

## TÜRKİYE VE CİVARINDAKİ FARKLI KAYNAK BÖLGELER İÇİN DEPREM HAZARD PARAMETRELERİNİN BÖLGESEL DEĞİŞİMLERİ

### REGIONAL VARIATIONS OF EARTHQUAKE HAZARD PARAMETERS FOR DIFFERENT SOURCE REGIONS IN TURKEY AND VICINITY

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**Anahtar Kelimeler:** Türkiye, deprem tehlikesi, olasılık, beklenen maksimum magnitüd

**ÖZ** Bu çalışmada, Türkiye'nin farklı sismik bölgeleri için geri dönüşüm periyodu, verilen bir zaman aralığındaki olası en büyük magnitüd ile verilen bir zaman aralığı ve magnitüd değeri için depremin oluşma olasılığı gibi deprem hazard parametreleri değerlendirilmiştir. Bu amaçla, deprem hazard parametrelerinin hesabı için gerekli olan değerler Gumbel I asimptotik dağılımı kullanılarak hesaplanmıştır. Çalışmada kullanılan veri KOERI ve ISC kataloglarından derlenmiştir. Sonuçlar, Kuzey Anadolu Fay zonunun orta kısmının gelecekte büyük bir depremin oluşumu için en olası bölge olduğunu göstermektedir. Bu sonuç, magnitüdü  $M \geq 7.0$  olan bir deprem için en büyük değeri (% 92.3) gösteren olasılık haritası ile güçlü bir şekilde desteklenmektedir. Bu magnitüd değeri için ortalama geri dönüşüm periyodu bu bölgede en düşüktür (39 yıl). Ayrıca, bu bölge için gelecek 100 yıldaki olası en büyük depremin magnitüdü 7.5'i aşmaktadır.

**Key words:** Turkey, earthquake hazard, probability, maximum expected magnitude

**ABSTRACT** In this study, the earthquake hazard parameters such as the mean return period, the most probable magnitude in a given time interval, and the probability of an earthquake occurrence for a given magnitude and time span are evaluated for different seismic regions of Turkey. For this purpose, the necessary values for the calculating of earthquake hazard parameters are computed by using the Gumbel's first asymptotic distribution. The data used in this study is compiled from the catalogues of KOERI and ISC. The results show that the middle part of North Anatolian Fault zone is probably the next region for the occurrence of a large earthquake. This conclusion is strongly supported from the probability map in which shows the largest value (92.3%) for an earthquake with magnitude greater than or equal to 7.0. The mean return period for such magnitude is the lowest in this region (39 years). Also, the most probable earthquake magnitude for this region in the next 100 years will exceed 7.5.

## INTRODUCTION

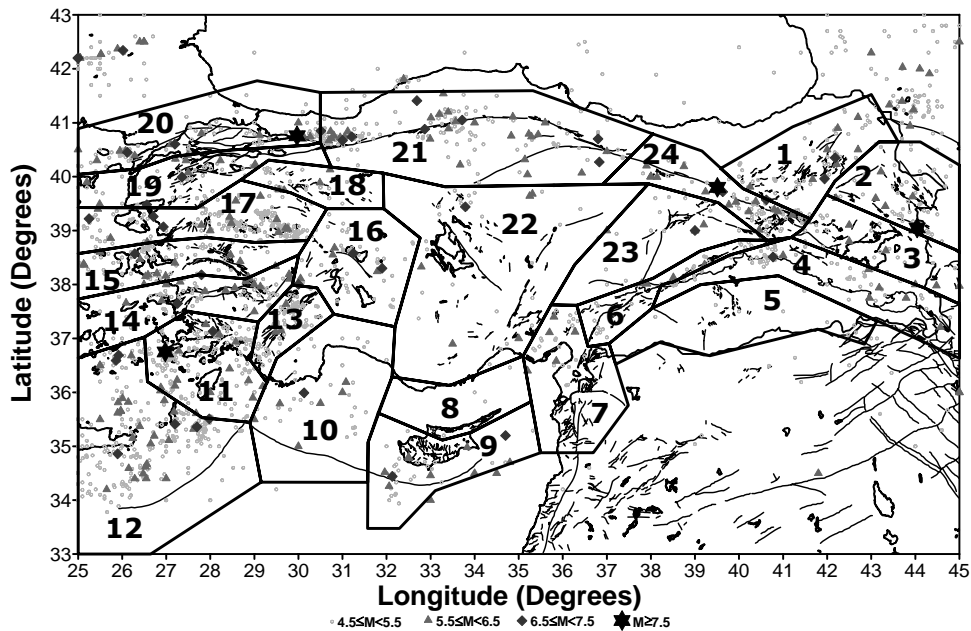
Turkey is located in a very seismogenic region and the qualitative techniques (epicenter maps, etc) as well as quantitative ones for the earthquake hazard in Turkey has therefore been widely applied using a number of different techniques and seismic quantities (e.g. Yarar et al., 1980; Erdik et al., 1999; Kayabalı and Akin 2003; Bayrak et al., 2005). The estimation of earthquake hazard involves the computation of long-term probabilities for the occurrence of earthquakes of a specified size in a given area during a

