250 Ma metagranitoid from Drangovo Village: a new discovery of Permo-Triassic magmatism in the Eastern Rhodopes, Bulgaria

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Abstract. This short communication reports a 251.4 ± 6.8 Ma age of a Permo-Triassic metagranitoid (augen gneiss) in the Bulgarian part of the Eastern Rhodopes. The rock is intruded by the early Eocene Drangovo pluton and represents part of the upper metamorphic unit of the Kessebir dome. The analyzed sample has slightly peraluminous ($ASI = 1.11$) granitic composition with $SiO_2 = 70.6$ wt.%. It is enriched in LILE and LREE and depleted in HREE, with a deep Eu ($Eu/Eu^* = 0.49$) anomaly consistent with garnet and plagioclase fractionation. The large number of xenocrystic zircons, along with the low (780°C) crystallization temperature and petrochemical data, suggests significant assimilation of basement rocks by the granitic magma. The rock has a subduction-related signature.

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INTRODUCTION

Triassic and Permo-Triassic (P-T) magmatic and metamagmatic rocks are relatively common in the Serbo-Macedonian Massif but very rare in the Rhodope Massif. Recent studies of this magmatism support two fundamentally different views on its genesis and tectonic significance. In the Serbo-Macedonian Massif, one group of authors considers this magmatism as anorogenic and hence rift-related (Christophides *et al.*, 1999; Himmercus *et al.*, 2009; Bonev *et al.*, 2018). A second group of authors regards the magmatism as A-2 type, which formed in a post-orogenic extensional environment, rather than in an anorogenic within-plate environment (Poli *et al.*, 2009), or as representing an island-arc/continental margin or a post-collisional geodynamic environment (Zidarov *et al.*, 2007; Peytcheva *et al.*, 2009). In the Central Rhodopes, this magmatism is almost unknown except for the 210–240 Ma age obtained from multigrain zircon fraction from gneisses in the vicinity of Shiroka Laka Village (Arnaudov *et*

al., 1998), and metamorphosed diorites from the Arda Unit east of the Rila-Rhodope batholith that yielded a discordia with an upper intercept age of 253 ± 13 Ma (von Quadt and Peytcheva, 2005). Until recently, P-T magmatism had not been identified in the Eastern Rhodopes. The first report for such magmatic rocks was the paper of Drakoulis *et al.* (2013) for the Papikion pluton (Greece), located in the south part of the Kessebir-Kardamos dome, close to the Bulgarian-Greek border. The Papikion pluton consists of six non-foliated or slightly foliated rock types: hornblende diorite, biotite hornblende diorite, hornblende granodiorite, biotite hornblende granodiorite, biotite granodiorite, biotite granite, as well as aplitic dikes intruding the six major rock types above.

This short communication reports the results of *in situ* zircon U-Pb age dating and chemistry of a newly found P-T metagranitoid (augen gneiss) in the Bulgarian part of the Eastern Rhodopes, close to Drangovo Village and only 20 km from Papikion pluton. We conclude that the P-T magmatism in

the Rhodope Massif had a wide distribution, thus resembling P-T magmatic activity in the Serbo-Macedonian Massif.

GEOLOGICAL BACKGROUND AND SAMPLING

The metagranitoid is located in the south-western-most part of the Kessebir-Kardamos dome in the Eastern Rhodopes (Fig. 1). It forms part of the metaigneous and metasedimentary rocks of the Upper Unit of the metamorphic basement, which is mainly composed of Ordovician (~455 Ma; Bonev *et al.*, 2013) metamafic-ultramafic ophiolites with a MORB-IAT signature, and marbles and Jurassic plagiogranites (~159 Ma; Peytcheva *et al.*, 1998). The metagranitoid body in Fig. 1 is included within the frame of a parametamorphic unit, the biotite gneiss of the Borovitsa lithotectonic unit (Sarov *et al.*, 2008). The studied area is southeast of the contact with the early Eocene (50 Ma) Drangovo pluton, which intrudes the metagranitoid (Marchev

et al., 2013, Raicheva *et al.*, 2018). Surface outcrops of the metagranitoid are strongly deformed fine-grained, almost mylonitic rocks, confirmed by microscopic observations of two samples. Sample Dr17-2 (coordinates N41.35041°, E25.25954°) was taken after careful selection in the field because of its relatively more preserved porphyritic texture. The outcrop is about 60 m from the contact with the Drangovo pluton (Fig. 1), but it falls in the frame of the pluton on the map of Sarov *et al.* (2008).

