Gondwana Research 39 (2016) 327–346

Contents lists available at ScienceDirect

Gondwana Research

journal homepage: www.elsevier.com/locate/gr

U–Pb zircon chronology and petrogenesis of Carboniferous plutons in the northern part of the Eastern Pontides, NE Turkey: Constraints for Paleozoic magmatism and geodynamic evolution

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ARTICLE INFO

Article history:
Received 18 April 2015
Received in revised form 29 January 2016
Accepted 30 January 2016
Available online 4 March 2016

Handling Editor: I. Safonova

Keywords:
Paleozoic Granite
Geochronology
Isotope
Petrology
NE Turkey

ABSTRACT

Numerous intrusive rocks of varying ages and compositions exist in the Paleozoic to Tertiary periods in the Eastern Pontides. Carboniferous intrusive rocks are commonly observed in the southern part of the Eastern Pontides. The nature of the rocks in the northern part of the region has not been determined because of Upper Cretaceous and Tertiary volcano-sedimentary units. Whole-rock geochemical, isotopic and geochronological data obtained from five different mapped granitoid bodies located in the northern part of the Eastern Pontides allow for the proper reconstruction of Carboniferous magmatism and the geodynamic evolution of the region. According to laser ablation ICP-MS U–Pb zircon dating, the Özdil, Soğuksu, Seslikaya, Kızılağaç and Şahmetlik plutons have similar $^{206}Pb/^{238}U$ vs. $^{207}Pb/^{235}U$ concordia ages of 340.7 ± 1.8 Ma and 323.1 ± 1.5 Ma, 348.4 ± 1.6 Ma, 335.4 ± 1.4 Ma, 337.2 ± 0.6 Ma and 334.5 ± 1.4 Ma, respectively. The aluminium saturation index (ASI) values of all of the samples from the plutons are between 1.0 and 1.32, which indicate peraluminous melt compositions. The plutons have SiO_2 contents between 59 and 79 wt.% and show low- to high-K calc-alkaline characteristics. The plutons are enriched in large-ion lithophile and light rare earth elements and are depleted in high-field strength elements. Chondrite-normalized rare earth element patterns are characterized by concave-upward shapes and pronounced negative Eu anomalies, with La_{CN}/Yb_{CN} = 1.9–46.8 and Eu_{CN}/Eu^* = 0.19–1.76. The studied plutons show considerable variations in $^{87}Sr/^{86}Sr_{(i)}$ (0.70255 to 0.71006) and $\varepsilon Nd_{(i)}$ values (−4.8 to −7.1), as well as Nd model ages (1.15 to 2.47 Ga). The Pb-isotopic ratios are $^{206}Pb/^{204}Pb$ = 17.11–18.60, $^{207}Pb/^{204}Pb$ = 15.58–15.64 and $^{208}Pb/^{204}Pb$ = 36.95–38.62. The crystallization temperatures of the melts range from 676 to 993 °C, as determined by zircon and apatite saturation thermometry. These data suggest that the Carboniferous granitic magmas were produced by the partial melting of meta-mafic to meta-felsic lower crustal source rocks, with minor contributions from the mantle. Collectively, these rocks represent a late stage of Hercynian magmatism in the northern part of the Eastern Pontides.

1. Introduction

Turkey is located on the east–west-trending segment of the Alpine–Himalayan orogenic belt (Fig. 1a). Thus, this country has various arc, collision and post-collision geological settings. In the orogenic belt, Turkey lies in an important geodynamic position, namely, the zone of interaction between Gondwanan and Eurasian plates. The Eastern Pontides (Fig. 1a), which is part of the Pontides orogenic belt in NE Turkey, includes various intrusive and eruptive rocks, many of which are related to the convergence of the Eurasian and Gondwanan plates.

