

## Evolution of the Paleozoic (Silurian–Devonian?) Sredogriv metamorphics, NW Bulgaria

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**Abstract.** The Sredogriv metamorphics are located in NW Bulgaria and referred to the Balkan Terrane. They represent an alternation of different parametamorphites and, to a lesser extent, polymict metaclastic rocks, phyllites and calcareous schists. Various in size allochthonous bodies from metamorphosed magmatites have been tectonically included among them. Recent studies on the Sredogriv metamorphics indicate their formation in a marginal basin of probable Silurian–Devonian age affected by subsequent Carboniferous tectonic processes and greenschist metamorphism.

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### INTRODUCTION

The Sredogriv metamorphics (NW Bulgaria) are referred to the Balkan Terrane with Gondwanan origin (Haydoutov and Yanev, 1997; Yanev, 2000). They represent an alternation of different parametamorphites (sericite, sericite-chlorite and graphite schists) and, to a lesser extent, polymict metaclastic rocks (conglomerates, gravelites, sandstones, siltstones), phyllites and calcareous schists all affected by green schist facies. Various in size allochthonous bodies (exoclasts, olistoplaques and olistotromes) from metamorphosed magmatites (metagabbro, metadiabases, greenschists, albitophyres and metamorphosed granitoids) have been tectonically included among them (Fig. 1).

The Paleozoic low-grade metamorphic complexes of the Balkan Terrane are a part of the Di-

abase-Phyllitoid Complex (Boyadzhiev, 1970) in Bulgaria and their petrography and mineralogy are relatively well studied (Dimitrov, 1929, 1939; Minchev, 1958; Moskovski *et al.*, 1963; Harkovska and Toprakchieva, 1964; Haydoutov, 1973; Kunov, 1974). However, the age of the protoliths, the provinces, the tectonic settings of sedimentation, the timing of metamorphism, and the tectonic evolution of the area are still debatable.

According to Haydoutov (1989, 1991) and Haydoutov and Yanev (1997), an ophiolite-island arc ensemble of Pan-African origin and Precambrian–Cambrian age forms the fundament of the Balkan Terrane and represents part of the Carpatho-Balkan Ophiolite Belt in Bulgaria, Serbia and Romania. This ensemble includes the Cherni Vrah metabasite complex (ophiolitic association) and the Berkovitsa low-grade metamorphic complex

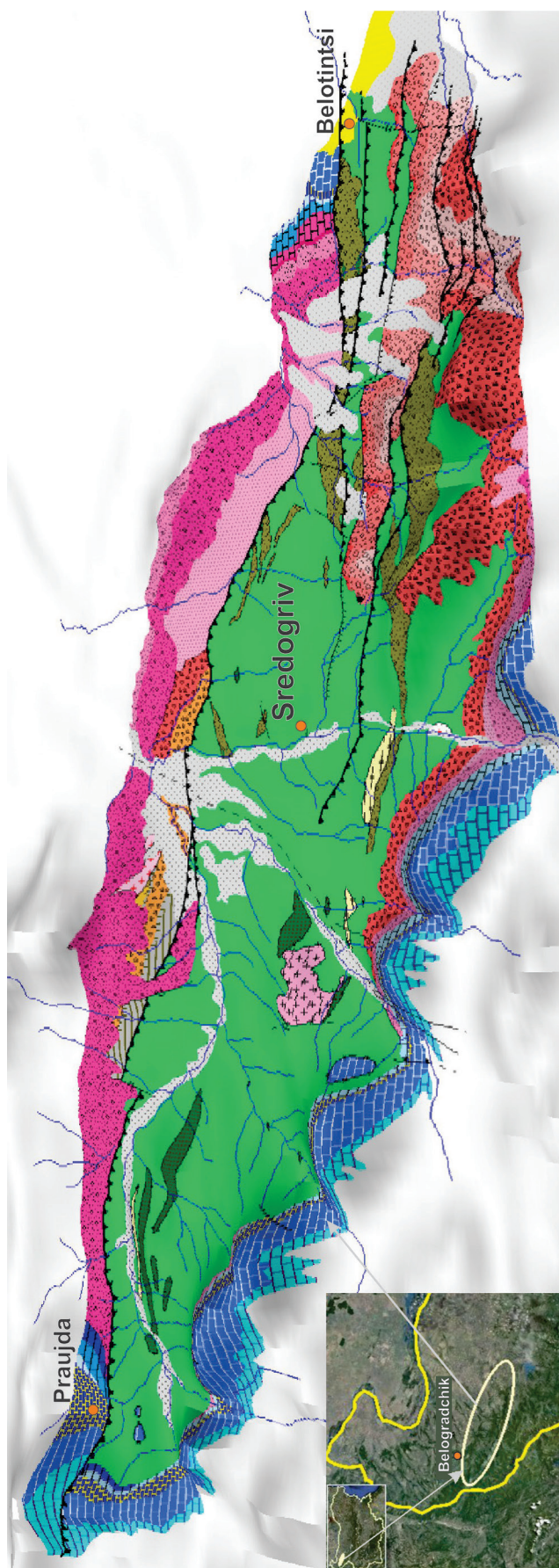


Fig. 1. Location of the studied area (modified after Angelov *et al.*, 2006a, b).

