GEOLOGICA CARPATHICA, DECEMBER 2023, 74, 6, 459–468 https://doi.org/10.31577/GeolCarp.2023.27

SHORT COMMUNICATION

Detrital zircon age constraints on low-grade sedimentary successions of the eastern Circum-Rhodope Belt, Bulgaria

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(Manuscript received July 31, 2023; accepted in revised form January 9, 2024; Associate Editor: Igor Broska)

Abstract: We focused on the eastern Circum-Rhodope belt (CRB) low-grade sedimentary sequences in Bulgaria, in which clastic rocks are presented. U–Pb detrital zircon geochronology indicates the latest Late Jurassic maximum depositional ages of two samples from two distinct locations. Prominent Jurassic zircon cluster in the first sample is consistent with provenance from CRB-related Evros arc, whereas the Triassic zircons come from the high-grade basement. In the second sample, the main Permian and Carboniferous zircon populations, minor Triassic clusters and two Jurassic zircons reflect a provenance mainly from the high-grade basement and to a lesser extent from the Evros arc. These new results indicate latest Late Jurasic sedimentation proximal to the Evros arc (CRB) and along the continental margin of Eurasia (Rhodope), respectively for the studied first and second sample. The results further support the presence of Mesozoic (Jurassic) oceanic lithosphere mantle remnants within the metamorphic basement of the eastern Rhodope Massif. The results obtained shed new light and could open a discussion on the Late Jurassic clastic sedimentation along the transect from the continental margin of Eurasia (Rhodope) towards the Evros arc system of the eastern CRB.

Keywords: U–Pb geochronology, metasedimentary rocks, Circum-Rhodope Belt, Bulgaria

Introduction

The Circum-Rhodope Belt (CRB) is a major tectonic unit that surrounds both the Rhodope and the Serbo–Macedonian zones of the Alpine orogen in the northern Aegean region (Fig. 1, inset). Mostly carbonate and shale sedimentary successions, and their Triassic–Jurassic fossil content, have been initially used to recognise the Mesozoic age and regionally extensive nature of the CRB across the Aegean Sea (Kauffmann et al. 1976). In the eastern CRB exposed in Thrace area and eastern Rhodope Massif of Bulgaria and Greece again biostratigraphic (Trikkalinos 1955; Maratos & Andronopoulos 1964; Boyanov et al. 1990; Dimadis et al. 1996; Dimadis & Nikolov 1997) and also limited radiometric (Meinhold et al. 2010) age constraints have been used to infer Triassic and Jurassic depositional ages, but only available from the territory of Greece. In addition to the long debatable stratigraphic ages, the radiometric ages come only from two samples with statistically limited number of detrital zircon grains, and novel temporal constraints are required in support of the depositional history of the unfossiliferous clastic rocks, particularly from the Bulgarian part of the eastern CRB.

In Bulgarian part of the eastern CRB only the lithological similarity to the two main CRB units in Thrace area of Northern Greece (see Fig. 1), namely Makri unit and Drimos–Melia unit, has been used for the exposed in this part CRB low-grade sedimentary successions (Boyanov et al. 1990). The eastern CRB has been shown to represent subduction–accretion complex related to early Alpine tectonic evolution of an intra-oceanic arc system that gave birth to the Jurassic supra-subduction zone Evros ophiolite along the Eurasian plate margin (Bonev & Stampfli 2008, 2011). It is therefore important to establish the timing of depositional history of the low-grade sedimentary successions contained in the distinct subunits and/or important localities of the eastern CRB, which will provide constraints for the nature and age of the sedimentation from the Jurassic island arc system to the continental margin of Eurasia. Therefore, constraining the timing of deposition of the CRB sedimentary successions is critical for a better understanding of the eastern CRB paleogeography, as well as the Mesozoic tectonic architecture of the region in which these successions were involved during the Alpine orogenesis.

In this paper, we provide a new U–Pb detrital zircon geochronology for low-grade sedimentary successions in two distinct localities of the eastern CRB in Bulgaria. Our goal is temporarily to identify their depositional history that will allows us to distinguish facial elements of the sedimentation at the Eurasian continental margin towards the Jurassic island arc system. The results obtained shed new light and could open a discussion on the Late Jurassic clastic sedimentation along the transect from the continental margin of Eurasia (Rhodope) towards the Evros arc system of the eastern CRB.

Geological setting

The largest outcrop area of the eastern CRB in Bulgaria called the Mesozoic low-grade unit (Bonev & Stampfli 2003, 2008) or Mandritsa Group (Boyanov et al. 1990), and also Mandritsa unit (Ricou et al. 1998; Bonev et al. 2010a), laterally continues in northeastern Greece (Fig. 1). The second large and important area exposing the Mesozoic low-grade unit is the Kulidzhik nappe (Boyanov 1969) whose allochthon cooled below 350 °C between 157 Ma and 154 Ma as derived from $^{40}Ar/^{39}Ar$ geochronology (Fig. 1; Bonev et al. 2010b, see also Georgiev et al. 2016).

The Mandritsa unit consists of basal marble horizon overlain by greenschist and basalt lavas, all included in greenschist sub-unit, which is overlain by mélange-like sub-unit consisting of metasedimentary lithologies and blocks and pebbles of Late Permian and Middle-Late Triassic limestones (Bonev & Stampfli 2008 and references therein; Fig. 2). The basal tectonic contact of the Mandritsa unit with the underlying units of the high-grade metamorphic basement is an Eocene extensional detachment (Bonev 2006; Bonev et al. 2013b) or reactivated as normal fault former Jurassic thrust (Bonev & Stampfli 2011). The Mandritsa unit low-grade rocks display top-to-the NNW-directed thrust kinematics associated with greenschist facies metamorphism. A marble horizon is exposed about two kilometers westerly from the main outcrop area of the Mandritsa unit, where $^{40}Ar/^{39}Ar$ amphibole inverse isochron age of ca. 157 Ma was documented by Bonev et al. (2010b), and this suggests it is an extension of the Mandritsa unit basal marble horizon. The basal marble horizon of the Mandritsa unit has been shown to contains greywacke small blocks and cobbles, together with basic rocks pebbles and rare quartz clasts, which are deformed and metamorphosed in greenschist facies conditions as detailed in Bonev (2005).

