Preliminary results of paleoseismic investigations on the Doruneh fault in Central Iran (northeast of Jandaq): Evidences for horizontal and vertical displacements in Holocene

Mehdi Torabi[1], Morteza Fattahi[2], Mohammad R. Ghassemi[3, 4], Samaneh Mombani[5], Hamideh Amini[6]

[1]*Institute of Geophysics, University of Tehran, Kargar Shomali, Tehran, Iran, torabi.mehdi@ut.ac.ir*

[2]*Institute of Geophysics, University of Tehran, Kargar Shomali, Tehran, Iran, mfattahi@ut.ac.ir*

[3]*Research Institute for Earth Sciences, Geological Survey of Iran, Azadi Square, Meraj Avenue, P.O. Box 13185-1494, Iran, ghassemi.m.r@gmail.com*

[4]*School of Geology, College of Science, University of Tehran, Tehran, Iran*

[5]*Institute of Geophysics, University of Tehran, Kargar Shomali, Tehran, Iran,Samane.mombeyni@ut.ac.ir*

[6]*Institute of Geophysics, University of Tehran, Kargar Shomali, Tehran, Iran, hiamini@ut.ac.ir*

ABSTRACT

The Doruneh fault with a length of 600-900 km, is among the longest strike-slip faults in Iran. Several studies have concentrated on determining the slip rate of several parts of this fault which is resulted to different values between 0.5 to 5.3 mm/yr. Based on these studies different opinions about the change of slip rate trough time have been suggested. However, some parts or segments of this long active fault have not yet been studied. Following two weeks of field work and with the help of satellite images, we discovered evidences of horizontal and vertical Holocene displacements in the northeast of Jandaq (central Iran) on the fault. We measured the displacement in beheaded streams along the fault and collected sediment samples from the displaced units to calculate the slip rate using the OSL dating method.

Keywords: Doruneh fault, slip rate, Central Iran, Jandaq, OSL dating

INTRODUCTION

The Doruneh Fault (DF) or Great Kavir fult (GKF) with a length of 600-900 km is one of the longest strike-slip faults in Iran (Fattahi et al., 2007; Javadi et al., 2015). However, Farbod et al. (2016) considered the length of seismic segment of the fault to be around 400 km. This fault has a curved pattern and changes its strike in space. The strike is roughly W-E in central part of the fault, and NE-SW in its western part. Javadi et al. (2015) explained that the active kinematics of the DF varies along its curvature from purely sinistral strike-slip in the west to sinistral transpression in the east (e.g. Fattahi et al., 2007).

Undoubtedly, one of the important features of this fault is its slip rate, about which a comprehensive agreement has not yet been formed. So far, various methods have been used to calculate the fault slip rate, each of which has achieved different results. Table 1 summarizes the efforts of previous researchers to calculate the fault slip rate. At first glance, the combination of satellite image data and OSL dating results has yielded closer results (1-3 mm/yr).

In the present study, for the first time we will try to calculate the slip rate of the fault in the western segment (northeast of Jandaq, Central Iran). Fault slip-rates can be determined from reliable dating methods of deformed/displaced sediments (Fattahi et al., 2006). In this study we will use the OSL dating method.

Table 1. Slip rate results for the Doruneh fault concluded from different methods.

Study area / segment	Method	Result	References
Eastern segment	GPS monitoring	0.5-3.5 mm/yr	Tavakoli, 2007
Middle segment	OSL	2.5-3.0 mm/yr	Fattahi et al., 2007
Middle segment	OSL	2.5-3.0 mm/yr	Walker and Fattahi, 2011
Middle segment	GPS monitoring	5.0 mm/yr	Pezzo et al., 2012
Middle segment*	TCN dating	5.3 mm/yr	Farbod et al., 2016
Across the fault	Satellite images and IRSL	1-3 mm/yr	Mousavi et al., 2021

*They just consider the seismic segment length of the fault to be about 400 km and named the western segment as GKF.