ANALYTICAL PROCEDURES

Whole-rock major and a limited number of trace elements were measured by Thermo ARL Perform'X WDXRF spectrometer at Hamilton College (USA) and calibrated against both international and internal standards. A larger set of whole rock trace elements were determined on freshly broken cross-sections of the fused pellets, using the laser ablation system New Wave UP193FX coupled with an ICP-MS PerkinElmer ELAN DRC-e at the Geological

Fig. 1. a) Map of the Kessebir dome and surrounding area after Ricou *et al.* (1998); b) Simplified geological map of the Drangovo pluton after Nedialkov *et al.* (1998) and Sarov *et al.* (2008).

Table 1

Major and trace element data for the Drangovo metagranitoid (Sample D17-2)

SiO ₂	TiO ₂	Al ₂ O ₃	FeO	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	LOI	Total	Sc	V	Cr	Co	Ni	Zn	Cu	Pb	Ga	Zr	Hf
70.56	0.356	14.14	1.91	0.03	0.72	1.36	3.16	4.72	0.171	2.53	99.65	12.2	35.2	6	1.97	4.39	41	3.88	24.2	22	143	4.03
Nb	Ta	U	Y	Th	Rb	Cs	Sr	Ba	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
8.81	0.79	3.35	9.75	16.3	133	0.84	221	878	45.89	93.42	10.63	41.13	7.31	0.93	5.09	0.51	2.24	0.31	0.83	0.11	0.55	0.07

Institute of BAS, Sofia. We used a 100- μ laser beam diameter and 10 Hz repetition rate. NIST 610 glass was used for an external calibration standard, and the XRF SiO₂ value was used as the internal standard and for cross-checking. The analysis is given in Table 1.

Cathodoluminescence (CL) images were taken in the Belgrade University prior to zircon analyses to identify inherited cores, cracks and inclusions. U–Pb isotope analyses of particular zircon zones were carried out, using the same LA–ICP–MS system at the Geological Institute, Bulgarian Academy of Science. Both rims and cores of the zircon crystals were analyzed to determine the magmatic crystallization age and the ages of the xenocrystic or/and inherited components. Spatial resolution was 35 μ m with a frequency of 8 Hz. The measurement procedure involved calibration against an external zircon standard (GEMOC GJ-1) at the beginning, middle and at the end of the analytical block. This technique allows a suitable correction for instrumental drift along with the minimization of elemental fractionation effects. Raw data were processed using GLITTER4, a data reduction program of GEMOC, Macquarie University, Australia. ²⁰⁷Pb/²⁰⁶Pb, ²⁰⁸Pb/²³²Th, ²⁰⁶Pb/²³⁸U and ²⁰⁷Pb/²³⁵U ratios were calculated and the time-resolved ratios for each analysis were then carefully examined. Optimal signal intervals for the background and ablation data were selected for each sample and automatically matched with the standard zircon analyses. U–Pb Concordia ages were calculated and plotted using ISOPLOT (Ludwig, 2003).

PETROGRAPHY

The rock has a porphyroclastic texture (augen gneiss), consisting of up to 2 cm K-feldspar augen (Fig. 2a) with quartz, lesser amounts of plagioclase, and white mica predominating over biotite. K-feldspar shows internal deformation expressed by undulatory extinction in the core, rimmed with

a vermicular (myrmekite) intergrowth of quartz and plagioclase (Fig. 2b). Most of the quartz is also undulose. The deformation-induced transition through equigranular to banded augen orthogneiss is evident in mylonitic gneiss varieties. Micas show preferred orientation aligned parallel to the foliation of the rocks (Fig. 2c). Chlorite is a common secondary mineral replacing biotite. Small carbonate patches replace K-Feldspar in the most deformed samples, whereas plagioclase is slightly sericitized. Along with rare pyrite, they suggest slight hydrothermal alteration. Accessories include apatite, zircon and allanite, sometimes rimmed by magmatic epidote (Fig. 2d).