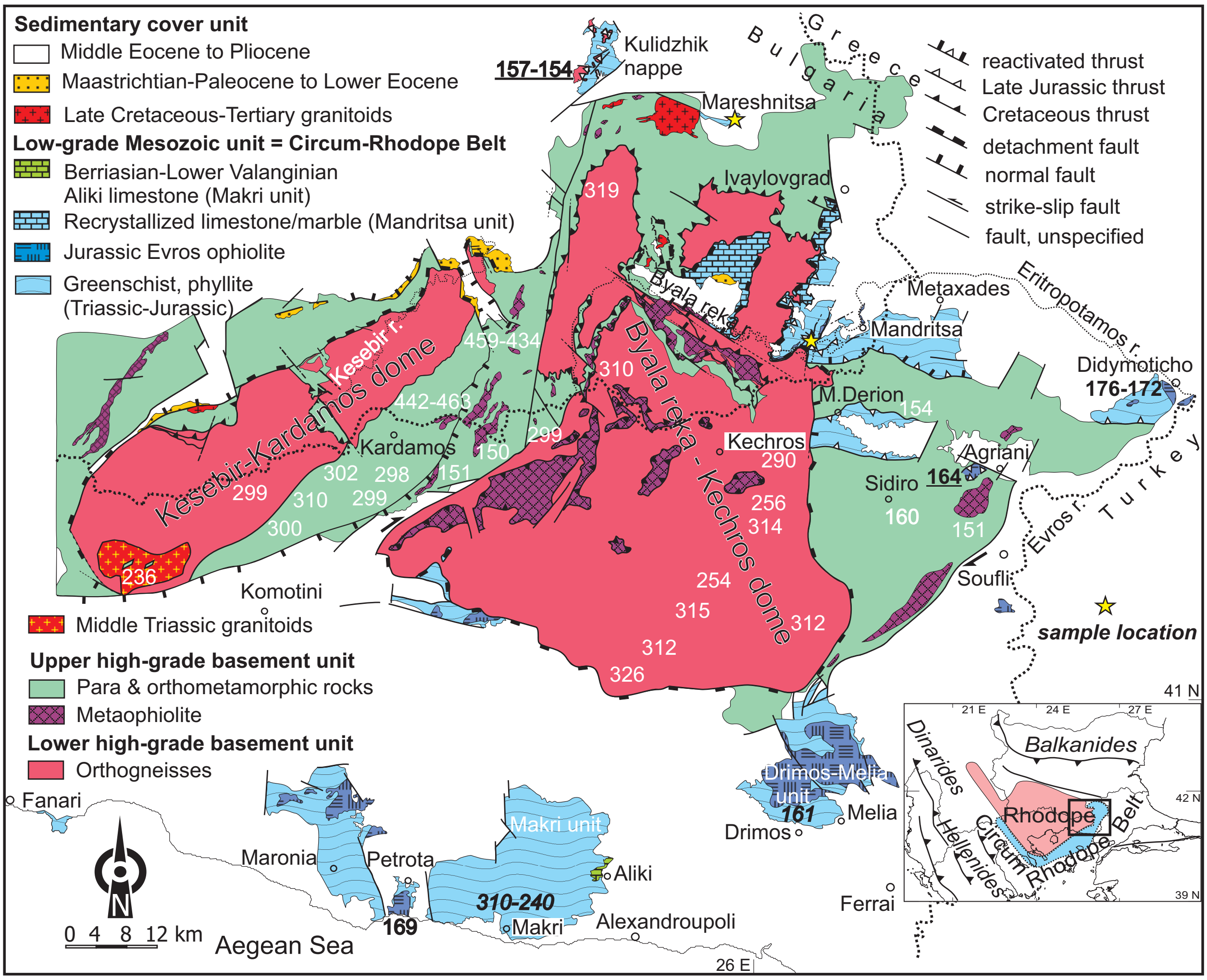

Fig. 1. Synthetic geological map of the eastern Rhodope Massif in Bulgaria and Greece (modified after Bonev et al. 2015). Inset: Tectonic framework of the Alpine orogen in the northern Aegean region of the eastern Mediterranean region. Stars point to the location of samples depicted in Figs. 2 and 3. Geochronology: U–Pb zircon – high-grade basement white numbers after Peytcheva & von Quadt (1995), Cornelius (2008), Liati et al. (2011), Drakoulis et al. (2013), Bonev et al. (2013a, 2015); Evros ophiolite – after Koglin et al. (2007), Bonev et al. (2015) numbers in black. Black italic – detrital zircon after Meinhold et al. (2010); $^{40}Ar/^{39}Ar$ – black underlined after Bonev et al. (2010b, 2015).

