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The geochemical and Sr–Nd isotopic characteristics of Eocene to Miocene NW Anatolian granitoids: Implications for magma evolution in a post-collisional setting

Dağhan Çelebi, Nezihi Köprübaşı *

Department of Geological Engineering, Kocaeli University, 41380 İzmit, Turkey

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ABSTRACT

Early Eocene to Early Miocene magmatic activity in northwestern Anatolia led to the emplacement of a number of granitoid plutons with convergent margin geochemical signatures. Granitoid plutons in the area are mainly distributed within and north of the suture zone formed after the collision of the Anatolide-Tauride platform with the Pontide belt. We present geochemical characteristics of three intrusive bodies in the region in order to identify their source characteristics and geodynamic significance. Among these, the Çataldağ and Ilıca-Şamlı plutons are located to the north and the Orhaneli pluton is located to the south of the IAESZ (Izmir-Ankara-Erzincan Suture Zone). The plutons are calc-alkaline, metaluminous, and I-type with compositions from granite to monzonite. They display clear enrichments in LILE and LREE and depletions in HFSE relative to N-MORB compositions and have high $^{87}Sr/^{86}Sr$ and low $^{143}Nd/^{144}Nd$ ratios.

The results of theoretical Fractional Crystallization (FC) model show that the samples are affected by fractionation of K-feldspar, plagioclase, biotite and amphibole. Assimilation and Fractional Crystallization (AFC) modeling indicates that the *r* value, the proportion of variable contamination to fraction, is high, indicating significant crustal contamination in the genesis of granitoid magmas. Combined evaluation of isotopic and trace element data indicates that the granitoids are the products of mantle-derived mafic magmas variably differentiated by simultaneous crustal contamination and fractional crystallization in lower to middle crustal magma chambers in a post-collisional setting.

1. Introduction

The northwestern Anatolian region, lying on one of the most important collision belts in the world, contains a number of deep-seated granitoid bodies formed in association with tectonic activity prevailed in the Post-Late Cretaceous (Fig. 1). These occurrences have been the subject of several recent investigations.

Harris et al. (1994) stated that the Orhaneli granitoid is represented by a metaluminous melt composition and calc-alkaline affinity which are typical of subduction-related magmas. Delaloye and Bingöl (2000) analyzed radiometric ages of granitoids in the western and northwestern Anatolia and found K–Ar ages of 20.8 ± 0.4 Ma for the Çataldağ granitoid and 57.9 ± 1.2, 53.0 ± 1.1, 31.4 ± 0.6 and 51.7 ± 1.0 Ma for the Orhaneli granitoid. They interpreted these granitoids to be of subduction origin. Köprübaşı and Aldanmaz (2004) suggested that the Eocene plutonic bodies in the Armutlu, Kapıdağ and Lapseki peninsulas are of mostly calc-alkaline, metaluminous and I-type in character with compositions from hornblende monzogranite to granodiorite and represented by an enrichment in LILE and LREE and a depletion in HFSE relative to MORB composition (negative Nb and Ta anomalies), similar to subduction-related or active continental margin granites. They also suggest that the heat which caused partial melting within the metasomatized part of lithospheric mantle following the cessation of subduction was probably either due to the late orogenic delamination of the subducting slab or the lowermost part of lithospheric mantle (delamination of thermal boundary layer) and associated rise of hot asthenosphere. According to Boztuğ et al. (2006), the Ilıca (Balıkesir) and Kozak (Bergama) granitoids in the west and northwestern Anatolia are composed solely of high and intermediate-K, calc-alkaline, metaluminous and I-type granitoids, whilst the Çataldağ (Balıkesir) granitoid consists of two different lithologic units. Altunkaynak (2007) examined two E–W extending linear belts of the Eocene plutons along the İzmir-Ankara-Erzincan Suture Zone (IAESZ) and suggested that the geochemical

* Corresponding author. Tel.: +90 262 303 3136.
E-mail address: nezihi@kocaeli.edu.tr (N. Köprübaşı).