given time interval (Mäntyniemi et al., 2004). The aim of this study is to evaluate the regional variations of earthquake hazard in Turkey in terms of the mean return period for an earthquake occurrence, the maximum expected magnitude of earthquakes in a given time interval and the probability for a large earthquake occurrence.

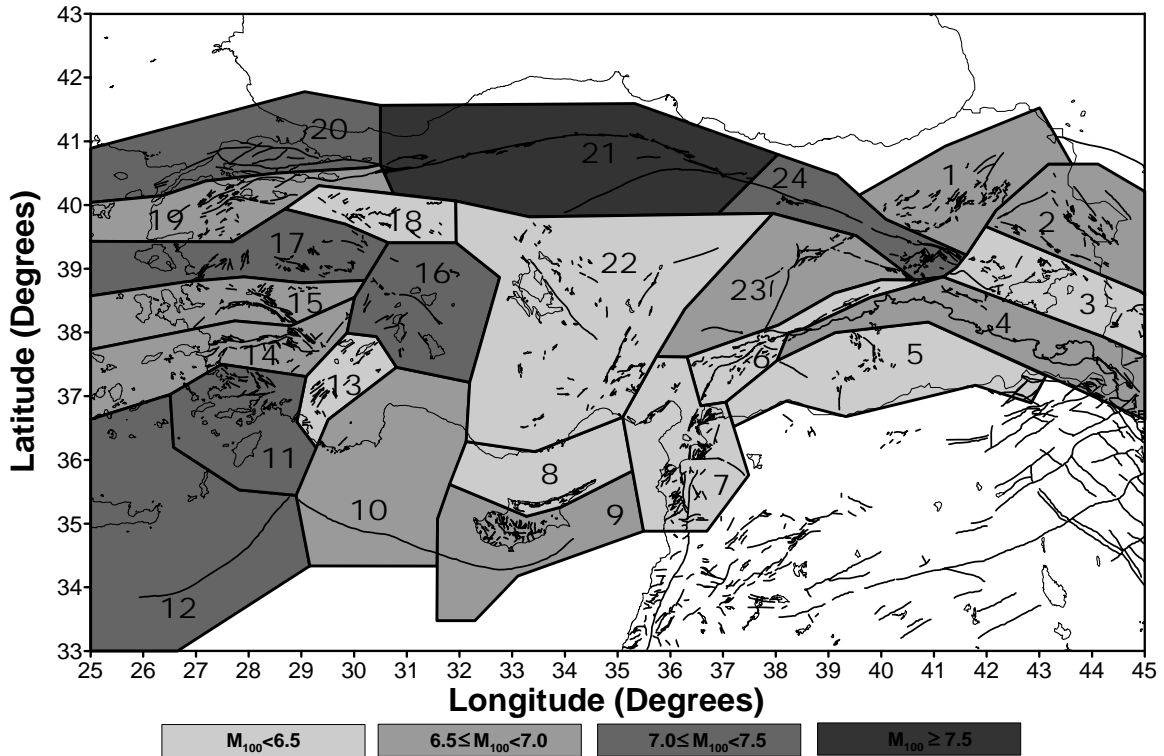
**DATA and METHOD**

The database we analyzed in this study is taken from the Boğaziçi University, Kandilli Observatory and Earthquake Research Institute (KOERI), starting from 1974 until 2005 which contains 68478 events, and from the International Seismological Center (ISC) and historical catalogue of KOERI, starting 1900 to 1974 which consists of 2398 events. Finally, we used a homogeneous catalogue of surface magnitude ( $M_S$ ) between the time interval 1900 and 2005 and shallow earthquakes (depth < 60 km) including 69339 events. We carried out our analysis in a rectangular area limited by the co-ordinates 25°E and 45°E in longitude and by the co-ordinates 33°N and 43°N in latitude. The seismic source zones considered in this study are defined according to the major fault systems and seismicity of Turkey as well as the studies and seismic source zones made by other authors (Yalçırak et al., 1998; Erdik et al., 1999; Kayabalı, 