DATING OF SOUTH AHAR FAULT SEISMIC ACTIVITY BY THERMO LOMINESENSE

Bahman ESMAEILI[1] Mehdi ZAREH[2]

ABSTRACT

On August 11th 2012, an earthquake with magnitude of Mw 6.4 (NEIC) struck near the cities of Ahar and Varzaghan at the depth of 9 km. This quake was followed by another Mw 6.3 tremble at the depth of 16 km. These earthquakes were clearly noticed in city of Tabriz. According to seismicity catalogue of Iran, a large number of earthquakes were recorded for city of Tabriz within the time span of 150 to 200 years ago. Notwithstanding Tabriz Fault is an active fault and has caused many earthquakes but it can be considered that many of the earthquakes occurred around the city of Tabriz were not triggered by Tabriz Fault. Close to the epicentre, there is a landslide that crawled over and buried parts of Chilan Village. During the field visit several clay pot remnants were collected from village homes and dated with Thermal Luminescence technique. The result from this dating approximately matches the time span of the numerous earthquakes incidents within Tabriz area, about 150 to 200 years ago, and therefore it could be assumed that the period of activity of South Ahar Fault goes back to aforementioned time span.

INTRODUCTION

On August 11th 2012 at 04:53 p.m. (local time), an earthquake with magnitude of Mw 6.4 (NEIC) struck in the vicinity of the cities of Ahar and Varzaghan in Eastern Azerbaijan Province, northwest of Iran. This quake was followed by another earthquake with magnitude of Mw 6.3 11 minutes later at 05:04 p.m. The local seismic network, Institute of Geo-physics, University of Tehran (IGTU), indicated the second quake was located just below the first one at a depth of around 16 km. These two earthquakes destroyed more than 20 villages and brought damages to cities of Varzaghan, Ahar, and Heriss. The earthquakes took lives of 327 people, caused more than 3,000 casualties, and left more than 30,000 down-and-out with no roof over their head. The twin earthquakes struck approximately 60 km northeast of Tabriz and around 20 km from Ahar and Varzaghan. Both trembles had similar geographic coordinates (38.41°N 46.78°E) (Moradi, 2012) and the focal depths were determined at 9 km and 16 km, respectively. The focal mechanisms of both quakes are consistent with right-lateral strike-slip faulting on an E-W trending fault parallel to the South Ahar fault; field observation also revealed an E-W trending right-lateral strike-slip surface rupture. However, the second shock shows a considerable reverse component (Global CMT, 2012). The shake was strongly felt in city of Tabriz too.

[1] Senior Engineer, Engineer Department of Kayson Company, Tehran, Iran, bahmanesm@yahoo.com
[2] Associate Professor, International Institute of Earthquake Engineering and Seismology (IIEES), Tehran, Iran. mehdi.zare.iran@gmail.com
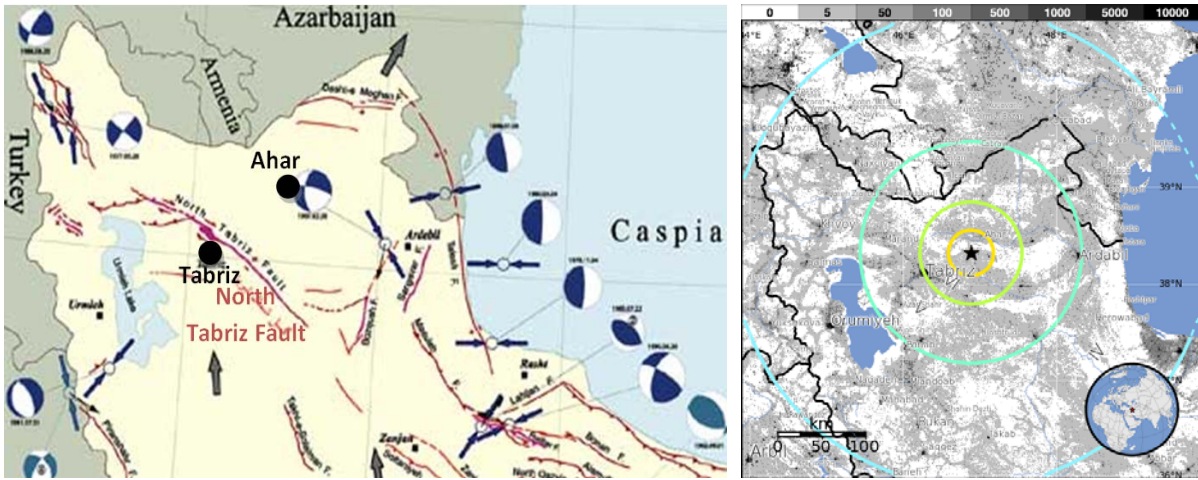
Figure1. Geographic location of cites of Tabriz and Ahar and North Tabriz Fault, Map of Active Faults of Iran (left).

