2. TECTONICS, SEISMICITY AND EARTHQUAKE OCCURENCE PATTERN OF TURKEY

2.1 Tectonics

The tectonic evolution of Turkey according to Şengor (1979) is shown in Figureure 2.1. Figureure 2.1 (A,B,C,D) indicates the evolutions at different geological periods. The evolution of Turkey has been associated with the uplift of the Levantine ocean base between Euro-asia and Africa as a result of the northward motion of the African continent (Ketin 1973). This phenomenon explains why the tectonic structure of the Turkish plate consists of melange Anadolu (Anatolides) and overlaying limestone-based sedimentary formations of Toros Dağları (Taurides) and Kuzey Anadolu Dağları (Pontides).

The maın fault system of Turkey is shown in Figure 2.2. Northward motion of of the Arabian plate relative to Euro-Asia causes lateral escape of the Anatolian block to the west and the North-East Anatolian block to the east. The North Anatolian Fault(NAF) and East Anatolian Fault (EAF) constitute the northern and southern boundaries, respectively, of the westward moving Anatolian block. The motion of the Northeast Anatolian block is complicated by extensive internal deformation of the block along conjugate faults.

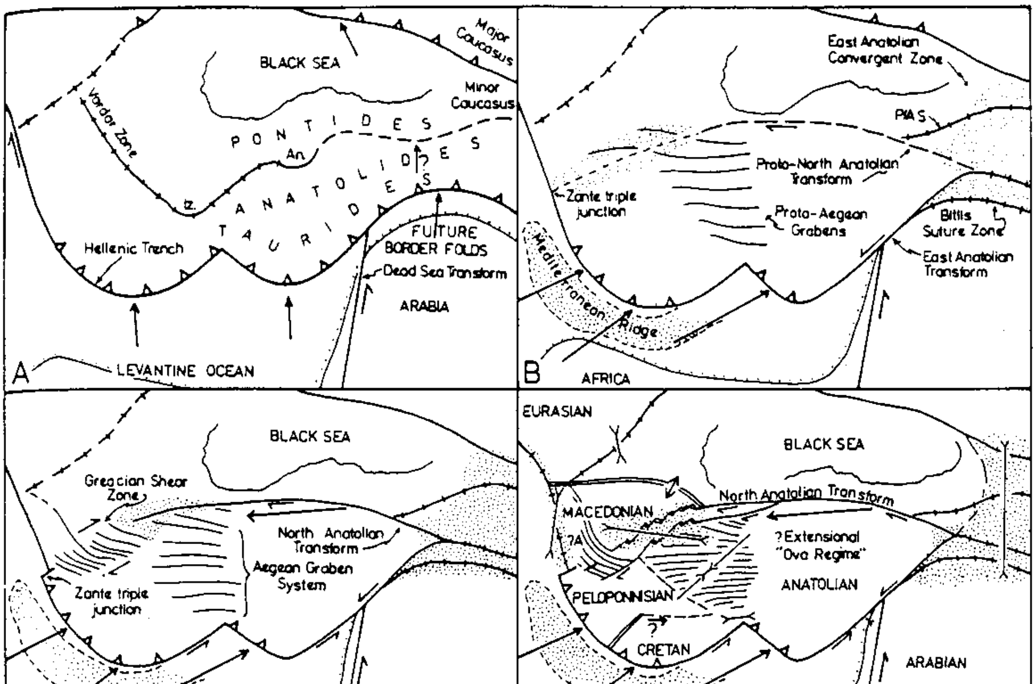

Figure 2.1 Tectonic evolution of the eastern Mediterranean(after Şengör 1979)

