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Paleo and New Earthquakes and Evaluation of North Tabriz Fault Displacement in Relation to Recurrence Interval of Destructive Earthquakes

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Abstract: Azerbaijan is one of the most active segments of the Alpine-Himalayan seismic belt and marks the junction between the African-Arabian and Indian plate to the south and Eurasian plate to the north. Several regional earthquakes have been strongly felt and caused damages in and around Tabriz during history. For example, the magnitude 7 to 7.7 Tabriz earthquake in 1780, which is the most strongest experienced one in Lesser Caucasus and east of Turkey and caused severe damage in Azerbaijan territory including Tabriz City. The urban area of Tabriz City lies on Miocene to Quaternary soft sediments (clays, sands, silts, and gravels.) resting on an old Tertiary basement. Previous studies have shown that the thickness of such soft sediments could largely influence the site response in case of an important regional earthquake. The accurate information about historical earthquakes and new faulting is an important tool for viewing the active tectonic and analyzing the earthquake risk and seismic migration. Historical records of earthquakes in Tabriz based on macro and micro seismic observations cover period of 1,000 to 1,400 years. Our study aims at mapping the seismic response of a pilot zone of Tabriz for different earthquake scenarios, a simple but robust.

Key words: NTF (North Tabriz Fault), destructive earthquake, macro and micro seismic.

1. Introduction

The region between the Black Sea and the Caspian Sea is part of the central Asian segment of the Alpine-Himalaya fold belt and comprises the great Caucasus fold and thrust belt in the north, and the lesser Caucasus-pontides (including Azerbaijan Iran) fold and thrust belt in the south. The mountain ranges of the Caucasus and Azerbaijan were formed by the collision of the African-Arabian and Indian plates with the Eurasian plate. The great and small Caucasus Mountains are geologically very young, having formed during the Middle Pliocene.

Compressional uplift and thrusting separated a once continuous basin into western and eastern parts.

Continuing plate convergence means that Azerbaijan experiences high seismic activity.

Over 600 seismic events have been recorded since 1600. By using satellite remote sensing techniques and geophysical methods (e.g., seismic reflection, seismic refraction, gravity, magnetic, and electrical techniques), along with microseismicity net work, and trenching, experts have attempted to develop field techniques for remediation of site susceptible to earthquake hazards.

Three classes of seismic activity are generally recognized, namely tectonic, volcanic, and artificially induced.

The tectonic variety is by far the most divesting and is caused by stress built due to movements of the plates that make up the earth's crust which is the characteristic of Caspian Sea.

2. NTF (North Tabriz Fault)

Most earthquakes occur in narrow belts that join to form a continuous network bounding regions that are seismically less active. The last damaging earthquakes on NTF occurred in 1721 and 1780.

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The recent study about seismic cycle along the NTF that has been conducted in 2004, assumes that north part of Caucasus displaces and truncates to the north-northeast and south-southwest about 8 ± 1 mm/year and the border of its resistant block is central Iran. The average recurrence interval of main historical earthquakes with *M* (magnitude) > 6.5 in Richter scale is once per 250 years [1].

The research that has been conducted in 2004 shows that the displacement value of NTF is 8 mm/yr with regard to its depth structure.

This study was done by GPS (global positioning system) in direction of NTF along two important profiles and each one is 80 km long and composed of six separate parts in 2 years and three main operational phases (Figs. 1-2 and Table 1).

Occurrence of main earthquakes in Tabriz City is finite indicating that there is no any comprehensive acknowledge about ordinary depth of this region's earthquakes. Also, the depth distribution of recent main earthquakes (*M* > 3, 1963-2008, radius = 200 km), shows that the earthquakes with focal depth of 15~32 km are the most frequent ones and September 16, 2007 Tabriz earthquake with a depth and acceleration of 8~15 km and 39 cm/s^2 is an good example of this sort of earthquakes. Moreover, successive earthquakes of Khajeh, Nahand dam, Basminj and Tabriz magnitude, 4.4-4.6, stand among this kind of earthquakes.

