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Comment on “Paleomagnetic evidence for an inverse rotation history of Western Anatolia during the exhumation of Menderes core complex” by Uzel et al. (Earth Planet. Sci. Lett. 415 (2015) 108–125)

Özgür Karaoğlu [a,*], Fuat Erkül [b]

[a] Eskisehir Osmangazi University, Department of Geological Engineering, 26040 Eskisehir, Turkey
[b] Akdeniz University, Vocational School of Technical Sciences, 07070 Antalya, Turkey

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ABSTRACT

In a recent article published in EPSL, Uzel et al. (2015) reported a paleomagnetic evidence on various rock types from Western Anatolia. It has been suggested that vertical axis rotations driven by the differential stretching along the İzmir Balıkesir Transfer Zone (İBTZ) were caused by slab detachment and slab tear processes at the northern edge of subducting African slab. Although the paper supplies high quality data regarding the geological evolution of western Anatolia, some points need to clarified in light of recently published data.

1. Introduction

Uzel et al. (2015) refer to a single conference paper for the first-time definition of İBTZ. However, the zone was described and discussed in great detail in various papers (see Appendix 1 in Supplementary data). Kaya (1981) was the first to document stratigraphic and structural data from the İzmir-Balıkesir Transfer Zone and formerly define the Akhisar depression. It has been proposed that the structural lines bounding the depression propagated from pre-Miocene faults (Kaya, 1981). Furthermore, this zone was also described by Ring et al. (1999). Moreover, Erkül et al. (2005) described the NE–SW-trending, strike-slip dominated shear zone and related faults as a crustal-scale, strike-slip dominated shear zone that has been active since the Early Miocene.

Authors mentioned that the vast amount of information on the geology of the Menderes Massif core complex (MMCC) has been accumulated but they do not give any background information regarding the geology and timing of exhumation of MMCC (see Appendices 1 and 2 in Supplementary data). It would have been convenient to provide information on the ongoing discussion in the literature about episodic or continuous core complex formation in the Aegean region. Limited data has been introduced on the timing of development of core complexes. This would be important to describe the relationship among rotational history related to the transfer zones, core complex formation and episodic or continuous extension. In the light of present data provided by Uzel et al. (2015) it may be assumed that a major change in the tectonic configuration of western Turkey occurred between Middle and Late Miocene and İBTZ had a substantial role in the development of core complexes under episodic or continuous extension. Therefore, a contribution to solving the question “how has İBTZ shaped the development of two distinct core complexes, northern and central Menderes MCCs?” would have been expected from Uzel et al. (2015).

Authors indicated that the E–W-trending grabens are terminated at the eastern boundary of the İBTZ. However, this is not correct as high-angle normal faults have also been active within (i.e. İzmir-Bay, Manisa and Soma Quaternary basins) and to the western part of the transfer zone (i.e. Dikili and Edremit grabens and also beneath the Aegean Sea). Post-Middle Miocene grabens occur throughout the western Turkey. These grabens dominantly trend E–W and NW–SE in direction but the majority were controlled by brittle faulting with random directions. The grabens surround structural highs formed by pre-existing basement rocks, resembling the occurrences of block faults that formed as a result of brittle deformation in the upper crust. Block faulting after Middle Miocene has also been defined by a crustal-scale unconformity between Early-Middle Miocene lacustrine-dominated successions and Late Miocene continental deposits. Erkül et al. (2013) have already made an attempt to describe the onset of block faulting in western Turkey. It has been argued that there is a spatial and temporal

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* Corresponding author. Fax: +90 222 2290535.
E-mail address: ozgur.karaoglu@deu.edu.tr (Ö. Karaoğlu).

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relationship between structural and geochemical characteristics of the extensive volcanic units in western Turkey. Volcanic rocks with orogenic affinity have been more or less coeval with core-complex development, while anorogenic, intraplate volcanism has been extruded along normal faults over widely exposed Late Miocene to Pliocene sedimentary units [e.g. Selendi basin, Asartepe formation, Orhanlar basalt, Ersoy et al., 2010; Karaoğlu et al., 2010]. The possible causes of change in the mode of extension from ductile to brittle along with change in the magmatic affinity in western Turkey has been mainly attributed to the development of tear or window within a northward subducted Aegean slab (see Appendices 1 and 2).

