Metamorphic rocks from Dospat area of Western Rhodopes – conventional and *in situ* U-Pb zircon dating, isotope tracing and correlations

Метаморфни скали от района на Доспат в Западните Родопи – конвенционално и *in situ* U-Pb цирконово датиране, изотопни характеристики и корелации

Albrecht von Quadt[1], Irena Peytcheva[2,1], Stoyan Sarov[3], Kalin Naydenov[4,3], Neven Georgiev[4]
Албрехт фон Квадт[1], Ирена Пейчева[2,1], Стоян Саров[3], Калин Найденов[4,3], Невен Георгиев[4]

[1] IGMR, ETH-Zurich, Switzerland; E-mail: quadt@erdw.ethz.ch
[2] Geological institute, Bulgarian Academy of Sciences, 1113 Sofia; E-mail: ipeytcheva@geology.bas.bg
[3] Research Institute "Geology and Geophysics" AD, 23 Sitnyakovo Blvd., 1505 Sofia; E-mail: k.naidenov@gmail.com
[4] Sofia University „St. Kliment Ohridski", Faculty of Geology and Geography, 1000 Sofia; E-mail: neven@gea.uni-sofia.bg

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Geological setting and sampling

The distinction of geological units in metamorphic terrains is usually complicated by the tectonic overprint of the normal superposition of the rocks. Important evidence to correlate metamorphic rocks is the protolith age and time of the metamorphism. Here we present new single zircon and *in situ* U-Pb zircon data for metagranites from the southern parts of Western Rhodopes (the region W of Dospat town). The analyses are carried out at IGMR, ETH-Zurich as part of a collaborative work with the Research Institute "Geology and Geophysics" AD during the new 1:50 000 scale geological mapping of the Rhodopes.

The southern parts of Western Rhodopes in the region W of Dospat consist mainly of metamorphic rocks, subdivided recently in three tectonic units (Sarov et al., this volume): 1) Mesta, 2) Slashten and 3) Sarnitsa. The *Mesta unit* (1) comprises the lowermost part of the metamorphic section in the studied area. It crops out south of Satovtcha and along the Bulgaria-Greece state border between the villages of Slashten and Beslen. The Mesta unit consists of strongly sheared biotite to two-mica orthogneisses or aplitic orthogneisses with equigranular to porphyroclastic structure. The *Slashten lithotectonic unit* (2) is composed mainly by amphibolite facies rocks of probably parametamorphic origin (schists, marbles, calcschists, paragneisses) including abundant mafic to ultramafic bodies in a meter to decameter scale. Scarce orthogneisses crop out as separate foliated sill-like bodies. The *Sarnitsa lithotectonic unit* (3) is characterized by abundant biotite to two-mica orthogneisses in a parametamorphic succession, which largely resemble of Slashten unit, but in stronger migmatization (metatexites) conditions.

We present data for the metagranites of Sarnitsa unit from an outcrop E of Surnitsa (AvQ-276) and for equigranular (AvQ-279) and porphyric orthogneisses (AvQ-280) close to the villages of Slashten and Vulkosel (Mesta unit). From the Slashten unit a leucosome from the vicinities of Kochan village was also dated (sample 6164). Conventional U-Pb-zircon ID-TIMS (Isotope Dilution – Thermal Ionisation Mass Spectrometry) method is applied for the precise dating of the metamorphic protoliths, using the double uranium and lead spike of the Earth-Time project (ET2535). In order to minimize the effects of secondary lead loss, zircons were pretreated by "chemical abrasion" techniques. The data are combined with the less precise (2σ errors of 2–8%) *in situ* LA-ICP-MS analyses of zircons, which were first imaged in cathodoluminescent (CL) and back-scattered electron (BSE) regime. So we can distinguish and date the inherited zircon grains/cores or the magmatic and/or recrystallized zones, which help unraveling the metamorphic history. Hf-zircon isotope data provide additional source information for the hosting magma.

U-Pb-zircon isotope geochronology and isotope tracing

Zircons of sample AvQ-276 (metagranite, N 41°43'59"; E 24°02'12") are mainly prismatic to long-prismatic, beige-brownish and semitransparent, slightly rounded. Their CL-images show oscillatory

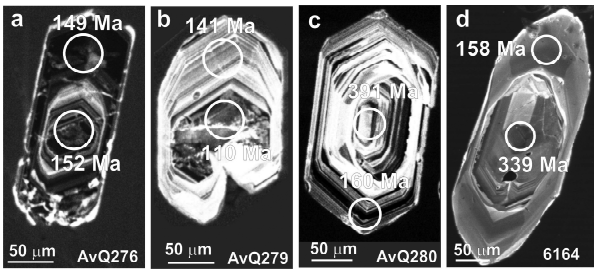

Fig. 1. Cathodoluminescent (CL) images of zircons from samples AvQ276 (a), AvQ279 (b), AvQ280 (c) and 6164 (d). The circles show the position of the laser-ablation craters with the corresponding $^{206}Pb/^{238}U$ age.