In an overall division based on faulting fracture physics, earthquakes can be divide into micro and macro groups: the micro-earthquakes are ones that

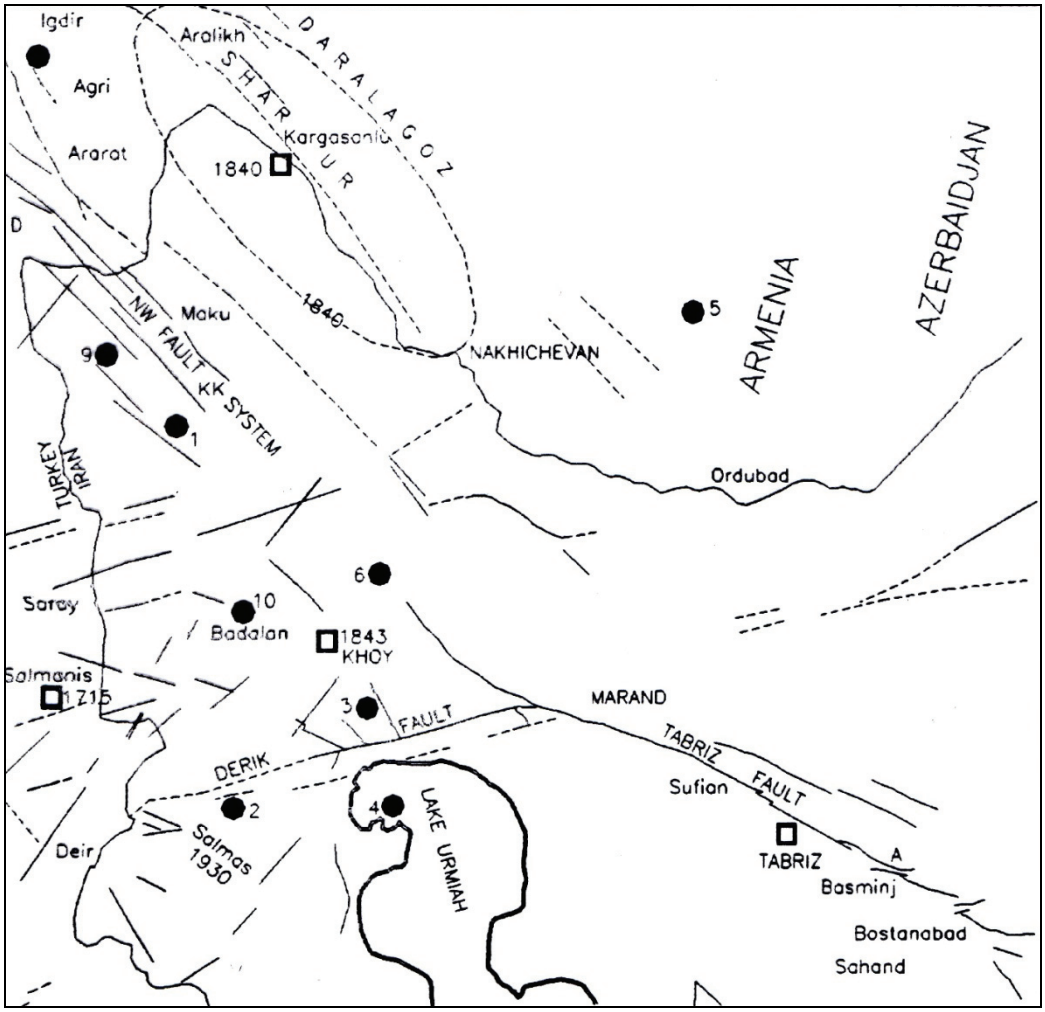

Fig. 1 North Tabriz Fault: western termination.

