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Plio-Quaternary kinematic development and paleostress pattern of the Edremit Basin, western Turkey

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ABSTRACT

The Edremit Basin and Kazdağ High are the most prominent morphological features of the Biga Peninsula in northwest Anatolia. There is still no consensus on the formation of Edremit Basin and debates are on whether the basin evolved through a normal, a right-lateral or a left-lateral strike-slip faulting. In this study, the geometric, structural and kinematic characteristics of the Edremit Basin are investigated to make an analytical approach to this problem. The structural and kinematic features of the faults in the region are described according to field observations. These fault-slip data derived from the fault planes were analyzed to determine the paleostress pattern of faulting in the region. According to the performed analysis, the southern end of the Biga Peninsula is under the influence of the ENE-WSW-trending faults of the region, such as the Yenice-Gönen, the Edremit, the Pazarköy and the Havran-Balıkesir Fault Zones. The right step-over geometry and related extension caused to the development of the Edremit Basin as a transtensional pull-apart basin between the Havran-Balıkesir Fault Zone and the Edremit Fault Zone. Field observations showed that the Plio-Quaternary faults at the Edremit Gulf and adjacent areas are prominently right-lateral strike-slip faults. Our paleostress analyses suggest a dominant NE–SW extension in the study area, as well as NW–SE direction. This pattern indicates the major effects of the North Anatolian Fault System and the component of Aegean Extensional System in the region. However, our kinematic analysis represents the dominant signature of the North Anatolian Fault System in basin bounding faults. The field observations and kinematic findings of this study are also consistent with the regional GPS, paleomagnetic and seismological data. This study concludes that the North Anatolian Fault System is the prominent structure in the current morphotectonic framework of the Edremit Gulf and adjacent areas.

1. Introduction

The neotectonic evolution of Turkey and its surrounding area is controlled by three primary geodynamic processes: (1) the collision of the Arabian Plate with the Eurasian Plate throughout Bitlis-Zagros Suture Zone, (2) the westward movement of the Anatolian Block throughout the North and East Anatolian Fault Systems starting from the Arabian–Eurasian collision zone (e.g. McKenzie, 1972; Şengör, 1979) and (3) the subduction of the African Plate underneath the Eurasian Plate throughout the Southern Aegean Trench (e.g. McKenzie, 1972; Jackson and McKenzie, 1988; Jolivet et al., 2013). This subduction is also thought to lead the extensional regime in western Turkey.

Our study area is located at northwest Anatolia. The main structural and geological characteristics of the region are the Edremit Gulf, Kazdağ and Madra Mountains, western branches of the North Anatolia Fault System (NAFS) and İzmir Ankara Suture Zone (Fig. 1). The İzmir-Balıkesir Transfer Fault Zone (İBTFZ), is another feature in southeast of the region, which is claimed to form an intersection of the Aegean Extensional System (AES) and the Anatolian Domain (Kaya, 1979; Uzel et al., 2013; Özkaymak et al., 2013; Gessner et al., 2013).

Northwest Anatolia was exposed to the reciprocal interaction of the compression-extension systems during the Late Cenozoic like the entire west Anatolia. The horsts and grabens in western Turkey, which are the most significant morphotectonic features of the region, were also formed during the Late Cenozoic (Fig. 1b). There are primarily two groups of basins according to their geometric positions: the E–W and N–S trending basins. The E–W-trending basins and associated faults are the most distinctive features of western Anatolia (e.g. Şengör, 1979; Yılmaz et al., 2000; Gürer et al., 2001; Bozkurt, 2003; Gürer et al., 2009, 2014; Yılmaz et al., 2010).

Our study area is located at the intersection of the right-lateral strike-slip regime of the ENE-WSW-trending NAFS and the N–S-trending extension by the AES (Fig. 1b). For this reason, it is accepted that the neotectonic deformation of the region has simultaneously been controlled by these two factors (e.g. Taymaz et al., 1991; Yılmaz