The crystallization ages of plutonic rocks in the Eastern Pontides (Fig. 1b) include Paleozoic (Çoğulu, 1975; Topuz et al., 2004, 2010; Ustaömer and Robertson, 2010; Dokuz, 2011; Kaygusuz et al., 2012), Cretaceous–Paleocene (Yılmaz et al., 2000; Boztuğ et al., 2006; Kaygusuz et al., 2008; Kaygusuz and Aydınçakır, 2009; Kaygusuz et al., 2009; Karslı et al., 2010; Kaygusuz et al., 2010; Kaygusuz and Aydınçakır, 2011; Kaygusuz and Şen, 2011; Kaygusuz et al., 2013, 2014) and Eocene–Oligocene (Boztuğ et al., 2004; Topuz et al., 2005; Arslan and Aslan, 2006; Karslı et al., 2007; Eyüboğlu et al., 2011, 2013; Temizel et al., 2014; Kaygusuz and Öztürk, 2015). The plutonic rock types in the region have low- and high-K calc-alkaline, metaluminous–peraluminous, granitic to alkaline syenitic compositions (Yılmaz and Boztuğ, 1996). Moreover, the emplacement of the plutons apparently occurred in various tectonic settings, including arc, syn-collisional and post-collisional regimes (Yılmaz and Boztuğ, 1996; Okay and Şahintürk, 1997; Yılmaz et al., 1997; Yeğingil et al., 2002). The Paleozoic

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http://dx.doi.org/10.1016/j.gr.2016.01.011
1342-937X/