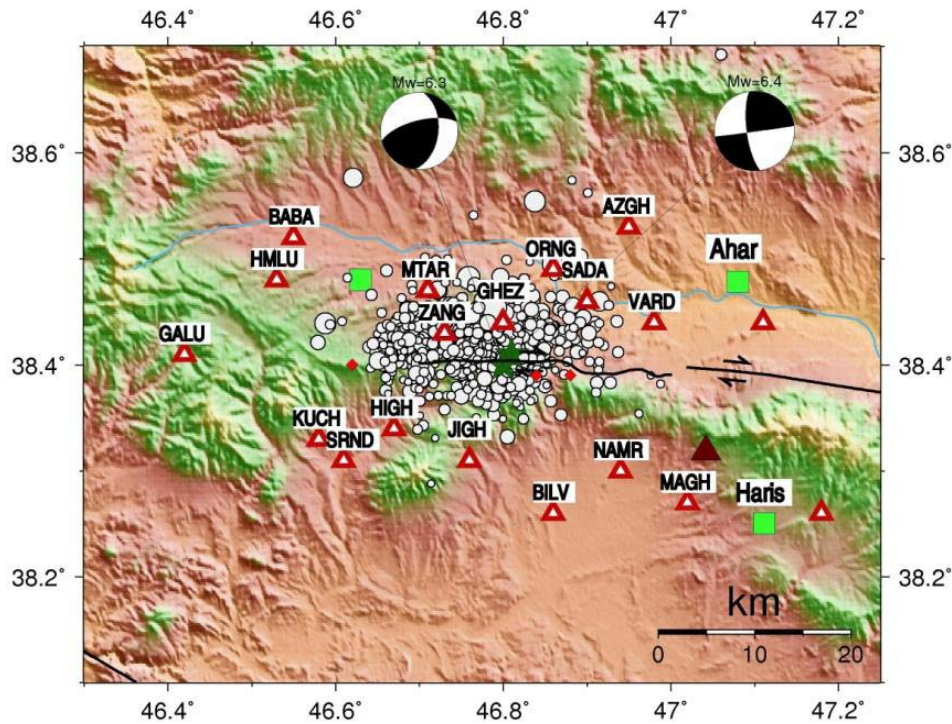Figure 2. Location of August 11th 2012 epicenter (Right).

Figure3. The locations of the aftershocks recorded at local permanent stations of IGTU. A local temporary seismic network of 17 stations, installed by IIEES two days after the man shock is shown as red triangles. The locations of the main shocks based IGTU relocated epicenters (green stars) and their focal mechanisms (CMT solution) are presented as well (IIEES, Prepared by Dr. M. Tatar).

