Ninth Canadian Conference on Earthquake Engineering
Ottawa, Ontario, Canada
26-29 June 2007

SEISMOTECTONIC EVENTS ALONG THE TABRIZ AND ANATOLIAN FAULT

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ABSTRACT

The seismicity of Iran can be divided into two main active regions or belts. First there is the northern seismic belt running from Black Sea that is bifurcated into two branches; west of the Azerbaijan-Caucasus and across the Caspian Sea in the Kopet-Dagh, northeast of Iran. Second, there is the southern seismic belt originating from the north Anatolian fault in Turkey and continuing along the Zagros Mountains to the Hormoz strait at the entrance of the Persian Gulf. More than 60 to 80 destructive earthquakes have been recorded in the past 1000 years in Azerbaijan. This study is an attempt to provide material and hypotheses for further investigation into the mechanisms of these earthquakes. The major regional faults, the North and east Anatolian fault and the main Tabriz fault in Azerbaijan-Iran are considered.

Introduction

Faults play a key role in a variety of process in the earth's crust. They produce some of nature's most destructive phenomena and accommodate tremendous deformation in the earth's crust over geological time. Observations along exhumed faults provide information on faulting processes at depth that is difficult to obtain by other means.

Our analysis area (Fig. 1) is situated in the northwest of Iran. This area developed the most dominant surface rupture that was related to the Salmas and Tabriz earthquakes. The objective of this research is to correlate the potentially dominant surface fracture zones, as determined from topography, and the potentially active surface fracture zones, as determined from the aftershock from the Tabriz and Tasuj and Salmas earthquakes. The potential fracture zones that are identified in this complex segment of the fault show a strong spatial correlation between the fracture zones at the surface and the seismicity of the region. Seismically active fracture zones develop along local zones of crust weakness that are compatible with the local stress field. Seismic activity associated with these tectonic structures occurs dominantly within these fracture zones, but many events also occur on minor secondary structures during local deformation and dilation.

The Tabriz fault starts in the southeast near Bostanabad (Ujan), follows a N280-300 direction passing along the northern suburbs of the town of Tabriz and divides near Marand into the Derik fault (Fig. 2) and the northwest fault system. A section of the fault between Tabriz and Soufian has been recently studied (Ghanbari 1991). At the surface, the fault plane is vertical and the southern block down thrown by up to 80-100 m. Northwest of Soufian, stream diversions visible on satellite and air photographs suggest young

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right-lateral displacements, which have not yet been verified on the ground.

Objective of this Study

The interaction of major fault systems, particularly where one type of fault terminates against another, is a subject of considerable interest but it is rarely subject to direct field investigation. The aim of this research is to study the behavior of the Tabriz fault in relation to dangerous earthquakes which have been very destructive for most of the cities and villages in this state.

The general direction of the Tabriz fault (Fig. 2) is continued after Marand town by a system of little known NW-SE faults of probable Plio-Quaternary activity, referred to here as the Northwest fault system. Plio-Quaternary lava flows and alluvial cover make it difficult to trace the faults in the depression of Khoy-Qarakelissa region. But near to the Turkish frontier, in the 39-40N and 44-45E sector, they can be distinguished on satellite photographs (Fig. 2). Other smaller faults are also seen in the E-NE and W-SW direction, i.e. approximately parallel to the Derik fault.