(island-arc association) of Precambrian–Cambrian age, as well as the Dalgi Del low-grade metamorphic complex (olistostrome association) of Ordovician(?) (Haydoutov, 1991) or Cambrian(?) age (Angelov *et al.*, 2007a, b).

The lithostratigraphy of the Sredogriv metamorphics has been studied by numerous authors (*e.g.*, Minchev, 1958; Nedjalkova and Harkovska *in*: Moskovski *et al.*, 1963; Haydoutov, 1973). In more recent studies, Angelov *et al.* (2006a, b) referred these rocks to an official unstratified unit called the Sredogriv metamorphics. They have been considered as a part of the Diabase-Phyllitoid Complex (Ivanov *et al.*, 1987) or as a correlate of the Dalgi Del Group (Haydoutov *et al.*, 1979; Haydoutov, 1995; Angelov *et al.*, 2006a, b).

Various ages have been suggested for the Sredogriv metamorphics: late Silurian (Bonchev, 1910), Devonian–early Carboniferous (Vrâbljanski *et al.*, 1962), early Carboniferous (Minchev, 1958), pre-Devonian (Moskovski *et al.*, 1963), early Ordovician (Haydoutov, 1995; Angelov *et al.* 2006a, b) and late Silurian–Devonian (Kiselinov, 2011).

## EVOLUTION OF THE SREDOGRIV METAMORPHICS

Based on the existing paleotectonic reconstructions (Haydoutov, 1991; Haydoutov and Yanev, 1997; Savov *et al.*, 2001; Haydoutov, 2002; Boncheva *et al.*, 2010; Haydoutov *et al.*, 2010), various hypotheses have been suggested about the evolution of the Sredogriv metamorphics and the similar low-grade metamorphic units – Inovo Formation (E Serbia), as well as the Dalgi Del Group and the Dabravka Formation (NW Bulgaria).

According to Haydoutov (Haydoutov, 1991; Haydoutov *et al.*, 2010), the low-grade metamorphic units were formed in an Ordovician basin due to obduction processes. However, the obtained complex geological data by Kiselinov (2011) indicate that the sediment protoliths were deposited within a marginal marine to shallow epicontinental late Silurian–Devonian basin (Fig. 2a). This assumption is also supported by the last obtained microfossil ages from the lithologically similar to the Sredogriv metamorphics low-grade metamorphic units – the Inovo Formation (E Serbia), the Dalgi Del Group and the Dabravka Formation (NW Bulgaria), which indicate late Silurian–Devonian ages (*cf.* Ercego-

vac *et al.*, 2011). Similar basin types are generally formed in intra-oceanic back-arc spreading settings (Karig, 1971). Another assumption is that the low-grade metamorphic units represent a part of an accretionary complex, indicative of fore-arc basins with episodic bimodal volcanism (Fig. 2b).

Boncheva *et al.* (2010) also suggested the development of a Devonian basin that inherited parts of the Ordovician peri-Gondwanan shelf margin. Moreover, the obtained geochronological data from the Deli Jovan ophiolite massive from eastern Serbia (which is a part of the Balkan-South Carpathian Ophiolite Belt) indicate Early Devonian ( $405 \pm 2.6$  Ma) age (Zakariadze *et al.*, 2006). Plissart *et al.* (2009, 2010) also investigated the Danubian ophiolite massifs from eastern Serbia and southwest Romania and obtained ages between  $372.6 \pm 1.3$  Ma and  $360.6 \pm 1.2$  Ma. Later, Kiselinov *et al.* (2017) dated the Cherni Vrah gabbro from the Cherni Vrah metabasite complex in northwestern Bulgaria at  $391.2 \pm 1.3$  Ma (Fig. 3). At the same time, Plissart *et al.* (2017) interpreted the Early Devonian Danubian ophiolite massifs as parts of oceanic crust formed in a back-arc tectonic setting. The same authors associated this setting with the evolution of the northern parts of the eastern Rheic Ocean.

