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Seismotectonics of the Antalya Basin and surrounding regions in eastern Mediterranean from 8 to 28 December 2013 M_w 5.0–5.8 earthquake sequence

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A B S T R A C T

The 8–28 December 2013 M_w 5.0–5.8 Antalya Basin earthquake sequence in eastern Mediterranean is examined. Centroid moment tensors for 16 earthquakes with moment magnitudes (M_w) between 3.6 and 5.8 are determined by applying a waveform inversion method. All earthquakes are shallow focus thrust events at a depth of 40–45 km. The seismic moments (M_o) of the earthquakes are estimated as 4.10×10^{16}–5.54×10^{17} N m and rupture durations of the mainshocks are 20–22 s. The focal mechanisms of the aftershocks are mainly thrust faulting with a strike-slip component and reveal NW–SE trending direction of *T*-axis in the entire activated region. According to high-resolution hypocenter relocation of the Antalya earthquake sequence, seven main clusters are revealed. The aftershock activity in the observation period between 1 December 2013 and 23 January 2015 extends in an N to S direction. A seismic cross-section indicates that a complex pattern of the hypocenter distribution with the activation of seven segments. The westernmost cluster (cluster 1) is associated with a fault plane trending mainly WNW–ESE and dipping vertical, while the cluster 5 is related to a fault plane trending NNE–SSW and dipping towards SSE. The best constrained focal depths indicate that the aftershock sequence is mainly confined in the crust (depth < 40 km) and are operating in the approximate depth range from 3 to 110 km. A stress tensor inversion of focal mechanism data is performed to obtain a more precise picture of the Antalya Basin stress field. The stress tensor inversion results indicate a predominant thrust stress regime with a NE–SW oriented maximum horizontal compressive stress (S_H). According to variance of the stress tensor inversion, to first order, the Antalya Basin is characterized by a homogeneous interplate stress field. The Coulomb stress change associated with two mainshocks are also investigated to evaluate any significant enhancement of stresses along the Antalya Basin and surrounding regions. Positive lobes with stress of more than 0.4 bars are obtained for two mainshocks, indicating that these values are large enough to increase the Coulomb stress failure towards NE–SW and NW–SE directions, respectively.

1. Introduction

The Antalya Basin earthquake (EQ) sequence occurred at 17:31:57.0 GMT on 8 December 2013 and at 15:21:02.5 GMT on 28 December 2013. The 8 December mainshock was of moderate size (M_w = 5.0) event at a depth of 40 km. The 28 December mainshock was also moderate size (M_w = 5.8) event and slightly deeper (45 km) than the 8 December event. The Antalya Basin earthquake (EQ) activities are located at the western part of the Aksu Fault (AF) of the eastern Mediterranean convergent system (Fig. 1). The mainshocks are revealed by a thrust motion with a minor strike-slip component (only the 8 December event). The 8 December EQ fault rupture zone extends typically from 10 to 20 km length and the 28 December EQ fault rupture zone expands from 15 to 50 km due to high resolution aftershock imaging.

The detailed tectonic architecture of the Antalya Basin and its role in the Miocene–Recent kinematic evolution of the eastern Mediterranean is not very well known. Wide angle seismic reflection profiles are used to comprehend the behavior of the Florence Rise and Anaximander Mountains (Woodside, 1977). The northward subsidence of the Antalya Basin and the continuation of the Strabo Trench south of the Florence Rise suggest that the regional tectonic around the Antalya Basin is characterized by the underthrusting of the Aegean Sea and Anatolian plates by the

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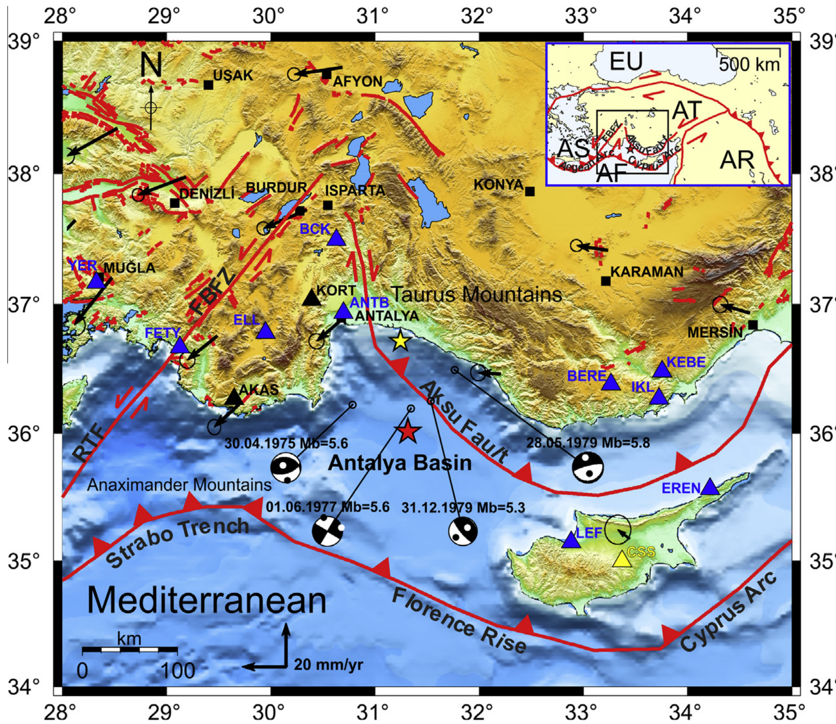

