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Geochemistry and $^{40}Ar/^{39}Ar$ geochronology of Miocene volcanic rocks from the Karaburun Peninsula: Implications for amphibole-bearing lithospheric mantle source, Western Anatolia

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ABSTRACT

New geochemical and $^{40}Ar/^{39}Ar$ age data are presented from the Neogene volcanic units of the Karaburun Peninsula, the westernmost part of Western Anatolia. The volcanic rocks in the region are associated with Neogene lacustrine deposition and are characterized by (1) olivine-bearing basaltic-andesites to shoshonites (Karaburun volcanics), high-K calc-alkaline andesites, dacites and latites (Yaylaköy, Armağandağ and Kocadağ volcanics) of ~16–18 Ma, and (2) mildly-alkaline basalts (Ovacık basalt) and rhyolites (Urla volcanics) of ~11–12 Ma. The first group of rocks is enriched in LILE and LREE with respect to the HREE and HFSE on N-MORB-normalised REE and multi-element spider diagrams. They are comparable geochemically with volcanic rocks in the surrounding regions such as Chios Island and other localities in Western Anatolia. The Ovacık basalt is geochemically similar to the first stage early–middle Miocene volcanic rocks but differs from NW Anatolian late Miocene alkali basalts.

Trace element models indicate that the Kocadağ and Armağandağ volcanics were produced from the Yaylaköy volcanics by assimilation and fractional crystallization (AFC). Melting models of several trace elements of the most primitive mafic volcanics indicate that their source was metasomatized by subduction-related fluids and was amphibole-bearing garnet–lherzolitic.

1. Introduction

The late Cenozoic geodynamic evolution of the Aegean extensional province (Fig. 1) is mainly controlled by: (1) the Aegean subduction zone along which the African plate is sinking underneath the Aegean–Anatolian plate (e.g., Jackson and McKenzie, 1984); (2) collisional events between continental blocks; and (3) a post-collisional extensional tectonic regime that begun during the latest Oligocene (Seyitoğlu and Scott, 1991). The latter has been accommodated by: (a) orogenic collapse of the Paleogene over-thickened Western Anatolian crust during which the mid-crustal units of the several metamorphic massifs were exhumed along the low-angle detachment faults throughout the late Cenozoic (Gessner et al., 2001; Lips et al., 2001; Sözbilir, 2001, Işık et al., 2003; Sözbilir, 2005); (b) the westward extrusion of the Anatolian block along the North Anatolian Fault (NAF) and the East Anatolian Fault (EAF) (Şengör et al., 1985; Koçyiğit et al., 1999); and (c) southwestward migration of the Aegean subduction zone (e.g., Jackson and McKenzie, 1984). These geodynamic regimes are also responsible for the volcanic activity in the region. In the area represented in Fig. 2, wide-spread late Cenozoic volcanic rocks crop out throughout the Western Anatolian coastal region and Aegean islands forming the eastern part of the Aegean extensional province.

The Karaburun Peninsula, forming the main scope of this study is located at centre of the region (Fig. 2) and contains well-preserved Neogene volcanic units of whose geochemical characteristics have not yet been well-documented. The Neogene volcanics in the Karaburun Peninsula are also located between two important areas which have been interpreted to have distinct geodynamic features: (1) a volcanic province in the south which is the easternmost part of the active Aegean arc located on the front of the Hellenic trench (namely the Bodrum Peninsula and surroundings in (Fig. 2); and (2) a large volcanic province in the north (a region located to the south of the Sea of Marmara, Fig. 2). The volcanic activity in the latter has produced wide-spread calc-alkaline basalts, andesites, dacites and rhyolites during Eocene to middle Miocene (first stage) and alkaline mafic volcanics after the middle Miocene (second stage). Geochemical features of the first-stage volcanic products clearly resemble those of other subduction-related volcanic rocks in the world (e.g., Pearce and Parkinson, 1993). The second-stage basalts, on the other hand, are represented by OIB-like geochemistry indicating that they originated from a different mantle source from the first stage volcanic activity (Güleç, 1991; Aldanmaz et al., 2000). These two stages of volcanic activity have been differently interpreted by several workers. A general agreement exists among most workers suggesting that the volcanic units in the region