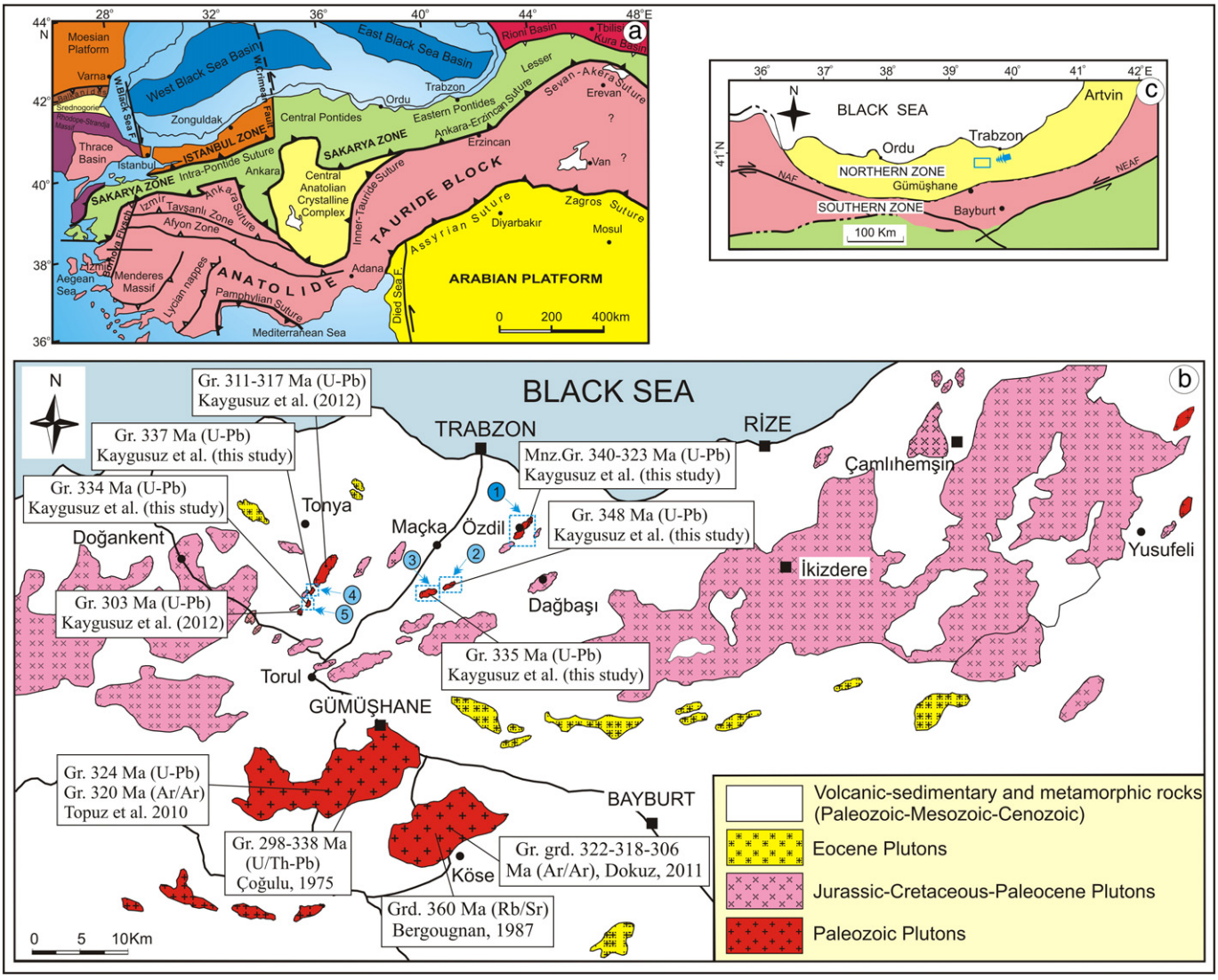

Fig. 1. (a) Tectonic map of Turkey and surrounding regions showing the major sutures and continental blocks (modified after Okay and Tüysüz, 1999); (b) Simplified geological map showing the main granitoid distribution in the Eastern Pontides (modified after Gedik et al., 1992; Güven, 1993); (c) Major structures of the Eastern Pontides. NAF, North Anatolian fault; NEAF, Northeast Anatolian fault; EAF, East Anatolian fault.

plutons are generally coarser grained than the Cretaceous and Eocene plutons in the Eastern Pontides. Their content of magmatic enclaves is less than that of the Cretaceous and Eocene plutons. They generally have biotite and muscovite as mafic minerals, whereas the Cretaceous and Eocene plutons generally have hornblende and biotite. The initial εNd values are lower and the $^{87}Sr/^{86}Sr$ values are higher in the Paleozoic plutons than in the Cretaceous and Eocene plutons.

Approximately 40% of the exposed Paleozoic basement rocks of the Eastern Pontides are composed of granitoids. Although Paleozoic plutonic rocks are common and have extensive outcrops in the southern part of the Eastern Pontides (Topuz et al., 2010; Ustaömer and Robertson, 2010; Dokuz, 2011), the presence of these rocks is unknown in the northern part of the Eastern Pontides. Kaygusuz et al. (2012) recently conducted a study of the Paleozoic plutonic rocks. The Paleozoic plutons from the northern part of the Eastern Pontides have geochemical and isotopic features that are similar to those in the Paleozoic plutons in the southern part of the Eastern Pontides. However, the plutons in the southern part feature much larger outcrops than the plutons in the northern part (Fig. 1b). The ages are between 303 and 348 Ma for the plutons in the northern part (Kaygusuz et al., 2012; in this study) and are between 298 and 360 Ma for the plutons in the southern part (Çoğulu, 1975; Bergougnan, 1987; Topuz et al., 2010; Ustaömer and Robertson, 2010; Dokuz, 2011) (Fig. 1b).

Numerous geochemical and petrological investigations have been conducted on various intrusive bodies in the Eastern Pontides. However, studies of the Özdil, Soğuksu, Seslikaya, Kızılağaç and Şahmetlik plutons in the northern part of the region are scarce and are mainly related to ore mineralogy, petrography and minor geochemistry (Gülibrahimoğlu et al., 1985; Aslan, 1991; Eşer, 1991; Güven, 1993; Sadıklar, 1993; Yazıcı, 1996; Saraç, 2003). Furthermore, the aforementioned plutons were reported to be Lower/Upper Cretaceous or Eocene in age in previous studies and were determined to be Carboniferous in age by the new U–Pb zircon dating presented in the present study. This study focuses on the Özdil, Soğuksu, Seslikaya, Kızılağaç and Şahmetlik plutons, which are geochemically and petrologically the least studied plutons in the northern part of the Eastern Pontides. Prior to this study, no geochronological data were available for these plutons. In our study, we present new whole-rock and Sr–Nd–Pb isotopic compositions and LA-ICP-MS U–Pb zircon age data from these intrusions to determine their magma parental sources and the Paleozoic geodynamic evolution of the region.