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Early Cretaceous closure of the Intra-Pontide Ocean in western Pontides (northwestern Turkey)

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ABSTRACT

The Intra-Pontide suture is the boundary between the İstanbul and Sakarya terranes in northwest Turkey. We provide new isotopic and stratigraphical data from the Intra-Pontide suture zone, which indicate Early Cretaceous collision between the Sakarya and İstanbul terranes. These two terranes along with the Strandja Massif make up the Pontides. Metamorphic units of the Intra-Pontide suture zone are best exposed in the Armutlu Peninsula. In the eastern part of the Armutlu Peninsula, three metamorphic units crop out forming an eastward dipping thrust stack. At the base of the thrust stack there is a metaclastic-marble sequence, which is tectonically overlain by a Cretaceous subduction-accretion complex, farther up in the thrust stack there is a high-grade metamorphic unit, which represents the Proterozoic basement of the İstanbul Zone. New clastic zircon ages from the metaclastic-marble sequence indicate that deposition of the sandstones must be later than Permian (~264 Ma) possibly during Triassic. Similar Triassic metasediments are also reported in Strandja Massif. We interpret that these metasediments were deposited during Triassic along the rift flanks leading to the opening of the Intra-Pontide Ocean, which suggest a possible Early Triassic opening for the Intra-Pontide Ocean. Our new Rb–Sr mica and Sm–Nd garnet ages dates the regional metamorphism between Late Jurassic–Early Cretaceous (158–111 Ma) along the Intra-Pontide suture zone, similar ages are also reported in the Strandja Massif. The metamorphic rocks of the Intra-Pontide suture are unconformably overlain by Campanian–Ypresian clastics. The collision between the İstanbul and Sakarya–Strandja terranes has occurred during Early Cretaceous and the Proterozoic basement of İstanbul terrane was reheated during this collision.

1. Introduction

Turkey consists of several continental blocks, which were once separated by oceans (Fig. 1, Şengör and Yılmaz, 1981; Okay and Tüysüz, 1999). Three of these continental blocks, İstanbul, Sakarya and Strandja terranes, make up the Pontides. The ocean separating the İstanbul and Sakarya terranes is known as the Intra-Pontide Ocean (Şengör and Yılmaz, 1981). There are different views on the age of opening and closing of the Intra-Pontide Ocean (cf. Robertson and Ustaömer, 2004 and references therein). Even the existence of this oceanic realm was questioned (e.g., Kaya, 1977; Kaya and Kozur, 1987; Elmas and Yiğitbaş, 2001). The Intra-Pontide suture zone is exposed in the Armutlu Peninsula bounded by strands of the North Anatolian Fault (Şengör, 1979; Barka, 1992). The Kocaeli Peninsula, located north of the Armutlu Peninsula, exposes Paleozoic–Mesozoic sequences of the İstanbul terrane, whereas the region south of the Armutlu Peninsula comprises rocks typical of the Sakarya terrane. The Armutlu Peninsula comprises a variety of metamorphic sequences, whose affinities are controversial (Robertson and Ustaömer, 2004; Elmas and Yiğitbaş, 2005). A major reason for this is the lack of geochronological data (Göncüoğlu et al., 1987, 1992; Bozcu, 1992; Yılmaz et al., 1995; Robertson and Ustaömer, 2004; Okay et al., 2008). In this paper we provide a new geological map as well as structural and geochronological data on the Intra-Pontide suture zone. We suggest that some of these rocks form the eastward continuation of the Strandja Massif.

2. Tectonic framework

The İstanbul, Sakarya and Strandja terranes show different geological histories as reflected in their stratigraphic record (Fig. 2, cf. Okay et al., 2008). The geological features of the İstanbul, Sakarya and Strandja terranes are summarized below.

2.1. The İstanbul terrane

The İstanbul terrane is a 400 km long and 55 km wide continental fragment on the southwestern margin of the Black Sea

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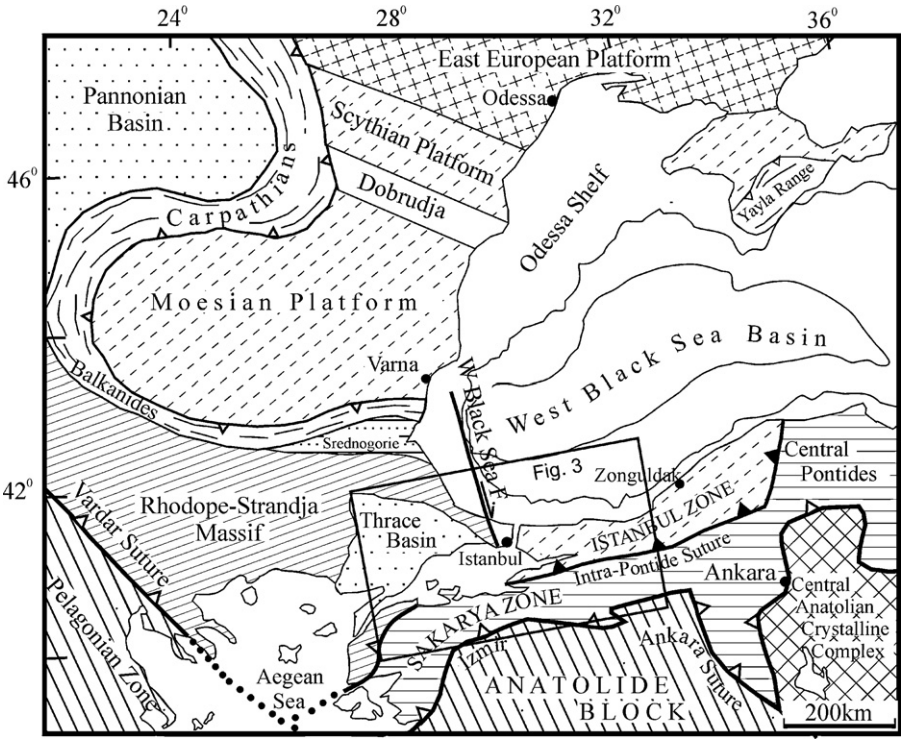

