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Mineral chemistry, crystallization conditions and geodynamic implications of the Oligo–Miocene granitoids in the Biga Peninsula, Northwest Turkey

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ABSTRACT

Widespread plutonic rocks in NW Turkey occur within the southward-younging and overlapping magmatic belts across the Aegean region. Post-collisional magmatism is represented by a series of granitoidic intrusions and volcanic successions. K–Ar and U–Pb LA–ICP–MS zircon dating of the Kazdağ and Yenice plutons yielded ages between 20.5 ± 0.5 Ma and 27.89 ± 0.17 Ma (Late Oligocene–Early Miocene). The granitoid samples are high-K calc-alkaline and metaluminous to slightly peraluminous. The $^{87}Sr/^{86}Sr$ values for the granitoids, enclaves and leucocratic rocks range between 0.705168 and 0.708357. The initial $^{143}Nd/^{144}Nd$ ratios calculated for the crystallization ages of ca. 23–27 Ma are between 0.512425 and 0.512614, and the εNd values vary from −3.5 to 0.2. The Nd T_{DM} model ages range between 0.73 and 1.13 Ga. These samples are enriched in LILEs and LREE and depleted in HFSEs with negative Eu anomalies, indicating that the melts were derived from an enriched lithospheric mantle modified by subducted slab-derived melts. Energy constrained-assimilation and fractional crystallization (EC-AFC) modelling indicates that fractional crystallization and crustal assimilation modified the parent magma's composition during its residence in the upper crust.

The mineral chemistry of amphiboles, pyroxenes, biotites and feldspars is used to constrain the pressure (*P*), temperature (*T*), oxygen fugacity ($\log fO_2$) and water contents (H_2O_{melt}) during the crystallization of the magmas in the studied granitoids. The clinopyroxene temperatures are in the range of 823–910 ± 45 °C. The amphibole temperatures for the studied plutonic rocks are in the range of 707–926 °C (mean = 798 ± 45 °C), and the crystallization depths are estimated to be in the interval of 1.02–10.2 km. The NW Anatolian plutonic rocks can be considered to have been equilibrated at the oxygen fugacities of calcic amphiboles ($\log fO_2$) between −8.99 and −13.96 bars (mean = −12.11 bar) and H_2O_{melt} contents between 1.63% and 6.79% (mean = 4.15%). Meanwhile, the biotites, which display consistent oxygen fugacity values (−10.65 to −13.22), suggest their reliability with the typical values of calc-alkaline magma crystallization. These values suggest a relatively higher oxidation state during crystallization and are related to arc magmatism. All of the calculated values indicate that all of the plutons were emplaced at shallow crustal levels.

It can be inferred that the Oligo–Miocene magmatism in NW Turkey may be linked to crustal thinning that resulted from slab roll-back and a back-arc extensional regime after the collision between the Sakarya Zone and Anatolide–Tauride Platform.

1. Introduction

The closure of the Neo-Tethyan Ocean and subsequent arc-continent collision played an important role in shaping the Eastern Mediterranean region and Anatolia at the end of the Late Cretaceous. The İzmir–Ankara–Erzincan suture zone (Fig. 1a) is one of the most important suture zones that represents this collision in the northern part of Anatolia and separates the Sakarya Zone from the Anatolide–Tauride Platform (Okay and Tüysüz, 1999; Şengör and Yılmaz, 1981). A magmatic arc that was active during the Late Cretaceous covered a widespread area in the northern part of İstanbul to the Balkans, which was attributed to a typical subduction zone (Georgiev et al., 2012; Karacık and Tüysüz, 2010; von Quadt et al., 2005). This arc magmatism was