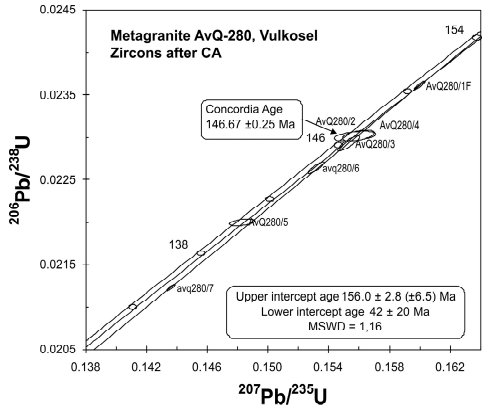

Fig. 2. Concordia diagram for zircons of sample AvQ280 (porphyric metagranite from the region of Vulkosel)

magmatic zonality and high uranium content (Fig. 1a). For the analyses we chose the most long prismatic crystals in order to avoid possible lead-inheritance. Most analysed zircons are dated around 145 Ma, whereas two zircons are concordant at 145.67 ± 0.83 Ma. The Jurassic age of the protoliths is confirmed by the *in situ* LA-ICP-MS dating of the zircons. The crystalline zones of the grains are dated in the range 150–160 Ma.

The zircons of the two orthogneisses from the Mesta lithotectonic unit (AvQ279 and AvQ280) are very U-rich (light zones in BSE and dark in CL, Fig. 1b, c). The grains are macroscopic muddy brownish-grey, prismatic to short prismatic in AvQ279. In the latter some crystals are almost without a prism, which is a characteristic feature for a highly differentiated and alkali-rich magma. Four prismatic zircons of sample AvQ279 (N 41°28'18"; E 023°59'44") are dated conventionally. In spite of the chemical abrasion two of them still show lead loss. Together with one almost concordant grain (at about 146 Ma) they define a discordia line with an upper intercept age of 153 ± 7.4 Ma and a poorly defined, but Late Alpine lower intercept age (34 ± 21 Ma). The *in situ* LA-ICP-MS age data confirm the Jurassic age of the granitic protoliths, ranging from 142 to 160 Ma in the crystalline parts of the zircons. The U-rich metamict areas reveal lead loss and discordant ages to 105 Ma that confirm the Late Alpine metamorphic overprint of the rock.

ID-TIMS single crystal dating of seven prismatic brownish zircons from sample AvQ280 (N 41°32'29"; E 024°00'31") determine a similar Jurassic age of the granitic protoliths. Three of them can be considered as concordant at 146.67 ± 0.25 Ma (Fig. 2). We could also assume all of the measured zircons as slightly discordant and calculate an upper intercept age of 156.0 ± 6.5 Ma (crystallization of the granite) and poorly defined Late Alpine lower intercept age 42 ± 20 Ma (overprinting metamorphism). The *in situ* LA-ICP-MS dating resembles partly the data for the sample of Mesta unit (AvQ-279): the crystalline zones of the zircons are dated at 148–164 Ma, and the metamict parts show apparent ages between 140 and 127 Ma. Some zircons of sample AvQ280 contain inherited cores (Fig. 1d) ranging from Paleozoic to Proterozoic in age (400 to 2100 Ma) and give evidence for the assimilation of old crustal materials by the magma.

The images of the zircons for the leucosome of sample 6164 are typical for metamorphic overprinted rocks: they contain cores, which are overgrown with rims (20–80%) with blurry oscillatory zonation, the crystals are with rounded edges, some rims are additionally recrystallised (Fig. 1d). The *in situ* LA-ICP-MS ages of the cores is consistent Permian-Carboniferous (250–340 Ma), and the rims are dated at 147–165 Ma.

In-situ LA-ICPMS-MC Hf-isotope zircon studies of the four samples reveal slightly positive (+1 to +4) ε-Hf (t) values. The latter argue for the participation of mantle-derived magma in the generation of the Jurassic granitoids. The inherited cores on the opposite are crustal dominated (with negative e-Hf (t) values).

Discussion

The oscillatory zoning of the zircons from the studied gneisses of the Mesta, Slashten and Surnitsa lithotectonic units give evidence for magmatic protoliths of the metamorphic rocks. The magmatic age of the granites and of the migmatization is Jurassic (146–156 Ma). The slightly positive ε-Hf (t) values of the magmatic zircons refer to a mixed (mantle-crust) origin of the magma. The latter was contaminated by Paleozoic to (rarely) Proterozoic crustal rocks (negative ε-Hf (t) zircon values).

Metamorphic rocks with magmatic Jurassic protoliths are widely distributed in the Central and Western Rhodopes (e.g. Raeva et al., this volume and references therein). Although the granitoids prevail among the dated rocks the positive ε-Hf characteristics of the analyzed zircons argue for a generation in a subduction-related tectonic environment. The complicated present position of the rocks results from the subsequent Late Alpine collisional and extensional tectonic events.