Kiselinov (2011) studied the geochemical composition of several samples of metabasites, metagranites and metavolcanites included in the Sredogriv metamorphites and interpreted them as having formed in different tectonic settings. These results support the suggestion of an older peri-Gondwanan origin of the igneous olistoliths and olistoplaques that were tectonically included during the late Silurian and Devonian into an epicontinental basin. The obtained Ediacaran age (618 Ma) of the Protopopintsi granite (representing a large olistoplaque in the Sredogriv metamorphites) also testifies to the peri-Gondwanan origin of the basement of the Balkan assemblage (Kiselinov *et al.*, 2009; Haydoutov *et al.*, 2012).

Most probably, during the early Carboniferous, the late Silurian–Devonian basin deposits were affected by compression and extension processes related to the initial stages of the collision between the northeastern peri-Gondwanan terranes and the marginal parts of Laurasia. Based on this suggestion, it could be assumed that the greenschist metamorphism that affected the Sredogriv metamorphics took place during the Late Devonian–early Carboniferous (Fig. 4).

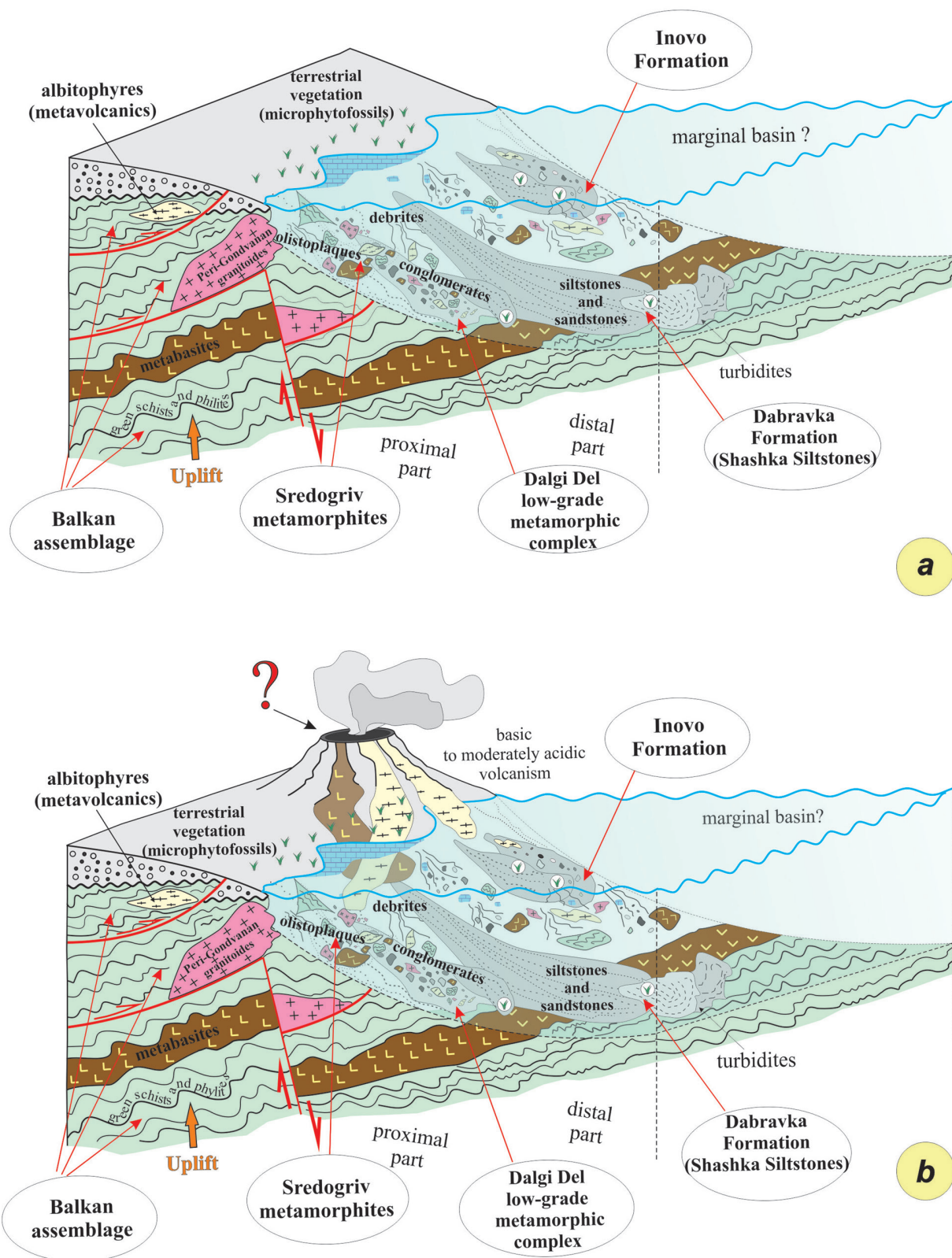


**Fig. 2.** Model sketches of probable sedimentogenic (a) or volcano-sedimentogenic (b) pre-Carboniferous environments of formation of the Sredogriv metamorphics and the correlated low-grade metamorphic complexes: Dalgi Del Low-Grade Metamorphic Complex (Dalgi Del Group), Shashka Siltstones (Dabravka Formation) and the Inovo Formation in Serbia. Note: Balkan assemblage = Stara Planina ophiolitic association (Balkan-Carpathian ophiolite) and Berkovitsa island arc association *sensu* Haydoutov (1991; Haydoutov *et al.*, 2010, Haydoutov *et al.*, 2012).