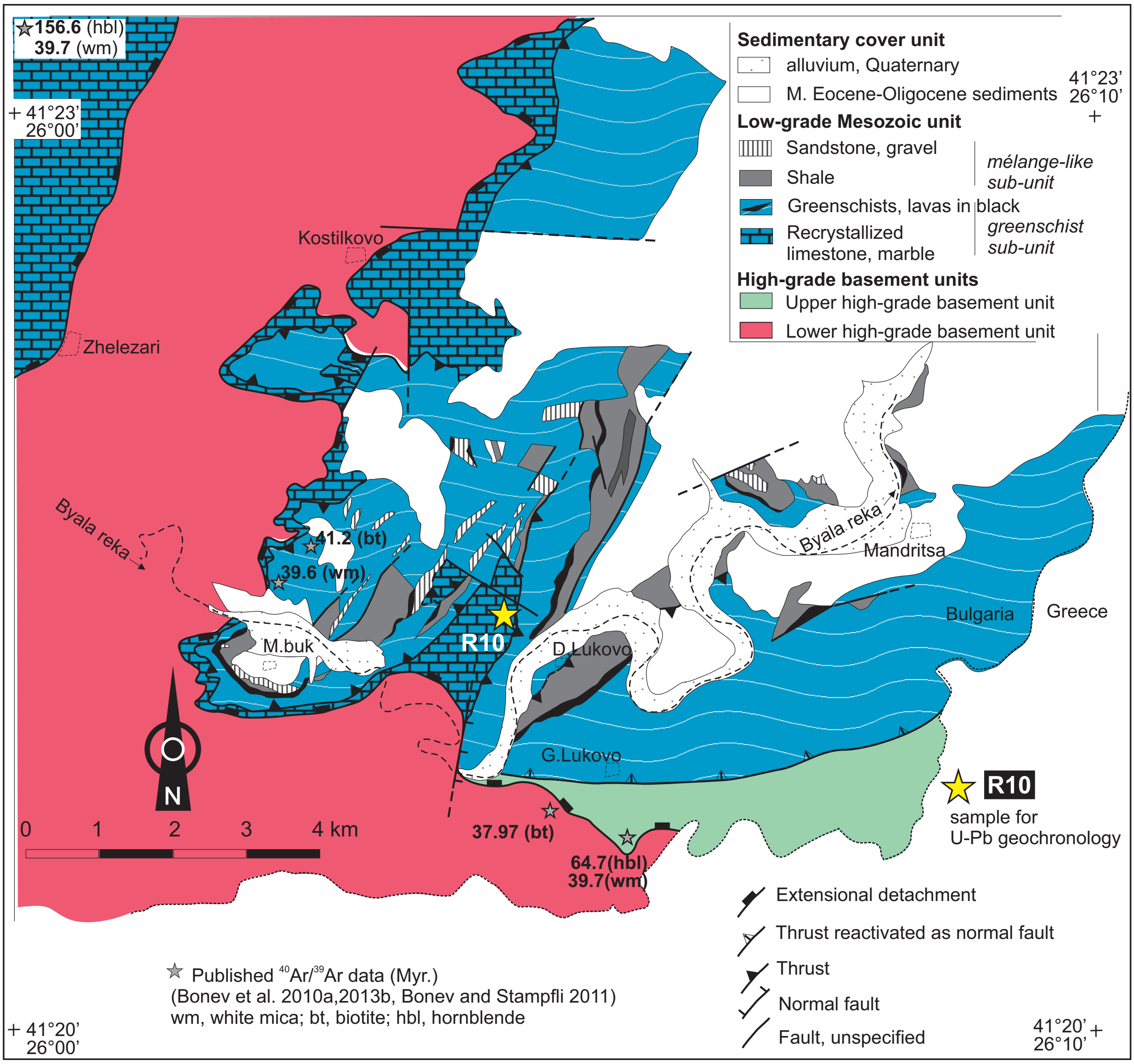

Fig. 2. Geological map of the Mandritsa unit (modified after Bonev & Stampfli 2011). The location of the sample studied for U–Pb geochronology is shown. $^{40}Ar/^{39}Ar$ geochronology after Bonev et al. (2010a, 2013b) and Bonev & Stampfli (2011).

The Kulidzhik nappe exposes a section of the Mesozoic low-grade unit consisting of greenschist sub-unit and phyllite sub-unit tectonically overlain by N-directed orthogneiss allochthon derived from the lower high-grade basement unit in the region.

Other exposure of the Mesozoic low-grade unit occurs along the Mareshnitsa river valley (Fig. 3). There, the metasedimentary rocks were described as at least 400-metre-thick low-grade series of probable Paleozoic (Ordovician) age (Ivanov 1961) reaching the grade of biotite–chlorite and sericite–chlorite sub-facies of the greenschist facies metamorphism. The main rock varieties are calc-schist, albite schist and quartz mica-schist. According to Ivanov (1961) the sedimentary protoliths were mostly shale and sandy rocks, whereas rare epidote–actinolite–chlorite schist were derived at the expense of basic tuffs and tuffites. Noteworthy, according to the latter author, is that the metamorphism of the low-grade series was not affected by the intrusion of the adjacent Chuchuliga granite, which was subsequently dated at 69 Ma by Marchev et al. (2006). In addition, Boyanov et al. (1963) have also described carbonate schist, greywacke schist and occurrences of ultrabasic rocks along the Mareshnitsa river valley and they correlated these lithologies with the low-grade rocks exposed in the Mandritsa area. Sarov et al. (2008) have also correlated the low-grade succession exposed along the Mareshnitsa river valley to the same grade metamorphic succession of the Mandritsa unit. However, the ultrabasic rocks included in the low-grade succession they assigned to the underlying Krumovitsa unit (Sarov et al. 2008), which is largely equivalent to the upper high-grade basement unit (Bonev 2006, see Fig. 1).

Samples and their structural context

Our study focuses on clastic rocks within the key basal marble horizon of the Mandritsa unit and clastic rocks overlying the low-grade schist along the Mareshnitsa river valley. Sample numbers mentioned below refer to those shown in Figures 2 and 3. These samples were used for U–Pb detrital zircon geochronology.

From the Mandritsa unit, a sample R10 (41°22’51.9”N, 26°04’19.7”E) was collected from the metagreywacke blocks included in the basal marble horizon (Fig. 2 for location, Fig. 4a). According to Bonev (2005) the metagreywacke has a composition of quartz (Q), feldspar (F) and lithic fragments (L) with a ratio Q≥F>L, all set in a matrix of fine quartz, feldspar grains and clayey-volcanogenic material (Fig. 4b). The mineral assemblage of the metagreywacke includes modally decreasing quartz, alkali feldspar, plagioclase, chlorite and epidote. The latter two mineral phases of metamorphic origin formed at expense of the recrystallization of the clayey-volcanogenic matrix material. Chlorite is Fe and Mg-rich, and the epidote occasionaly is Mn-rich (i.e. piemontite). Accessory minerals include zircon, apatite and rare opaques. A provenance of the clastic material mostly from continental terrane and volcanic arc sources was deduced from the geochemistry that implies tectonic setting at active continental margin (Bonev 2005). The basal marble horizon has the bulk structural pattern and NNW-directed thrust kinematics as the rest of the Mandritsa unit as described and depicted by Bonev and Stampfli (2011).

