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U-Pb SHRIMP Zircon Ages, Geochemical and Sr-Nd Isotopic Compositions of the Late Cretaceous I-type Sarıosman Pluton, Eastern Pontides, NE Turkey

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Abstract: The petrogenesis and U-Pb SHRIMP zircon ages of the Late Cretaceous Sarıosman pluton in the Eastern Pontides is investigated by means of whole-rock Sr-Nd isotope data with field, petrographic and whole-rock geochemical studies. The bulk of the I-type Sarıosman pluton consists of biotite-hornblende monzogranite, with minor quantities of porphyritic hornblende-biotite monzogranite. The biotite-hornblende monzogranite contains a number of mafic microgranular enclaves (MMEs) of quartz monzodiorite composition. U-Pb zircon sensitive high-resolution ion microprobe dating (SHRIMP) dates the magma emplacement age of the biotite-hornblende monzogranite at 82.7±1.5 Ma. The rocks of the pluton show high-K calc-alkaline, metaluminous to slightly peraluminous characteristics, and are enriched in large ion lithophile elements (LILE) and light rare earth elements (LREE) relative to high field strength elements (HFSE), thus displaying features of arc-related granitoids. Chondrite-normalised rare earth-element (REE) patterns have concave upward shapes (La_{cn}/Lu_{cn}= 10.1–17.4) with pronounced negative Eu anomalies (Eu/Eu*= 0.61–0.80). Initial ε_{Nd} values vary between –3.0 and –4.1 and initial $^{87}Sr/^{86}Sr$ values between 0.7062 and 0.707. The MMEs are characterised by higher Mg-numbers (27–29) and lower values of both SiO_2 (56–58 wt%) and aluminium saturation index (0.9–1.0), compared to the monzogranites. Fractionation of plagioclase, hornblende and Fe-Ti oxides played an important role in the evolution of the Sarıosman pluton. The crystallisation temperatures of the melts ranged from 700 to 800 °C and a relatively shallow intrusion depth (~2 to 7 km) is estimated from the Al-in-hornblende geobarometry. The geochemical and isotopic compositions of the Sarıosman pluton suggest an origin through dehydration melting of mafic lower crustal source rocks.

Key Words: SHRIMP dating, Sarıosman pluton, mineral chemistry, I-type, Sr-Nd isotope geochemistry, eastern Pontides

Üst Kretase Yaşlı I-Tipi Sarıosman Plutonu'nun U-Pb SHRIMP Zirkon Yaşları, Jeokimyasal ve Sr-Nd İzotopik Bileşimleri, Doğu Pontidler, Kuzeydoğu Türkiye

Özet: Doğu Pontidler'de Geç Kretase yaşlı Sarıosman plutonu'nun petrojenezi ve U-Pb SHRIMP zirkon yaşları, tüm kayaç Sr-Nd izotop verileri ve arazi, petrografik ve tüm kayaç jeokimyasal verilerine dayanarak irdelenmiştir. I-tipi Sarıosman plütonu'nun ana kütlesi biyotit-hornblend monzogranit ve daha az olarak da porfirik hornblend-biyotit monzogranitten oluşur. Biyotit hornblend monzogranitler az sayıda kuvarslı monzodiyorit bileşimli mafik magmatik anklavlar içerirler. U-Pb zirkon SHRIMP yöntemine göre biyotit hornblend monzograniti oluşturan magmanın yerleşim yaşı 82.7±1.5 My'dır. Plütonu oluşturan kayaçlar yüksek K'lu kalk alkalen, metalümin kısmen de peralümin karaktere sahiptirler. Kayaçlar yüksek alan enerjili elementlere kıyasla büyük iyon yarıçaplı litofil elementler ve hafif nadir toprak elementlerce zenginleşmiş olup, yay ile ilişkili granitoyid özelliği gösterirler. Kondirite göre

normalleştirilmiş nadir toprak element dağılımları konkav şekilli (La_{cn}/Lu_{cn}= 10.1–13.4) olup, hafif negative Eu anomalisi (Eu/Eu*= 0.61–0.80) gösterirler. $\varepsilon_{Nd(i)}$ değerleri –3.0 ve –4.1 arasında değişirken, $^{87}Sr/^{86}Sr_{(i)}$ değerleri 0.7062 ve 0.707 arasında değişmektedir. Mafik magmatik anklavlar monzogranitlere kıyasla daha yüksek Mg# (27–29), daha düşük silis (56–58) ve alüminyum doygunluk indeksi (0.9–1.0) değerleri içerirler. Sarıosman plutonu'nun gelişiminde plajiyoklas, hornblend ve Fe-Ti oksit fraksiyonlaşması önemli bir rol oynamıştır. Magmanın kristalleşme sıcaklığı 700–800 °C arasında olup, Al-hornblend jeobarometresine göre intrüzyon nisbeten sığ bir derinliğe (~2 to 7 km) yerleşmiştir. Jeokimyasal ve izotopik veriler, Sarıosman plutonu'nun kaynağının dehydratizasyona uğramış mafik alt kabuk kayaçları olabileceğini göstermektedir.

