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Eocene-Quaternary magmatic activity in the Aegean: Implications for mantle metasomatism and magma genesis in an evolving orogeny

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ABSTRACT

We present a compilation and comparison of geochemical data of Aegean Eocene to Recent magmatic rocks: (1) North Anatolian Eocene magmatic rocks (NAEM), (2) Aegean to west Anatolian Oligocene–Miocene magmatic rocks (AOMM), (3) Pliocene–Quaternary South Aegean volcanic arc (SAVA), (4) Pliocene–Quaternary Denizli–Isparta volcanics (DIV), and (5) Na-alkaline basalts with intra-plate geochemical affinity (IPV). These rocks are also compared with Miocene Galatean volcanics (GVP) from central Anatolia.

The NAEM, SAVA and GVP show similar geochemical features indicative of a subduction-related origin in which subducted oceanic plate contaminated the overlying mantle wedge. The distinct geochemical features of the AOMM reflect derivation from an intensely metasomatised mantle source, resulting from partial subduction and accretion of both continental and oceanic assemblages in the fore-arc of a southward migrating subduction system. These features provide an insight into the history of the distinct types of mantle metasomatism in the region and into its geodynamic evolution — an evolution that include complex interaction of subduction roll-back, slab break-off, strike-slip faulting along major transfer zones, block rotations and core complex formation.

Thus, the Eocene to recent magmatism in the region was controlled by various tectonic events: (1) the NAEM was most probably related to break-off of the subducted slab in western Anatolia, (2) magmatic activity in the western AOMM was controlled by rotational extension around poles in northern Greece developed in response to rotational roll-back of the Hellenic subduction system, (3) while AOMM magmatism in the east is closely associated with core complex formation and asthenosphere-related thermal input along a ~N–S-trending slab tear. In contrast, the rocks of the DIV and IPV carry asthenospheric mantle geochemical signatures indicative of roll-back induced asthenospheric upwelling in Rhodope to NW Anatolia, and slab tear-induced asthenospheric upwelling beneath the Menderes Core Complex.

1. Introduction

The western part of the Alpine–Himalayan orogenic belt, along which the Aegean region lies, marks the zone where the Tethyan oceans are being consumed by subduction, and following continental collision, crustal subduction and accretion occurred (Fig. 1; cf. Şengör and Yılmaz, 1981; Okay and Tüysüz, 1999). This area is characterized by the presence of extensional domains in which magmatic activity generated, (1) widespread low- to high-K calcalkaline and associated shoshonitic-ultrapotassic rocks with subduction-related geochemical affinity (orogenic magmas), which are mostly followed by, (2) generally Na-alkaline basaltic volcanic rocks with OIB-like intraplate affinity (anorogenic magmas) throughout the orogenic to post-orogenic phases (e.g., Aldanmaz et al., 2000; Carminati et al., 2012; Conticelli et al., 2009; Cvetković et al., 2004; Dilek and Altunkaynak, 2009; Peccerillo and Martinotti, 2006; Pe-Piper and Piper, 2007a; Prelević et al., 2005; Seghedi and Downes, 2011; Tommasini et al., 2011). The geochemical characteristics of the orogenic magmas, such as high K and radiogenic Sr contents and high ratios of large ion lithophile elements (LILE) to high-field strength elements (HFSE), have been attributed to multi-stage interaction of the mantle wedge with fluids/melts from subducted crustal sediments (i.e., metasomatism in their mantle sources) and subsequent crustal contamination processes (cf., Pearce, 1982), but the details and origin of the crustal material, the type of metasomatism and the nature of the mantle sources remain debated. In oceanic and continental arcs mantle metasomatism normally develops in response to chemical alteration of the mantle wedge by metasomatizing agents released from subducted oceanic crust and sediments (cf., Turner et al., 1997). However, in the Alpine–Himalayan geodynamic setting, small oceanic branches