TECTONIC SUMMARY

The August 11, 2012 two earthquakes with magnitudes of M 6.4 and M 6.3 hit northwest of Iran as a result of oblique strike-slip faulting in the shallow part of the crust of Eurasia plate, approximately 300 km east of the plate-boundary between the Eurasian and Arabian plates. The two earthquakes are apart by just 10km in an east-west direction. Focal mechanisms, describing the style of faulting for the earthquakes, suggest slip on either fault planes striking roughly east-west, or those striking roughly

north-south. On a broad scale, seismotectonics of this region is controlled by the collision of the Arabian and Eurasian plates; at the latitude of the earthquakes, the Arabia plate moves almost due north with respect to the Eurasia plate at rate of approximately 26 mm/yr. To the south of today's earthquakes, towards Iraq and the Persian Gulf, tectonics is dominated by the Zagros folding and thrust belt. To the west, in Turkey, tectonics is controlled by strike-slip faulting on the East (in southern Turkey) and North (in northern Turkey) Anatolian fault zones, Accommodating the westward motion of the Anatolian block as it is being squeezed by the converging Arabian and Eurasian plates. The August 11, 2012 earthquakes occurred in the broad, elevated Turkish-Iranian Plateau region between these regimes and the Alborz Mountains further east. These incidents are consistent with the distributed, dominantly strike-slip mechanisms of historic earthquakes nearby, and with the orientation of mapped faults in the region.

What is the Luminescence

Luminescence is a technique to measure the reserved energy in a soil or rock sample. By this technique the time of saving of energy can be detected. There are two methods in this technique; Thermal Luminescence (TL) and Optical Stimulated Luminescence (OSL). Thermal Luminescence measures the time of rising the temperature of the sample of rock, soil or earthenware up to 400 centigrade. Thermal Luminescence could detect the approximate time of faulting in a fault zone (geological studies) or heating a brick or earthenware (archaeological studies). Optical Stimulated Luminescence determines the time of shine on sample. During sampling and test, no light must shine on the sample while using this method. Thermal Luminescence technique was used to measure the approximate age of clay pot remnants of Chilan Village and approximate date of landslide occurrence and related earthquake.

Historical Earthquake in Tabriz Area and Related Events

According to seismicity catalogue of Iran, a large number of earthquakes were recorded for city of Tabriz within the time span of 140 to180 years ago. Notwithstanding Tabriz Fault is an active fault and has caused many earthquakes but it can be considered that many of the earthquakes occurred around the city of Tabriz were not triggered by Tabriz Fault. August 11th 2012 earthquake is a typical example of such quakes that struck Tabriz hard and caused severe anxiety and grievance in this city. Historically, it could be assumed this earthquake was recorded for city of Tabriz (North Tabriz Fault) instead of cities of Ahar or Varzaghan (South Ahar Fault) in the past. So, reliable indication and evidence should be found for the historical earthquakes in order to determine the exact location of each one.

Table1. Recorded earthquakes of Tabriz area from 1721 to 1856 AD.

No.	Date	Longitude	Latitude	Magnitude (Ms)	Reference	Area
1	26.04.1721	37,900 N	46,700 E	7.7	Ambraseys	Tabriz
2	08.01.1780	38,200 N	46,000 E	7.7	Ambraseys	Tabriz
3	05.1806	38,100 N	46,300 E	----	Ambraseys	----
4	14.05.1812	38,100 N	46,300 E	----	Ambraseys	----
5	23.06.1812	38,100N	46,300E	----	Ambraseys	----
6	01.1819	38,100N	46,500E	----	Ambraseys	Tabriz
7	06.1820	38,100N	46,300E	----	Ambraseys	----
8	12.1823	38,100N	46,600E	----	Ambraseys	----
9	1831	38,100N	46,300E	----	Ambraseys	----
10	04.10.1856	38,200N	46,500E	----	Ambraseys	Tabriz