Anahtar Sözcükler: SHRIMP yaş, Sarıosman plütonu, mineral kimyası, I-tipi, Sr-Nd izotop jeokimyası, doğu Pontidler

Introduction

I-type, calc-alkaline plutonic rocks are common in many different convergent tectonic settings and include subduction-related and collisional magmatic suites. They are characterised by a large compositional diversity arising from different source compositions, variable melting conditions, fractional crystallisation (FC) and crustal contamination, in addition to the complex chemical and physical interactions between mafic and felsic magmas (DePaolo 1981; Zorpi *et al.* 1991; Roberts & Clemens 1993; Thompson & Connolly 1995; Galan *et al.* 1996; Altherr *et al.* 2000; Altherr & Siebel 2002). Because there is a link between the mineralogy, geochemistry and geodynamic setting of granitoids, compositionally well-characterised granitoids of known age may constrain the evolution and development of the continental crust through geological time (Barbarin 1999).

The Alpine-Himalayan orogenic belt embraces various arc, collisional, and post-collisional geological settings; in addition, magmatic rocks were generated in each of these settings. In this belt, Turkey, as a zone of interaction between Eurasia and Gondwanaland plates, lies in an important geodynamic position. The Pontide unit (Ketin 1966) of Turkey includes various intrusive and eruptive rocks that constitute the widespread eastern Pontide terrane: many of these are related to the convergence of these two plates (Figure 1a).

The eastern Pontides represent a well-preserved arc system (Tokel 1977; Eğin *et al.* 1979; Manetti *et al.* 1983; Gedik *et al.* 1992; Çamur *et al.* 1996; Yılmaz & Boztuğ 1996; Boztuğ *et al.* 2003), resulting from the subduction of the Neotethyan oceanic crust beneath the Eurasian plate during the Senonian. Closure of the Neotethyan Ocean caused a collision between the Pontide arc and the Tauride-Anatolide platform in the Palaeocene–Early Eocene, and this collision continued until the middle Eocene (Yılmaz & Boztuğ 1996; Yılmaz *et al.* 1997; Okay & Şahintürk 1997).

The contemporary geological setting of the eastern Pontides is mainly the result of three main Neotethyan volcanic cycles during the Jurassic, Late Cretaceous and Eocene (Adamia *et al.* 1977; Eğin *et al.* 1979; Kazmin *et al.* 1986; Korkmaz *et al.* 1995; Çamur *et al.* 1996; Arslan *et al.* 1997, 2000). The intrusive rocks were formed in different geodynamic environments and emplaced at various crustal levels (Boztuğ *et al.* 2003, 2006). Crystallisation ages of these intrusives range from Permo–Carbonifeous (Çoğulu 1975) through Cretaceous–Palaeocene (Delaloye *et al.* 1972; Giles 1974; Taner 1977; Gedikoğlu 1978; Moore *et al.* 1980; Jica 1986; Okay & Şahintürk 1997; Yılmaz *et al.* 2000; Köprübaşı *et al.* 2000; Yılmaz-Şahin 2005; Boztuğ *et al.* 2006; Dokuz *et al.* 2006; Boztuğ 2008; İlbeyli 2008; Kaygusuz *et al.* 2008; Kaygusuz & Aydınçakır 2009) to Eocene (Boztuğ *et al.* 2003, 2004; Arslan *et al.* 2004; Karslı *et al.* 2004; Topuz *et al.* 2005; Yılmaz-Şahin 2005) periods (Figure 1b). The compositions of the plutons range from low-K tholeiitic through high-K calc-alkaline metaluminous-peraluminous granites to alkaline syenites (Yılmaz & Boztuğ 1996; Boztuğ *et al.* 2003). The emplacements of these plutons also occurred in a wide spectrum of tectonic settings, ranging from arc-collisional through syn-collisional to postcollisional (Yılmaz & Boztuğ 1996; Okay & Şahintürk 1997; Yılmaz *et al.* 1997; Yeğingil *et al.* 2002; Boztuğ *et al.* 2003; Arslan & Aslan 2005). In the Torul region of the Eastern Pontides, arc-related magmatism developed under a compressional regime and is characterised by the predominance of calc-alkaline granitoids.