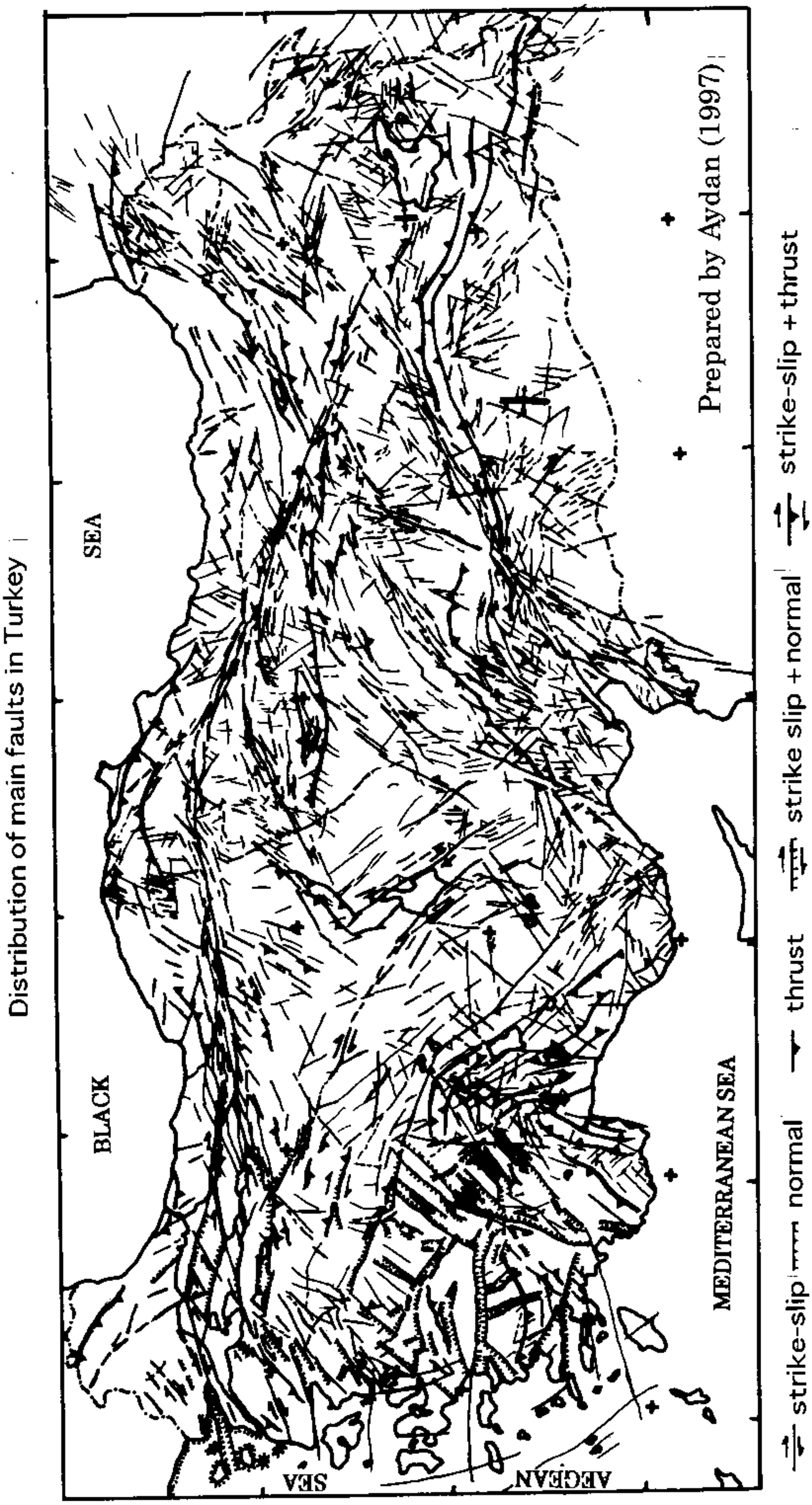

Figure 2.2 The main fault system of Turkey

2.2 Seismicity

Figure 2.3 shows the distributions of the epicenters and depth of earthquakes in Turkey for a period between 1975-1998 compiled by NEIC. It is noted that epicenters are concentrated on the famous NAF and EAF and the graben system of the Western Turkey. The depth of hypocenters along the NAF and the Western block are between 10 to 20 km while the earthquakes along the EAF are much deeper since the EAF corresponds to the subduction zone between the Arabian plate and the Anatolian plate.