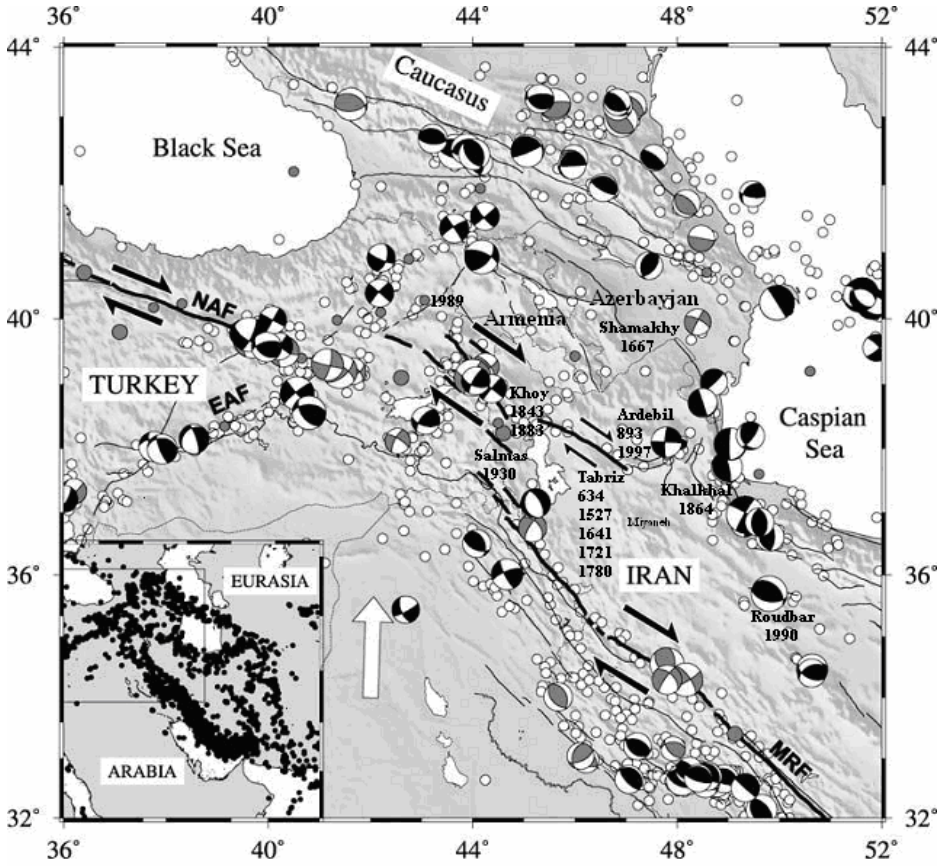

Figure 1. Summary seismotectonics map of NW Iran, eastern Turkey and the Caucasus. Continental lithosphere including the westward motion of Anatolia and the N-E motion of the Eastern Turkey, Lesser Caucasus (including Azerbaijan) region away from the Arabia-Eurasia collision zone (Reilginger et al. 2004).

