Recent Devastating Earthquakes in Turkey and Active Tectonics of the Aegean and Marmara Seas

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Abstract The Eastern Mediterranean region, including the adjacent areas of western Turkey and Greece, is indeed one of the most seismically active and rapidly deforming regions within the continents. Thus, the wide range of active deformational processes observed in the Eastern Mediterranean means that this region provides a unique opportunity to improve our understanding of the complex dynamics of continental collision, including strike-slip faulting, subduction and crustal extension, as well as associated volcanism, intense seismic activity and geomorphological events (e.g. tsunamis) and their impacts on societal life and civilization. Recent devastating earthquakes along the North Anatolian Fault Zones (NAFZ) such as the August 17, 1999 Gölcük-İzmit (Mw=7.4) and the November 12, 1999 Düzce (Mw=7.1) earthquakes confirm the complexity of the crustal deformations throughout the region. Furthermore, the source mechanisms and rupture histories of the moderate and large size earthquakes that occurred in the last decades contribute to conceive the nucleation and growth of fault system in the region.

In this article, we present novel seismological observations and briefly presented the source characteristics of the recent damaging earthquakes in Turkey and adjacent areas. The latter includes the Marmara and North Aegean Seas, the Lake districts region of SW Turkey, Orta-Çankin of central Turkey and the East Anatolian Fault Zone (EAFZ) in order to display the active tectonic structures associated with seismicity. Investigating and monitoring of the active seismogenic zones will provide a better understanding for predicting the occurrences of future earthquakes and hence an improved physical basis for mitigation of their effects on environment and societies in this earthquake-prone region.

Keywords active tectonics, Anatolia, crustal deformations, earthquakes, eastern Mediterranean, source rupture modelling, slip distribution studies, Turkey
1 Introduction

The complexity of the plate interactions and associated crustal deformation in the eastern Mediterranean region is reflected in the many destructive earthquakes that have occurred throughout recorded history. Turkey, alas, experienced two destructive earthquakes in 1999: the Gölçük-İzmit event on 17 August (Mw = 7.4), and the Düzce event on 12 November (Mw = 7.1); the most devastating earthquakes that this nation has suffered in recent decades (Taymaz, 1999). They took place on segments of the well-known North Anatolian Fault Zone (NAFZ), the most prominent active fault zone in Turkey. It passes close to Istanbul and other major urban centers, and cuts along northern Turkey for more than 1,500 km, accommodating ~25 mm/year of right-lateral motion between Anatolia and the Eurasian plate (e.g. McClusky et al., 2000, 2003; Taymaz et al., 2004a-b). The tectonic evolution of the Eastern Mediterranean region is dominated by deformations tied to ongoing subduction along the Hellenic (Aegean) arc and of continental collision in eastern Turkey (Anatolia) and the Caucasus (e.g. Taymaz, 1990; Taymaz et al., 1991a-b; Sato et al., 2004; Tan and Taymaz, 2006; Podgorski et al., 2007; Georgiev et al., 2007; Kotzev et al. IBID). Northward subduction of the African plate beneath western Turkey and the Aegean region is causing extension of the continental crust in the overlying Aegean province (Taymaz and Price 1992). In contrast, eastern Turkey is instead experiencing crustal shortening and thickening due to northward motion of the Arabian plate relative to Eurasia. The resulting combination of forces: the “pull” from the subduction zone to the west and “push” from the convergent zone to the east, is causing the Turkish micro-plate to move westward, bounded by strike-slip fault zones: the NAFZ to the north and the East Anatolian Fault Zone (EAFZ) to the south. Interplay between dynamic effects of the relative motions of adjoining plates thus controls large-scale crustal deformation and the associated earthquake activity in Turkey (Figure 1, Yolsal et al., 2007a-b). In this presentation we give an overview of active plate tectonics and associated crustal deformation reflected by intense earthquake activity in the Eastern Mediterranean region.

2 Marmara Sea (NW Turkey)

The Sea of Marmara is a marine basin in northwest Turkey that connects the Aegean Sea with the Black Sea, and includes a series of tectonically active basins at the western end of the right-lateral North Anatolian Fault (NAF). Across most of Turkey the NAF is a relatively simple, narrow, right-lateral strike-slip fault zone; however it splits into several fault strands in the vicinity of the Sea of Marmara so that the deformation (surface faulting of the NAF) becomes distributed over a 120 km broad zone (Smith et al., 1995, Taymaz 1999; Le Pichon et al., 2001). The region of the Marmara Sea is a transition zone between the strike slip regime of the NAF and the extension regime of the Aegean Sea, and the Main Marmara Fault (MMF) exhibits all the characteristics of a major through-going active strike-slip fault (Le Pichon et al., 2001; Armijo et al., 2002). We have conducted seismological observations