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O, Sr and Nd isotopic constraints on Cenozoic granitoids of Northwestern Anatolia, Turkey: Enrichment by subduction zone fluids

Yeşim Yücel-Öztürk*

Dokuz Eylül Üniversitesi, Mühendislik Fakültesi, Jeoloji Mühendisliği Bölümü, TR-35160 İzmir, Turkey

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ABSTRACT

The oxygen and strontium isotope compositions of Cenozoic granitoids cropping out in the İzmir-Ankara-Erzincan suture zone help constrain the petrological evolution of magmatism in northwest Anatolia. The magmatism was mostly widespread between late Eocene (~37 Ma) and the middle Miocene (~14–15 Ma), and is represented by volcanic and plutonic rocks of orogenic affinity, of which Ezine, Eğrigöz, Çataldağ and Kozak are the largest Tertiary granitic plutons exposed in northwest Anatolia. They vary from granite to granodiorite, and are subalkaline, belonging to the high-K calc-alkaline I-type granite series. All these characteristics, combined with major, trace element geochemical data as well as mineralogical and textural evidence, reveal that the Oligocene-Miocene granitoids of NW Anatolia are comparable with volcanic arc granites, formed in a transitional oceanic to continental collisional tectonic setting, from a hybrid source, having crustal and mantle components that underwent further interaction with the upper crust. These plutons have initial $^{87}Sr/^{86}Sr$ ratios of 0.7072–0.7094, and εNd(t) values ranging from −3.48 to −1.20. These characteristics also indicate that a crustal component played an important role in the petrogenesis of NW Anatolian Oligocene-Miocene granitoids. The moderately evolved Ezine, Eğrigöz, Çataldağ and Kozak granitoids, have $\delta^{18}O$ values that are consistent with those of normal I-type granites (6–10‰), but the $\delta^{18}O$ relationships among minerals of samples collected from the intrusive contacts which are closest to mineralized zones, indicate a major influence of hydrothermal processes under subsolidus conditions. The oxygen isotope systematics of the samples from these plutons result from the activity of high-$\delta^{18}O$ fluids (magmatic water), with major involvement of low-$\delta^{18}O$ fluids (meteoric water) evident, near the edge zone of these plutons. This is most evident in $\delta^{18}O$ quartz-feldspar pairs from these granitoids, which commonly have values characteristic of open-system hydrothermal conditions, and is consistent with the presence of large scale base-metal mineralization around the NW Anatolian granitoids.

1. Introduction

The widespread granitic plutons and associated volcanic rocks of NW Anatolia formed following continent–continent collision between the Sakarya and Tauride-Anatolide continental fragments in the eastern Mediterranean region (Şengör and Yılmaz, 1981; Okay et al., 1996). Plutonic bodies were emplaced into the crystalline basement rocks of the Sakarya continent to the north and the Anatolide-Tauride continental blocks to the south during the late Oligocene to middle Miocene. The magmatic intrusions range in composition from quartz-diorite to granite, with peraluminous and metaluminous types that both show moderately evolved compositions. Previous studies based on radiogenic isotopes, age determinations and major elements, revealed the crystallization age of the Tertiary granitoids (Ezine, Eğrigöz, Çataldağ, Kozak) as well as their general geotectonic affinities (Delaloye and Bingöl, 2000; Altunkaynak and Dilek, 2006; Altunkaynak, 2007; Dilek and Altunkaynak, 2007, 2009; Altunkaynak et al., 2012a; Black et al., 2013).

Crustal and mantle reservoirs are characterized by distinct isotopic compositions of stable isotopes that can be used to determine their relative contributions and the mixing processes involved in generating granitic rocks (Taylor, 1980; DePaolo, 1981; James, 1981). Hence, there have been many studies of the relationships between O, Sr and Nd isotopes at scales ranging from individual plutons (e.g.,

* Postal address: Dokuz Eylül Üniversitesi, Mühendislik Fakültesi, Jeoloji Mühendisliği Bölümü, Tınaztepe Kampüsü, TR-35160 Buca/İzmir, Turkey.
E-mail address: yesim.yucel@deu.edu.tr.

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Ben Othman et al., 1984; Kistler et al., 1986) to large granitoid provinces (e.g., DePaolo, 1981; McCulloch and Chappell, 1982). In this context, oxygen isotopes are an important proxy for crustal assimilation and derivation, especially when coupled with other monitors of these processes, such as $^{87}Sr/^{86}Sr$ and Sm/Nd isotopes (Taylor, 1980).

The aim of this study is to determine the source of the parental magmas of these intrusions, and to provide a genetic interpretation using first determinations of oxygen isotopic composition of the granitic rocks in the Northwestern Anatolia. This work is largely based on the combined use of the oxygen-strontium isotopic systematics in order to investigate petrogenetic processes and crust/mantle interactions (e.g. Taylor, 1980; DePaolo, 1981; James, 1981). New O, Sr and Nd isotope data are presented for the Tertiary granitoids (Ezine, Eğrigöz, Çataldağ, Kozak) in NW Anatolia (Fig. 1) has allowed for further investigation of the petrogenetic processes and crust/mantle interactions involved in the generation of these rocks.