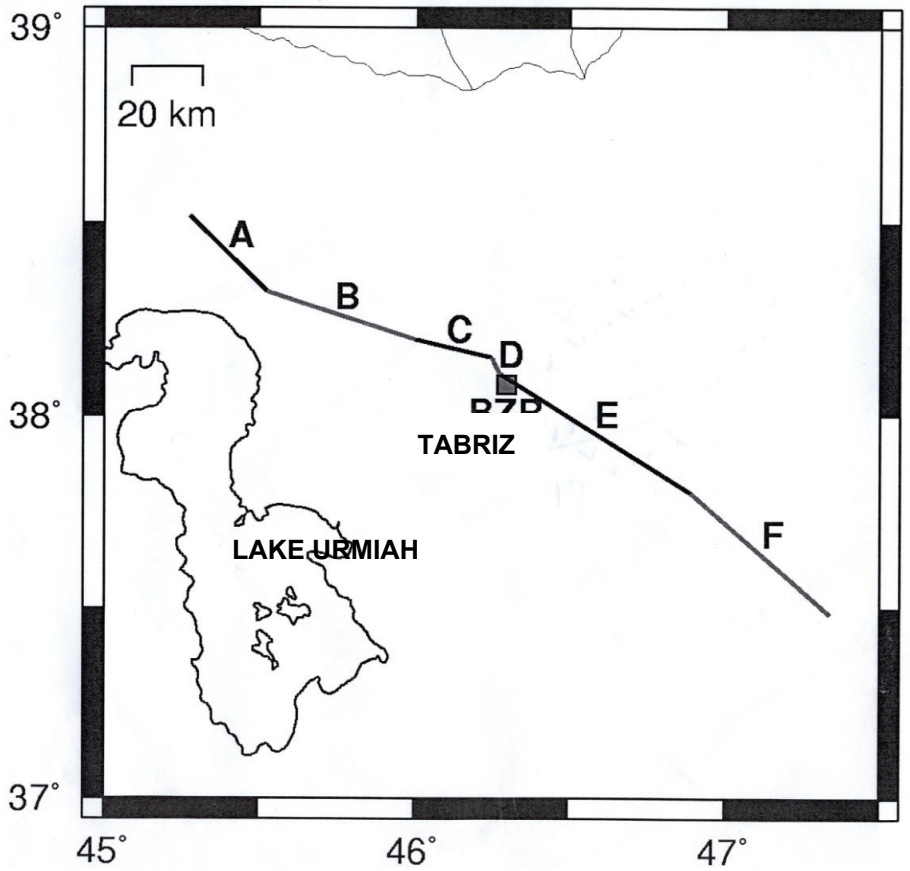

Fig. 2 The seismogenic segments of North Tabriz Fault.

Table 1 Outer Fault Parameters of Each Segment.

		Segment A	Segment B	Segment C	Segment D	Segment E	Segment F
NW edge	Degree	38.5143 N 45.2779 E	38.3214 N 45.5247 E	38.2000 N 46.0000 E	38.1530 N 46.2485 E	38.1096N 46.2717 E	37.8000 N 46.8900 E
SE edge	Degree	38.3214 N 45.5247 E	38.2000 N 46.0000 E	38.1530 N 46.2485 E	38.1096 N 46.2717 E	37.8000 N 46.8900 E	37.4857 N 47.3400 E
Top depth	km	2.0	2.0	2.0	2.0	2.0	2.0
Bottom depth	km	20.0	20.0	20.0	20.0	20.0	20.0
Strike	Degree	134.9	108.0	103.5	157.1	122.4	131.4
Dip	Degree	90.0	90.0	90.0	90.0	90.0	90.0
Rake	Degree	180.0	180.0	180.0	180.0	180.0	180.0
Length	km	30.4	43.7	22.4	5.2	64.3	52.9
Width	km	18.0	18.0	18.0	18.0	18.0	18.0

faulting fracture dimensions in them are smaller than the depth of earthquakes zone, such as micro-faults and micro-fractures that are visible in the faulting zone of September 16, 2007 earthquakes in Tabriz and its suburbs as well as earthquakes on September 2, 2008 in old Harzand (Dash-Harzand) and Zunuz small town.

But in case of the macro-seismic, the dimensions of fractures are same as or more than depth of seismic zone and could grow horizontally. Their vertical growing is not possible due to being free surface in ground and brittleness property of surface rocks upward and plastic surface downward [2].

Based on the comparison the authors have conducted about North Anatolian fault (NAF) and North Tabriz fault (NTF) with San-Andreas Fault

(SAF), these views are confirmed about NTF [3].