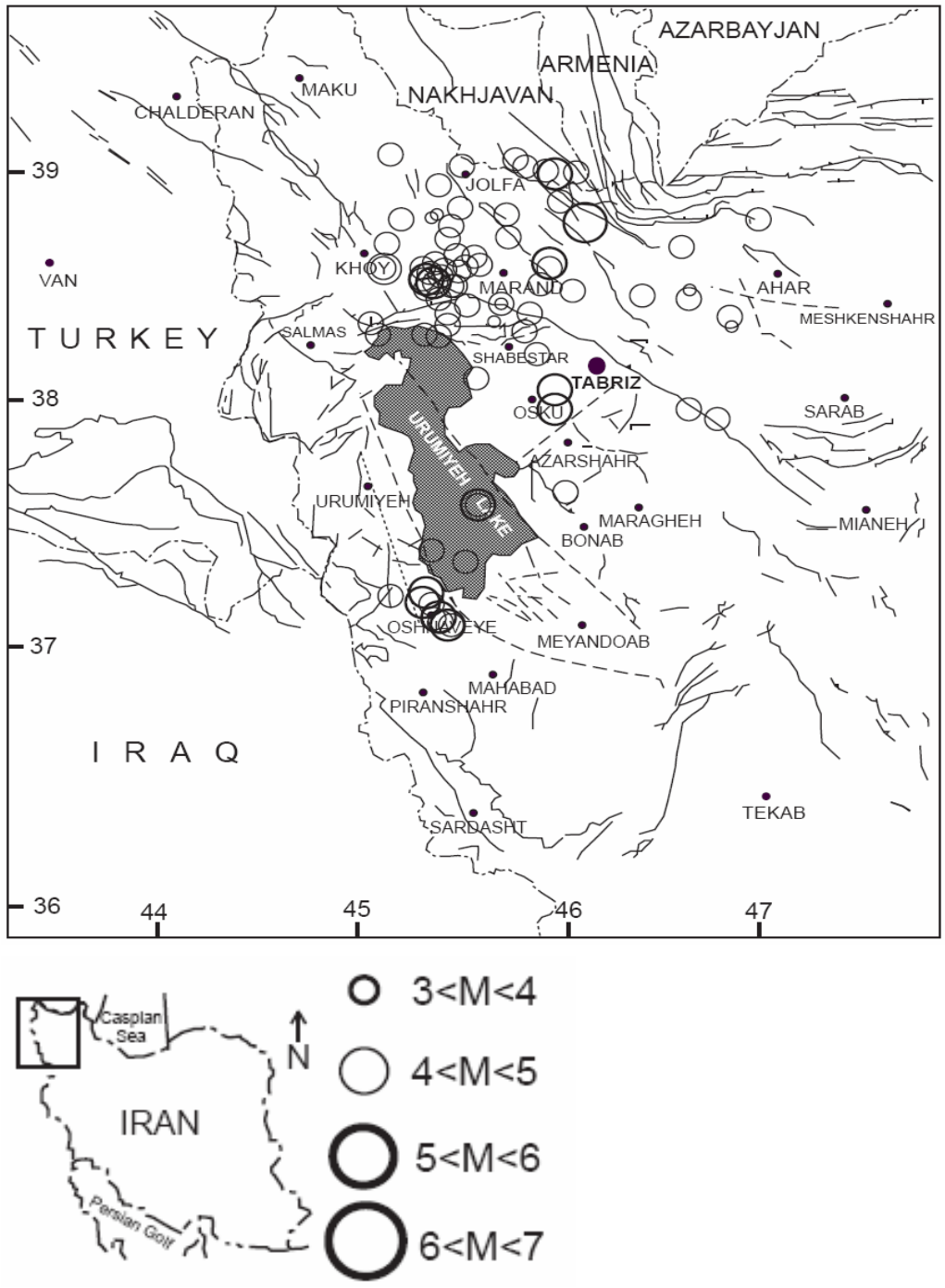

Figure 2. Quaternary fault map and seismogenic zoning of studied area. Scale: 1/2000000

Seismic Hazard in the North West of Iran

Historical studies have shown that Tabriz city has been devastated by several destructive earthquakes in the past, but a critical study is required to establish whether they were actually associated with the Tabriz-fault or not. No strong earthquakes are known to have occurred near this fault during the late 19th and early 20th centuries.

More than 60-80 destructive earthquakes have been described in the last 1000-1200 years in the history of Azerbaijan. Recurrence intervals for destructive earthquakes from each of the Azerbaijan active faults, which have average slip rates of 5-6 millimeters a year or less, are estimated at about 750-1000 years or longer. For example, an average recurrence interval of approximately of 1000 years is obtained from faults that move 2-3 mm/yr (i.e. the Tabriz and Salmas fault), if we assume co-seismic slips of 2m or destructive earthquakes with approximately M=6.5-7 (Matsuda 1991), i.e. Rudbar-Manjil earthquake (1990). Historical records of repeated destructive earthquakes along the same fault are extremely rare (Fig. 3). The only exception is the Salmas fault along which destructive earthquakes occurred in 1930, with M=7.3.

As previously observed, the Tabriz region has not experienced any major destructive earthquakes since 1854, and it seems that there has been seismic quiescence from 1854 till now. Preliminary investigation of the tectonics and geomorphologic evidence along the North Tabriz fault is capable of sudden seismic slip, especially since the walls and buildings of the villages built on the fault line show no evidence of creep.

