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Deformation pattern and structural analysis along the western termination of the North Anatolian Fault

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The North Aegean Trough (NAT) is considered to be an expression of the prolongation of the North Anatolian Fault (NAF) into the Aegean Sea (McKenzie, 1970; Lyberis, 1984; Armijo et al., 1999; Papanikolaou et al., 2002, 2006; Brun et al., 2016). The NAF is divided into eastern and western branch, with mean strike N70°E and N40°E respectively, and the turning point is been located NW of Lemnos Island (Sakellariou and Tsampouraki-Kraounaki, 2018). These two branches of the fault are responsible for the formation of the eastern and the western North Aegean basins, respectively. The present study is specialized in the western termination of the NAT, in order to analyze the tectonic structures that consist the North Anatolian Fault.

The database utilized in this analysis, i.e. swath bathymetry data and seismic profiles, was acquired in the framework of the nationally funded "YPOTHER/Aegean Explorations" project, implemented by the Institute of Geology & Mining Exploration (IGME) and the Hellenic Centre for Marine Research (HCMR). Swath bathymetry data were acquired with a 20 kHz SeaBeam 2120 (L3 ELAC Nautic), hull-mounted, multibeam system and were complemented with data obtained by HCMR in 2000, reprocessed at 25m grid. The fault network across the western branch of NAF was analyzed using 53 seismic profiles, of which 38 are airgun 10 in^3 seismic profiles and 15 are airgun 40 in^3 seismic profiles.

The analysis of the submarine morphology and the structural analysis along the western termination of the NAF, revealed that it consists a fault – controlled area. The western NAF is not a major, linear brittle structure, but rather a zone of numerous, parallel to sub – parallel, undulating fault segments, overlapping with others with soft – linkage, forming the western NAF zone. The fault segments are arranged in a mean strike N40°E, they are very steep or nearly vertical, their direction of dip is towards NW or SE and they accommodate a combination of shear and dip slip component, with the latter being greater towards the southwestern segments. The results of the seismic profiles analysis of the area, implied that the fault segments consist the upper parts of negative and positive flower structures that are created due to the oblique slip accommodating by the main strike – slip faults. Furthermore, the pure dextral strike – slip motion with a dip – slip component is verified by the determined focal mechanisms for all the earthquakes with magnitude Mw > 3.5 that occurred in the vicinity of the study area from 2006 until present (Figure 1B).

The submarine morphology of the NE – SW oriented marginal zone is rather complex and disparate. In particular, subsided areas with relatively greater water depth and uplifted areas with relatively smaller water depth can be observed. In other words, the southern marginal zone of NAT consists of a series of spatially alternating structural highs and lows. Specifically, three morphological depressions and two ridges can be distinguished from SW to NE: Alonissos Deep, Psathoura Ridge, Psathoura Deep and Myrina Ridge and Lemnos Deep. Alonissos Deep is the last structure before the SW end of the NAF zone and corresponds to a tectonic half – graben. The master marginal fault is located along the southern margin of the deep. This marginal fault accommodates significant normal component, with dip direction towards NW. The uplifted footwall is composed of the alpine basement and the basin is formed on the subsided hanging wall block. The direction of the extension of the basin is almost N44°W. The depression is characterized by enhanced subsidence, due to the contemporary activity of the NE – SW trending strike – slip fault segments of the NAF zone with the normal component, dipping towards NW and the normal Pelion – Skiathos Fault with direction NW – SE, dipping NE (Papanikolaou et al., 2006; Sakellariou et al., 2016). The area between Alonissos Deep and Psathoura Ridge is a submarine hill with the SE area being uplifted. The hill is formed by parallel, NE – SW trending faults segments with normal component, dipping NW. Psathoura Ridge is located east of the islet Psathoura, and represents a structural high that is formed by two parallel fault segments that accommodate normal dip – slip component and have opposite direction of dip, i.e. the major northern marginal fault has dip direction towards NW and the southern one has dip direction towards SE. Between the two aforementioned faults, a tectonic horst is pushed upwards. Psathoura Deep consists a tectonic graben by arranged strike – slip NAF segments with normal component that dip towards the center of the depression. The northern NE – SW margin is composed of two overlapping marginal fault segments that have a dip direction towards SE. The direction of the extension of the basin is almost N42°W. The area between Psathoura Deep and Myrina Ridge is quite complex and only few insufficient data were available, thus detailed structural analysis and therefore, submarine mapping, could not be possible. However, on Myrina Ridge, two major, parallel fault segments were mapped. These faults dip NW and accommodate normal component that uplifts the footwall block of both of them (SE block) and subsides the hanging wall block (NW block). There were not data available further NE, to investigate the possibility of the existence of an antithetic NE – SW trending fault that dips SE and might be the marginal fault of a horst structure, like the one on Psathoura Ridge. A major landslide affected Lesvos Deep, creating a characteristic submarine morphology and thus, the original structure of the deep cannot be determined.