There are numerous old and young landslides in Varzaghan-Ahar area. In addition to factors such as lithology, slope of the ground and the rate of precipitation in the area, the main factors that trigger such landslides are the earthquakes and tectonic incidents. Of these landslides it can referred to Chilan Landslide that ran over and buried parts of Chilan Village and consequently led to migration of village people to a new location nearby. Alongside this the evidence of young tectonic activities is seen within Holocene deposits. During the field visit several clay pot remnants were collected from village homes located around the landslides and dated with Thermo Luminescence technique. The result from this dating approximately matches the time span of the numerous earthquakes incidents within Tabriz area (about 140-150 years, table 1). In other words it could be assumed that the period of activity of South Ahar Fault is about 140-150 years. Finally considering the dating results and recent powerful earthquakes that struck Varzaghan-Ahar area and its surrounding, and after a relatively quiet period of time, it could be concluded that more earthquakes might be about to happen within the next one or two decades after a seismic lag in Azarbaijan Province in Iran.

Figure4. A young new landslide created after August 11th 2012 earthquake (left).

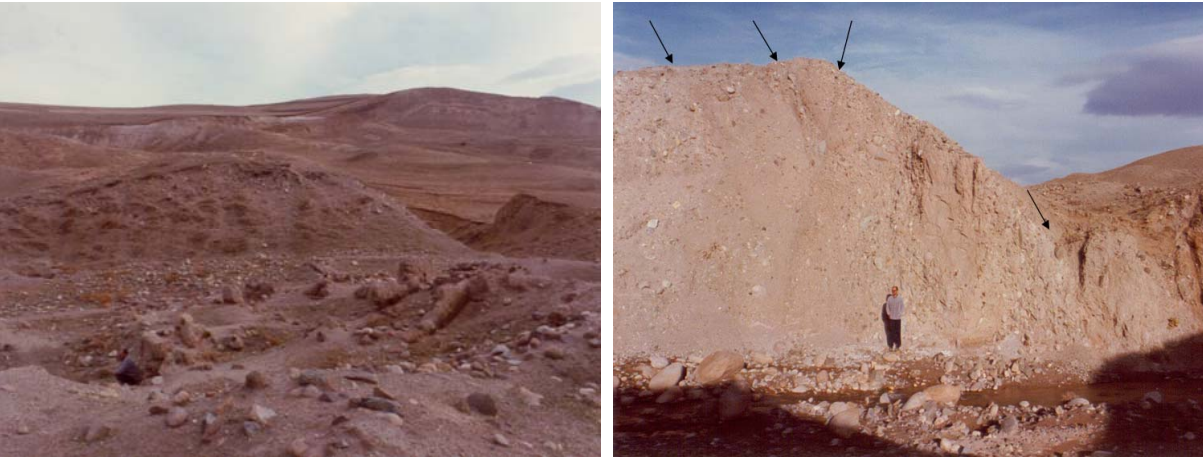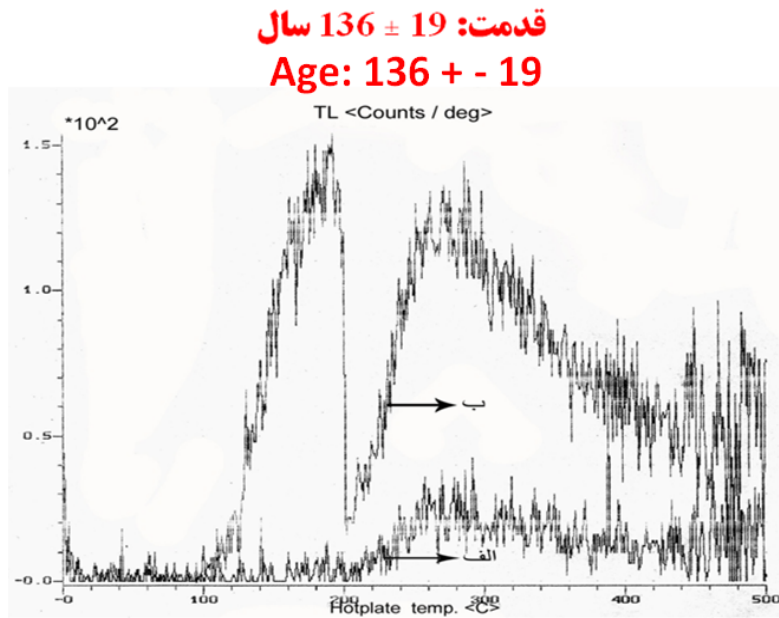Figure5. An old landslide in south Ahar Fault area (right).