WHOLE-ROCK MAJOR AND TRACE ELEMENT GEOCHEMISTRY

As shown in Table 1, the rock has a felsic composition with SiO₂ 70.6 wt.% and a high content of K₂O (4.7 wt.%) and Na₂O (3.2 wt.%). The A/CNK ratio [molecular Al₂O₃/(CaO+Na₂O+K₂O)] of 1.11 classifies the rock as an S-type granite, but very close to the S-type – I-type boundary (Fig. 3a). It has a steep chondrite-normalized pattern with high light REE and low heavy REE (Fig. 3b). The total content of REE is high (~210 ppm). The high La_N/Yb_N and Dy_N/Yb_N ratios (58.9 and 2.7, respectively) are consistent with significant garnet fractionation, whereas the strong negative Eu/Eu* = 0.49 anomaly suggests extensive plagioclase fractionation. The primitive mantle normalized pattern (Fig. 3b) of the metagranitoid is slightly enriched in many of the most incompatible elements including Th, U, Rb, K and Pb, and markedly depleted in Nb, Ta, Ti, Sr and P (Fig. 3b), resembling patterns typical for evolved orogenic rocks.

A prominent feature of the rock is its low HREE and Y content (0.56 ppm Yb and 9.8 ppm Y). The rocks display elevated Sr/Y (22.7) and La/Yb (82.8) ratios, which classifies them as adakite-like rocks.

Fig. 2. Field and microphotographs of the Drangovo metagranitoid: a) Typical view of the augen orthogneiss with shear structure; b) Undulatory extinction of the K-feldspar with myrmekites at the edge of the crystal (arrow); c) Muscovite ‘fish’ associated with incipient shear bands and plagioclase deformation band; d) Allanite, rimmed by magmatic epidote. Abbreviations: Pl – plagioclase, Kfs – potassium feldspar, Ms – muscovite, Qz – quartz, Ep – epidote, Aln – allanite.

U-PB LA-ICPMS ZIRCON GEOCHRONOLOGY RESULTS

The BSE images of the gneiss zircon grains show either prismatic or rounded to ovoid forms. In CL images, zircons commonly show core-rim structure (Fig. 4a). Their most characteristic feature is that most of the cores are predominantly xenocrystic. The cores are rounded or subrounded, with irregular surfaces or embayment indicative of resorption. Most of them exhibit strong luminescent brightness and great variations in their zonation. Most cores are mantled by thick overgrowths with typical oscillatory zonation, suggesting magmatic growth. A few crystals have planar zonation.

Analytical data and zircon ages are listed in Table 2 and shown in Fig. 4. Four analyses on zircon crystals from the gneiss, mostly from the rims,

yield a concordant $^{206}\text{Pb}/^{238}\text{U}$ age 248.3 ± 8.9 Ma and MSWD = 1.07 at 95% confidence (Fig. 4b), whereas seven analyses yield a mean $^{206}\text{Pb}/^{238}\text{U}$ age of 251.4 ± 6.8 [2.7%] and MSWD = 11.4 at 95% confidence (Fig. 4c). We interpret the age of ~251 Ma as the emplacement age of the granite. Another eight concordant points from the cores record an inherited component of Carboniferous age 298.6 ± 2.6 Ma (not shown). Five other analyses on strongly corroded cores yield concordant ages of Devonian, Ordovician to Neo-, Meso-, and Paleoproterozoic ages (Fig. 4d). Two overgrowths yield discordant ages of 52.2 Ma. Interestingly, these ages are similar to the age of the nearby Drangovo pluton (50 Ma; Marchev *et al.*, 2013) and Pripek granites (53 Ma; Ovtcharova, 2003) and are identical to the monazite age of ~53 Ma in the Jurassic (146 Ma) deformed pegmatite in the same area (Ovtcharova,

Fig. 3. a) ANK (Al₂O₃/(Na₂O+K₂O) molar) vs. ACNK (Al₂O₃/(CaO+Na₂O+K₂O) molar) diagram for the Drangovo metagranitoid and Papikion pluton; b) Chondrite-normalized REE pattern; c) Primitive mantle normalized plots.

2003). We interpret the ages of the rims as a thermal overprint by the higher-temperature early Eocene plutons.

Zircon saturation temperature was used to calculate the crystallization temperatures of the Drangovo gneiss (Watson and Harrison, 1983). The chemistry of the rock meets the critical requirement for the application of this geothermometer: $M = 0.9$ to 1.7 , where M = cation ratio $(Na+K+2Ca)/(Al*Si)$. The calculated T_{zr} of 781 °C belongs to inheritance-rich (cold) granites (Miller *et al.*, 2003). This temperature is similar to the average temperature of 767 ± 14 °C calculated for the Papikion pluton (Drakoulis *et al.*, 2013) and is also typical for granites from subduction-related or collisional settings.

