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A study of the 8 January 2013 Mw5.8 earthquake sequence (Lemnos Island, East Aegean Sea)

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ABSTRACT

The 8 January 2013 Mw5.8 earthquake sequence south of Lemnos Island (East Aegean Sea) is investigated. The focal mechanisms of the strongest events, obtained by waveform modelling, together with the HypoDD relocated epicentres, clearly show the activation of a dextral strike-slip fault, no more than 14 km in length, trending N60°E, and extending in depth from approximately 3 to 25 km, with the best determined focal depths in the range 3 to ~13 km. The distribution of slip onto the fault plane shows a single patch of 7 × 8 km^2, where the average and the peak slip are equal to 30 cm and 130 cm, respectively. The locus of the peak slip is well resolved to be ~2.5 km away from the hypocentre, towards SW. The slip model was used to forward model the distribution of Peak Ground Velocity (PGV in cm/s) in the near source. The PGV contours imply that if any directivity is associated with this event, this is towards SW. The sequence in study, is located in the eastward extension of the Agios Efstratios Fault Zone, which was the locus of the February 19, 1968 Mw7.2 earthquake, which produced surface rupture on the island itself. The Agios Efstratios Fault Zone terminates off shore, south of Lemnos Island. The 2013 sequence is not connected, in a strict sense, with the Agios Efstratios Fault. It indicates rupture of another fault, approximately parallel to it, and the characteristics of the sequence are in accordance with the regional tectonics and previous knowledge. The Coulomb stress change associated with the mainshock, is also examined to evaluate any significant enhance of stresses along the Agios Efstratios Fault Zone.

1. Introduction

It is generally accepted that the North Aegean Basin (NAB) in the Northern Aegean Sea (Fig. 1) has tectonically developed after the collision of Arabia with Eurasia in late Miocene and the subsequent westward escape of Anatolia relative to Eurasia, during the early Pliocene (e.g. Angelier, 1979; Armijo et al., 1999; Jackson, 1994; LePichon et al., 1995; McKenzie, 1978; Papazachos et al., 2000; Taymaz et al., 1991; Tranos, 2009). This westward motion of Anatolia is facilitated by the strike-slip faulting along the North Anatolian Fault Zone (NAFZ) and the East Anatolian Fault Zone (EAFZ). It is further facilitated by the fast (~20 mm/yr relative to Eurasia) south-westward retreat of the Hellenic subduction zone (e.g. Armijo et al., 2003; Kiratzi, 2002; Kreemer et al., 2004). As far as dynamics are concerned, Jolivet et al. (2013) suggest that the extrusion of Anatolia and the Aegean extension are partly driven from below (asthenospheric flow) and partly from above (extrusion of a lid of rigid crust). The opening and deepening of the North Aegean Basin increase towards southwest, from 20 to 40 km, and from 950 m to 1650 m, respectively (Papanikolaou et al., 2006). The most prominent structures within the North Aegean Basin are the Sporades Basin in its western part, the Athos Basin in its central part and the Lemnos Basin and Saros Basin in its eastern part (Karabulut et al., 2006; Koukouvelas and Aydin, 2002). An approximately 160-km long NE–SW trending fault, that bounds the southern margin of the NAB, and extends from the Sporades Basin to Lemnos Basin, can be also seen in the bathymetry, which by Papanikolaou et al. (2006) is considered as the possible continuation of the NAFZ into the Aegean Sea.

South of the North Aegean Basin, another topographic depression is prevailing, the Skyros–Edremit Basin, which opens and deepens with the same polarity as the North Aegean Basin (e.g. towards southwest). The focus of our study is the region eastwards of the Skyros–Edremit Basin, which is less well studied compared to the North Aegean Basin, at least from the seismological point of view, simply because no strong event occurred there during the modern instrumental period. In this context, we will study the 8 January 2013 Mw5.8 earthquake sequence, which is located ~25 km SE of Lemnos Island as well. Most importantly the sequence is located in a broader region which also includes the Agios Efstratios Fault Zone (Basili et al., 2013), a segment of which ruptured during the 19 February 1968 earthquake (Kiratzi et al., 1991; Papazachos and Papazachou, 2002; Pavlides and Tranos, 1991). Thus, this sequence is important because it provides evidence for the eastern segments of this major deformation zone (Fig. 2).

The 2013 sequence was well recorded by the stations of the Greek and Turkish Seismological Networks (see Fig. 1), whose broad band velocity records are used here. The sequence included only three events of magnitude Mw ≥ 4.0 and greater. Although no serious damage was reported, the mainshock was strongly felt in wide parts of the Greek and

