRODUCTION

The Doruneh Fault (DF) with a length of 600-900 km (e.g. Fattahi et al., 2007; Javadi et al., 2015) is one of the largest strike-slip faults in Iran, but in many cases, there is no comprehensive agreement between researchers on its specific features. The length and also its slip-rates are among the most important disagreements between scientific communities. While Farbod et al. (2016) considered the length of seismic segment of the fault around 400 km, Fatahi et al. (2007) and Javadi et al. (2015) have provided larger numbers of about 600 and 900 km respectively. This fault has two main strikes. Roughly W-E in northeast of Iran and NE-SW in Central Iran. Different numbers between 0.5 to 5.3 mm/yr for fault slip rate in different locations are mentioned previously by researchers (mostly in the middle segments).

The DF has three main segments. The eastern segment from Afghanistan to around South Sabzevar (NW-SE), the Middle segment from Sabzevar to Doruneh village (E-W), and the western segment from Doruneh village to around Naein in central Iran (NE-SW). Several studies have been done on the middle segment of the fault and conflicting values for the slip-rate have been obtained from different methods. While Fattahi et al. (2007) and Walker et al. (2011) reported values of about 2.5-3 mm/yr which obtained from OSL dating methods, Farbod et al. (2016) suggested that the slip-rate of the fault should be about 5.3 mm/yr. GPS monitoring also resulted in values of about 5 mm/yr for the slip-rate of the middle segment (Pezzo et al., 2012). However, Mousavi et al. (2021) used a combination of satellite images and IRSL (Infrared Stimulated Luminescence) dating and suggested that the slip-rate across the fault is around 1-3 mm/yr. There is a huge gap in the study of the western segment of the fault. Tectonic studies have been done on a part of the western segment (Pis Kuh, west Jandaq - Javadi et al., 2015), but

despite this, no accurate slip rate has been reported for the western segment.
In this article, according to the library and remote sensing studies, as well as field studies, and the digging of two trenches, we have extracted the geometry of the fault and taken OSL samples to calculate the slip rate.

METHODOLOGY AND DATA

Novel Quaternary dating methods such as OSL (e.g. Fattahi et al., 2007; Walker et al., 2011; Mousavi et al., 2021), and TCN (Farbod et al., 2016) can be used to calculate the slip-rate of the faults.

