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Full length Article

Mass and stress changes in the Menderes Massif (Western Anatolia, Turkey)

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A B S T R A C T

Comparing the results of the microgravity and GNSS measurements is useful for understanding the vertical displacements of the plates. In this study, for determining the geodynamical behaviors of seismically active tectonic structures of Gediz and Büyük Menderes grabens which are located in Western Anatolia (Turkey) graben system, the mass changes were examined by processing of GNSS and microgravity data. Besides, after modeling the GNSS velocity by Coulomb stress analysis, the stress distributions were investigated for these models. Therefore, first of all, the changes of gravity and the vertical components of GNSS velocity values were evaluated together with a statistical method. Secondly, GNSS velocities were calculated relative to the main tectonic structures and the stress changes of tectonic structures were obtained at different depths with Coulomb stress analysis by using these velocities and all results were evaluated with the earthquakes that had occurred in the study area. Consequently, the crustal movements of the areas located at the GNSS stations and their surroundings were put forwarded as in compensation or uncompensation concept of surface and subsurface loadings due to the mass or groundwater effects by using both microgravity and GNSS measurements, as an initial study on Western Anatolia graben system.

1. Introduction

Western Anatolia (Turkey) is one of the most seismically active and extensional areas in the world. It is a part of the 'Aegean Extensional Province' which is the region of distributed extension (Bozkurt, 2001). In this province, several compressional and extensional deformation has occurred as was discussed in many papers (Şengör and Yılmaz, 1981; Okay and Tüysüz, 1999; Rimmelé et al., 2003; van Hinsbergen et al., 2005, 2010; Çemen et al., 2006; Ring et al., 2010; Jolivet et al., 2013). This region has undergone N-S contraction until the beginning of the late Miocene. Then, the region experienced N–S extension at the beginning of the Tortonian, therefore, thick and the partially melted crust extended and the horst-graben system occurred within the brittle and thin lithosphere (Yilmaz, 1989; Ilkışık, 1995). As the result of the extension, the E-W and NE-SW oriented continental grabens have appeared (Şengör et al., 1985; Yılmaz et al., 2000). The seismically active E-W oriented grabens (e.g. Gediz and Büyük Menderes grabens) locate in the Menderes Massif (Fig. 1). NE–SW-trending Massif is the significant structure in the formation of the southwestern Turkey extensional province (Seyitoğlu et al., 2002; Erkül et al., 2005; Bozkurt, 2007) where the region Izmir-Ankara Neotethyan suture and Bornova flysch zone in the north and the Lycian nappes in the south are located. The Menderes Massif includes three submassifs namely as Northern Menderes Massif (NMM), Central Menderes Massif (CMM) and Southern Menderes Massif (SMM) (Bozkurt, 2007) (Fig. 1). Gediz and Büyük Menderes grabens are the boundaries of the massif in the north and south, respectively (Bozkurt, 2007). Menderes massif was formed as the results of two cases. Firstly, during the closure of Neotethys along the Izmir–Ankara suture zone, the continental divergence and crustal thickening occurred in pre-Alpine basement (Şengör et al., 1984; Satır and Friedrichsen, 1986; Bozkurt and Oberhansli, 2001; Gessner et al., 2001; Jolivet et al., 2004; Bozkurt, 2007; Bozkurt et al., 2011). Secondly, during disinterment of the metamorphic rocks of the massif, post-orogenic extension eventuated. The basement of the massif consists of different types of submassifs (Bozkurt et al., 2011). Among two E-W oriented significant grabens, the Gediz graben extends more than 100 km and is bordered by normal faults at its northern and southern sides (Çiftçi and Bozkurt, 2010). Two types of normal faults exist in the Gediz graben. These are; the major, low-angle (0–20°), north dipping, normal fault and high-angle normal faults (Çiftçi and Bozkurt,