Uzel et al. (2015) stated that the ^{40}Ar/^{39}Ar data obtained from volcanic rocks will be published in a following paper. However, compilation of ^{40}Ar/^{39}Ar results of these volcanic rocks together with pre-existing data is crucial to make major conclusions regarding the timing and nature of the extensional regime along the İBTZ. Furthermore, there are some distinct discrepancies on the proposed age of rocks subjected to paleomagnetic studies. The Cumaovası basin, which is located within the İBTZ, has been considered to be Middle to Upper Miocene, while Karacık et al. (2013) demonstrated that the Cumaovası basin is in fact Early Miocene in age on the basis of geochronological data from the volcanic rocks that were sampled for paleomagnetic studies by Uzel et al. (2015). Similarly Uzel et al. (2015) proposed a Lower Miocene age for the Turgutlu granite, while ^{40}Ar/^{39}Ar dating indicates emplacement at 16.1 Ma (e.g. the beginning of the Middle Miocene, see Appendix 1). Therefore, a table of Ar/Ar ages should have been given to correlate each sample for paleomagnetic measurements to avoid such inconsistencies and provides constraints on the timing of rotation. Their paleomagnetic evidence is unsupported as a consequence of not providing ^{40}Ar/^{39}Ar data from various different types of rocks. The dataset published on its own is insufficient to reach a conclusion on slab tear processes directly related to magmatic processes.

Uzel et al. (2015) stated that "too few have addressed – in sufficient detail – the tectonic history of the İBTZ and the western Anatolian extensional regime". In this statement, they have not cited Karaoğlu (2014) that gave detailed structural data along the İIBTZ and discussed the role and timing of İBTZ, and also some incremental tectonics controlling the Yamanlar and Yuntdağı volcanic regions since Early Miocene. Critical structural and volcanological data in this study highlight the tectonic controls of the western part of the Menderes Massif and implications for the incremental deformation of the region using fault kinematic data, geological maps and structural trends of dykes and eruptive vents.

2. Discussion

The authors document a comprehensive geological evolution of the western Anatolia since Early Miocene based on their unpublished radiometric age data. However, the authors neglected several fundamental papers directly focused on magmatic processes and geodynamic evolution of the western Anatolia (Ersoy et al., 2012; Erkül et al., 2005, 2013; Erkül and Erkül, 2012; Karaoğlu, 2014; Karaoğlu and Helvacı, 2014). Radiometric data of these studies could have been compiled together with their own data in order to better evaluate the consistency of the results.

Uzel et al. (2015) propose an extension model for the Menderes core complex (their Fig. 8), western part of the massif is controlled by İBTZ, however it is ambiguous how they reach this conclusions using their paleomagnetic results. There is no published evidence in the existing literature to support their model.

Furthermore, the authors suggest two stages of extension based on rotational history of the IBTZ and its surroundings. This style of extension has already been discussed in the paper by Erkül et al. (2013) which provided an approach to understanding the evolution of regional structural patterns using a combination of geological data and petrogenetic tracers of magmatic associations over the Menderes and Cycladic MCCs. They also inferred the timing of change in tectonic regime from ductile to brittle mode of extension in western Turkey. It is suggested that the transition from a ductile to a brittle mode of extension in western Turkey may be linked to the opening of a slab window beneath the Menderes Massif, while authors argue that the progressive slab tear mechanism was responsible for the development of the İBTZ. Biryol et al. (2011) provide clear evidence for the discontinuity on the slab beneath the Menderes Massif (e.g. slab window or tear; see Appendix 3), which is unlikely to be related to STEP faults proposed by Wortel and Spakman (2000) (Appendix 3). On the other hand, Uzel et al. (2015) suggested that the slab tear occurred beneath the İBTZ or so-called "western Anatolia shear zone". In this case, it would be expected that asthenosphere-derived (OIB-like) Na-alkaline basaltic rocks should be emplaced along the İBTZ, however, such volcanism is only seen in the centre of the Menderes Massif (Kula volcanics). Furthermore, interpreted mantle tomography data provided by Biryol et al. (2011) do not show any evidence of discontinuity beneath the transfer zone.

The authors surprisingly conclude a model that apparently ignores magmatic aspects, which in turn implies magmatic processes beneath the western Anatolia. Their proposed mantle flow and slab tear mechanism across the eastern margin of the Menderes Massif has been extensively discussed by Karaoğlu and Helvacı (2014). Besides, the authors avoided discussing the structural geology and geodynamic aspects of the structural margin of the Menderes Massif and have failed to acknowledge key publications. Recent papers uncited by Uzel et al. (2015) record that extensional tectonic regime and related Cenozoic volcanism in western Anatolia was mainly controlled by three thermally induced tectonic zones (Karaoğlu, 2014, reference therein). So, the authors systematically avoided to make an extensive discussion about those documented geological, petrologic and tectonic records about western Anatolia.