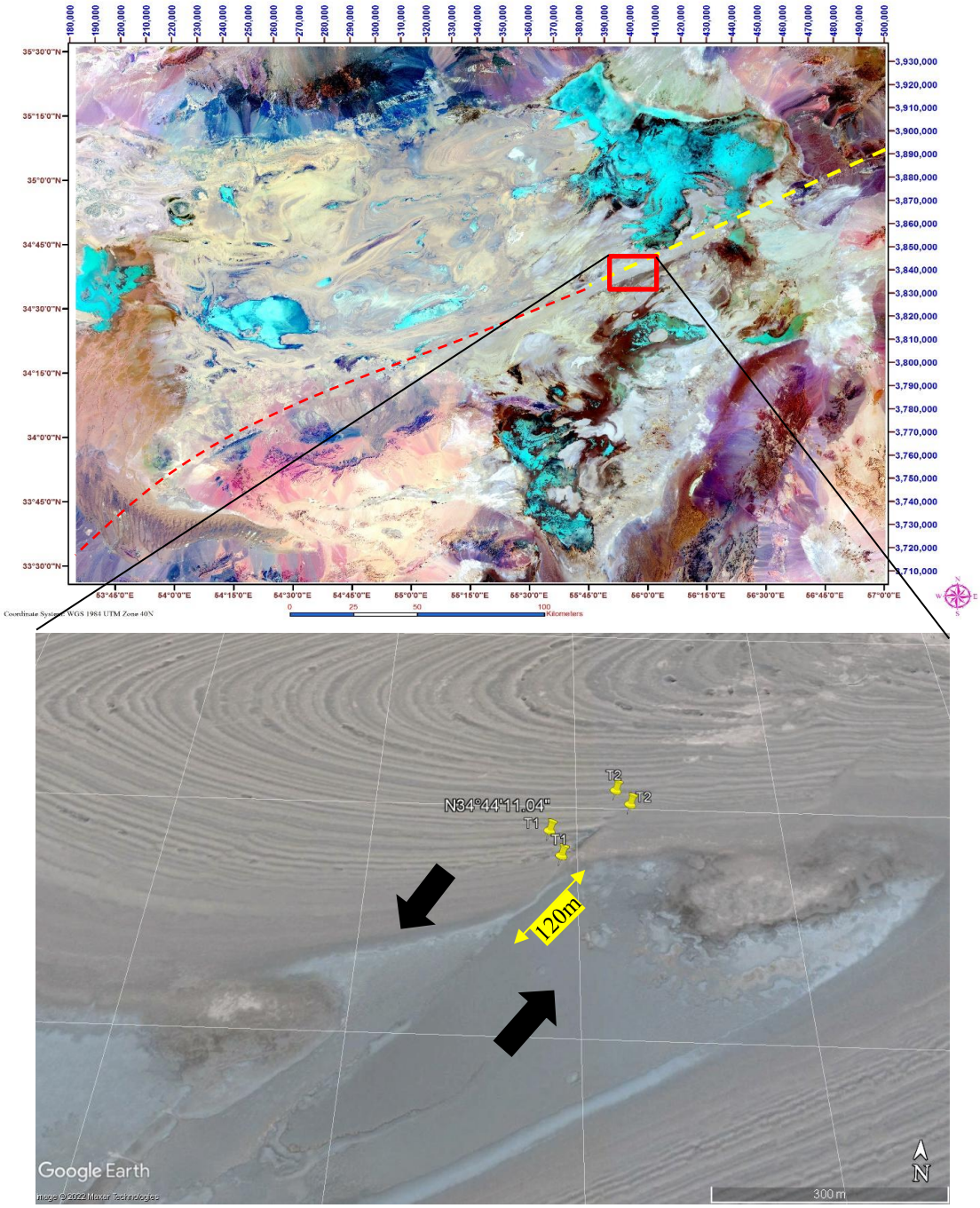

Figure 1. Map of central Iran (top) and the study area (down). The yellow dashed line represents the Doruneh-south TP segment of DF with a length of 130 km. Offset of the fault also shown. T1and T2 are trenches.

We considered the OSL dating method as a tool for dating and calculating the age of fault related sediments associated with the late Quaternary movement of Doruneh-south of TP segment of DF in central Iran. To do this, we excavated two trenches with lengths of 30 and 50 m, namely T1 and T2 respectively (Figure 1). The distance between these two trenches, which are dug perpendicularly along the fault, is 100 meters. So that if the evidence of fault in one is not complete, the other one will cover the defects. However, the T2 revealed the fault manifestations completely. While the T1 was out of reach due to the high water level and being swampy.
At the location of the trenches, the late Quaternary activities of the fault have shifted the sediments of the lake by 120 meters (left-lateral with a reverse component). Therefore, the age of the lowest point of pre-faulting lacustrine sediments (lake deposits) can provide us with a near-realistic estimate of the slip-rate of the fault in southern of TP. The slip-rate will be calculated by dividing the amount of offset by the age calculated by the OSL method (e.g. Fattahi et al., 2007).