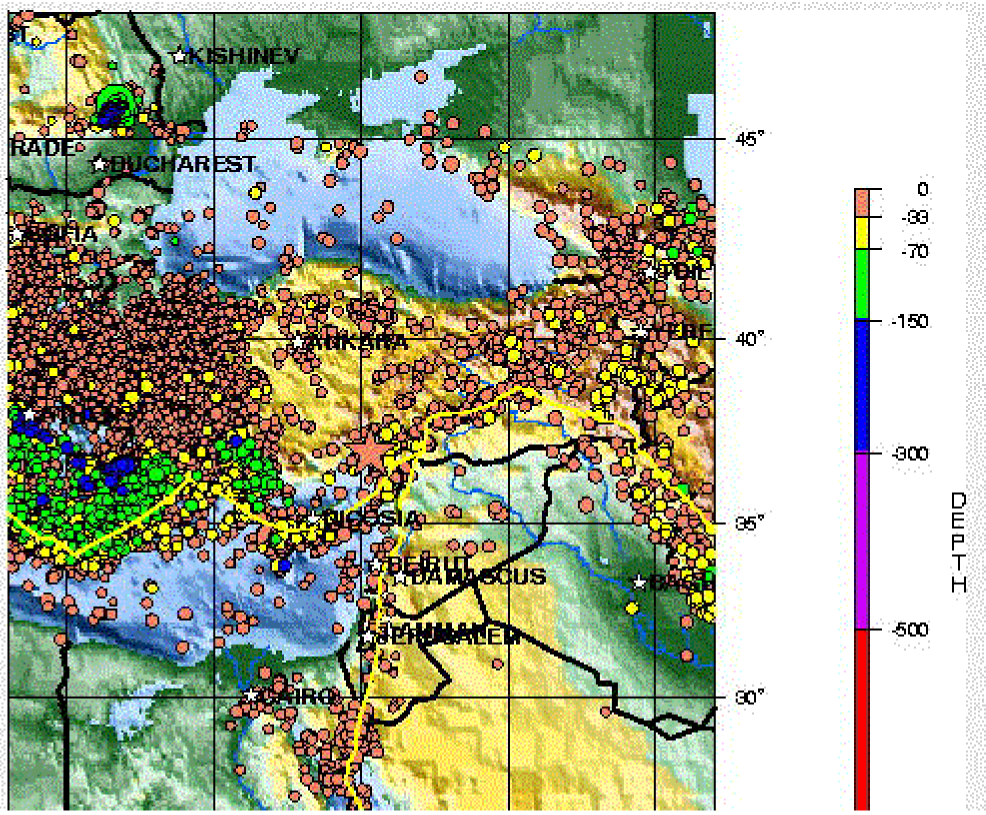

Figure 2.2 Epicenters of earthquakes in Turkey and its close vicinity (after NEIC)

2.3 Earthquake Occurrence Patterns

Aydan investigated the earthquake occurrence pattern of Turkey through a data-base system covering a time span of 2000 years (Aydan et al. 1996, Aydan 1997). Aydan et al. grouped earthquakes in association with the main fault system of Turkey. These faults are grouped into: North Anatolian Fault Zone (NAF), East Anatolian Fault Zone and Bitlis-Zagros Thrust (EAFBT), North East Anatolian Fault Zone (NEAF), West Anatolian Fault System (WAFS), and Central Anatolian Fault System (CAFS). Figure 2.4 shows the relation between time (year) and Magnitude M_s of earthquakes for various faulting groups of Turkey, processed by this system. As it is noted from the Figure, very large events ($M_s > 7$) occur at the NAF and at the EAFBZ while the magnitude of events at the WAFS and the NEAF are generally less than M_s=7. It seems that the initiation of seismic activity occurs in the near vicinity of Karlıova junction (see Figure. 1 for the location) in the form of lateral strike slip and/or reverse faulting. Reverse faulting events are generally shallow (h<15km) while strike-slip faulting events are deeper. As a result, events are simultaneously or with a slight delay initiated in the WAFS in the form of normal faulting. For example, the Kuşadası earthquake (M_L=6.0) on 06/11/1992 and the recent Dinar earthquake (M_L=6.0) on 01/10/1995 followed the Erzincan earthquake (M_L=6.9) on 13/03/1995 and Pülümür earthquake (M_L=6.0) on 15/03/1995 confirm this conclusion. The events in the WAFS have smaller magnitudes as the stress state to cause normal faulting could not result in higher energy accumulation as compared with those in the NAF and the EAFBZ. However, the frequency of events in the WAFS is greater than that of the eastern events. This is mechanically a quite natural consequence of the stress states to cause normal faulting and strike-slip faulting.

Although it is still immature to propose an exact model for earthquake occurrence pattern in Turkey, the following model may be put forward in view of the available data:

1) Crushing and strike-slip faulting in the vicinity of the Karlıova junction of the NAF, NEAF and EAFBZ: The driving force results from the northward moving and anti-clock wisely rotating Arabian plate. It must be noted that it is almost impossible to push the Anatolian plate westward by a purely northward-moving Arabian plate. If the anti-clock wise rotation of the Arabian plate exists, then it will provide an enough momentum to push the Anatolian plate towards the west. Recent Çaldıran earthquake (24/11/1976) validates the above statement.

2) **Uplifting and normal faulting in the western Anatolia:** The westwardly pushed Anatolian plate is restrained by the Aegean plate and is uplifted by the northwardly moving African continent against the stationary Euro-Asian plate. This results in bending the western part of the Anatolian plate which causes normal faulting in the uppermost part of the crust. This results in a further growth of the host-graben structure in the western Anatolia. However, it should be noted that there is a general tendency for uplifting the whole western Anatolia. For example, the historic sea-side cities such as Efes (Ephesos) and Milet (Miletos) in the grabens of Küçük Menderes

and Büyük Menderes respectively are retreated by 3 to 4 km away from the present sea shore, which validates the above conclusion.