Fig. 1. Tectonic map of the northern Aegean and the Balkans showing the major terranes and the bounding sutures (Okay and Tüysüz, 1999). The filled triangles indicate the Intra-Pontide suture and polarity of the subduction whereas empty triangles indicate other sutures. Rectangle box shows location of Fig. 3.

(Okay et al., 1994). Its characteristic feature is a continuous and well-developed Paleozoic sedimentary succession, ranging in age from Ordovician to Carboniferous (e.g., Haas, 1968; Görür et al., 1997; Dean et al., 2000) deposited on a Neoproterozoic metamorphic basement (Ustaömer and Rogers, 1999; Chen et al., 2002). The basement is composed mainly of gneiss and amphibolite, intruded by voluminous Late Proterozoic–Cambrian granitoids (Yiğitbaş et al., 2004; Ustaömer et al., 2005).

Deformation of the Palaeozoic sequence of the İstanbul terrane was interpreted as related to north to northeast vergence during the Carboniferous (Zapcı et al., 2003). Paleozoic rocks of the İstanbul terrane were intruded by a latest Permian (255 Ma) granitoid (Yılmaz-Şahin et al., 2009) and unconformably overlain by the Lower Triassic red sandstones and conglomerates (Yurttaş-Özdemir, 1971; Gedik, 1975). Lower Triassic transgression was accompanied by basaltic lava flows and followed by shallow to deep marine limestone deposition (Altınlı et al., 1970). Upper Triassic deep sea flysch marks the end of this sedimentation episode.

In the western part of the İstanbul terrane, the Jurassic and Lower Cretaceous sequence is absent, and the Paleozoic and Triassic rocks are unconformably overlain by Upper Cretaceous–Paleocene clastic, carbonate and andesitic volcanic rocks (Dizer and Meriç, 1983; Tansel, 1989; Özcan et al., 2012). In contrast, in the eastern part of the İstanbul terrane there is a thick Upper Jurassic to Eocene succession separated by small unconformities (Akyol et al., 1974). Senonian andesitic lavas, dykes and small acidic intrusions are widespread in the northern part of the İstanbul terrane.

2.2. The Sakarya terrane

The Sakarya terrane forms an elongate crustal ribbon extending from the Biga Peninsula in the west to the Eastern Pontides in the east (Fig. 1). The basement of Sakarya terrane is commonly considered in three pieces. (1) A high-grade metamorphic sequence of gneiss, amphibolite and marble. The high-grade metamorphism is dated to the Carboniferous (330–310 Ma; Topuz et al., 2004, 2007; Okay et al., 2006a,b; Ustaömer et al., 2012). (2) Palaeozoic granitoids that are scattered throughout the Sakarya terrane, with Devonian, Carboniferous, Early Permian crystallization ages (Delaloye and Bingöl, 2000; Okay et al., 2002, 2006a,b; Topuz et al., 2007; Aysal et al., 2012). (3) The Karakaya Complex is interpreted as a Permo-Triassic subduction-accretion complex. It is divided into two units. The Lower Karakaya Complex consists of greenschist facies metabasites with lesser amounts of marble and phyllite (Okay and Göncüoğlu, 2004). It also includes tectonic slices of Late Triassic blueschists and eclogites (Okay et al., 2002). It is tectonically overlain by the Upper Karakaya Complex, which is made up of thick series of strongly deformed arkosic sandstones, greywacke with exotic blocks of Carboniferous and Permian limestone and radiolarian chert, basalts, olistostromes, and grain flows with Upper Permian limestone clasts and dark shales (cf. Okay and Göncüoğlu, 2004).

All these basement units are unconformably overlain by a Mesozoic sedimentary series strating with Lower to Middle Jurassic continental to shallow marine clastic rocks with ammonitico rosso horizons (Fig. 2, Altıner et al., 1991). By Late Cretaceous (between Campanian and Maastrichtian), a deep sea flysch deposited in the Sakarya terrane marks the onset of the Alpide orogeny (Gölpazarı Formation of Saner, 1978 and Yenipazar Formation of Yücel and Soner, 1991).

2.3. The Strandja Massif

The Strandja Massif is a large crystalline terrane in the southeastern Balkans. It has a Variscan quartzofeldspatic gneissic basement intruded by Late Carboniferous–Early Permian granitoids (e.g., 257 ± 6 Ma; Okay et al., 2001; Sunal et al., 2006). The basement lithologies extend some 200 km, from Bulgaria to the