DISCUSSION

Age of the P-T magmatism in the Rhodope and Serbo-Macedonian Massifs

Our 251.4 ± 6.8 Ma age for the Drangovo gneiss and the age of the nearby Papikion pluton (236 ± 8 Ma and antecrysts of 250 Ma) establish the presence of Triassic magmatic activity in the Eastern Rhodopes. The 251.4 ± 6.8 Ma age of the Drangovo metagranitoid is close to the 253 ± 13 Ma age of metadiorites from the northern parts of the Western Rhodopes (von Quadt and Peytcheva, 2005), to the ~ 240 Ma age of gneisses from the Central Rhodopes

(Arnaudov *et al.*, 1989), and to the 245.6 ± 3.9 Ma and 255.8 ± 2.1 Ma ages of amphibolitized and/or eclogitized metabasites in the western and eastern parts of the Greek Rhodopes (Liat, 2005). These ages clearly show that P-T magmatism is a regional characteristic feature of the entire Rhodope Massif.

Magmatic products of similar age are widely distributed in the nearby Serbo-Macedonian Massif. For example, the granitic plutons of Kerkini and Arnea from the Greek part yielded ages of 247.0 ± 2.3 Ma (Christophides *et al.*, 2007) and 243 ± 6 and 255 ± 6 Ma (Poli *et al.*, 2009), respectively. A similar age of 240.2 ± 1.8 Ma has been recorded for the Volvi metamafic body intruded in the Arnea granite (Bonev *et al.*, 2018). In the Bulgarian part, the Skrut pluton was dated at 248.85 ± 0.70 Ma (Zidarov *et al.*, 2007) and the Igralishte granite at 243.3 ± 0.8 Ma (Peytcheva *et al.*, 2009), whereas the Bujanovac pluton from Serbia yielded ages of 255 ± 3 Ma and 253 ± 2 Ma (Antić *et al.*, 2016). Clearly, most of the published ages straddle the Permian/Triassic boundary (251 Ma), although some ages suggest that the magmatic activity lasted until 240 Ma.

Tectonic environment

The tectonic setting of the P-T magmatic rocks in the Serbo-Macedonian Massif is still debated, with two distinct models having been proposed. For the granitic Arnea and Kerkini plutons in the Serbo-

Fig. 4. a) Representative CL images of zircons from the Drangovo metagranitoid. Zircons commonly show xenocrystic cores rimmed by a zoned magmatic outer rim; b) U/Pb concordia plot of the P-T zircons; c) Mean age plot; d) Probability density diagram showing age distribution of magmatic and xenocrystic zircons from the Drangovo metagranitoid. Note distinct age peaks at 251 Ma and 299 Ma.

Macedonian massif, Christofides *et al.* (1999) and Himmercus *et al.* (2009) suggested rift-related A-type affinity of the magmatism related to the opening of the Meliata-Vardar Ocean. Similarly, Bonev *et al.* (2018) proposed rift-related formation

of Therma Volvi and the Gomati mafic-ultramafic bodies and bimodal rift-related comagmatic origin of the entire P-T Serbo-Macedonian and Rhodope magmatism. Conversely, Poli *et al.* (2009) concluded that the Arnea and Kerkini granites are