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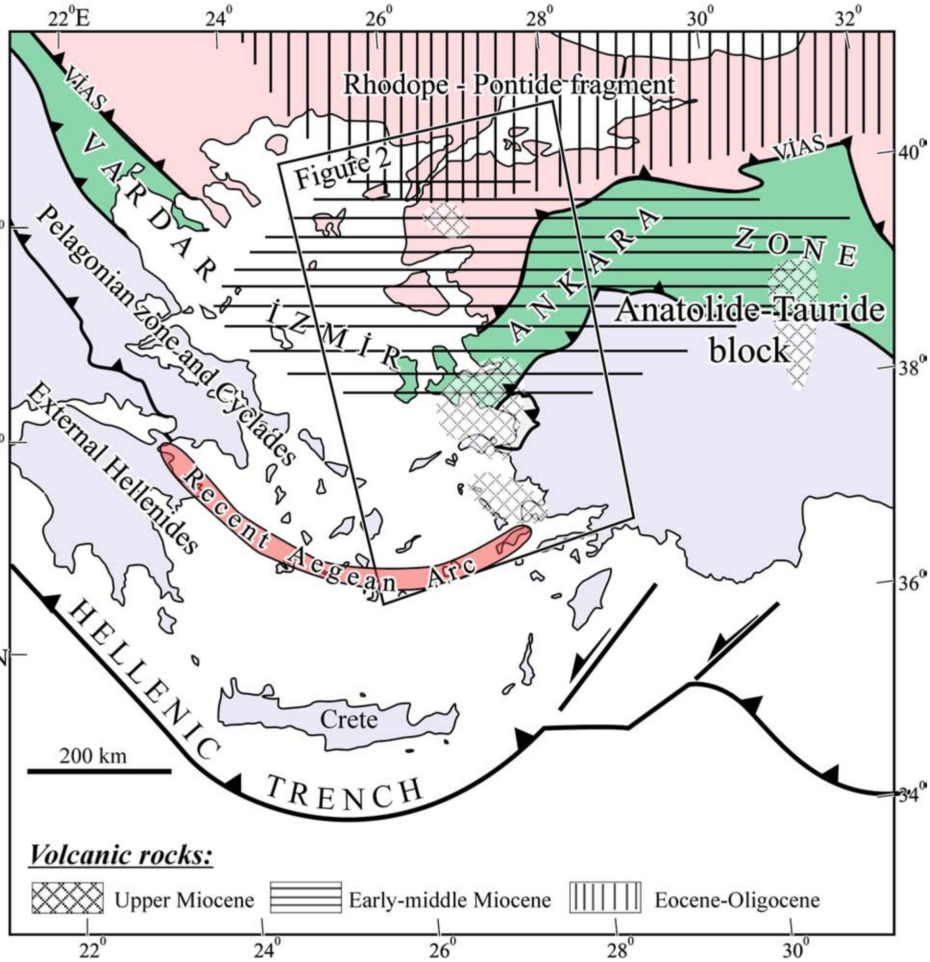

Fig. 1. Regional map of the Aegean region (from Okay and Tüysüz, 1999; Ring et al., 1999). VIAS: Vardar–İzmir–Ankara suture zone. Distribution of volcanic rocks is from Fytikas et al. (1984).

are the products of post-collisional settings (Yılmaz, 1989, 1990; Güleç, 1991; Aldanmaz et al., 2000; Altunkaynak and Dilek, 2006; Altunkaynak and Genç, 2008; Pe-Piper et al., 2009). On the other hand, some workers have proposed that the whole volcanic activity of the region was related to the southwestward migrating Aegean subduction system (Fytikas et al., 1984; Okay and Satır, 2000; Erkül et al., 2005; Innocenti et al., 2005).

The mantle source(s) of the magmas forming the Neogene volcanic units (except for those of the late Miocene) is accepted to had been metasomatized, either by active or previous subduction in the region, although its characteristics and mineralogy have not been well-constrained. In this study, we present new geochemical and radiometric age data from the Karaburun Peninsula, and compare them with the other volcanic occurrences in the Aegean region to examine the petrogenetic evolution of the volcanic rocks in the region throughout the late Cenozoic. We also examine their geochemical features to reveal the source characteristics of the volcanic rocks.

2. Distribution of volcanic rocks in the Aegean region

In the eastern part of the Aegean extensional province, widespread volcanic activity has taken place from the Eocene to Recent. The volcanic rocks of the Eocene to late Miocene are mainly accepted to have been produced in a post-collisional setting. The volcanic rocks in the Karaburun Peninsula lie in the southern part of this large volcanic province. On the other hand, the younger volcanic units are related to active subduction along the Hellenic trench in the south Aegean (Aegean subduction system).

In the Biga Peninsula and surroundings, along the southern coast of the Sea of Marmara, the first magmatic activity in the area occurred in the Eocene (Fig. 2). During the Eocene, calc-alkaline volcanic rocks (42–29 Ma, Ercan et al., 1995, 1998; Altunkaynak and Genç, 2008; Altunkaynak and Dilek, 2006) and I-type granitodes (49–45 Ma, Delaloye and Bingöl, 2000; Karacık et al., 2007b) were formed. The magmatic activity in this region also continued in the Oligocene and early Miocene (31.3–18 Ma) with similar products (Ercan et al., 1995, 1998; Altunkaynak and Genç, 2008), which can also traced in the Gökçeada (Ercan et al., 1995) and Samothraki Islands (Seymour et al., 1996) and Thrace Basin (Ercan et al., 1998). Early Miocene volcanic activity also occurred in Limnos Island with high-K and calc-alkaline and lamproitic products formed at ~22–18 Ma (Pe-Piper and Piper, 2007a; Pe-Piper et al., 2009). On the other hand, there are several mafic volcanic centers which were emplaced in the Biga Peninsula during the late Miocene (11.16–7.65 Ma; Ercan et al., 1995; Kaymakçı et al., 2007). These mafic volcanics are characterized by intra-continental alkali basaltic lavas with OIB-like isotopic and trace element compositions

Fig. 2. Distributions of the late Cenozoic magmatic rocks in the eastern Aegean (Modified from MTA (2002) on the basis of age data of Borsi et al. (1972); Robert et al. (1992); Ercan et al. (1985, 1986, 1995, 1998); Helvacı (1995); Delaloye and Bingöl (2000); Aldanmaz et al. (2000); Alther and Siebel (2002); Emre and Sözbilir (2005); Innocenti et al. (2005); Erkül et al. (2005); Karacık et al. (2007b); Pe-Piper and Piper (2007b); Altunkaynak and Genç (2008); Pe-Piper et al. (2009).