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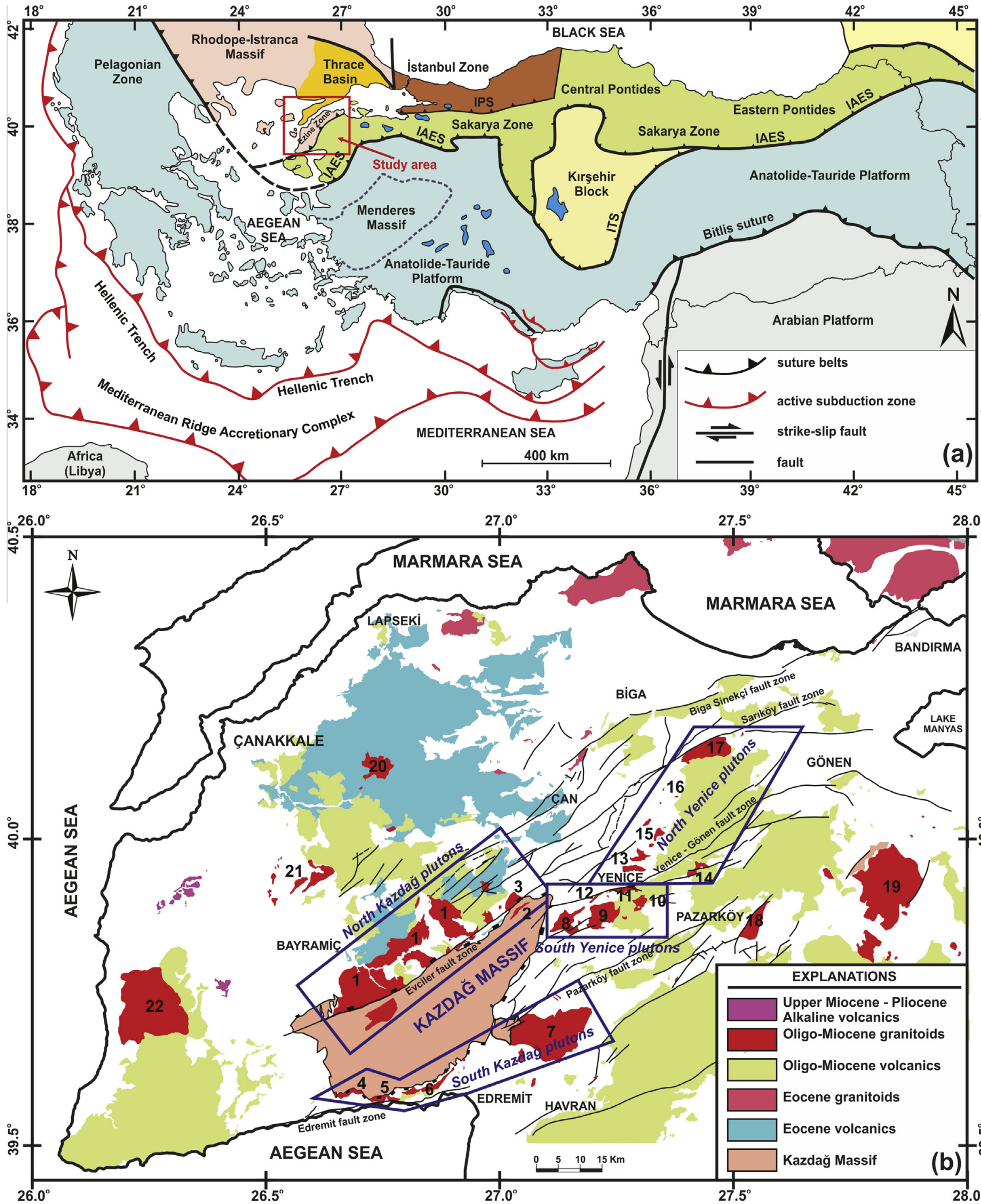

Fig. 1. (a) Tectonic map of Turkey and the surrounding area with major suture zones (Okay and Tüysüz, 1999; http://giseurope.brgm.fr/Tethyan/WTethysideMed2.gif). IPS: Intra Pontide suture, IAES: İzmir–Ankara–Erzincan suture, ITS: Inner Tauride suture. (b) Simplified and revised geological map of NW Anatolian plutons (revised from Duru et al., 2012). 1: Evciler, 2: Zeybekçayırı, 3: Eskiyayla, 4: Narlı–Şelale, 5: Altınoluk, 6: Avcılar, 7: Eybek, 8: Hıdırlar, 9: Kurtlar, 10: Namazgah, 11: Yenice, 12: West Yenice, 13: Nevruz–Çakıroba, 14: Kızıldam, 15: Soğucak stocks (Soğucak, Sofular, Yapaztepe), 16: Karadoru, 17: Sarıoluk, 18: Karadağ, 19: Solarya, 20: Çamyayla, 21: Kuşçayırı, 22: Kestanbol.

followed by the development of syn- to post-collisional magmatic belts in the Middle Eocene (Lutetian) (Altunkaynak et al., 2012b; Delaloye and Bingöl, 2000; Ersoy and Palmer, 2013; Köprübaşı and Aldanmaz, 2004; Harris et al., 1994; Ustaömer et al., 2009). These Eocene magmatic rocks were mainly situated in the northern part and a portion in the southern part of the İzmir–Ankara–Erzincan Suture belt (Altunkaynak et al., 2012b and references therein).

Extensive magmatic activity during the Late Oligocene and Early Miocene is known to have produced the widespread granitoidic plutons and coeval volcanic rocks in NW Anatolia (Aldanmaz et al., 2000; Altunkaynak et al., 2012a,b; Altunkaynak and Genç, 2008; Erkül, 2012; Erkül and Erkül, 2012; Genç, 1998; Hasözbek et al., 2010a,b; Karacık et al., 2008; Yılmaz-Şahin et al., 2010). The Upper Miocene–Pliocene is represented by alkaline basic volcanic rocks (Aldanmaz et al., 2000; Aysal et al., 2011).