Although there are data on some segments of this fault (Table 1), but no dating studies have been performed on it in Central Iran (western segment), and therefore its slip rate and potential seismic hazard in Central Iran remains completely unknown. The reason that this fault and its behavior remains unknown in Central Iran is probably the existence of hard desert lands and very difficult access to the fault. Also, most of this fault passes through the playas of Central Iran and areas with an abundance of sand dunes, which has buried the surface manifestations of this fault. In this article, we will review the preliminary paleoseismological results of the DF in Central Iran. Calculating the age of OSL samples of sediments in near future will result in the slip rate of this fault in Central Iran.

METHODOLOGY AND DATA

Remote sensing and library studies, as well as two weeks of field visits to the north of the city of Jandaq, showed the existence of significant traces of the Doruneh fault in central Iran. Javadi et al. (2015) have previously studied the effects of this fault in the west of Jandaq city to near Anarak (from Pis-Kuh in the west of Jandaq to Talmesi in Anarak). During field visits of the 10-15 m scarp of the Doruneh fault in the east and northeast of Jandaq, significant manifestations of fault were observed in the Miocene to present day sediments. The fault plane was very difficult to find in this area and only due to gypsum mineralization on the fault plane and less erodibility of gypsum with respect to the sediments, the fault was observed within the Pliocene sediments that were severely eroded and covered the fault strike.

The first effect of fault activity that can be found in this area is the height difference of 10-15 meters created on the slopes of the vast desert of Jandaq. Preliminary field studies showed a right-lateral reverse motion in the Pliocene sediments up to the present time, which differs from the mechanism reported by Javadi et al. (2015, left-lateral). They concluded a change from right-lateral to left-lateral kinematics along the western part of the DF in the Neogene up to 8–10 Ma. However, our field studies show that the latest movements of this fault in central Iran have been right-lateral reverse faulting. Fortunately, traces of rake (slip vector) could be seen on the fault plane. We have detected three sets of rakes on the fault plane (25NE, 35NE, 40NE), all three of which show a right-lateral movement along the fault strike (N70E). The dip direction of the fault plane is 70 degrees to the south (Fig. 1).

In addition to the difference in height observed in the area, a number of beheaded streams are also observed in the area, which have been displaced between 35-40 meters due to the right-lateral movement of the fault. At least five consecutive displacements of between 7 and 8 meters are observed in the beheaded streams, which can be initially assumed that major movements on the fault could have created horizontal displacements of 7 meters. Since all the effects of vertical and horizontal displacement of the fault in this area can be measured, only if suitable sediments are found in the trench dug across the fault, then by dividing the displacement to the sediment age, the specific and exact slip rate of the fault will be calculated in Central Iran. At present, sediment samples related to the fault layers have been collected and sent to the National Laboratory of Optically Stimulated Luminescence Dating of the Institute of Geophysics, University of Tehran, to calculate the age and slip rate. In the near future, we will report the results of accurate fault slip rate in Central Iran (Western segment, northeast of Jandaq).

