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Paleoseismicity and new seismicity studies in Azerbaijan and the necessity for seismic zonation

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Abstract: Azerbaijan is the site of convergent plate collisions along the Alpine-Himalayan active mountain belt. Brittle faults in the Azerbaijan area are mostly Cenozoic in or younger. The data presented demonstrate clearly that geological structures are commonly repeated at all scales from outcrop to regional. In order to forecast earthquake activity we need to determine the past history of faults. A fault that is active is likely to move again.

The great earthquakes of 6 May 1930 at 22 h 34 m. 24s (GMT) with M = 7.3 (the Salmas Earthquake), of 4 January 1780 with M = 7.7 (the Tabriz Earthquake) and of 21 June 1990 at a few minutes after midnight (local time) with a magnitude 7.4 (the Zanjan-Roudbar Earthquake) and located about 320 km NE of Tabriz, caused about 40 to 50 thousand deaths. 60000 were injured and 50000 to 60000 made homeless. These earthquakes have ruptured progressively from east to west. Consequently, there is a probability of a large earthquake occurrence in the North Tabriz Fault (NTF) and the central part of Tabriz to Khoy-Salmas fault. The average recurrence interval is estimated to be 250-300 years; more than 60-80 destructive earthquakes have been described in the 1000-1200 years in the history of Azerbaijan. Therefore, as there is a likelihood of large and dangerous earthquakes in Tabriz, micro-seismic zonation of the Tabriz and other seismic regions of Azerbaijan should be included in future construction planning of the country and it will be effective for the macro-economic and industrial planning of the country.

Résumé: L'Azerbaïdjan est l'emplacement des collisions convergentes de plat le long de l'alpestre - ceinture active de montagne de Himalayan. Les défauts fragiles en Azerbaïdjan appartiennent la plupart du temps à cénozoïque de plus jeune dans l'âge quaternaire. Les données présentées démontrent clairement que des structures géologiques sont généralement répétées à toutes les balances d'affleurement à régional. Afin de prévoir l'activité de tremblement de terre que nous devons déterminer l'histoire passée des défauts. Un défaut qui est en activité est susceptible de se déplacer encore. Les grands tremblements de terre de 6 peuvent 1930 22 à M. 24s (GMT) de h 34 avec M = 7,3 (tremblement de terre de Salmas) et tremblement de terre de Tabriz en 4 janvier 1780 avec M = 7,7 et Zanjan - le tremblement de terre de Roudbar 21 juin 1990 aux minutes après le minuit du temps local un tremblement de terre de la grandeur 7,4 a frappé environ 320 kilomètres de Ne de Tabriz, causant environ 40 à 50 mille personnes tuées. 60000 blessés et 50000 à 60000 sans-abri ces tremblements de terre ont rompu progressivement d'est-ouest. La probabilité de la grande occurrence de tremblement de terre dans le défaut du Nord de Tabriz (NTF) et la partie centrale de Tabriz au défaut de Khoy-Salmas. On estime à que l'intervalle moyen de répétition de 250-300 ans, plus de 60-80 tremblements de terre destructifs ont été décrits en 1000-1200 années dans l'histoire de l'Azerbaïdjan, par conséquent, car il y a grand et les périodes dangereuses de tremblement de terre dans la zonation microsismique de Tabriz est nécessaire à Tabriz et d'autres régions séismiques de l'Azerbaïdjan inclure dans la future planification de construction du pays et de lui sera efficace dans la planification économique et industrielle de pays.

Keywords: Data analysis, Earthquake, Geological hazard, Regional planning, North Tabriz Fault (NTF).

INTRODUCTION

The fight against damage, destruction, loss of property and life from earthquakes continues. Efforts for prediction of earthquakes for over the last 100 years have not enabled researchers to effectively predict the location, time and size, so as to save loss of life and property. Even if the prediction of individual large earthquakes were possible, it would be of questionable utility. The Azerbaijan and the south Caspian Sea basin belongs to the Alpine- Himalayan system, an area high geological complication and large - scale active deformation (Jackson and McKenzie 1984).

This paper is concerned with the active tectonics and structure of the Azerbaijan and South Caspian basin and its role in the collision between Arabian and Eurasian plates.

These studies can be effective in seismic- microzonation for industrial and economical aims and planning in the area. On a map of earthquake epicenters (Figure 1), the Azerbaijan and southern Caspian basin stands out as a seismic block about 300×300km^2 (Jackson *et al.* 2002) surrounded by belts of intense earthquake activity.