2. General overview of granitic magmatism and mineralization in western Anatolia

During the Oligocene-Middle Miocene, widespread magmatic activity developed in western Anatolia, following collision of the Sakarya continent with the Tauride-Anatolide platform (Şengör and Yılmaz, 1981; Şengör et al., 1993). This magmatism produced both intrusive (Altherr et al., 1988; Okay et al., 1996; Delaloye and Bingöl, 2000; Boztuğ et al., 2009; Akay, 2009; Aldanmaz et al., 2000; Şahin et al., 2010; Altunkaynak et al., 2012a, 2012b; Hasözbek et al., 2010; Oyman et al., 2012; Black et al., 2013; Aysal, 2015) and extrusive rocks (Ersoy et al., 2010, 2012; Ersoy and Palmer, 2013), which appear to be associated in space and time in this region. The earliest Cenozoic granitoid plutons are represented by the widespread Late Cretaceous to Early Eocene belts that lie in the northernmost part of western Anatolia and have a clear subduction-related origin (Delaloye and Bingöl, 2000). The earliest post-collisional magmatism in western Anatolia took place in the Eocene and move progressively southwards over time (Dilek and Altunkaynak, 2009).

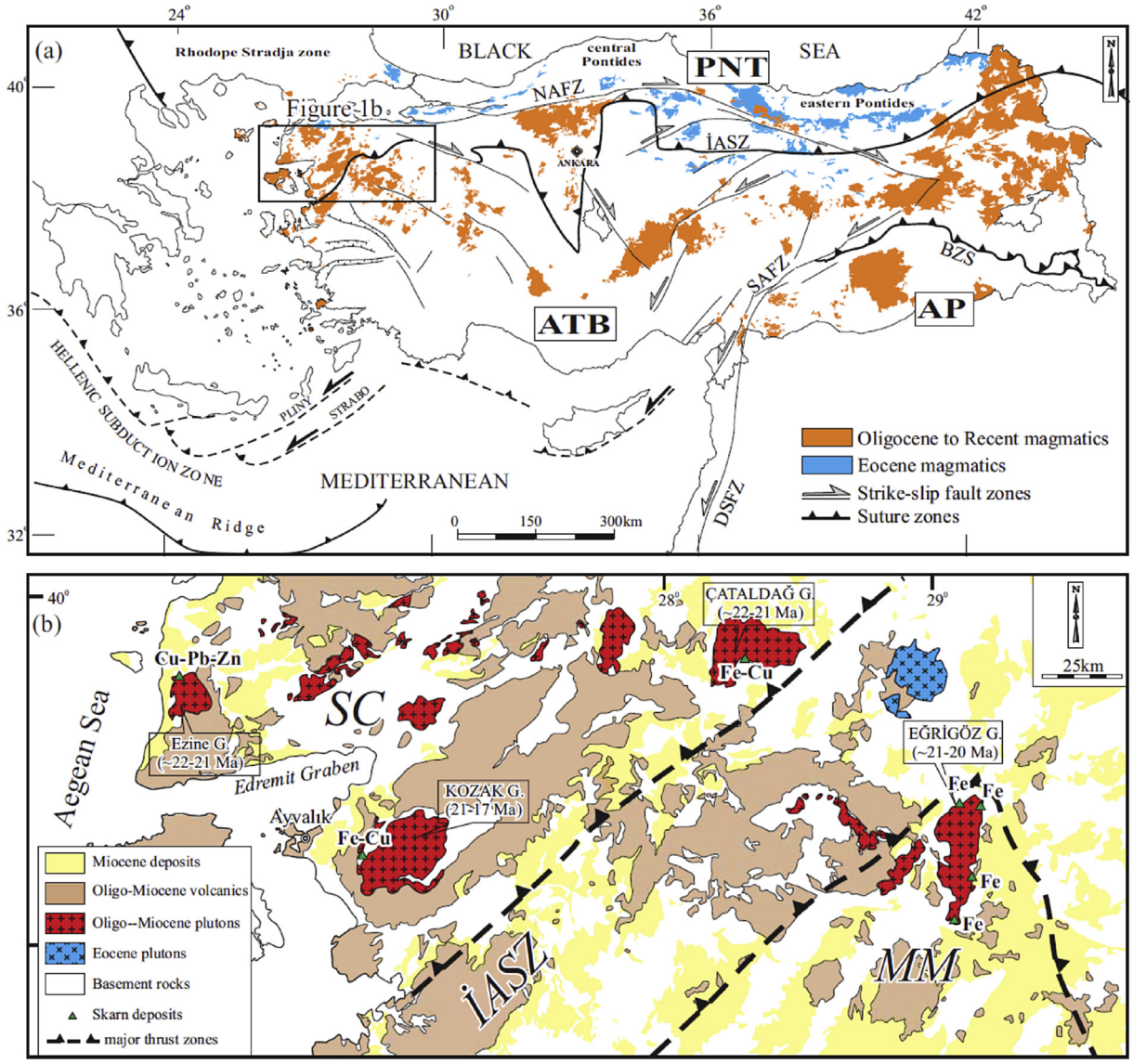

Fig. 1. a,b)Geological map showing locations of the studied granitoids and the NW Anatolian magmatic provinces (Modified from General Directorate of Mineral Research and Exploration, 2001).