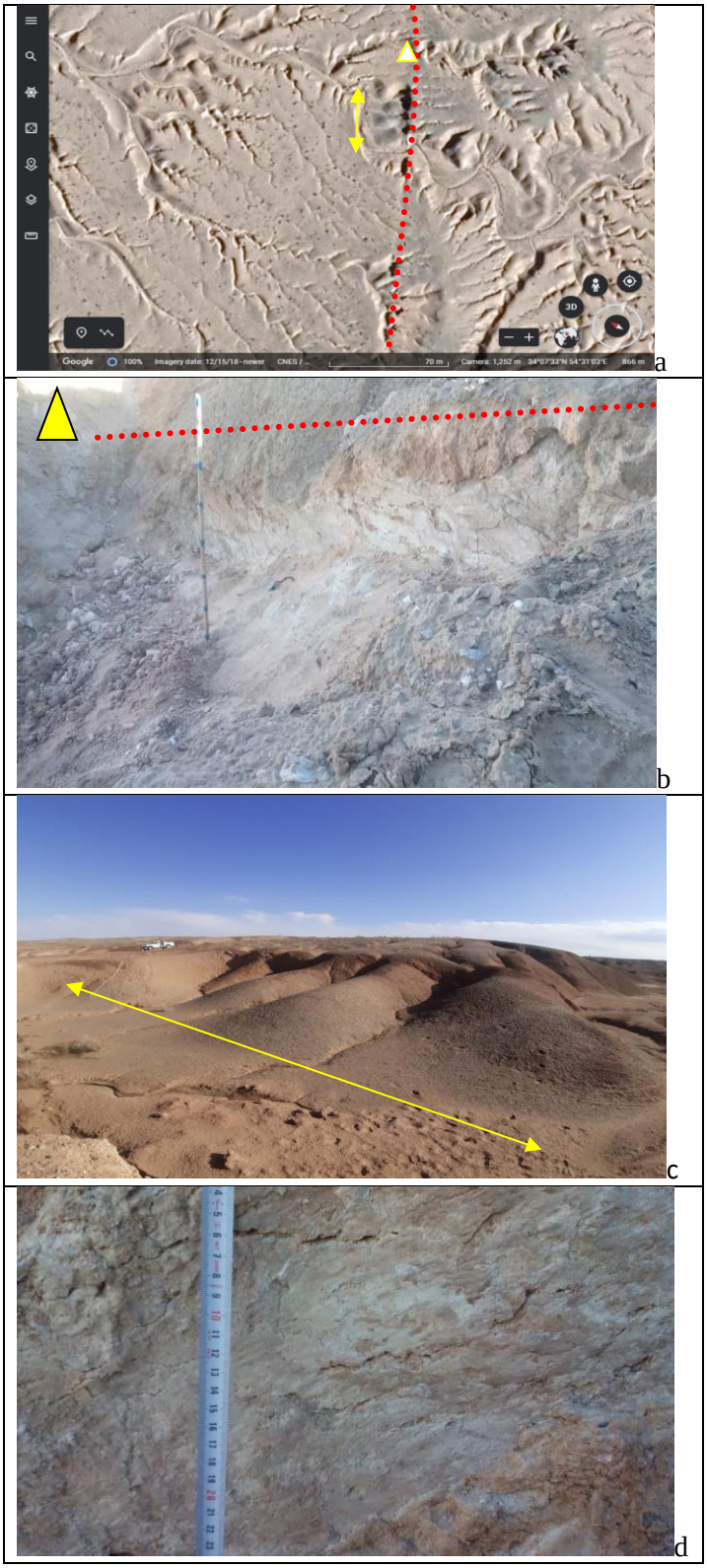

Figure 1. Summary of field studies in Jandaq area. a) Google Earth map of the study area. Dotted line is the Doruneh fault in northeast of Jandaq, yellow triangle is the location of fault plane (also see b and d) and yellow arrow represent the 35 m horizontal displacement of the beheaded streams along the fault. b) Fault plane with a strike of N70E (dip direction 70 degree to the south). c) Beheaded streams displacement for about 35m. d) Rake on the fault plane (30 NE).

CONCLUSIONS

Our work shows that the effects of the recent movements of the Daroneh fault in the Holocene and in the northeast of Jandaq (central Iran) are present and measurable. We measured a displacement of about 35 m in beheaded streams along the fault. The fault has a strike of N70E (dip 70 degree and dip direction to the south). To calculate the slip rate of this fault, we have taken our sediment samples from the displaced sediments, and in the near future, the results of age measurements will determine the slip rate of the fault in Central (western segment). It is worth mentioning that vertical displacement between 10-15 meters is visible in the area, which can help in the future to calculate the vertical slip rate of the fault.

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