Other similar a seismic blocks occur in the same region, such as the Dasht - Lut, Central IRAN, south of Ourmiah - lake in Azerbaijan and NW areas, historical studies show that the seismicity within all of these blocks has been low for at least 1000 years (Ambraseys and Melville 1982). These seismic blocks are effectively rigid, and that the 30-35 mmyr^{-1} of N-S shortening between Arabian and Eurasian plates, is absorbed in the active earthquake belts that surround them (Jackson and McKenzie 1984).

Severe earthquakes are felt in Tabriz and its surroundings. Tabriz city in Azerbaijan is in a seismically active region and hence it is important to understand the existing earthquake hazard to the city on a scientific basis. A general review of the seismic status of Tabriz, highlights the importance of seismic microzonation.

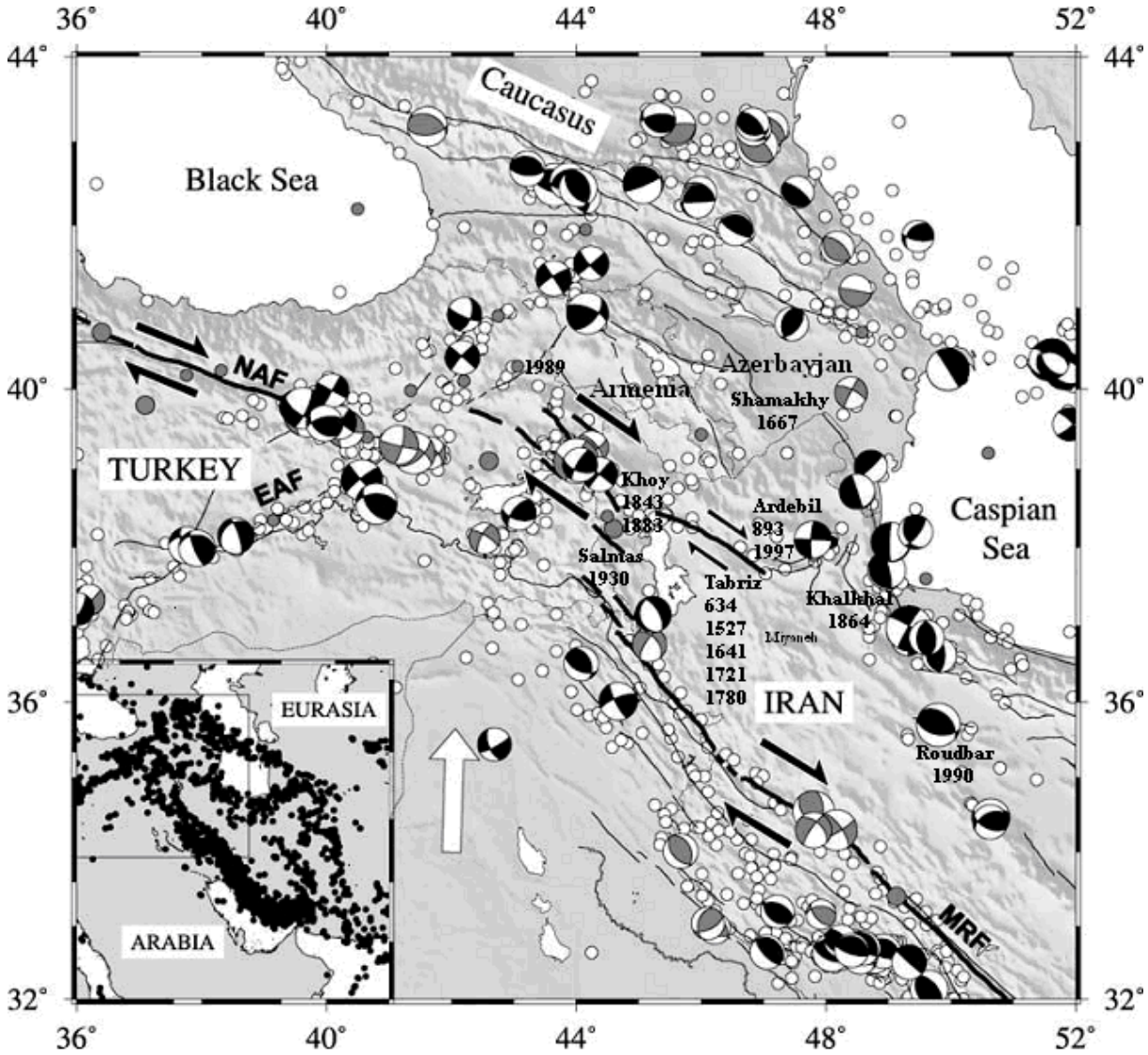

Figure 1. Summary seismo-tectonic map of NW IRAN, eastern Turkey and the Caucasus

Seismotectonics events and the major active faults in Azerbaijan and south Caspian Sea

IRAN, as one of the world's most earthquake- prone countries, has been exposed to many devastating earthquakes in the past long years. Earthquakes occur when any of the 12 or 13 plates important to the region's seismicity collide at their boundaries. A 13th plate was created by the break up of the Indo- Australian plate and was documented in 1995. The paleoseismics and neoseismics are due to compression between the Arabian and or Touran plates in the area.