Along the Mareshnitsa river valley, a sample R22 (41°34’24.7”N, 25°58’01.4”E) was collected from a metasandstone overlying quartz mica-schist (Fig. 3 for location). The medium-grained metasandstone displays subvertical schistosity and/or metamorphic layering (Fig. 4c). The metasandstone consists of modally decreasing quartz, alkali feldspar, plagioclase, chlorite, epidote and muscovite (Fig. 4d). In the metasanstone, the accessory minerals include zircon and apatite. Hovewer, the most geologically important feature along the Mareshnitsa river valley is the internal shear deformation of the low-grade sedimentary succession, which has never been described before. Our field observations confirmed the predominance of quartz mica-schists that vary in mineral composition from biotite schist, sericite schist, chlorite schist and calc-schist and a combination among them in the

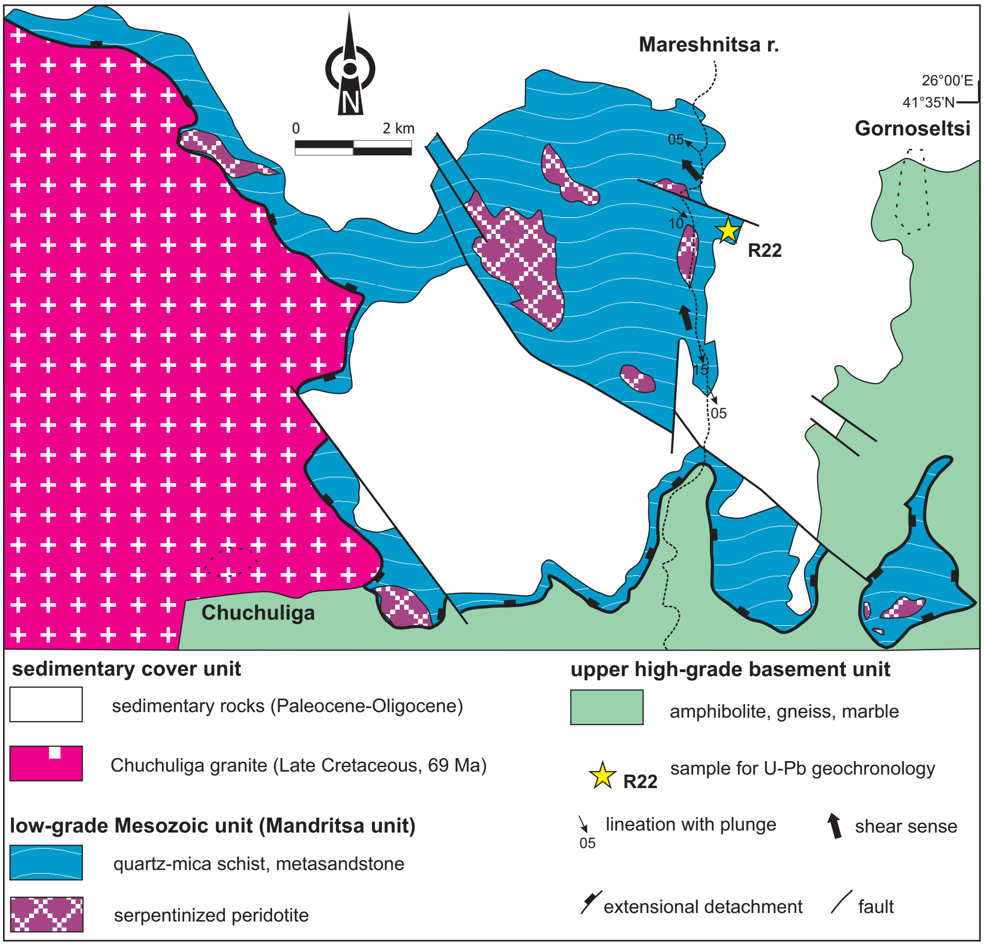

Fig. 3. Simplified geological map along the Mareshnitsa river valley (after Sarov et al. 2008). The location of the sample studied for U–Pb geochronology is shown. U–Pb age of Chuchuliga granite ca. 69 Ma after Marchev et al. (2006).

metamorphic succession (Fig. 4e), in which the field observations also confirmed the occurences of two small ultrabasic rock bodies (see Fig. 3). Quartz mica-schist are intercalated with calc-schist layers and both demonstrate a well-developed NNW and mainly SSE plunging mineral stretching lineation outlined by elongated quartz and mica aggregates. The schists are folded into tight to isoclinal metre-scale folds showing NNE gently plunging axes and pronounced NNW asymmetry. Fold asymmetry and associated kinematic indicators such as asymmetric quartz clasts demonstrate top-to-the NNW-directed ductile shear deformation in greenschist facies (Fig. 4f, g). In the host mica-schist succession the two ultrabasic bodies are not deformed and metamorphosed, and they exhibit characteristic mesh texture of olivine altered to serpentine and also demonstrate preserved spinel (Fig. 4h). This olivine alteration is likely due to ocean floor fluid circulation.

U–Pb geochronology

In order to date the deposition of the marble precursor in the Mandritsa unit and the clastic precursor of the metasandstone in the Mareshnitsa river valley, we analysed detrital zircons of the two samples R10 and R22 for U–Pb geochronology. The locations of samples are given in Figures 2 and 3. Sample preparation and analytical procedures are the same as described by Bonev et al. (2019). The analytical data are presented in Supplementary Table S1. Cathodoluminescence (CL) imaging was carried on motorized optical system Cathodyne NewTec Scientific attached to microscope Leica 2700 at the Geological Institute of the Bulgarian Academy of Sciences and JEOL JSM-6610 LV SEM-EDS at the University of Belgrade, Serbia. U–Pb in-situ LA-ICP-MS zircon dating was performed at the Geological Institute of the Bulgarian Academy of Sciences using a New Wave UP193FX LA coupled to a Perkin Elmer ELAN DRC-e quadrupole ICP-MS.