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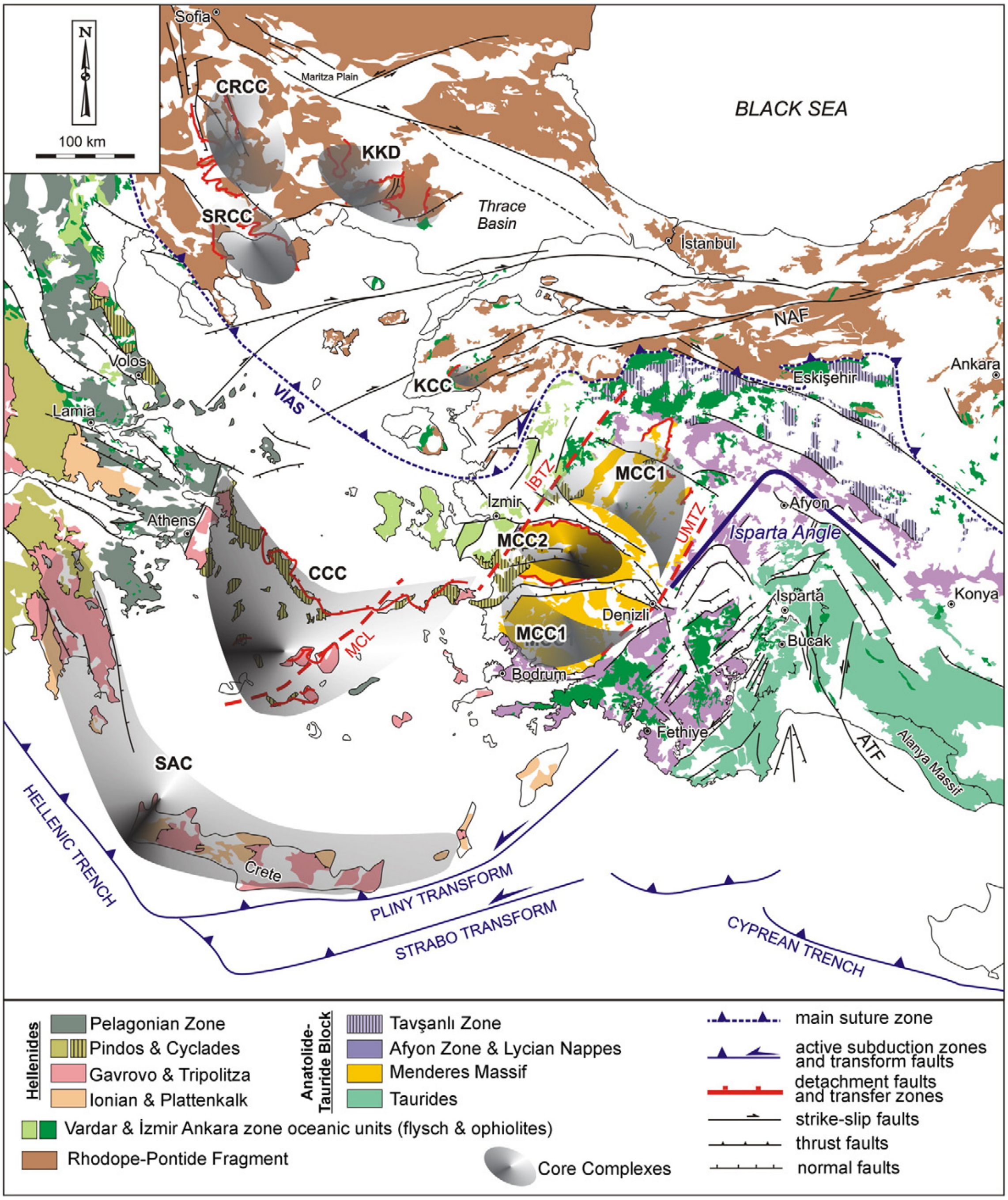

Fig. 1. Tectonostratigraphic units and major tectonic elements of the Aegean region (compiled geological maps of Greece (IGME) and Turkey (MTA), Okay and Tüysüz, 1999; Ring et al., 2001, 2010; Pe-Piper et al., 2002; Candan et al., 2005; van Hinsbergen et al., 2005). CRCC: Central Rhodope, SRCC: Southern Rhodope, KCC: Kazdağ, CCC: Cycladic, SAC: South Aegean (Crete) core complexes. KKD: Kesebir–Kardamos Dome. MCC1 and MCC2 refer to first- and second-stage development of the Menderes Core Complex. VİAS: Vardar–İzmir–Ankara suture zone, NAF: North Anatolian Fault Zone. İBTZ: İzmir–Balıkesir, UMTZ: Uşak–Muğla transfer faults. MCL: Mid-Cycladic lineament. ATF: Aksu thrust fault.

were consumed by intra-oceanic subduction(s) (e.g., Okay and Tüysüz, 1999; Ricou et al., 1998) and there were subsequent collisional events between small continental blocks (and arcs) that complicate these processes. Hence, it is suggested that the mantle domains were contaminated by fluid/melt components released from, (a) subducted oceanic assemblages and continentally-derived sediments (including tectonic mélange rocks) (Gao et al., 2007; Peccerillo and Martinotti, 2006; Prelević et al., 2012; Tommasini et al., 2011), and (b) crustal blocks or slivers subducted during collisional events (Çoban et al., 2012; Ersoy et al., 2012b; Flower et al., in press; Mahéo et al., 2002; Parkinson and Kohn, 2002; Prelević et al., 2013; Schreyer et al., 1987; Zhao et al., 2009).

The Aegean region lies along the Alpine-Himalayan orogenic belt and marks an area where consumption of small oceanic branches by subduction was followed by continental collision, crustal subduction and accretion (Fig. 1). Geochemical evaluation of the rock groups and their relationship to the geodynamic history of the region has the potential to provide insights into the wider understanding of the geochemical evolution of magma series and their mantle sources in complex orogenic settings. Here, we summarize the geodynamic evolution of the Aegean region and provide a compilation of major and trace element, and isotope data for Eocene to recent magmatic rocks in eastern Rhodope, Aegean and western Anatolia. This information has been used to explore the petrogenetic processes responsible for the magmatism and to test the hypothesis