The Iranian plateau accommodates the 35 (mm/yr) convergence rates between the Eurasian and Arabian plates by strike-slip and reverse faults with relatively low slip rates in a zone 1000 km across, (Berberian and Yeats 2001). GPS measurements suggest right-lateral displacements in Azerbaijan and south Caspian basin. The right-lateral deformation occurring between south Kura basin and the Central Iranian block could be distributed along NW-SE Iranian and Nakhjvan – Armenian fault systems.

Paleoseismologic studies (Philip et al. 2001) suggest low velocities and long-recurrence time interval (2.24±0.96 mm/yr, 3000-4000 years) along the Nakhjvan-Armenian faults.

The recurrence time interval on the north Tabriz fault (NTF) are shorter ~250 year, Berberian and Yeats (1999) with large events up to M = 7.7 if we assume that about 5mm/yr of right-lateral displacement occurs along the (NTF) with a recurrence time interval of 250 years. The average displacement is about 1.25m for each event.

Using empirical relationships between moment magnitude and maximum displacement a magnitude is ≈ 7 would be anticipated for future events, (Wells and Coppersmith 1994).

The series of faulting events during 1780-1999 (Tabriz earthquake 4 January 1980, Ms = 7.7, Salmas earthquake 6.May 1930 Ms = 7.5, Mb = 7.0, and Manjil earthquake 21 June 1990) is one of the most striking observed examples

of fault segmentation on land. The Tabriz to Salmas faults have produced more than two large earthquakes and have ruptured the fault progressively from east to west, (Ghanbari 1998, 1999, 2004) and increased the probability of large earthquake occurrence in the (NTF) and the central part of the Tabriz to Salmas fault.

Finally, these studies are consistent with the magnitudes proposed by Berberian and Yeats (1999) for the historical events along the (NTF). Therefore, most of the right-lateral displacements could be located on the (NTF) and other faults in the NW Iran and south Caspian basin. The NTF system could be the eastward prolongation of the north Anatolian fault (NAF) in Turkey, which is consistent with background information on the historical earthquakes in Tabriz and the relationship with the NTF. Seismicity in Azerbaijan especially in Tabriz city is moderate and high.

Reliable historical records of earthquakes is Azerbaijan based on macroseismic observations, cover a period of 1200 years. The historical record of small, felt earthquakes with no damage to constructions is complete for the period 1780.

The map of historical seismicity of Azerbaijan (Figure 2) displays regions and zones of differing seismic activity. A similar pattern of seismically active and less active regions shows up both in the distribution of stronger earthquakes and in the distribution of weak local events. North-west to south-east Azerbaijan trending zones of higher seismic activity are located in NW of Iran and in the western Caspian basin.

Paleoseismic investigations performed along the (NTF) scarp, which is part of a NE-NW oriented fault system along the Moro - Mishow - Dagh mountains, show clear evidence of repeated normal faulting events. Over its central part, between Sofian town and north of Tabriz (Baghmesha), the fault trace is approximately N115^{o} E and the dip is vertical (Berberian and Arshadi 1975). The north Tabriz fault (NTF) forms a well-marked boundary between the rocks of the Miocene upper red formation of the Tabriz border folds and Pliocene-Quaternary alluvial deposits.

Of the Tabriz piedmont zone, up thrusting the Miocene rocks are juxtaposed against the alluvial deposits, especially west of the Tazek and Khaje-Marjan villages and NE of Tabriz airport.