The dated zircons in metagreywacke sample R10 vary in size from 70 µm to 300 µm, with an average aspect ratio of 1.5. They display semi-rounded shapes and preserved oscillatory- and sector zoning patterns, which are characteristic for a magmatic origin (Fig. 5a). Zircons are partly disturbed by resorption and corrosion. Sixty-one concordant zircon analyses out of 105 performed in total yielded an Early Silurian to earliestmost Early Cretaceous ages (Fig. 6a, Supplementary Table S1). A single, oldest zircon, yielded a ^{206}Pb/^{238}U age of 431.3±4.8 Ma. The main age cluster of twenty-three zircons between 298.7 and 252.8 Ma span across the Permian yielding concordant ages at 297.7±1.1 Ma, 289.8±1.8 Ma, 266.8±3.3 Ma and 257.1±2.9 Ma. The second age cluster of twenty zircons in the range from 313.1 Ma to 299.9 Ma encompasses the Late Carboniferous, with a peak around 310 Ma (Fig. 6a). The latter age cluster yielded concordia ages at 317.1±1.4 Ma, 311.6±1.4 Ma, 308.8±1.2 Ma and 303.8±1.4 Ma. Seven-grains of concordant ages in the range from 247.5 Ma to 224.0 Ma define concordia ages at 242.9 ±7.6 Ma and 233.7±3.6 Ma, corresponding to the Middle Triassic. A further minor age cluster includes two Middle Jurassic zircons dated at 175.0 Ma and 169.9 Ma, which yielded a concordant age at 171.4±2.6 Ma. The youngest concordant zircon yielded an age of 144.3±1.9 Ma, and hence, defines the maximum depositional age in earliest Early Cretaceous (Fig. 6b). The convolute to patchy zoning pattern observed in CL image and the low Th/U ratio (0.09) of the youngest concordant zircon suggest a metamorphic origin (Fig. 5a, Supplementary Table S1). The Th/U ratios of the dated concordant zircons vary from 0.07 to 0.59, with the majority of zircon grains having a high ratio of 0.11–0.59 (Supplementary Table S1), which is characteristic for magmatic zircons (Rubatto 2002; Tiepel et al. 2004). However, a very minor amount of the detrital zircons with chaotic internal zoning patterns and low Th/U ratios have detectable metamorphic origin (see Supplementary Table S1).

Zircons from the metasandstone sample R22 show semi-rounded to rounded shapes of visibly prismatic and pyramidal crystals varying in size from 80 µm to 450 µm (av. aspect ratio 1.7), some of which have a homogeneous pattern and others magmatic oscillatory- and sector zoning patterns (Fig. 5b). The ^{206}Pb/^{238}U ages obtained from 105 analyses range from 667.8 Ma to 142.64 Ma (Fig. 6c, Supplementary Table S1). In sample R22 were established from ninety-one concordant zircons a series of clusters with different density and various ages. The main age cluster of twenty-five zircons yielded a concordia age of 156.86±0.53 Ma, followed by a cluster of twelve zircons that gave a concordia age of 162.69±1.0 Ma, and a cluster of nine zircons with a concordia age of 152.8 ±1.2 Ma. Two pairs of seven concordant zircons cluster at 169.05±0.81 Ma and 201.1±1.6 Ma. Two pairs of six zircons each gave concordant ages at 186.8±1.4 Ma and 234.1±1.5 Ma. Four clusters of three zircons each yielded concordant ages at 175.5±2.5 Ma, 220.3±1.8 Ma, 240.3±1.8 Ma and 251.6 ±4.0 Ma. Single zircons yielded concordant ages at 277.5 ±5.9 Ma, 304.02±3.2 Ma, 541.2±5.8 Ma, 586.3±8.6 Ma and 667.3±7.0 Ma. The two youngest concordant zircons provided an age of 145.3±1.8 Ma, and hence, define a maximum latest Late Jurassic depositional age (Fig. 6d). The Th/U ratios of the dated concordant zircons in this sample range from 0.03 to 0.93 (Supplementary Table S1), but the majority (>90 %) of these ratios are in the range of 0.11–0.93, which is typical for magmatic zircons.

Discussion

The U–Pb detrital zircon geochronological data obtained for the Mandritsa unit indicate an earliest Early Cretaceous maximum depositional age as young as 144.3 Ma for the metagreywacke blocks, and thus for the deposition of the limestone precursor of the basal marble horizon of the unit. The Mareshnitsa river valley metasandstone layer overlying the schist has a latest Late Jurassic maximum depositional age of 145.3 Ma (Fig. 6). The number of dated zircons from the R10 and R22 clastic rock samples meets the required amount for statistical