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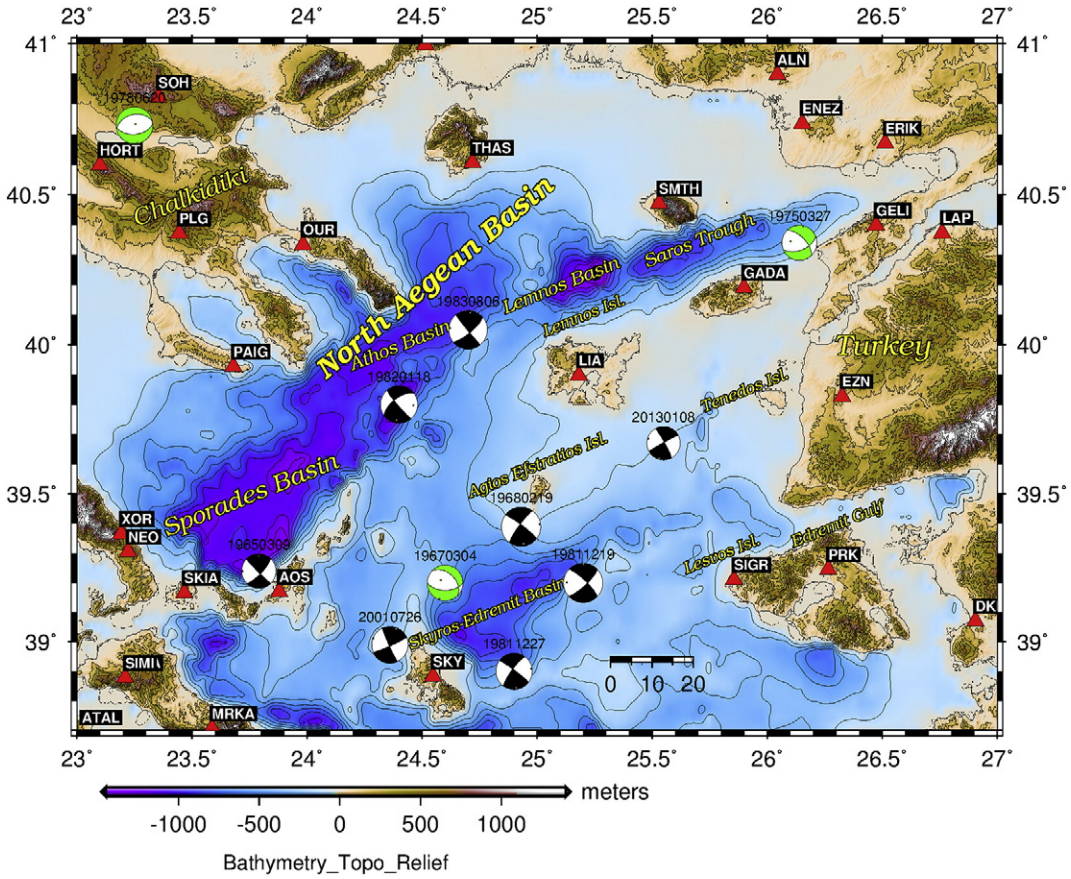

Fig. 1. Significant features of the general geodynamic setting of the North Aegean Sea area. The focal mechanisms of the strongest (Mw > 6.0) events, are also plotted (Kiratzi and Louvari, 2003; Kiratzi, 2013 unpublished data), together with the locations of the broadband stations (triangles) whose waveforms were used here. The location and the focal mechanism of the 20130108 event studied here are also shown.

Turkish territories. Peak ground acceleration values, from the mainshock, recorded at Bozcaada station, located at the city of Çanakkale in Turkey, was 33 gal in NS direction, 18 gal in EW direction and 10 gal in up-down direction (preliminary report, at http://www.deprem.gov.tr/ last accessed Sept 16, 2013).

In the sections that follow we will present a) the spatial evolution of the sequence using HypoDD relocated epicentres; b) the focal mechanisms of the stronger events using waveform modelling; c) the slip model of the mainshock; and d) the Coulomb static stress changes. The results are discussed in the context of the general tectonic setting.

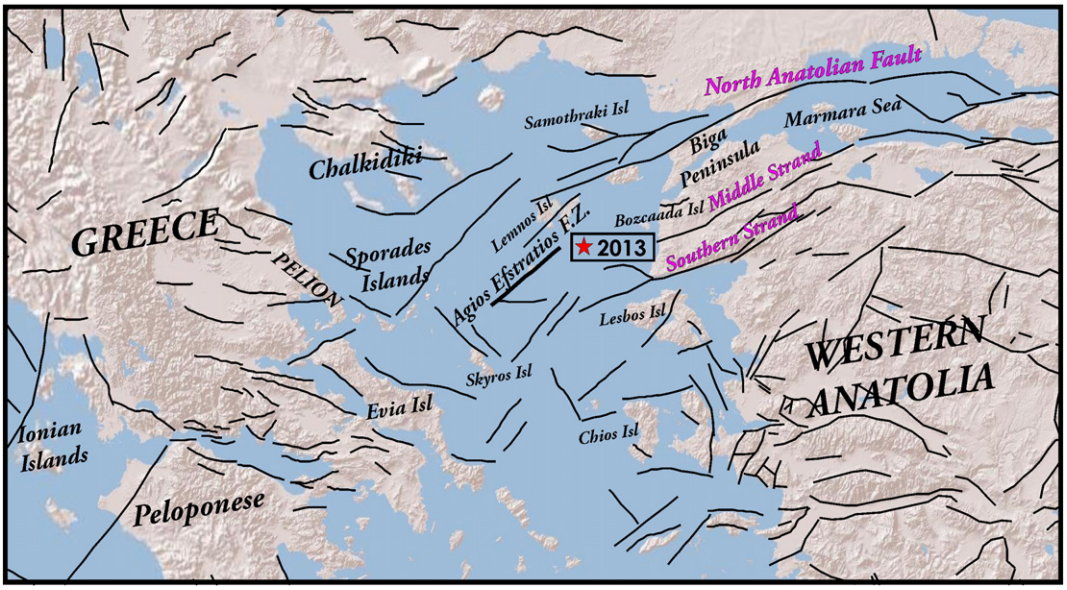

Fig. 2. Significant faults along the broader region, from the database of Basili et al. (2013). The star denotes the location of the 2013 sequence and the close active structure of the Agios Efstratios Fault Zone (discussed in the text) is shown in bold.