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The Circum-Rhodope Belt, northern Greece: Age, provenance, and tectonic setting

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ABSTRACT

The Circum-Rhodope Belt (CRB) sensu stricto comprises low-grade metamorphosed Triassic and Jurassic sedimentary rocks fringing the high-grade metamorphic rocks of the Serbo-Macedonian and Rhodope massifs in northern Greece. Main outcrops occur in the easternmost part of the Vardar suture zone in the Chalkidiki peninsula (Melissochori Formation; formerly Svoula flysch) and in Thrace (Makri unit and Melia Formation). The tectonostratigraphic relationship between the CRB and the high-grade metamorphics has been the subject of long discussions. Older interpretations maintain that the CRB represents the original Mesozoic stratigraphic cover of the Serbo-Macedonian crystalline basement, whereas later revisions propose the existence of two distinct greenschist-facies Mesozoic metasedimentary units: an eastern unit related to the development of a Jurassic black shale basin north of the Rhodope, and a western unit related to the development of an olistostromic flysch in the Cretaceous. Here we present a critical re-evaluation of the CRB with regard to its age, provenance, and tectonic setting based on novel geochemical and isotopic data.
The Makri unit and the Melissochori Formation belong to the CRB proper and were deposited in proximity to Carboniferous–Early Permian igneous basement rocks (Pelagonia / Strandja / Thracia Terrane) in latest Triassic and Jurassic times, as shown by a prominent detrital zircon age population of 350–290 Ma. By contrast, the Melia Formation is unrelated to the CRB and was deposited in a foreland basin in front of a metamorphic nappe pile with Rhodopean affinities in the early Cretaceous, as shown by a prominent detrital zircon age population of 315–285 Ma and xenocrysts of ~550 Ma and ~450 Ma. Thus, the commonly accepted CRB concepts have to be revisited. All units have been tectonically juxtaposed to their present location during Balkan and Alpine orogenic processes.

1. Introduction

The Hellenides of Greece are an integral part of the Alpine–Himalayan orogenic system and have traditionally been classified into External and Internal Hellenides (Brunn, 1956). The latter are subdivided into several geotectonic zones (e.g., Jacobshagen, 1986) and/or terranes (Papanikolaou, 1997, 2009). The most prominent of them are, from west to east, the Pelagonian Zone, the Vardar Zone, the Serbo-Macedonian Massif and the Rhodope Massif (Fig. 1). In older literature, the Serbo-Macedonian and Rhodope massifs appear as the hinterland of the Hellenic orogen. The present study focuses on the Circum-Rhodope Belt (CRB), which is an integral part of the eastern Vardar Zone. The term CRB was coined by Kauffmann et al. (1976) to describe low-grade Triassic and Jurassic metasedimentary rocks fringing the unified high-grade metamorphic mass of the Hellenic hinterland (i.e. Rhodope plus Serbo-Macedonian massifs), thought of as representing the original Mesozoic stratigraphic cover of the crystalline basement (Model 1). However, the concept of a CRB was rejected by Ricou et al. (1998) who proposed the existence of two distinct greenschist-facies Mesozoic metasedimentary units: an eastern unit (fringing the Rhodope Massif to the southeast in the Thrace area) related to the development of a Jurassic black shale basin north of the Rhodope, and a western unit (fringing the Serbo-Macedonian Massif to the west) related to the development of olistostromic flysch in the Cretaceous (Model 2). The complex Late Mesozoic and Cenozoic structural and metamorphic overprint (e.g., Tranos et al., 1999) gave rise to equivocal palaeo-tectonic models and interpretations (e.g., Brown and Robertson, 2003, 2004; Meinhold et al., 2009; Ricou et al., 1998).

This paper presents a review of the CRB in the light of new geochemical and geochronological data we collected over the last years. We focus on metasedimentary rocks cropping out in the Chalkidiki peninsula and in the Thrace area of northern Greece. In Chalkidiki, the Late Triassic–Jurassic Melissochori Formation (former Svoula flysch) is the target of our study (Fig. 2). In Thrace, we concentrate on the Late Triassic–Jurassic Makri unit and the Late Jurassic/Cretaceous Melia Formation (Figs. 3 and 4). Selected units containing sedimentary and magmatic rocks cropping out adjacent to the CRB rocks proper are briefly discussed here because of their importance in understanding the geological evolution of the region.

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Fig. 1. Simplified tectonic map of Greece and adjacent countries showing the main geotectonic units and the bounding sutures (modified from Meinhold et al., 2008). The location of the Circum-Rhodope Belt (CRB) according to Kauffmann et al. (1976) is indicated. However, the southern boundary of the CRB in NE Greece has been moved to the south, according to the findings by Okay et al. (2010) at Saros Bay. A close up of northern Greece is shown in Fig. 2. SB – Saros Bay.

The present review may give an impetus for a new tectonostratigraphic concept and palaeotectonic models of the Neotethyan realm in the eastern Mediterranean.

2. Geological framework

As outlined above, the original CRB concept of Kauffmann et al. (1976) was rejected by Ricou et al. (1998) who suggest that the CRB belongs to two distinct greenschist-facies belts and that the cover sequences of the Rhodope Massif cannot be older than Late Cretaceous. In the following we use the term western CRB for the western part of the belt and eastern CRB for its eastern part, which are equivalent to the "western greenschists" and the "roof greenschists", respectively, of Ricou et al. (1998). The western CRB comprises the Melissochori Formation (former Svoula flysch of Kauffmann et al., 1976). The eastern CRB (also called 'Greenschists') includes two distinct tectonostratigraphic units (von Braun, 1993), which are the mid-greenschist-facies Makri unit and the tectonically overlying anchizonal Melia Formation. According to the original definition by Kauffmann et al. (1976), the Melissochori Formation, the Makri unit and the Melia Formation constitute the main units of the CRB and are the focus of this study. They are briefly described below together with adjacent (both tectonostratigraphically underlying and overlying) units (Fig. 5). Our description first focuses on the western CRB (Chalkidiki peninsula) and then on the eastern CRB (Thrace area). The correlation of units between the two belts (i.e. the tectonostratigraphic concept) is outlined in Section 3. It must be noted here that the original CRB concept of Kauffmann et al. (1976) was modified in later studies which assigned ophiolitic rocks to the CRB as well (e.g., Bonev and Stampfli, 2003, 2009; Magganas, 2002; Papanikolaou, 1997, 2009). In this study, however, we want to test the original concept of Kauffmann et al. (1976) and, therefore, we place emphasis on the sedimentary successions only.

2.1. Chalkidiki peninsula

On the Chalkidiki peninsula, the CRB belongs to the Peonias subzone of Mercier (1968) that is a complex imbricate belt mainly consisting of Mesozoic sedimentary and igneous rocks, various types of metamorphic rocks and ophiolites (De Wet, 1989; Kauffmann et al., 1976; Kockel et al., 1971, 1977; Mercier, 1968; Michard et al., 1998; Ricou and Godfriaux, 1994; Ricou et al., 1998). The CRB sensu lato includes the Examili Formation, Pirghoto Formation, Svoula Limestone, Melissochori Formation (former Svoula flysch), Aspro Vrisi Serie and