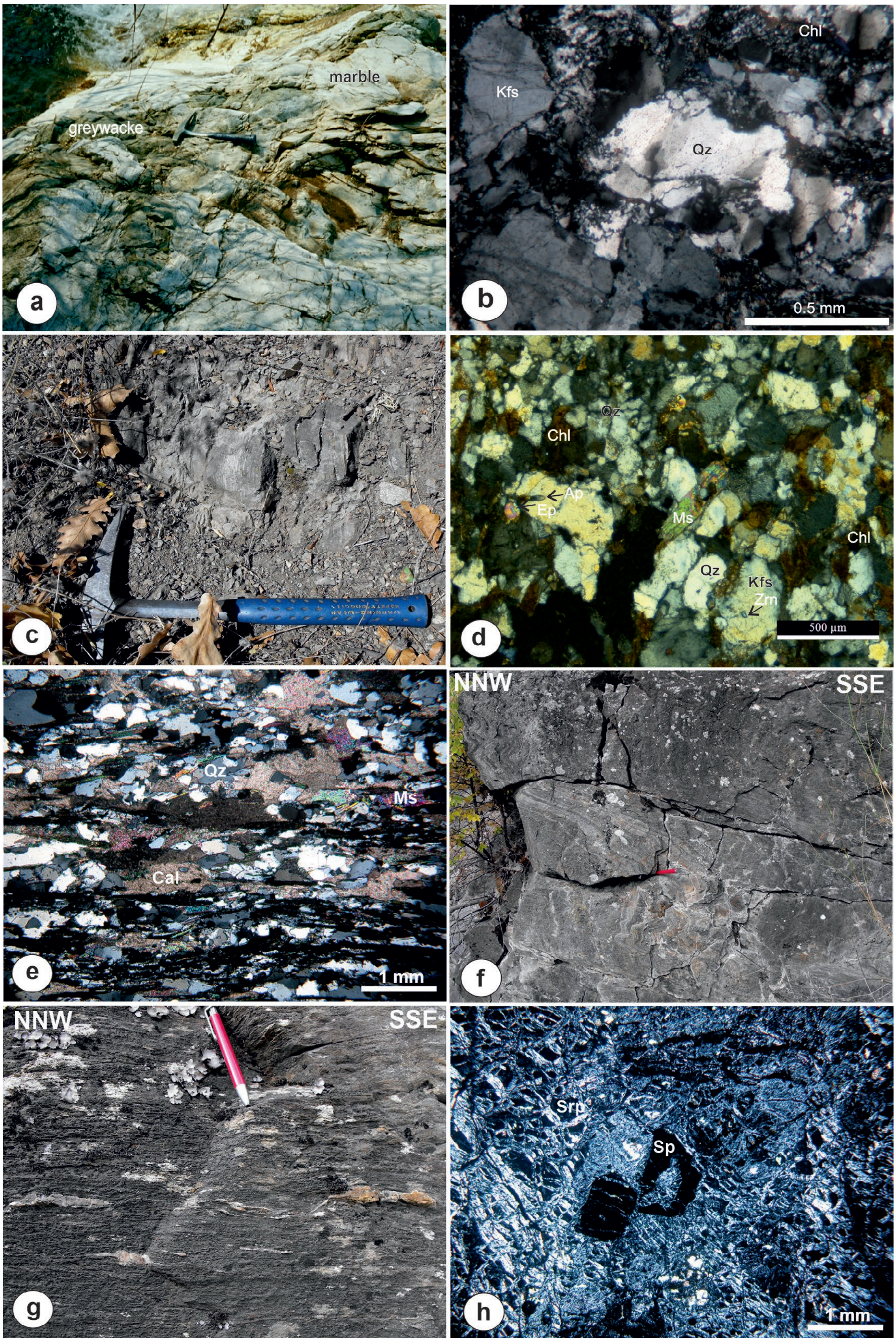

Fig. 4. Photographs of the low-grade successions of the Mandritsa unit and along the Mareshnitsa river valley. **a** — Field aspect of the marble hosting metagreywacke lenses in the Mandritsa unit; **b** — Microphotograph of the metagreywacke; **c** — Field aspect of the metasandstone along the Mareshnitsa river valley; **d** — Microphotograph of the metasandstone; **e** — Microphotograph of calc-schist; **f** — Folds in biotite schist; **g** — Asymmetric quartz clasts in biotite schist; **h** — Mesh texture of peridotite. Mineral abbreviations (after Whitney & Evans 2010): Ap, apatite; Cal, calcite; Chl, chlorite; Ep, epidote; Kfs, alkali feldspar; Ms, muscovite; Qz, quartz; Sp, spinel; Srp, serpentine, Zrn, zircon.

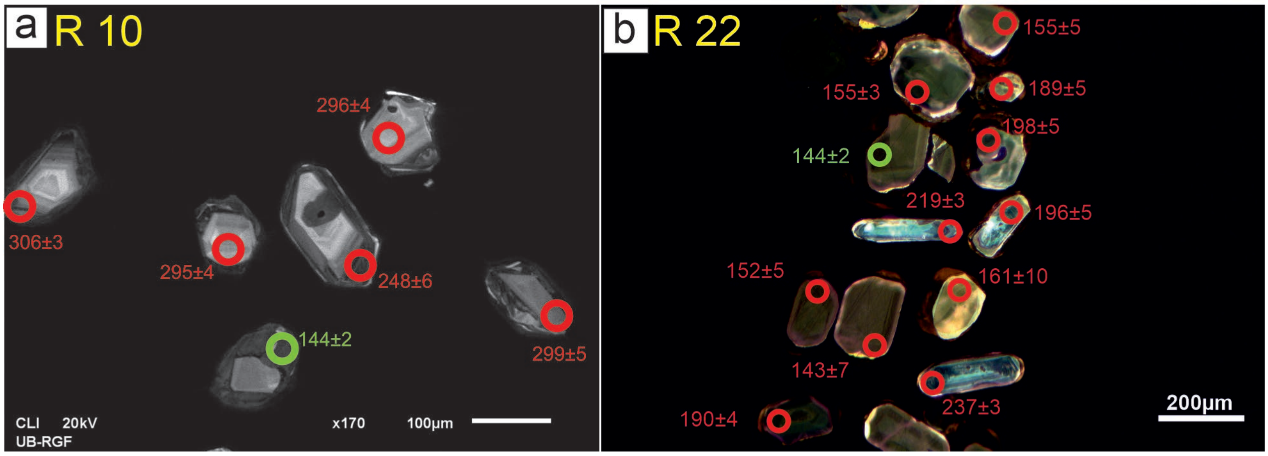

Fig. 5. Selected cathodoluminescence images of dated zircons in the clastic rocks of the Mesozoic low-grade unit. Circles represent the location of spot analyses with corresponding ages given with 2σ error. Green coloured numbers correspond to the youngest population. **a** — Sample R10; **b** — Sample R22.

criteria (Vermeesch 2004). Taken collectively, the number of dated zircons from both clastic samples satisfies and exceeds the statistical confidence at the 95 % level. Therefore, the latest Late Jurassic–earliest Early Cretaceous detrital zircon record obtained in this study provides an unequivocal depositional age constraint for the limestone and clastic rocks within the Mesozoic low-grade unit or CRB of the eastern Rhodope Massif.