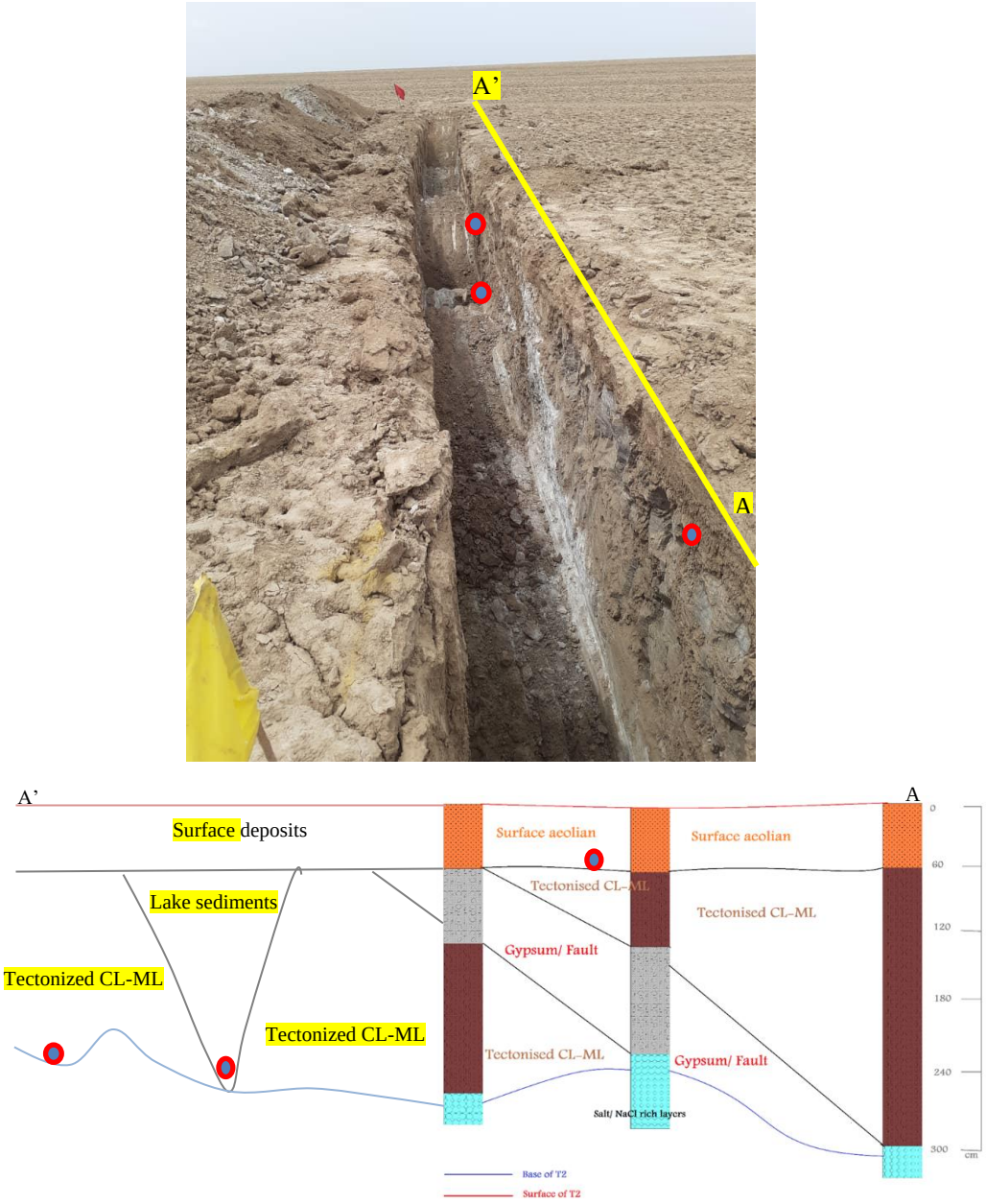

Figure 2. T2 trench with view to the NW. A-A' section is shown below. Red circles are the location of the OSL

samples. The gypsum mineralization in the fault plan can be seen in the T2 with a dip of 39° SE.

We observed favorable evidences of fault geometry in the T2 (Figure 2). The left-lateral strike-slip fault with the reverse component has offset the sediments (lake sediments, mostly lacustrine) about 120 meters along the edge of the lake (Figures 1 and 2). The lowest layer observed in the T2, which was dug to a depth of 2.2 m, is a dense layer of evaporites, which is mainly composed of NaCl. Strongly tectonized clay sediments are placed on this layer, which have different thickness along the trench. These sediments have well preserved the slickenlines (the direction of slip) of faulting. According to our measurements, the strike of the fault is N58E, and also the slickenlines indicate a rake of about 5-10 SE. The dip of the fault plane is 39 degrees and towards the southeast. The fault plane is mineralized by gypsum with a thickness of 50-70 cm (Figure 2). We have taken samples from three layers to calculate the age of the layers and estimate the value of slip-rate (Figure 2) in near future.

CONCLUSIONS

We observed evidences and offsets of about 120m in the southern part of TP along the DF fault. The fault has a strike of N58E (dip 39 degree and dip direction to the southeast). The rake of faulting was about 5-10 SE. It is worth mentioning that vertical displacement between 4-6 meters is visible in the area, which can help in the future to calculate the vertical slip rate of the fault. Currently, the collected sediment samples are in the stage of calculating the luminescence signal in the National Laboratory of Optically Luminescence Dating of Iran (OLDI), and in the near future, by calculating the age of the samples, in addition to calculating the first reliable slip-rate of the fault in central Iran, the paleoclimate of this region will also be reconstructed.

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