# A new look at the western Anatolia-Aegean morphotectonics

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The Western Anatolian-Aegean Extended Terrain stretches from the Balkan region in the north to the Mediterranean Sea in the south. The terrain has the following 4 major geological components (Yilmaz, 1989, 2007; Yilmaz et al., 2000, 2010):

1. The Metamorpic Massives
2. The Magmatic Associations
3. The Neogene Cover rocks
4. The N-S extensional regime

A number of different views have been proposed about each of these subjects. In this paper, a review of the nature of these problems will be briefly outlined, but the main concentration will be on the most active events: the development of the present morphology.

In western Anatolia, there are about ten approximately east-west trending grabens. They are about 100–150 km long and 5–15 km wide. The present morphology is the result of the ongoing extensional tectonic regime, which has produced very distinctive features: the present grabens and horsts (Yilmaz et al., 2000, 2010). The stretching is continuing at a high rate (ß>1.2–1.4). This has had pronounced effects on the morphology, particularly along the coastal regions, and it influenced greatly the locations of ancient settlements, such as Miletus, Ephesus, Troia, and many others.

The Neogene history of the region may be summarized as follows: during the Early-Middle Miocene period, thick volcano-sedimentary associations were formed within approximately north-south trending fault-bounded continental basins under an east-west extensional regime (Yilmaz et al., 2000; Bozcu, 2010). The coeval sedimentary rocks of similar lithofacial characteristics cropping out extensively suggest that interconnected (lake) basins invaded the entire Western Anatolian-Aegean region in which low energy lacustrine sediments were deposited. During this period, magmas were emplaced along the north-south trending tensional openings.

In the late Miocene, north-south extension started. During this period, major breakaway faults began to form around Bozdağ, located in the central part of the region (Bozcu, 2010). Consequently, Bozdağ began to rise. The depositional response of this elevation is red, coarse clastics deposited along the periphery of Bozdağ. Away from the Bozdağ, high clastic rocks pass laterally into white lacustrine limestones (Yilmaz et al., 2000; Bozcu, 2010).

During the Late Miocene-Early Pliocene period, the north-south extension ceased for a brief period until the end of the Early Pliocene, and a regionwide erosional surface was formed consequently. When the north-south extension was reactivated, the present graben system began to form. The east-west trending graben-bounding faults cut and disconnected the continuity of the previously developed north-south grabens. As a result, they remained as hanging grabens on the footwall blocks of the east-west grabens (Bozcu, 2010).

The Magmatic Associations cover all of western Turkey from the Thrace and Marmara region in the north down to the Hellenic Arc in the south. They were initiated in 2 discrete phases, an early phase and a late phase (Yilmaz 1989, 2008). During the initial phase, granitic stocks, small plutons, and intermediate and felsic volcanic rocks were extensively developed. The plutonic and volcanic rocks are closely associated in time and place. These rocks are calc-alkaline in composition, and their compositions form a cluster displaying a common character and origin. The composition of the volcanic rocks of this episode shift from calc-alkaline to shoshonitic through time. Presently, they are developing along the Hellenic Arc. This initial phase of magmatic associations displays magmatic arc geochemical signatures; the mantle-derived magmas were enriched by crustal components and later underwent AFC processes (Yilmaz, 1989).

The later phase of the magmatic events produced mainly basic rocks which were missing during the early phase. They are sporadically developed and much less extensive. They form a distinctly different compositional cluster from the chemical composition of the early phase. Geochemically, the latter is alkaline in character and displays similar affinities to the magmas that formed under extensional regimes (Yilmaz, 1989). The later phase of magmatic rocks began to form during the late Miocene, around 10 million years ago, and has continued until the present time. Therefore, there is an apparent time gap between the developments of the two magmatic phases, which narrows southward. The gap is large in the northern regions where the initial phase began during the Eocene-Oligocene period (Yilmaz, 2008).

The gradual migration of the volcanic front of the early phase displaying the arc magmatic affinities leads to the following assumptions:

1. They were formed in association with the subduction along the Hellenic trench. This subduction is assumed to have been continuing since at least the Late Cretaceous period. This assumption is based on the length of the subducting slab, which is more than 600 km (Hinsbergen et al., 2005).

2. The southward migration of the arc magmas may be regarded as linked to the roll-back of the subducting slab; at least two stages of roll-back are observed along the length of the slab (Hinsbergen et al., 2005).

The late magmatic phase, which is closely related to the east-west trending faults and associated structures, is considered to be the magmatic products formed under the extensional regime, when the north-south extension began (Yilmaz, 1989, 2008).

The Neogene sedimentary rocks are terrestrial deposits in western Anatolia and form three tecto-stratigraphic units separated by unconformities (Yilmaz et al., 2000). The Lower Unit is Early to Middle Miocene in age. The Middle Unit is Late Miocene-Early Pliocene in age and is represented primarily by lacustrine white limestones. They are the most extensive Neogene rocks in western Anatolia and apparently were formed in interconnected basins (Yilmaz et al., 2000). Shallow lakes appear to have covered all of western Anatolia during that period. Above the sequence of the Middle Unit, a region-wide, flat-lying erosional surface can be observed, corresponding to a period of severe denudation that affected the region through the end of the Early Pliocene. This surface may be used as a key stratigraphic horizon (Yilmaz et al., 2000).

In recent years, the Aegean extensional region has come to be regarded as comparable to the Basin and Range region of the western United States (Wernicke, 1992; Dilek and Whitney, 2000), and accordingly, the Metamorphic Massifs are evaluated as a core complex formed under the extensional regime (Bozkurt and Park, 1994; Çemen et al., 2006). However, the main geological characteristics of western Anatolia are not quite similar in nature to those of the Basin and Range (Yilmaz, 2008).

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