Actually, the depositional ages of both clastic lithologies sampled are very close to each other separated within 1 Myr and undistinguishable within the error, but the age obtained for the deposition of the basal marble horizon opens the question about the timing of carbonate sedimentation of some levels in the section of the eastern CRB. Particularly, in northern Greece, the Aliki limestone of Berriasian–Lower Valanginian biostratigraphic age is unmetamorphosed and undeformed and seals the underlying deformed greenschist of the Makri unit (Ivanova et al. 2015). As such the limestone precursor of deformed basal marble horizon of the Mandritsa unit should be younger than the Early Cretaceous. We therefore consider within the error of the age obtained for sample R10 the basal marble horizon as latest Late Jurassic (Tithonian) in age. Furthermore, in addition, the depositional age of the metasandstone sample R22 provides a minimum latest Late Jurassic igneous age for the peridotite lenses enclosed in the schist succession along the Mareshnitsa river valley and/or tectonic emplacement age of the peridotite in the schist succession. This temporal constraint for the peridotite along the Mareshnitsa river valley further supports the presence of Mesozoic (Jurassic) oceanic lithosphere mantle remnants in the high-grade metamorphic basement of the eastern Rhodope Massif (Filipov et al. 2022), but also within the Mesozoic low-grade unit representing the eastern CRB.

The high Th/U ratios of the detrital zircons reflect mostly a magmatic provenance and an additional limited provenance from metamorphic influence. In this direction, the Th/U ratios and the documented age clusters of detrital zircons testify for the same age as the magmatic protoliths of the metamorphic basement of the central-eastern Rhodope Massif, including the eastern CRB (see Fig. 1).

The detrital zircon age clusters of the studied samples differ relative to the immediate sedimentary source area, but the clusters precisely reflect the age of the basement rocks of each source area location and the proximity to the Evros island arc system. Particularly, the metasandstone sample R22 reveals a major cluster of Jurassic zircons, which corresponds to the age of the magmatic members of the Evros ophiolite (176–164 Ma, Bonev et al. 2015), as well as of the metagranitoid protoliths in the high-grade metamorphic basement of the eastern Rhodope Massif (151–150 Ma, Cornelius 2008; 160–154 Ma, Bonev et al. 2015). The same is valid for the minor cluster of Triassic zircons, with ages overlapping with those of the Triassic metagranitoids in the high-grade metamorphic basement (Drakoulis et al. 2013). This implies that these Triassic metagranitoids were already exposed at the surface by Late Jurassic times. Other volumetrically minor zircon clusters and single zircon grains of Permian–Carboniferous age have their age equivalents in Carboniferous–Permian magmatic rocks that also built the high-grade metamorphic basement (Peytcheva & von Quadt 1995; Peytcheva et al. 2004; Cornelius 2008; Turpaud & Reischmann 2010; Liati et al. 2011). Single Neoproterozoic zircons have also provenance from the high-grade metamorphic basement of the eastern Rhodope Massif (Bonev et al. 2013a and references therein). As the major detrital zircon age cluster of the metasandstone overlaps with the ages of the Jurassic Evros ophiolite magmatic rocks, this suggests that the source area was not far from the depositional area proximal to the Evros arc system.

The metagreywacke sample R10 contains a major detrital component from Permian and Carboniferous magmatic rocks, which are major constituents of both high-grade metamorphic basement units of the eastern Rhodope Massif (Peytcheva &