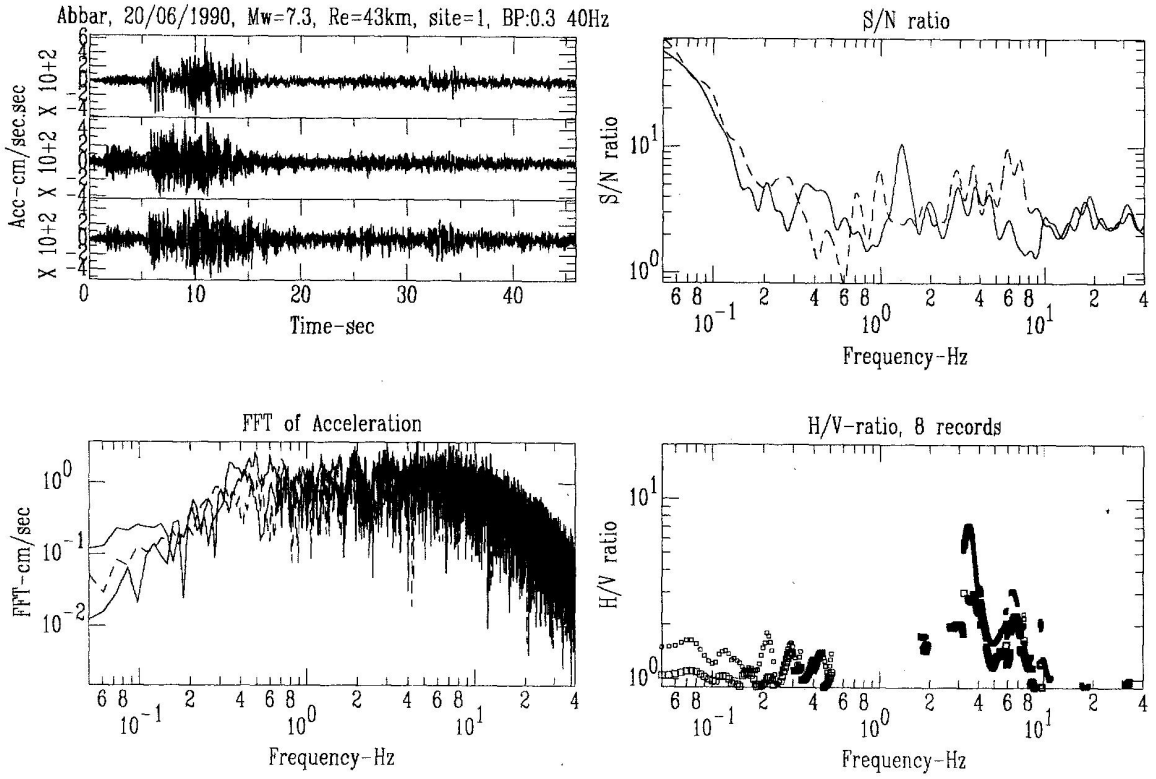

Figure 3. Diagram of acceleration, velocity and displacement.

Salmas Earthquake in 1930

On the 6th of May, 1930 at 07h03m an earthquake occurred as a multiple shock with magnitude given as M=7.3. It caused destruction and some casualties in a small region centered around 38.15O 44.75'E, corresponding approximately to the future macro seismic epicenter and southeastern Turkey and was clearly felt by most of the inhabitants of the three nearest towns; Tabriz, Ourmiah and Khoy, as well as in Binab and Maragheh. This area has been recognized as a seismically active zone for a long time and has been considered as a high seismic zone in the Azerbaijan code for seismic resistant design of buildings.

Historical seismicity of the region shows that an intensive earthquake has hit the region and caused heavy

causalities. The Salmas plain, the epicenter region of the earthquake, is located to the NW of Ourmiah Lake and has an area of about 300 km^2. About 60 villages located in the Salmas plain and the surrounding mountains were destroyed. Casualties, which occurred nearly exclusively amongst the section of the population which had not heeded the foreshock, amounted to about 2514 killed.

