Applying the OSL to determine the slip-rate of the Abr Fault

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ABSTRACT

The Abr fault is one of the left-lateral strike-slip faults in the southeast of the Alborz Mountains. Previously, by means of Cosmogenic Nuclide dating (TCN- ages of boulders samples 90-100 ka), the cumulative displacement and the slip-rate of the fault were calculated as 400 m and 3-4 mm yr^{-1}, respectively. We decided to employ OSL for determining the slip rate. To compare the OSL and TCN ages, we chose our sampling location close to the sampling location (the Q3 unit) of Javidfakhr et al. (2011). However, the ages obtained from sediments using the OSL method were much younger (2۲ ka) than the ages from boulders using the TCN method. This suggest that the layer which was used for OSL dating was created after the abandonment of the Q3 unit, and possibly this layer exist in that region, and therefore, according to the new displacements of the region, which is about 60 meters, the slip-rate has been calculated 2.۷ mm yr^{-1}, which is slightly lower than the slip rate calculated by the TCN dating method (3-4 mm yr^{-1}).The OSL provides the age of a much younger layer.

Keywords: (Abr fault, Slip-rate, OSL)

INTRODUCTION

Northeast of Iran and east of Alborz, due to its location in the Himalayan Alps, is tectonically active and has experienced major earthquakes throughout history (e.g. Berberian, 2014). Researchers have used different Quaternary dating methods to calculate the slip rate of the faults in NE Iran and eastern Alborz. Fattahi et al. (2006) calculated Holocene slip-rate on the Sabzevar thrust fault (1 mm yr^{-1}), NE Iran using Optically Stimulated (OSL) Dating method. They assumed the convergence rate across the fault to be 0.4-0.6 mm yr^{-1}. Ghassemi et al. (2014) used a combination of 14C and OSL dating methods in the east of central Alborz and investigated the kinematic links between Mosha and North Tehran fault and stated that the left-lateral kinematics on the two faults in their linkage zone is about 1.8 and 3.0 mm yr-1 (max and min, respectively) for Holocene time scales. OSL and Infrared Stimulated Luminescence (IRSL) dating techniques used for the slip-rate of Astaneh fault and resulted in horizontal slip-rate of 2 mm yr-1 (Rizza et al., 2011). Mousavi et al. (2021) used the satellite images and IRSL dating methods across the Doruneh fault and reported a slip-rate of about 1-3 mm yr^{-1}. By means of TCN dating, Javidfakhr et al. (2011) suggested the values of 3-4 mm yr^{-1} for the slip-rate of the Abr fault.

The Abr fault (Shahvar - Berberian, 2014) produced sharp Quaternary deformation (Javidfakhr et al., 2011; Berberian, 2014) and was associated with the 9 August 1981 (Ms 4.9), and the 11 May 1984 (Ms 4.5) Qatri and Abr earthquakes, however, Berberian (2014) claimed that the fault was not activated during 1890 earthquake. Nonetheless, Mousavi et al. (2013) suggested that the 1890 earthquake took place along Abr fault. Javidfakhr et al. (2011) argued that the cumulative left-lateral displacement of Abr and Khij faults is about 420±50 and 400±50 m. The 1985 earthquake (1985.10.29, 03:13:42, 36.68 N / 54.77 E, Gorgan, M 6.2, depth 13 km, strike 246, dip 66, rake 71) was also attributed to the Abr fault zone (Javidfakhr et al., 2011).

We used OSL dating method to date alluvial sediments adjacent to the Abr fault. We discuss our findings and compare them with previously calculated slip-rate (using TCN).

METHODOLOGY AND DATA

The study area (Fig.1) is located 45 km north of Shahrood city, Semnan province, in the northeast of central Iran and southeast of eastern Alborz. The target areas for visiting and sampling were identified by using Google Earth images, geological maps and satellite photos, and according to the geographical location, the desired area was accessed and studied and displacement measurements were carried out. Field investigations was carried out to identify the Abr fault and two OSL samples was taken on November 11, 2021.