2002; Bayrak et al., 2005). Thus, Turkey was divided into 24 seismic source regions. These seismic regions with the tectonic structures and the hypocenter locations of earthquakes in Turkey from 1900 to 2005 are shown in Figure 1.

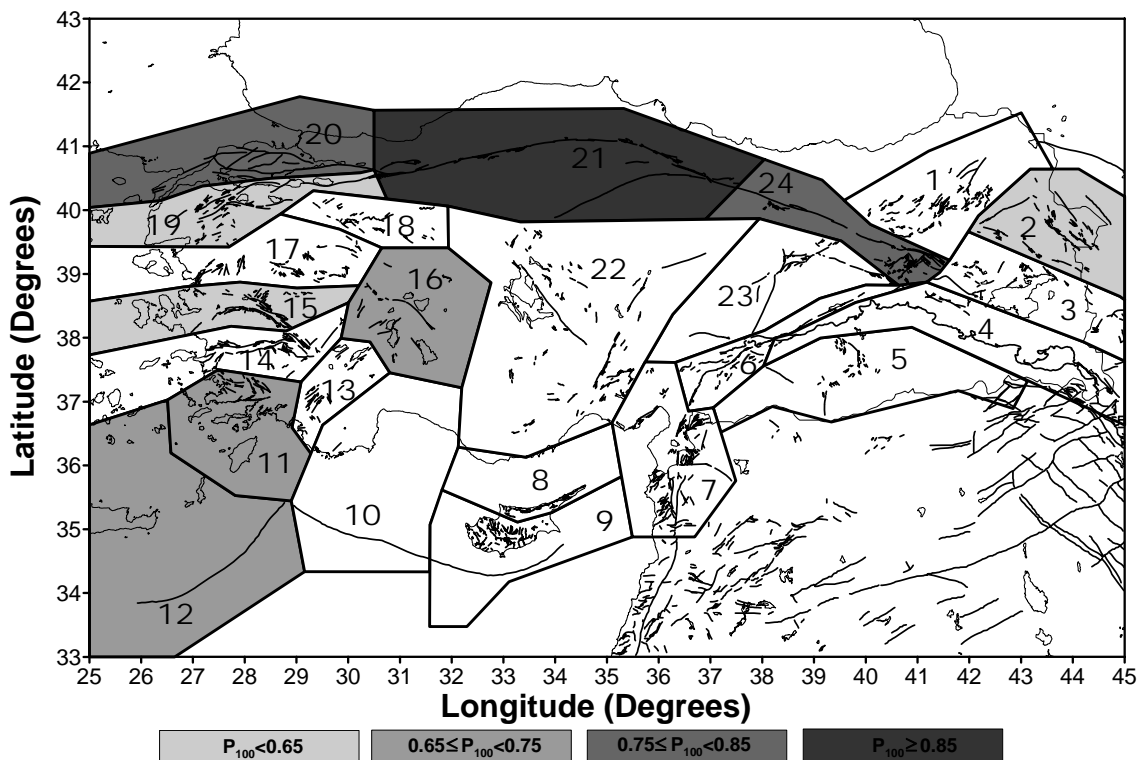
The distribution of earthquake magnitudes in time and size is generally processed by two methods: 1) using the extreme value magnitude and 2) using the whole available data. The former based on the theory of extreme value statistics developed by Gumbel (1935, 1966) and used in many applications. Generally the theory of extremes is formulated under the assumptions that: a) the prevailing conditions must be almost the same in future and b) observed largest values are independent of each other. Irrespective of the parent distribution, the extreme value distribution must take one of three forms. We applied the first type asymptotic distribution of extreme values in order to calculate the fundamental values which are necessary for computing of hazard parameters. Thus, spatial distributions of the maximum expected magnitudes to be occurred in the next 100 years ( $M_{100}$ ) and the probability of the occurrence for the earthquakes with magnitude  $M \geq 7.0$  in the next 100 years ( $P_{100}$ ) are shown in Figures 2 and 3.



