Determination of the rotational regime in the North Aegean region based on palaeomagnetic and geodetic data

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North Aegean is in the broader Eastern Mediterranean region. The general geodynamic evolution of the area is related to the westward tectonic escape of the Anatolia plate, which is interacting with the Arabian plate, as well as with the ongoing subduction of the African plate beneath the Eurasian one. This coupled interaction is causing the southwestern movement of the Aegean region (McKenzie, 1978; Le Pichon and Angelier, 1979). The recorded, by permanently installed GPS/GNSS stations, geodetic data confirm this movement (McClusky et al., 2000; Hollenstein et al., 2008). The surficial deformation of the area can also be estimated by using the recorded GPS/GNSS velocities.

Regarding the tectonic setting of the study area, numerous onshore and offshore active tectonic structures have been documented (Sboras, 2011 and references therein). The dominant one is the ENE – WSW trending North Aegean Trough (NAT) fault zone, while fault zones of different strikes (Thrace, Drama, Belles, Mygdonia, Aliakmonas, Tyrnavos, etc.) associated to the Oligocene – Miocene extensional regime are deforming parts of the northern Greek mainland (e.g. Mountrakis et al., 2006; Sboras et al., 2017). Several of these fault zones are associated with modern or historical seismic events.

Palaeomagnetic research in the broader Aegean area (including continental Greece and western Anatolia) has provided a considerable amount of data, a part of which covers the presently studied area (Kondopoulou, 2000 and references therein; van Hinsbergen et al., 2005; Kaymakci et al., 2007; Zananiri et al., 2013). The pattern arising from these studies for the last 5 to 20Myr clearly defines a fast, clockwise rotating block at the north-western part of the studied area. The pattern is less precise at its eastern and northern parts with a mixture of counter-clockwise and no rotations. The northern Greece deformation appearing from palaeomagnetic data has also been documented by independent models (Brun and Sokoutis, 2018).

The use of Satellite Geodesy is a reliable way for estimating the current activity pattern, as well as the crustal deformation of a study area. To this end, a dense network of permanently installed GPS/GNSS is necessary to collect the geodetic data. The study area is covered by 77 different GPS/GNSS stations collecting primary geodetic data. A subset covering a seven-year period (2008 – 2014) was used in this study, using data recorded during 30-sec daily GPS observations. The European Terrestrial Reference Frame 2000 (ETRF2000), which considers Eurasia plate as stable, is the geodetic data reference frame.

Based on the primary geodetic data, including the East and North velocity components and their uncertainties, derived from the permanently installed GPS/GNSS stations, both the rotation rate and the orientation were calculated, implementing the triangulation method. The combination of 77 stations resulted in the construction of 1,610 different triangles and therefore the extraction of 1,610 different rotation rate vectors.

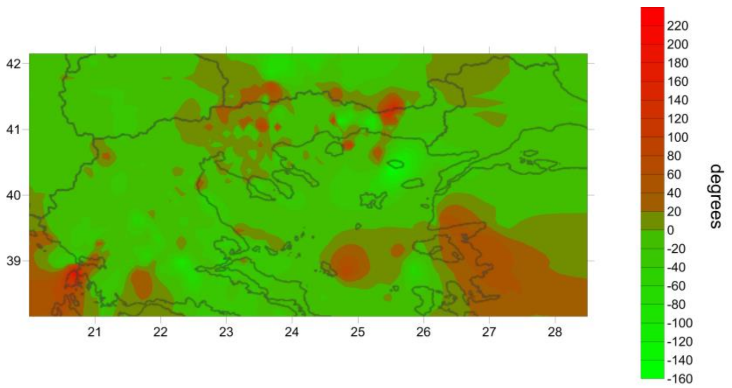

Figure 1. Interpolation of the rotation rate values of the study area, extracted from the primary geodetic data, for a -5 Myr time period.

Based on this process, the annual rotation rate and type (clockwise rotation, counter-clockwise rotation, zero rotation) were calculated for the triangular centroids. The rate of annual rotation is minimal, therefore it cannot be visualized properly, nor can it lead to the construction of rotation models. By assuming that the rotation rate of the study area is constant, the annual rotation rate values were extrapolated, resulting in the extraction of the rotation models of -5, -10, -15 and -20 Myr (Lazos et al., 2018). The results were then geostatistically processed, using interpolation methods, in order for the entirety of the study area to be covered (Figure 1). The extrapolated rotation model has then been compared to the one suggested from palaeomagnetic data, so that it can be validated and checked for each of the time periods under consideration, to provide information about the geodynamic evolution of the study area.

Based on the combination of palaeomagnetic and geodetic rotational models, the North Aegean region can been divided into five distinct blocks (Figure 2). Blocks 1 and 3 are characterized by clockwise rotation, while Blocks 2 and 4 show counter-clockwise rotation. Although Blocks 1 and 3 both show clockwise rotational behavior, they are considered separate based on their different rotation rate. Block 5 delimits an area, where the rotational regime is not clear; this block however is subjected to the general clockwise rotation of the broader area.

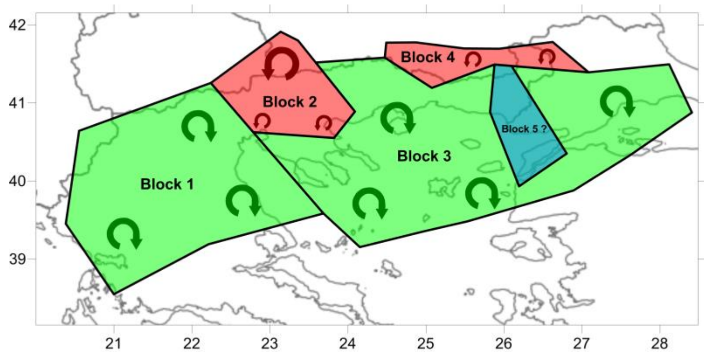

Figure 2. Classification of the study area into distinct rotational blocks, based on palaeomagnetic and geodetic data. Green blocks (1 and 3) are characterized by clockwise rotation, while red blocks (2 and 4) show counter-clockwise rotation. The rotational regime of the blue block (5) is not clear.

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