Discussion and Conclusions

Observations along exhumed faults provide information on faulting processes at depth that is difficult to obtain by other means. Active faults, such as the Tabriz and Salmas fault, are faults that show evidence of repeated movements in recent geologic time (Fig. 4). An extensive study of active faults began in the early 1985, as one of the research tasks of the International Institute of Earthquake Engineering and Seismology (IIEES) in Iran. The investigation has been conducted co-operatively by geomorphologists, geologists, geophysicists and seismologists who are affiliated with various universities and research institutions.

In the NW of Azerbaijan there are two major faults: Tabriz fault and Derik-Salmas fault. But ground displacements associated with the Salmas earthquake (1930) were interpreted in terms of a regional extension and an eastward motion of crustal material. The present study is reconnaissance aimed at providing material and hypotheses for further investigation of this problem. It is shown how are the Major faults, North and East Anatolian fault and Tabriz fault in Azerbaijan-Iran. By Means of seismographs which have been installed in NW of Iran, recently, more than 2850 slight earthquakes have been recorded in Julfa and Nakhjavan regions (Oct.1995 to Oct.1996) There were mainly small and medium earthquakes with magnitude between M=2 and M=5. This fact demonstrates that recent Plio-Quaternary faults are active in the mentioned zones.

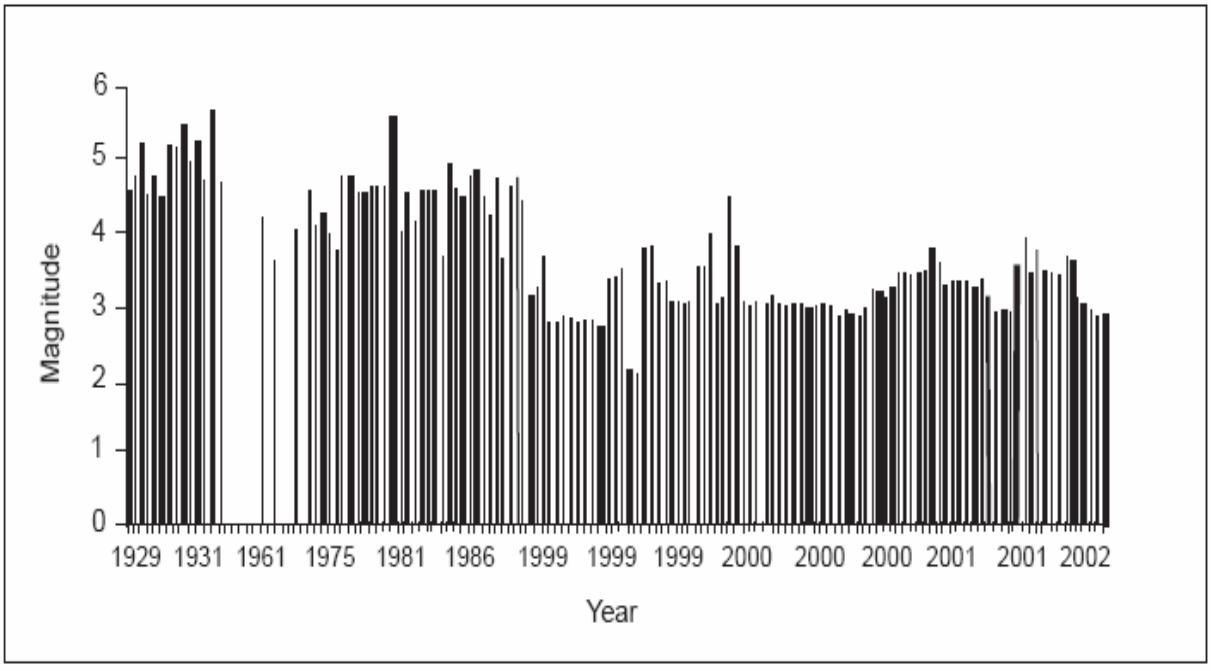

Figure 4: Magnitude of earthquakes from 1929 to 2002 in Azerbaijan, Iran.

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