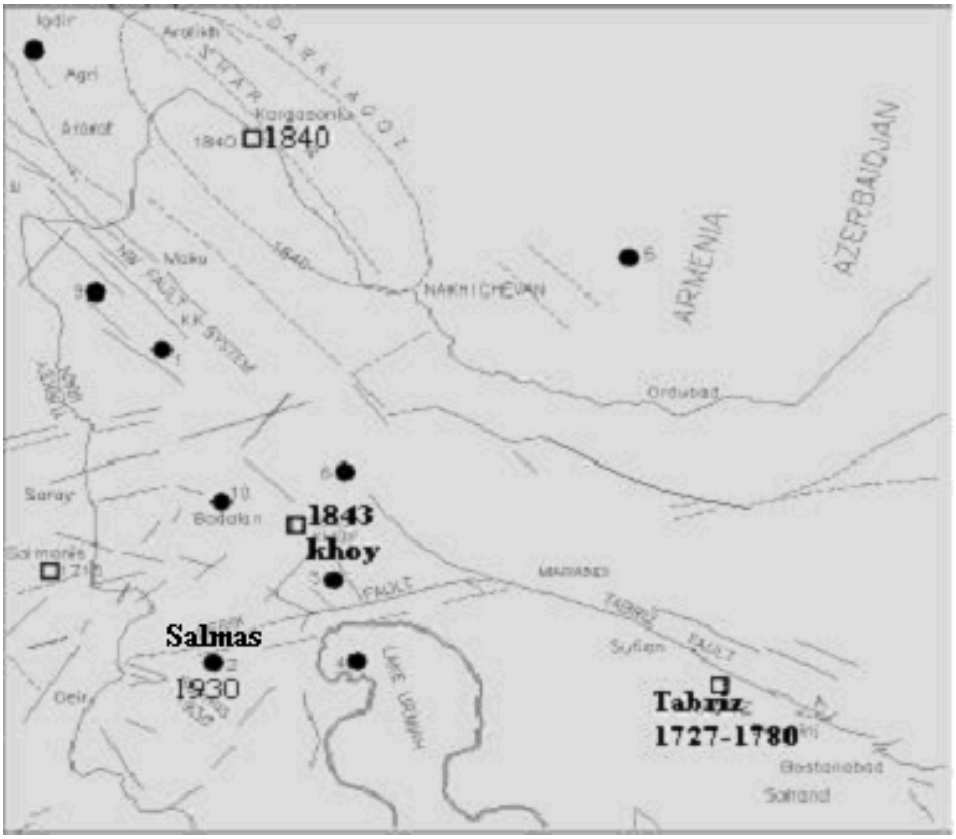

Figure 2. Distribution of historical large earthquakes of NW IRAN (Azerbaijan).

Historical devastating earthquakes in Tabriz city

The (NTF) is a geological fault which has been reactivated during movements. In recent times parts of it have been reactivated and the rest also has high seismicity.

Study of the seismic history of Tabriz based on available data shows that the region has been seismically active since 634 A.D., although there are several recorded shocks for which there is no macroseismic information, however these earthquakes were strong enough to be reported by the early chroniclers (Ambraseys 1974 and Berberian 1974).

The destruction of Tabriz by several catastrophic earthquakes during historical times needs critical study to establish whether they were associated with the (NTF). One of the most likely cases of ground deformation, which could be due to earthquake faulting is mentioned by Brydges (1834) is the description of the region just north of Basminj town. According to Eprikian (1903), five major destructive earthquakes are remembered as having occurred in Tabriz, four of which took place in 634, 1441, 1522, and 1780. During the first two (634,1441) earthquakes the city

was completely destroyed, and during the latter two (1522, 1780) there were 70,000 and 40,000 casualties, respectively (Berberian 1974). During these destructive earthquakes the most famous historical building of Tabriz collapsed.

Finally nowadays in the (NTF) piedmont of Tabriz a number of small and large towns have buildings such as " Bagmesha, Eram, Rushdieh… that all are parallel to the (NTF). The Tabriz north freeway, with a length of 15 km extending from SE to NW of Tabriz runs to the airport. In any probability of earthquake this part of Tabriz will have considerable damage because or its location.

CONCLUSION

Iran is one among the countries that are most vulnerable to a variety of natural disasters. Perhaps, due to their relatively higher frequency, hazards due to floods, droughts and earthquakes hazard are managed in a more professional manner.

A spate of earthquakes in the recent past, causing extensive damage has heightened sensitivity of engineers and planners to the looming seismic risk in densely populated Azerbaijan cities. Tabriz city is in a seismically active region and hence it is important to understand the existing earthquake hazard to the city on a scientific basis. For example, by considering the studies performed on the period of historical earthquakes and comparison with the return period of earthquakes larger than M = 7. Seismicity of this type has occurred during the last three decades in the (NTF), where the recurrence period of dangerous earthquakes is about 250 to 260 years.

This requires the seismic microzonation of Tabriz and other cities with earthquake potential in Azerbaijan and the regions of Caspian basin and NW of Iran.

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