Uzel et al. (2015) also stated that the interpretation of İBTZ as a NE-continuation of the mid-Cycladic lineament (MCL) has been recognized only by Uzel et al. (2013). This is not correct as the relationship between İBTZ and MCL has already been defined by a number of researchers (Kokkalas and Aydin, 2013, references therein). On the other hand, it should be noted that the İBTZ and MCL have a number of contrasting features. (1) The İBTZ mainly occurs within the melange rocks of the Late Cretaceous Bornova Flysch Zone that juxtaposes the metamorphic rocks of the Menderes Massif in the east and the non-metamorphic rocks of the Sakarya Zone in the west. However, the Mid-Cycladic lineament is a relatively short-lived, narrow shear zone that extends through the Cycladic metamorphic core complexes. (2) The İBTZ is considered to have been a pre-existing zone of weakness which probably operating since the Late Cretaceous (Okay et al., 2012) while the MCL formed within the Cycladic MCC during Late Miocene to Pliocene (Walcott and White, 1998; Kokkalas and Aydin, 2013). (3) Typical low-angle detachment faults in the MCC abruptly terminate at the İBTZ while the MCL lies across the Cycladic MCC and detachment faults. (4) İBTZ controls the emplacement of high-K, calc-alkaline to shoshonitic volcanic rocks over the Bornova Flysch Zone, while MCL controls the syn-extensional pluton emplacement in a core-complex setting. The role of MCL during development of the İBTZ is not clearly defined and requires much more data from the MCL to understand these contrasting features and to highlight the mutual relationship of the İBTZ and MCL.

Authors also argue that the rotational patterns in crustal blocks along the İBTZ and its surroundings revealed that the İBTZ were operated as a dextral shear zone during Early Miocene. This statement is not in agreement with their Fig. 6a as sinistral shear sense was marked in the western part of the İBTZ. Their Fig. 8a also indicates a sense of displacement in two directions, which causes confusion regarding the sense of the shear zone. It is clear that the İBTZ is structurally rather complex and much more structural/kinematic data are required to characterize the development of such crustal-scale shear zone.

Moreover, a possible mechanism for the evolution of the İBTZ, in a regional geodynamic concept, has been discussed by Ersoy and Palmer (2013) and Ersoy et al. (2014), in which the activity of the İBTZ is linked to the southward rotational roll-back of the subduction zone in the Aegean since the late Eocene. This interpretation is supported by south-westward younging of sedimentary basins and volcanic rocks along the İBTZ.

Another issue is the fact that the eastern margin of the Gördes basin was controlled by strike-slip faults. Ersoy et al. (2011) suggested that this fault zone was controlled the deposition of the Early Miocene sedimentary units of the basin, and that it marks the eastern structural boundary of the Menderes Extensional Complex, as well as the eastern boundary of the strike-slip faulting along the İBTZ. Uzel et al. (2015) excluded this fact by using the rotational data of the volcanic rocks in the basin. However, this region might not be affected by rotation locally as a distinct block, and this does not mean that the region lie outside of the İBTZ. In any case, we would like the authors to have discussed these data before the regional geodynamic interpretations and modelling.

Authors also use the results of the geochemical models of the Miocene volcanic rocks in order to support their ideas. They mention that the lithospheric mantle beneath the region has been thinner from east to west, as inferred from decreasing potassium compositions of the volcanics. Ersoy et al. (2010) has already suggested that the eastward increasing potassium and other incompatible element enrichment can be explained by a thickening lithospheric mantle that would allow to multi-stage in-situ enrichment via melting and melt-rock interaction.

As a conclusion, the İBTZ has been extensively defined in the literature as a significant structural element during development of a post-collisional extensional regime in the Aegean region. We propose a number of issues with the author's interpretation of the İBTZ development. We believe that Uzel et al. (2015) has not provided sufficient data and has failed to combine the data presented with very recent published information which has led to the development of a tectonic model based on misinterpreted and lacking data.

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Appendix A. Supplementary data

Supplementary material related to this article can be found online at http://dx.doi.org/10.1016/j.epsl.2015.07.009.

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