Though in subduction zones, such as chili coasts or Japan and pacific rims, where the depth of seismic zone is great, these values are equal to 7~7.5 in Richter scale.

The reviewing of major historical and instrumental earthquakes shows that the paleo-earthquakes (before the 20th century) restricted to historical books and reports.

The use of such data is difficult for evaluation of occurred earthquakes in the past, because of Iranian traditional house building such as houses of Bam City, where more than 90% of the city was destroyed by earthquakes of September 26, 2003 with M = 6.4, and more than 30 thousands persons were killed.

This is the case for remained houses in Iran which have not been built based on standards, and are vulnerable against earthquakes with M = 5.2~5.5 and acceleration of 45~60 cm/s^2.

The best examples are given at Dash-Harzand, Gargar-Alamdar.

3. Discussions and Conclusions

Continuing plate convergence means that Azerbaijan experiences high seismic activity. Over 500 seismic events have been recorded since 1600.

Recent research has been carried out in order to indentify general background seismic characteristics and define possible factors which lead to destabilization of the seismic regime and to determining the degree of seismic danger.

The new investigation about historical and instrumental earthquakes of Tabriz shows that it has experienced various destructive earthquakes throughout historical periods, for example earthquake of 1721, M = 7.6, and earthquake of 1780, M = 7.4. Based on obtained data, 18 historical earthquakes with $M \approx 6$ and distance of 200 km from Tabriz have been located, three cases with $M > 7$.

Our investigation show that no earthquake of an $M > 5.5$ has been observed within 50 km distance of Tabriz. Nevertheless, according to previous studies [4], eight historical earthquakes of an $M > 5.5$ have been recorded in this area.

The earthquake of April 26, 1721 with M = 7.3, RI (radius of influence) = 650 km, RMZ (radius of macro seismic zone) = 24 km, FFL (faulting fracture length) about 50 km, was from Tikmeh Dash to Tabriz.

The earthquake of January 8, 1780 with RI = 660 km, RMZ = 28 km, FFL = 60 km, destroyed Tabriz totally as well as approximately 400 villages have been ruined [4, 5].

Beyond that, the houses and buildings of Khoy, Salmas, and Urmiah were severely damaged but it didn't cause mortality.

The Salmas earthquake in 1930 is one of the eight earthquakes of $M \geq 7$ which have occurred in Iran since 1900, and one of the few which was accompanied by surface faulting with an increased regional seismotectonics studies. About 60 villages located in the Salmas plain were destroyed. Two surface faults were formed with the earthquake. The first oriented NW-SE and located at the southern edge of the Salmas plain, was about 20 km long and displayed a maximum right-lateral movement of 4 m and maximum vertical throw (NE down) of about 5 m. The second oriented NE-SW and located in the western mountains, was over 3 km long, left-lateral, and had a vertical throw (NW down) of about 1 m. The aftershocks of these earthquakes have been continued until 100 days [6-8].

On the basis studies, main mechanism in Tabriz and surrounding regions is tensional pressure to right lateral mechanism.

The reviewing of greater distribution about earthquakes with RI =200 km from Tabriz shows the heterogeneity of them throughout the time. The record of 26 earthquakes before 1900 is one indication of unimportant historical earthquake role in statistical distribution.

Most of these earthquakes have M = 4.4~4.6 which is called threshold magnitude.

If we assume the activity base of NTF 150 years

ago and consider the annual displacement of fault as 8 mm/yr, the width of fault would be about 1,200 m, and also if we presume the beginning of Quaternary two million years ago, the width of fault would be about 16 km [3]!

Based on the studies about periodical interval, the earthquake with $M > 6.5$ could occur in 250-260 years intervals. If we assume the earthquake of 1780 the last destructive earthquake of Tabriz, thus through next 25-30 years, if one of the segments of NTF releases energy, it can cause destruction of Tabriz and its surroundings. Finally, based on studies by Ghanbari [3]), activity of NTF and unbalanced regions indicate that it can be the cause of earthquakes with $M > 5$ Richter scale.

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