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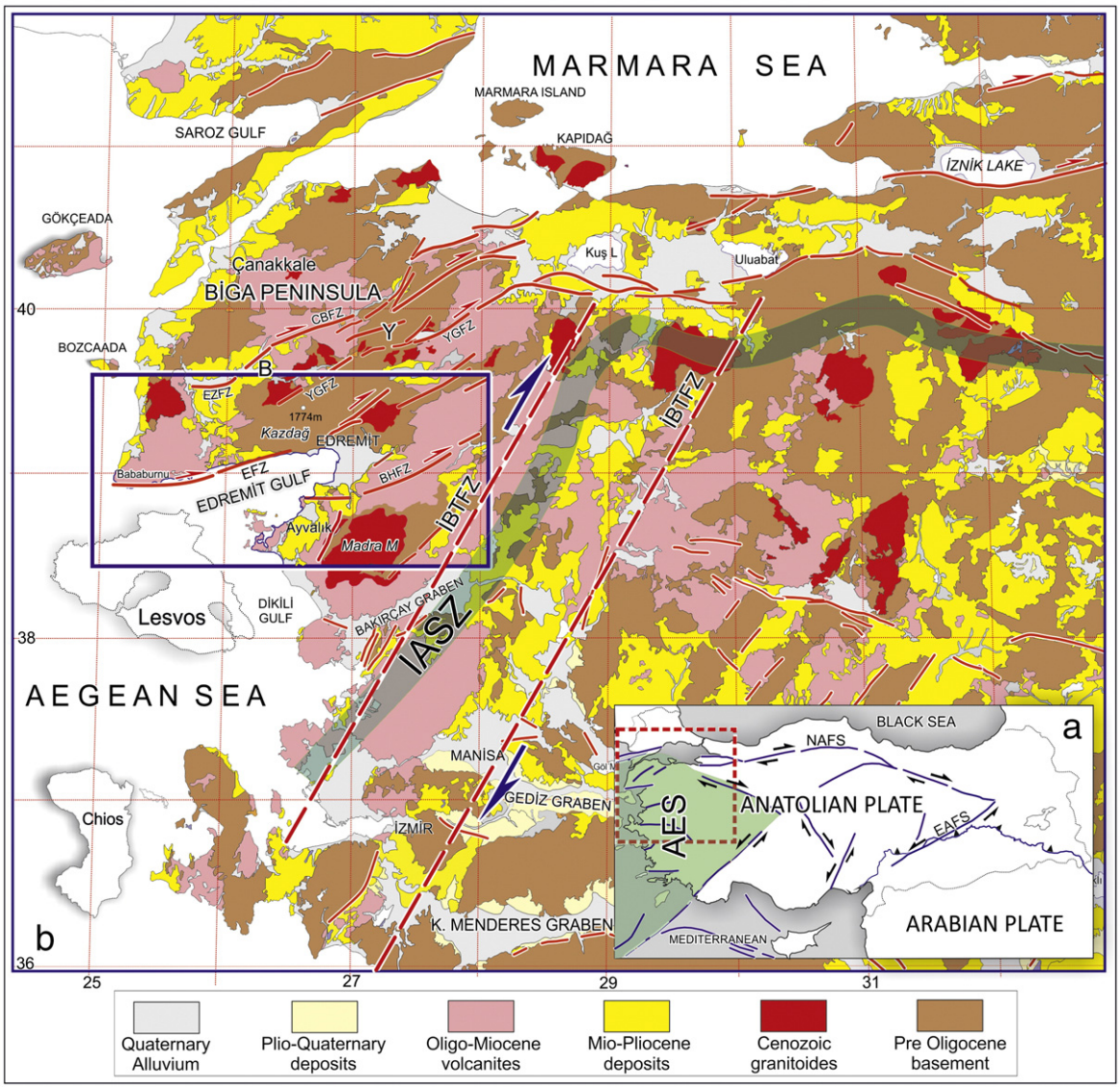

Fig. 1. a. Tectonic map of Turkey showing major tectonic structures (Gürer et al., 2013). b. Simplified geologic map of northwest Anatolia Region (modified from MTA, 2002). IASZ: İzmir-Ankara Suture Zone (Şengör and Yılmaz, 1981), B; Bayramiç, Y; Yenice, EZFZ: Ezine Fault Zone, EFZ: Edremit Fault Zone, HBFZ: Havran-Balıkesir Fault Zone, YGFZ: Yenice Gönen Fault Zone.

et al., 2000; Pfister et al., 2000; Gürer et al., 2003, 2006). We investigated the effects of extensional and strike-slip systems in the region via studying the Edremit Basin which is one of the most significant tectonic structures of northwest Anatolia.

The western part of Edremit Basin is in the Edremit Gulf, while its small eastern part is located on the land. The northern margin of the basin displays a well-developed and basinward-facing step-like morphology due to the considerable amount of normal slip component along the margin-boundary faults. However, owing to the high gradient transverse drainage system shaping the northern margin, this morphotectonic pattern is highly dissected. In particular, the northern margin of Edremit Basin is surrounded by thick and weakly consolidated fan-apron deposits formed by the coalescence of older isolated fans covering areas of 1–3 km^2. The southern edge is indented with less steep hillsides. The highest peak of the region is on the Kazdağ with a height of 1774 m. The length of the gulf is 80 km, while the width increases from 1 to 5 km at the east end to 30 km at the west. The shelf on the northern side of the gulf is particularly steep and narrow. The shelf area on the east and southern edge is less steep and wider. The water depth in the gulf is 100 m on average while the deepest point is 139 m in NE to SW direction. It is bounded by the Müsellim Strait at the narrowest point between the Lesbos Island and the Biga Peninsula to the west, and by the Dikili Strait between Ayvalık and the Lesbos Island to the south. (Fig. 2).

There are several paleomagnetic (İşseven et al., 1995; Schindler, 1997; Kaymakçı et al., 2007) and GPS studies (Straub and Kahle, 1997; Straub et al., 1997; Aktuğ et al., 2009) in the region that explain the opening of Edremit Basin. All of the paleomagnetic studies suggest counterclockwise rotation values between 7–40° around the Edremit Basin. According to paleomagnetic data by İşseven et al. (1995), the northern and the southern blocks around the Edremit Gulf have different rotation directions, which their difference has led to development of the basin.

According to GPS data, the Biga peninsula and its surroundings move to the west and southwest with a velocity of 2–3 cm/year (Fig. 3b) (McClusky et al., 2000; Straub and Kahle, 1997; Aktuğ et al., 2009). The GPS data around the Edremit Gulf show a velocity of 2 cm/year to the SW direction (B. Aktuğ personal communication, 2013). The GPS vectors and the strain directions obtained from them (e.g. Straub and Kahle, 1997 suggest strain extension axes in a NE–SW direction in the northern part of the Edremit Gulf, while a NW-SE strain axis dominant in the southern part (Fig. 3b; Barka and Reilinger, 1997).

Tectonic features of the continental shelf of Bababurnu promontory (Fig. 2) and their relations to those observed onshore and offshore were investigated by multi-channel seismic reflection and seismicity