3) **Rotation of the Anatolian Plate:** Because of the combined action of the slower rate of motion of the African plate with respect to that of the Arabian plate, westward pushing by the Arabian plate, restraining by the Aegean plate and uplifting by the African plate, the Anatolian plate tends to rotate anti-clock wise, aided with the motion of the rotating Earth. This action causes subsequent events along the entire perimetry of the Anatolian plate. Without doubt the magnitude of events at bends, where stress concentrations occur, are larger than at other less restraining segments of the faults.

The information from the present data-base systems and previous two dimensional elasto-plastic finite element analyses of Turkey and its close vicinity (Kasapoğlu and Toksoz 1983) confirms most of the above statements. Nevertheless, three-dimensional elasto-visco-plastic analyses with the consideration of the actual geologic structure of the Earth's crust in Turkey and its close vicinity are necessary. If these analyses are backed up by in-situ stress and deformation measurements, they can probably yield an exact model for the earthquake occurrence pattern in Turkey.

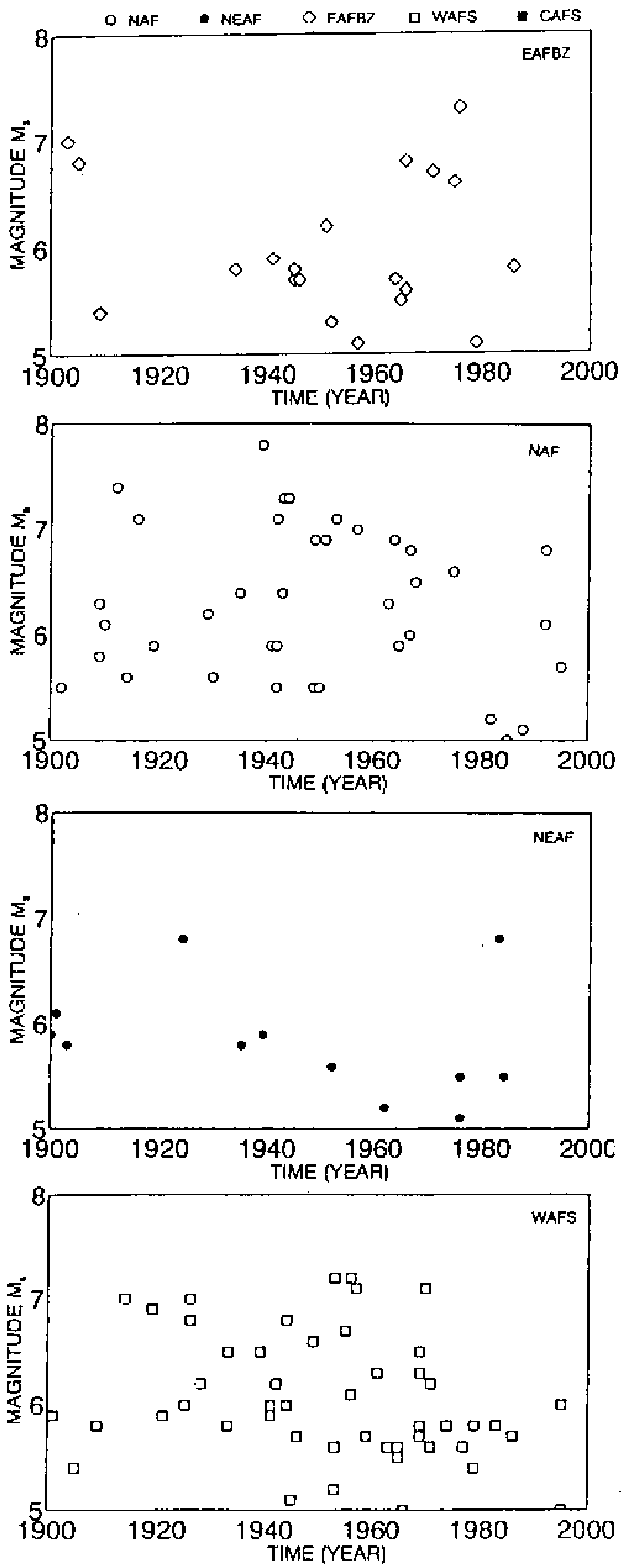

Figure 2.4 Migration of earthquakes along the main fault system of Turkey