Further analysis of the submarine morphology was made by constructing a slope map of the study area. The abrupt change of slope usually reflects the location of active tectonic structures, thus corresponds to their location and the negligible change of slope corresponds to the location of flat-lying areas that are tectonically inactive (Papanikolaou et al., 2002;

Sakellariou et al., 2018) Consequently, the slope map of Figure 2 confirms the results of the structural analysis through the seismic reflection profiles, that is the area along the western NAT consist of many active tectonic elements.

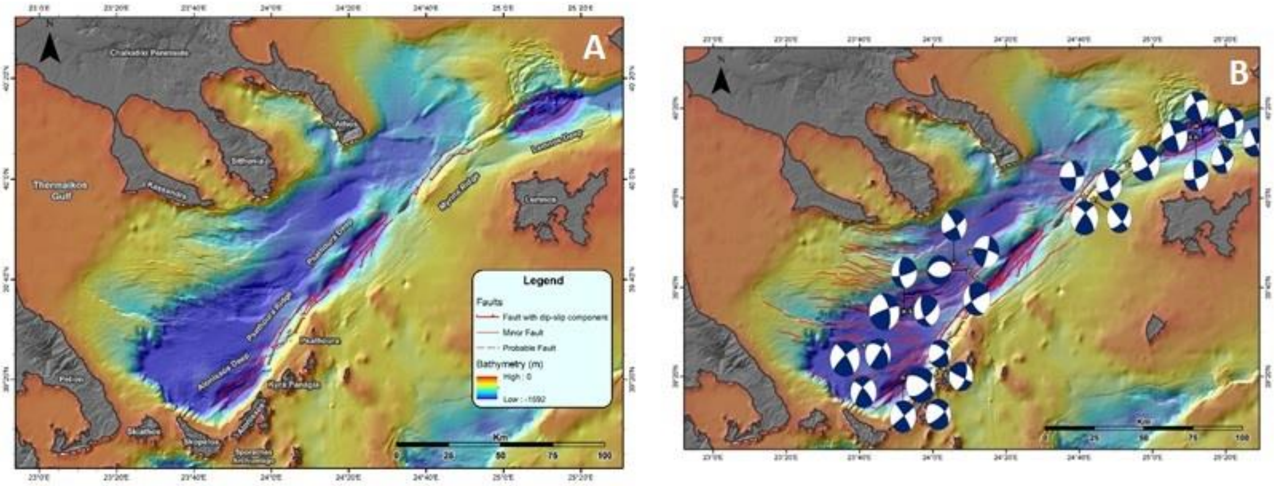

Figure 1. A) Morphotectonic map of the western North Aegean Trough. The North Anatolian Fault Zone is mapped in detail. B) Morphotectonic map of the western North Aegean Trough (NAT). The detailed fault network of the NAF zone, as long as the faults that occur in the wider NAT, from Sakellariou et al. (2018), are illustrated by red lines. The epicenters of the earthquakes (yellow stars) and the corresponding fault plane solutions that occurred in the area, are also indicated. The seismic data were acquired from the Seismological Laboratory of NKUA (http://dggsl.geol.uoa.gr/en_index.html).

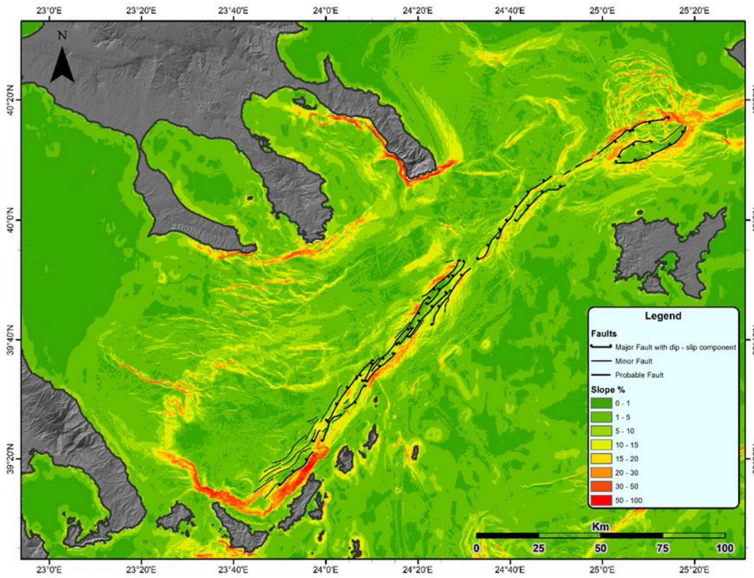

Figure 2. Slope map of western North Aegean Trough. Slope values distinguished in eight categories. The black lines correspond to the mapped North Anatolian Fault segments.

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