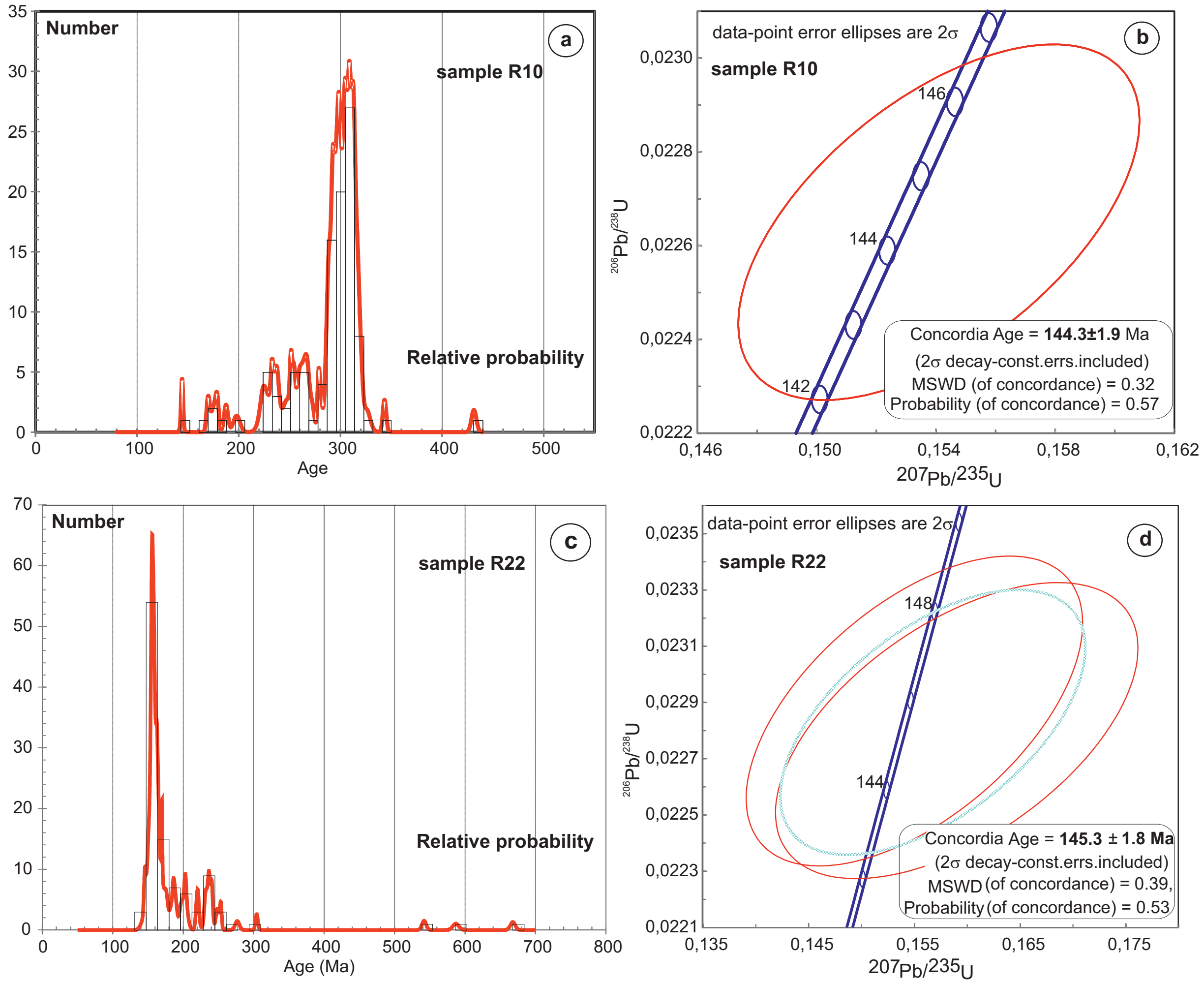

Fig. 6. Diagrams of U–Pb LA-ICP-MS zircon analyses of dated clastic rock samples of the Mesozoic low-grade unit. **a** — Density distribution diagram of zircons from sample R10; **b** — Concordia diagram for the two youngest zircons in sample R10; **c** — Density distribution diagram of the zircons in sample R22; **d** — Concordia diagram for the youngest zircon in sample R22.

von Quadt 2005; Cornelius 2008; Liati et al. 2011). The same provenance applies relative to the minor zircon cluster of Triassic detrital zircons, whereas the few Jurassic detrital zircons overlap magmatic crystallization ages of the Evros ophiolite. A single Silurian zircon grain might have also provenance from the high-grade metamorphic basement of the eastern Rhodope Massif, in which occurs Ordovician metamagmatic rocks (Bonev et al. 2013a). As the major detrital zircon age cluster of the metagreywacke overlaps with the ages of the Permian–Carboniferous magmatic rocks, this suggests that the source area was not far from the depositional area close to the Rhodope continental margin of Eurasia. Compared to the major zircon cluster (315–285 Ma), minor cluster (550–450 Ma) and youngest zircon of 161±10 Ma reported for the Drimos–Melia unit (33 grains), and the major zircon cluster (310–290 Ma), minor cluster (240 Ma), single zircons of ages at 376 Ma, 343 Ma and 262 Ma and youngest zircons of 233±6 Ma and 214±6 Ma reported for the Makri unit (35 grains; Meinhold et al. 2010), nearly all of them exist in sample R10. This comparison provides additional support and regional consistence for the source areas of the detrital material derived from the high-grade metamorphic basement of the eastern Rhodope Massif.

To sum up, the detrital zircon record in Mandritsa unit clastic sample is evidence for a provenance of the sedimentary material mainly from the continental (shelf area) eastern Rhodope high-grade basement, whereas the clastic sample from Mareshnitsa river valley received detrital material mainly from the magmatic rocks of Evros arc system. Because of Evros arc system proximal location of the Mareshnitsa river valley low-grade succession that contains peridotite lenses, this implies its shallow crustal level position in trench to arc depositional setting. Relative to the structures, kinematics and metamorphic grade recorded in the Mareshnitsa river valley low-grade metamorphic succession, all these features fully correspond to that characteristic for the internal deformation pattern of the Mesozoic low-grade unit or eastern CRB. We therefore consider the low-grade metamorphic succession along the Mareshnitsa river valley as an element of the CRB allochthon tectonically emplaced in Late

Jurassic–Early Cretaceous times, which was subsequently eroded and overprinted by Tertiary extensional tectonics in the region.

Conclusions

- Detrital zircon U–Pb geochronological data obtained for the two clastic rock samples of the eastern CRB reveal their latest Late Jurassic and earliest Early Cretaceous maximum depositional ages, respectively of 145.3 Ma and 144.3 Ma, which we consider both as Late Jurassic within the error and based on regional constraints. In the metagreywacke blocks hosted by marble from the Mandritsa unit the main population of Permian-aged detrital zircons is followed in decreasing abundances of Carboniferous and Triassic age clusters, and two Jurassic zircons. The main clusters of Permian and Carboniferous zircons and Triassic detrital zircons are sourced by the Late Carboniferous–Permian and Middle Triassic meta-magmatic bodies that constitute the high-grade metamorphic basement of the eastern Rhodope Massif. In a metasandstone along the Mareshnitsa river valley, the main Jurassic-aged zircon populations are followed in decreasing abundances of Triassic age clusters, and few Carboniferous and Neoproterozoic zircons. The prominent clusters of Jurassic zircons are sourced from the Jurassic Evros island arc system, which age of magmatic products is overlapped by the established detrital zircons, together with a minor contribution of detrital material from the high-grade metamorphic basement.
- Based on structures, NNW-directed kinematics, metamorphic grade and depositional age derived from detrital zircon record, the greenschist succession along the Mareshnitsa river valley can be regionally considered as an integral part of the CRB. As the greenschist contains peridotite lenses, the whole low-grade metamorphic succession might be located at shallow crustal level position of trench to island arc system. A minimum Late Jurassic igneous age is evidenced for the peridotite lenses from the detrital zircon record along the Mareshnitsa river valley and/or considered as the peridotite tectonic emplacement age.
- From a paleotectonic point of view, we interpret the provenance of the Jurassic detrital zircons from the Evros island arc system in the metasandstone sample, whereas the provenance of the Permian–Carboniferous to Jurassic detrital zircons in metagreywacke sample comes from the eastern Rhodope high-grade metamorphic basement. Therefore, we have a record of differently located depositional environments, one proximal to the Evros island arc system, and other proximal to the continental margin of Eurasia represented by the Rhodope Massif high-grade metamorphic basement.

Acknowledgements: The study was supported by the Bulgarian National Science Fund projects no. KP-06-N54/5 and DN 04/6. We thank the two anonymous reviewers for their constructive comments on the manuscript, which helped us to improve the final paper. We thank Evelyn Boneva for language proofreading.

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Electronic supplementary material is available online:
Supplementary Table S1 at http://geologicacarpathica.com/data/files/supplements/GC-74-6-Bonev_TableS1.docx