Figure6. The abandoned Chilan Village that was ran over and buried under an old landslide (left).

Figure7. Different sheared of South Ahar Fault Zone in young Holocene sediments in eastern Part of Chilan Village (right).

Figure 8. A clay pot remnant of Chilan Village analyzed and dated by Thermal Luminescence (left).

Figure9. Geographic location of city of Ahar, Chilan Village and South Ahar Fault (right).

Graph1. Thermal Luminescence dating graph of clay pot remnants of Chillan Village.

Conclusion

In many cases, historical earthquakes in Iran were recorded for the most important and closest cities and the main cities or epicenters of the earthquake were forgotten. As it is presented in Table 1, from 1806 to 1856, eight earthquakes were recorded for Tabriz area but, only two incidents were related to North Tabriz fault and the others (like August 11th 2012 Ahar-Varzaghan earthquake) could be related to other tectonic structures and systems. To identify the exact location and epicentre of historical earthquakes, the field related evidences should be detected. As important related field evidence, large number of old and young landslides could be found within South Ahar Fault area. Of these landslides it can be referred to Chilan Landslide that ran over and buried parts of Chilan Village and also located near to epicenter of August 11th 2012 Ahar-Varzaghan earthquake. Near Chilan Village the shear zone of South Ahar Fault that cut through Holocene alluviums could be seen. Age dating of a clay pot remnant of Chilan Village proposes the age of about 140 to 150 years (Graph 1 and Figure 7). With

regard to the hypothesis about main location and epicentres of historical earthquakes in Tabriz area (Table 1) and result from age dating (Graph 1), it can be concluded that one of the recorded earthquake in Tabriz area, between 140 -150 years ago, was related to South Ahar Fault. So the period of activity for South Ahat Fault could be estimated as old as 140-150 years.

REFERENCES

Ambraseys N.N, Melville C.P (1982) " A History of Persian Earthquakes" Cambridge University, Britain.

Bahrololoomi F, Azimi MS (2013) "Dating Report of Clay Pot Remnants in Chilan Village-Ahar City Area" Institute of Historical and cultural Monuments, Report No. TLD-92/4.

Ghafory- Ashtiany M, S.Razzaghi, Davoodi M, Tatar M, Parsizadeh F (December 2012) "The Mw 6.4 and Mw 6.3 Iran Earthquakes of August 11, 2012" , EERI Special Earthquake Report.

Razzaghi M.S, Ghafory- Ashtiany M, A Preliminary Reconnaissance Report on August 11th 2012, Varzaghan-Ahar Twin Earthquakes in NW Of Iran, Iranian Earthquake Engineering Association.

Hosseini S. K (2012) "Two source faults of Ahar-Varzaghan Earthquakes, August 11, 2012, NW- Iran" , Ferdowsi University of Mashhad, Iran.

Major Active Fault of Iran (2003), International Institute of Earthquake Engineering and Seismology (IIEES), Tehran, Iran.

USGS (2012) "M 6.4 Ahar, Iran Earthquake of 11 August 2012" , U.S DEPARTMENT OF THE INTERIOR / U.S. GEOLOGY SURVEY / GLOBAL SEISMOGRAPHIC NETWORK.

Zareh M., Shahvar M. (2012), An Urgent Report on the 11 August 2012, Mw6.2 and Mw 6.1; Ahar Twin earthquakes in East Azarbayjan Province of NW Iran, www.iiees.ac.ir.