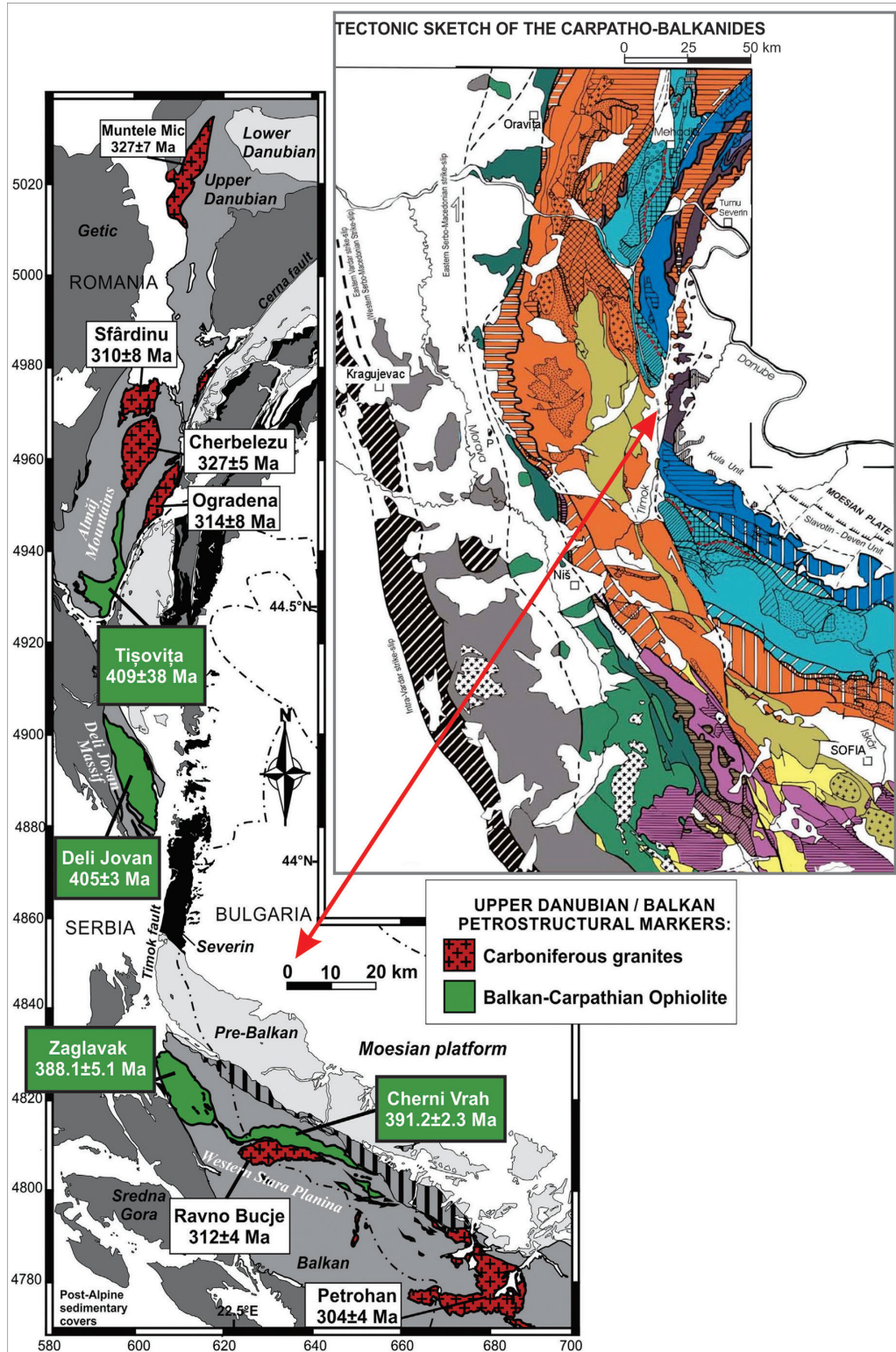


**Fig. 3.** Geological map of the Upper Danubian-Balkan Alpine nappe with the four ophiolitic massifs of the Balkan-Carpathian ophiolite (after Plissart *et al.*, 2017, with modifications). One complete magmatic body is subdivided into four parts: Tișovița luți fragment in the South Carpathians, Romania – Sm-Nd isochrones 380±35 Ma (Plissart *et al.*, 2017); Deli Jovan Massif in eastern Serbia – 405±3 Ma by U-Pb SHRIMP zircon (Zakariadze *et al.*, 2012), 382±46 Ma (Plissart *et al.*, 2017); Zaglavak Ophiolite Massif in eastern Serbia – 388.1±5.1 Ma (Zakariadze *et al.*, 2012); Cherni Vrah gabbro (part of the Cherni Vrah Group of Haydutov, 1989, 1991) in Northwest Bulgaria – U-Pb zircon dating 391.2±2.3 Ma (Kiselinov *et al.*, 2017). Tectonic sketch of the Carpatho-Balkanides after Kräutner and Krstić (2003).

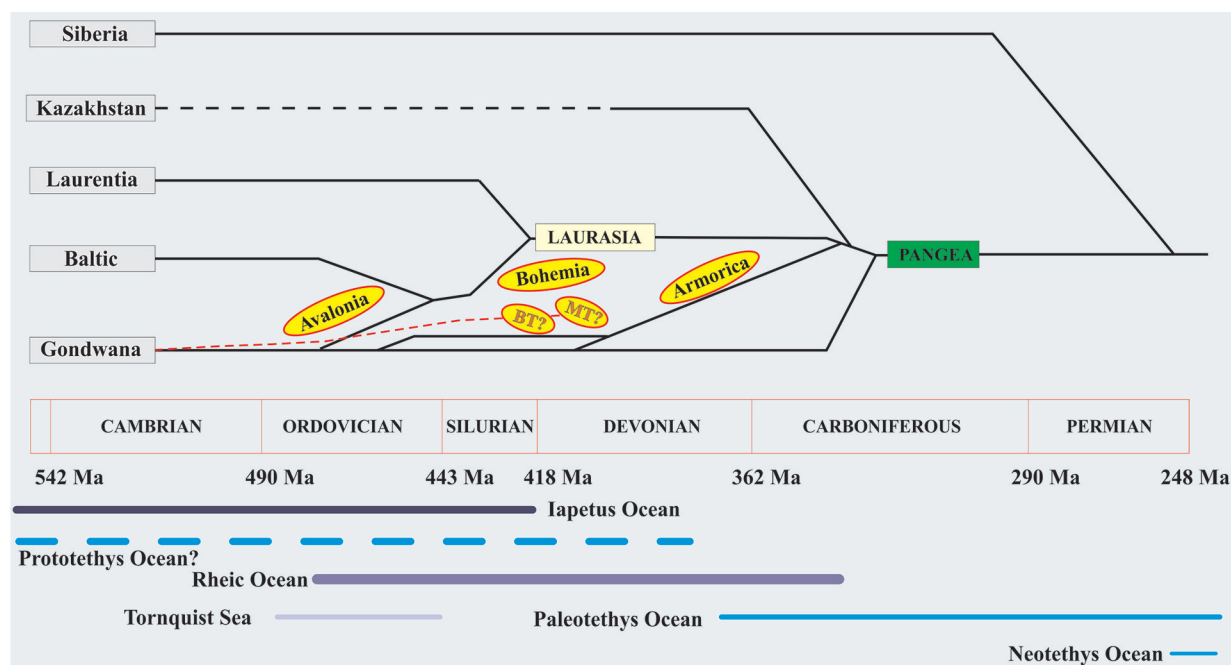


**Fig. 4.** Sketch of the development, migration and amalgamation of the various paleo-oceans and paleocontinents (after Cocks and Torsvik, 2006; with modifications). Abbreviations: BT – probable position on the Balkan Terrane; MT – probable position on the Moesian Terrane.

## CONCLUSION

The Sredogriv metamorphics from NW Bulgaria are interpreted as a component of a low-grade metamorphic complex, where the sedimentary protoliths were deposited in a marginal basin with possible late Silurian–Devonian age. The de-

velopment of this basin was a result of the early Carboniferous compressional and extensional processes related to the early stages of the collision between the northeastern peri-Gondwanan terranes and Laurasia. Then, the siliciclastic sediments were deformed and metamorphosed into a greenschist facies.

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