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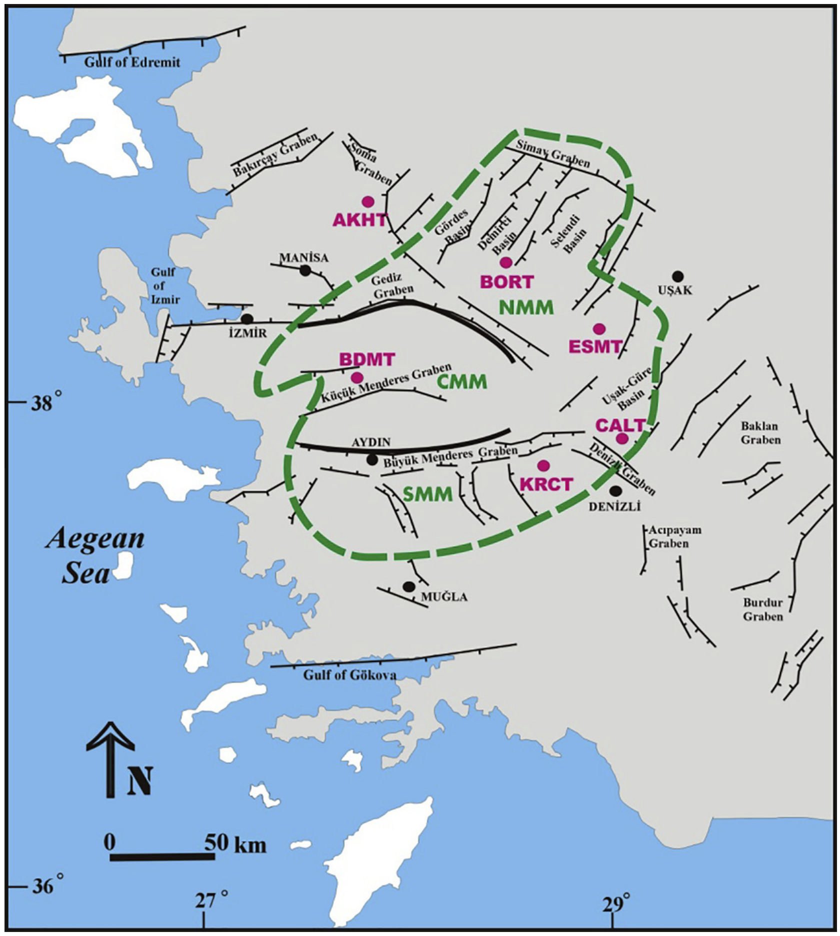

Fig. 1. Simplified tectonic map of Western Anatolia, Turkey. The outlined area with dashed green lines represents Menderes Massif. Pink points represent the locations of GNSS and microgravity stations. Dark black faults represent the Gediz and Büyük Menderes Detachment faults located at the northern and southern borders of CMM, respectively. NMM: Northern Menderes Massif; CMM: Central Menderes Massif, SMM: Southern Menders Massif; AKHT: Akhisar (Manisa); BDMT: Bademli (Izmir); BORT: Borlu (Manisa); ESMT: Eşme (Uşak); CALT: Çal (Denizli); KRCT: Karacasu (Aydin) (the figure was modified from Bozkurt (2001, 2007) and Gessner et al. (2013)). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

2009a). Likewise Gediz graben, the Büyük Menderes graben extends 150 km and is bordered by the normal fault systems along its length (Çifçi et al., 2011). Additionally, most of the significant geothermal fields of Turkey are located in the boundaries of these grabens (Gemici and Tarcan, 2002) (Fig. 2). The temperatures of these geothermal fields vary between 150 and 230 °C (Gonenc

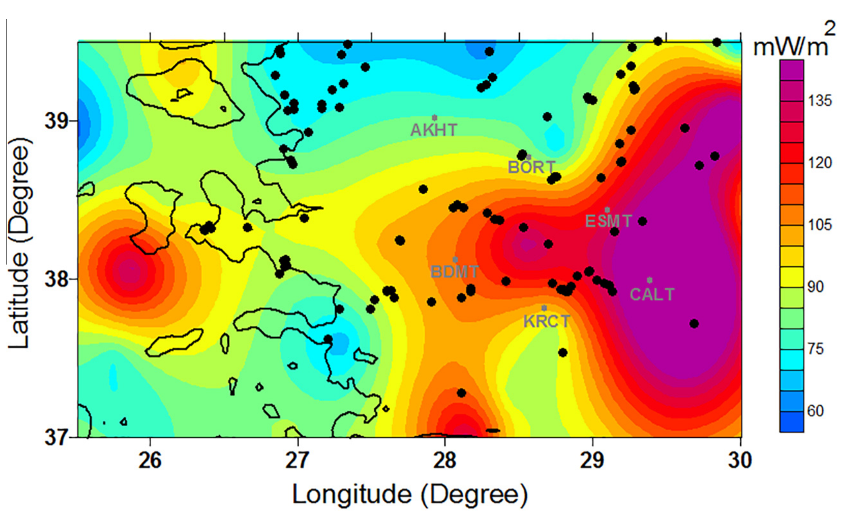

Fig. 2. Heat flow map of Western Anatolia, Turkey (modified from Şalk et al. (2005)). Black points represent the geothermal sources (Mineral Research & Exploration General Directorate (MTA), 2005).