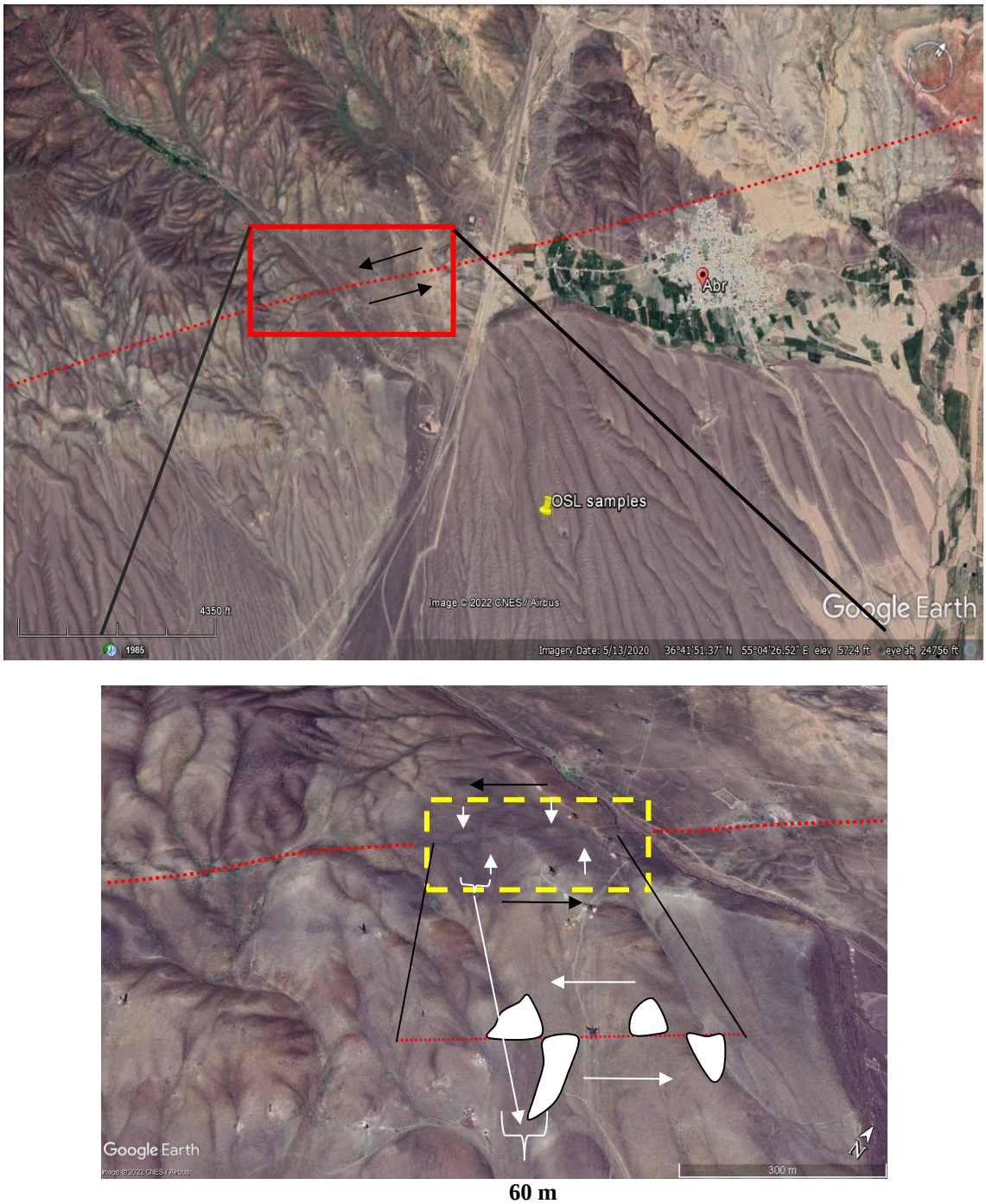

Figure 1. Google Earth image of the study area. OSL sampling location, the Abr Fault and 60 m left-lateral offset of late Quaternary deposits. Cartoon is not in scale.

To compare the slip-rate using OSL with the slip-rate calculated by the TCN dating method, the sampling site was chosen close to the sampling site of Javidfakhr et al. (2011). A one-meter pit was dug at geographical coordinates of 36◦ 41’ 26” N and 55◦ 05’ 03” E for sampling. Two OSL samples were collected under a lightproof tarpaulin fabric by hammering stainless steel tube into freshly cut section of the alluvial deposits and then covered with an aluminum foil soon after taking it from the section, then sealed in a black plastic bag and transferred to OSL lab of the institute of Geophysics. Potassium feldspar was separated and IRSL was measured. All the luminescence measurements reported here were carried out in a lexsygsmart – Automated TL/OSL Reader (equipped with a 90Sr-90Y beta source type 3203 with activity of 1.85 GBq and a maximum energy of 2.27 MeV) fitted with blue and IR laser diode as stimulation sources. The post IRSL290 ages of the samples were ۲۲,٤۹±۱,۲ ka and ۲۲,۸6±۱,٥ ka. The results of our study show that the age of the sediments (۲۱,۳- ۲۳,۹ ka) is much younger than the ages from boulders using the TCN method (90-140 ka) calculated by Javidfakhr et al. (2011).

If we assume that the age of the abandonment of the Q3 unit is ۲۲ ka (OSL dating), and calculate the slip-rate according to the cumulative displacement of 400 meters (reported by Javidfakhr et al., 2011), the result of which will be an irrational number (۱۸,۲ mm yr^{-1}). That is not logical. Therefore, the obtained Post IRSL age is due to possibly an erosional layer that has been offset by the more recent fault movements in the area.

We detected a series of displacements of about 50 to 60 meters. According to the observed displacements, the left-lateral movement was confirmed. As in the south of Abr village (north of the sampling site), due to human activities, the manifestation of the fault has disappeared, we used the closest offset to the sampling location (two kilometers northwest of the sampling site) with the value of≈ 60 m for determining the slip-rate. (Fig.1). By dividing the offset value (60 m) by the OSL age (22 ka) of the sediments we calculate 2.7 mm yr^{-1} as the late Quaternary slip-rate of the Abr fault.

CONCLUSIONS

Our dating results show that the OSL ages of alluvial sediments are ۲۲,٤۹±۱,۲ ka and ۲۲,۸6±۱,٥ ka, which are far less than the ages of 90-140 ka reported by Javidfakhr et al. (2011) calculated by TCN dating method. The OSL ages show that no correlation can be found between them and the cumulative displacement of 400 reported by Javidfakhr et al. (2011).

We identified the recent 60-meter displacements of the fault in the region and therefore, we assumed we have determined the age of the sediments that were displaced by recent fault movements. By using these displacements, we calculated the slip-rate of 2.7 mm yr^{-1}, which is slightly lower than the slip rate reported by the TCN dating method (3-4 mm yr^{-1})

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