Fig. 1. Tectonic map of western Turkey showing GPS velocities with respect to Eurasia and 95% confidence ellipses for western Anatolia (McClusky et al., 2000; Reilinger et al., 2006). Seismically active faults are shown by red lines (Şaroğlu et al., 1992). Blue, black and yellow triangles with station codes depict locations of the KOERI, AFAD and GFZ broadband seismic stations, respectively. The epicenters of the 8–28 December 2013 Antalya Basin mainshocks are indicated by the yellow and red stars, respectively. For reference, focal mechanisms of the previous significant earthquakes are plotted (Tan et al., 2008; Kalafat et al., 2009). FBFZ and RTF stand for Fethiye-Burdur Fault Zone and Rhodes Transform Fault, respectively. Two closely spaced red single arrows display shear sense of major faults. Black and white circles on beach-balls exhibit *P* and *T*-axes, respectively. The inset in the above right shows whole Turkey. Plate boundaries are indicated by heavy colored red lines, namely the Aegean Sea (AS), Anatolian (AT), African (AF), Arabian (AR) and Eurasian (EU) plates (Bird, 2003). The solid black rectangle shows the study area, which is enlarged in Fig. 1. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

African plate. Woodside (1977) also stated that the lack of seismicity in the Antalya Basin and the absence of both volcanism and a clearly described trench along the Florence Rise probably show that subduction had ended within the past 5 my. Sage and Letouzey (1990) observed two internally parallel south-facing fragmented thrust belts within the Antalya Basin. They evaluated there thrust belts as the southern extension of the Alpine orogenic arc, containing a pile of nappes, which became established in several phases from the upper Cretaceous to Recent. They also observed that the Lycian Nappes contain lower Cretaceous ophiolitic material and pointed out that the thrust belts form the basement of many offshore basins with an Oligocene to Recent fill, including Antalya Basin. Glover and Robertson (1998) interpreted as the contractional tectonic regime dates only from the Late Miocene and is followed by a transtension until the Early Pliocene, which continued as an extensional regime in the Late Pliocene–Quaternary. They are related the transtensional movement to shear along the eastern margin of the Aegean Plate controlled by extension–rotation, and associated the extensional tectonics with a regional change in stress direction on the margins of the Aegean Plate (İşler et al., 2005). During early Pliocene to Recent the fold–thrust belt is overprinted by extensional/transtensional faults in the northeastern Antalya Basin, while transpression dominated the southwestern Antalya Basin. This tectonic phase is related to the westward displacement of the Tauride block as the eastern segment of the Aegean Sea and Anatolian plates initiated its westward escape in the latest Miocene to early Pliocene (İşler et al., 2005).

The Antalya Basin is one of the most seismically active parts of the eastern Mediterranean convergent tectonic regime (Şengör et al., 1985; İşler et al., 2005). The eastern Mediterranean is characterized by very uniform (in magnitude and orientation) plate velocity vectors from Global Positioning System (GPS) indicating SW motion at about 10–20 mm/yr (Fig. 1, McClusky et al., 2000; Reilinger et al., 2006, 2010). It is dominated by a series of thrust and strike-slip structures bounded by normal or oblique faults (Şengör et al., 1985; Mascle et al., 1986; Barka et al., 1997; İşler et al., 2005). The main tectonic structures of the eastern Mediterranean region are the Aegean and Cyprus arcs that compose convergent plate boundaries where the African plate (AF) to the south is subducting beneath the Anatolian (AT) and Aegean Sea plates (AS) to the north (inset in Fig. 1). Convergent zones in the eastern Mediterranean, namely Cyprus Arc and Florence Rise, have traditionally been interpreted as interacting between AT and AF plates. The deformation zone associated with the convergence is very wide from the Florence Rise to the Cyprus Arc (İşler et al., 2005; Hall et al., 2014). This broad deformation zone is defined by three major tectonic structures which are Florence Rise, Cyprus Arc and Aksu Fault (Fig. 1). Elongation of the Aksu Fault is almost parallel to the Florence Rise and Cyprus Arc. Compressional motion is transformed into strike-slip on north part of the Aksu Fault (Fig. 1; İşler et al., 2005; Aksu et al., 2009; Hall et al., 2014). The Antalya Basin is located north of Florence Rise marking the boundary between the AF and AT plates (Fig. 1). This basin is situated between Florence Rise and Aksu Fault. A line with a projection of the Florence Rise along Aksu Fault and Taurus Mountains of southern Turkey is interpreted as the Antalya Basin (see Fig. 1; İşler et al., 2005; Aksu et al., 2009; Hall et al., 2014). Bathymetric trends associated with the Aksu Fault in the Antalya Basin link with N135°E striking faults in the Turkish continental slope. This interpretation, strongly supported by marine geophysical data (Hall et al., 2014),