**Figure-1.** Different seismic regions with major tectonics and epicenter of earthquakes in Turkey from 1900 to 2005. Magnitude size of earthquakes is shown by different symbol.



**Figure-2.**  $M_{100}$  (the maximum expected magnitudes to be occurred in the next 100 years) values for different 24 seismic source regions in Turkey and vicinity.



**Figure-3.**  $P_{100}$  (the probabilities in the next 100 years with magnitude  $M \geq 7.0$ ) values for different 24 seismic regions in Turkey and vicinity. In regions with white color, there is not an earthquake probability of occurrence for magnitude  $M \geq 7.0$  in the next 100 years.

## CONCLUSIONS

The aim of this study is to make an effort in order to obtain the useful information concerning the earthquake hazard parameters in Turkey and vicinity. For this purpose, we used Gumbel first asymptotic distribution of extreme values in order to compute the main values which are necessary to calculate the earthquake hazard parameters such as the mean return periods, the maximum expected magnitudes to be occurred in a given time interval, and the probability of an earthquake occurrence for a given magnitude and time span. The data we used in this study is taken from KOERI catalog, which starts from 1974 until 2005 and contains 68478 events, and from ISC and historical catalogue of KOERI, which starts 1900 to 1974 and has 2398 events. Finally, we used a homogeneous catalogue of  $M_S$  between the time interval 1900 and 2005 and shallow earthquakes (depth < 60 km) including 69339 events. Turkey was divided into 24 different source regions considering different zonation studies made by several authors for modeling of seismic hazard in Turkey, and drawing the existing tectonic structure with the episant distribution of earthquakes. Thus, we mapped the spatial distributions of earthquake hazard parameters. The results show that the middle part of North Anatolian Fault zone is probably the next region for the occurrence of a large earthquake. This conclusion is strongly supported from the probability map in which shows the largest value (92.3%) for an earthquake with magnitude greater than or equal to 7.0. The mean return period for such magnitude is the lowest in this region (39 years). We also estimated the maximum expected earthquake magnitude for next 100 years. This parameter also supports that in the middle of North Anatolian Fault zone the most probable earthquake magnitude in the next 100 years will exceed 7.5.

## REFERENCES

- Bayrak Y., Yılmaztürk, A., and Öztürk, S., 2005, Relationships between fundamental seismic hazard parameters for the different source regions in Turkey, **Natural Hazards**, 36, 445-462
- Erdik, M., Alpay, B. Y., Onur, T., Sesetyan, K., and Birgoren, G., 1999, Assessment of earthquake hazard in Turkey and neighboring regions, **Annali di Geofisica**, 42, 1125-1138
- Gumbel, L. J., 1935, Les valeurs extrêmes des distribution statistiques, **Ann. Inst. Henri Poincaré**, 5, 815-826
- Gumbel, L.J., 1966, Statistics of Extremes, **Columbia University Press**, New York, N.Y., 375pp
- Kayabali, K., 2002, Modeling of seismic hazard for Turkey using the recent neotectonic data, **Engineering Geology**, 63, 221-232
- Kayabali, K., and Akın, M., 2003, Seismic hazard map of Turkey using the deterministic approach, **Engineering Geology**, 69, 127-137
- Mäntyniemi, P., Tsapanos, T.M., and Kijko, A., 2004, An estimate of probabilistic seismic hazard for five cities in Greece by using the parametric-historic procedure, **Engineering Geology**, 72, 217-231
- Yaltrak, C., Alpar, B., and Yüce, H., 1998, Tectonic elements controlling the evolution of the Gulf of Saros (Northeastern Aegean Sea, Turkey), **Tectonophysics**, 300, 227-248

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Yarar, R., Ergünay, O., Erdik, M., and Gülkan, P., 1980, A preliminary probabilistic assessment of the seismic hazard in Turkey, **Proc. 7<sup>th</sup> World Conf. Earthquake Eng.**, Istanbul, 309-316