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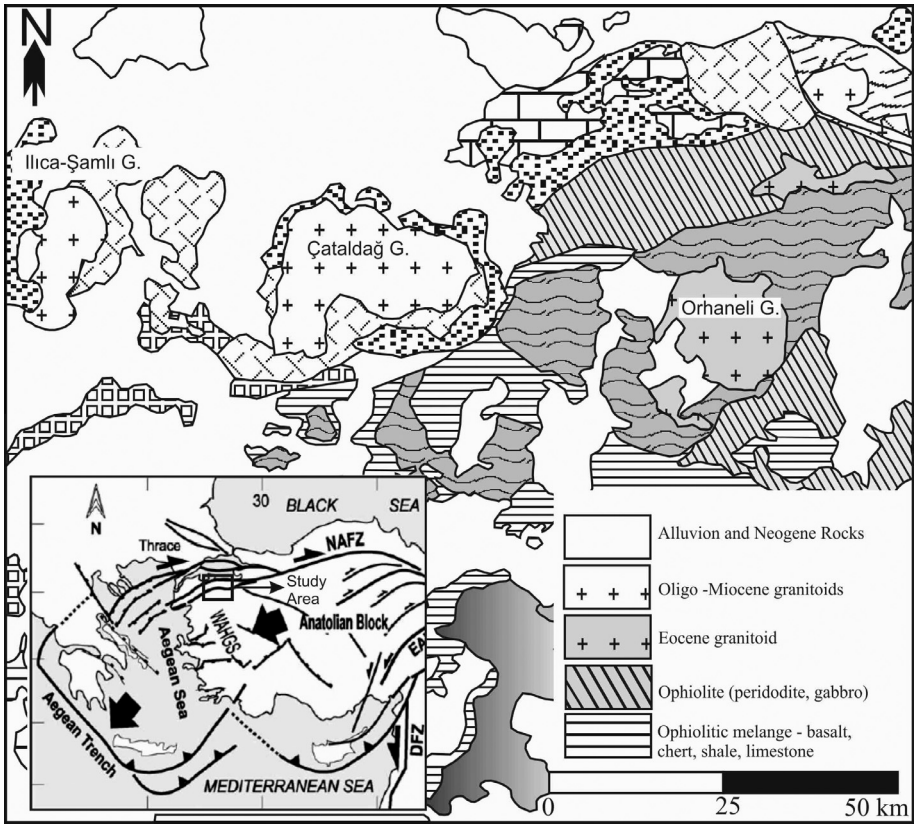

Fig. 1. Map of northwestern Anatolia showing the distribution of the Eocene–Miocene post collision granitoid plutons along with the main rock units exposed across the collision zone.

characteristics and age relations of these plutons are in support of a slab break-off. Karacık et al. (2008) studied the plutons in the southern Marmara, including the Ilıca granitoid, which are generally represented by granodiorite bodies, stocks and sills within the Triassic basement rocks. They proposed that, although the granitoids are of Late Cretaceous to Miocene age, they can be predominantly divided into two groups: The Eocene granitoids in the north and the Miocene granitoids in the south.

This study reports the geochemical and isotopic (Sr–Nd) data for the Orhaneli, Çataldağ and Ilıca-Şamlı granitoid bodies and particularly focuses on the major-trace element and isotopic data from three plutonic bodies for interpreting the evolution of the Eocene to Miocene magmatism. The Eocene–Miocene granitoid bodies outcropped in the NW of Turkey provide important data for understanding the age and stages of the extension regime that has not been fully explained in western Anatolia. This study could also contribute to the investigation of similar post-collision granitoid rocks.

2. Geological background

Most part of tectonic – geologic history of northwest Anatolia reflects the evolution of Tethys Ocean and is represented by accretion of lithospheric blocks due to a series of collisional events prevailed during the upper Mesozoic-Eocene (Köprübaşı and Aldanmaz, 2004). In northwest Anatolia, in the period between the end of late Cretaceous and Tertiary, as a result of northerly subduction of northern branch of Neotethys Ocean under the Sakarya continent, the Tauride-Anatolide platform at south and the Sakarya continent at north were collided and, as a consequence, IAESZ crossing the whole northern Anatolia was formed. Granitoid plutons are exposed in a large area at north and south of the Izmir-Ankara suture zone (Köprübaşı and Aldanmaz, 2004). Collision of Tauride-Anatolide platform with the Sakarya continent at north resulted in formation of compression deformations in the Paleocene and extension in the Oligo-Miocene (Seyitoğlu and Scott, 1992, 1997; Işık et al., 2004; Purvis and Robertson, 2004; Kaya et al., 2007). The Çataldağ, Ilıca-Şamlı and Orhaneli plutons are situated approximately in the east–west direction in the NW Anatolia (Fig. 1). The Çataldağ granitoid cut the Mesozoic units of the Sakarya Zone and was covered by the Neogene deposits and volcanic lavas. The Ilıca-Şamlı granitoid intruded into the Kiraz Metamorfits and Çataltepe marble of the Sakarya Zone. The Orhaneli granitoid intruded into the base rocks of the Tavşanlı Zone and was covered by the Early Miocene volcanics (Altunkaynak, 2007).

3. Field and petrographic characteristics

The geographical distributions of the plutons are shown in Fig. 1. The Çataldağ granitoid locally presents contact with the metamorphic rocks of the area. It generally intruded into the bedding and discontinuity planes of the older rocks concordantly. The sills intruded into the foliation planes and dikes cut or intruded vertically into the foliation planes. The Ilıca-Şamlı granitoid presents sharp contacts with the neighboring rocks, forming an approximately 2 km wide contact metamorphic zone. The Orhaneli pluton is in contact with the Miocene andesites and dacites along the western border of the pluton. Besides, the pluton has bordered by approximately NE–SW normal faults in its southeast part where it contacts with blue schists.

Petrographically, the Çataldağ Granitoid is composed of holocrystalline granitic and granodioritic rocks. These rocks contain 30–35% quartz, 15–20% K-feldspar (orthoclase-microcline) and 35–45% plagioclase (albite-oligoclase) and rare biotite together with accessory minerals of sphene, zircon and apatite (Table 1).