Table 2
U(-Th)-Pb isotope data of zircons from the Drangovo metagranitoid

Analysis#	grain	Isotope ratios								Rho	Age (Ma)			
		$^{207}\text{Pb}/^{206}\text{Pb}$	1SE	$^{206}\text{Pb}/^{238}\text{U}$	1SE	$^{207}\text{Pb}/^{235}\text{U}$	1SE	$^{208}\text{Pb}/^{232}\text{Th}$	1SE		$^{206}\text{Pb}/^{238}\text{U}$	1SE	$^{207}\text{Pb}/^{235}\text{U}$	1SE
13oc31c13	2 r	0.05082	0.00409	0.03834	0.00079	0.26867	0.02124	0.01520	0.00195	0.56	242.5	4.9	241.6	17.0
13oc31c14	3 r	0.05262	0.00405	0.04943	0.00098	0.35858	0.02715	0.01804	0.00199	0.56	311.0	6.0	311.2	20.3
13oc31c15	4 cr	0.05643	0.00284	0.05955	0.00094	0.46329	0.02308	0.02622	0.00242	0.57	372.9	5.7	386.5	16.0
13oc31c16	5 r	0.05383	0.00277	0.03809	0.00062	0.28271	0.01433	0.01293	0.00133	0.57	241.0	3.8	252.8	11.3
13oc31c17	5 c	0.05756	0.00373	0.04997	0.00088	0.39658	0.02534	0.01776	0.00191	0.56	314.3	5.4	339.2	18.4
13oc31c18	6 r	0.10563	0.01765	0.00812	0.00031	0.11831	0.01932	0.00908	0.00156	0.56	52.2	2.0	113.5	17.5
13oc31c19	8 r	0.05288	0.00208	0.05198	0.00075	0.37902	0.01486	0.01415	0.00165	0.58	326.7	4.6	326.3	10.9
13oc31c20	7 c	0.10665	0.01198	0.04076	0.00120	0.59944	0.06564	0.02036	0.00278	0.56	257.6	7.4	476.9	41.7
13oc31d03		0.05758	0.00375	0.05386	0.00093	0.42763	0.02740	0.01514	0.00269	0.56	338.2	5.7	361.5	19.5
13oc31d04	1' r	0.05453	0.00468	0.04191	0.00090	0.31515	0.02653	0.01786	0.00330	0.56	264.7	5.6	278.2	20.5
13oc31d05	2' r	0.05242	0.00349	0.04850	0.00085	0.35060	0.02300	0.01356	0.00210	0.56	305.3	5.2	305.2	17.3
13oc31d06	3' r	0.05137	0.00447	0.03332	0.00069	0.23607	0.02019	0.02857	0.00723	0.56	211.3	4.3	215.2	16.6
13oc31d07	4' cr	0.06831	0.01408	0.03932	0.00184	0.37043	0.07465	0.01191	0.00241	0.56	248.6	11.4	320.0	55.3
13oc31d08	5' r	0.05123	0.00460	0.04050	0.00085	0.28616	0.02528	0.02175	0.00431	0.56	255.9	5.2	255.5	20.0
13oc31d09	5' c	0.05230	0.01882	0.04438	0.00203	0.32005	0.11436	0.01076	0.00233	0.53	279.9	12.5	281.9	88.0
13oc31d10	6' c	0.05213	0.00915	0.05060	0.00163	0.36380	0.06302	0.01528	0.00419	0.55	318.2	10.0	315.1	46.9
13oc31d13	8' r	0.05160	0.00851	0.03208	0.00098	0.22831	0.03711	0.09174	0.03763	0.55	203.6	6.1	208.8	30.7
13oc31d14	8' c	0.06846	0.00452	0.14638	0.00271	1.38218	0.08929	0.03692	0.00756	0.57	880.7	15.2	881.4	38.1
13oc31d15	9' c	0.07296	0.00674	0.14861	0.00345	1.49533	0.13517	0.03854	0.00830	0.56	893.2	19.4	928.5	55.0
13oc31d16	9' r	0.05438	0.00471	0.04648	0.00094	0.34856	0.02961	0.01557	0.00681	0.56	292.9	5.8	303.6	22.3
13oc31d17	10' c	0.05218	0.00456	0.04606	0.00095	0.33148	0.02835	0.01276	0.00289	0.56	290.3	5.8	290.7	21.6
13oc31d18	11' c	0.08452	0.00652	0.18825	0.00399	2.19399	0.16479	0.05560	0.01319	0.57	1111.9	21.7	1179.1	52.4
13oc31d19	12' r	0.07077	0.00666	0.03961	0.00091	0.38651	0.03549	0.03723	0.01029	0.56	250.4	5.7	331.8	26.0
13oc31d20	14' c	0.05601	0.00671	0.07246	0.00175	0.55961	0.06593	0.02592	0.00731	0.55	451.0	10.5	451.3	42.9
13oc31e03	15' r	0.05512	0.00493	0.04240	0.00093	0.32225	0.02824	0.01769	0.01124	0.56	267.7	5.8	283.6	21.7
13oc31e04	15' c	0.04905	0.02451	0.04705	0.00215	0.31827	0.15847	0.01192	0.00198	0.52	296.4	13.2	280.6	122.1
13oc31e05	16' r	0.07523	0.02228	0.00812	0.00036	0.08428	0.02470	-0.00241	0.01153	0.54	52.2	2.3	82.2	23.1
13oc31e06	16' c	0.13388	0.00692	0.34470	0.00584	6.36379	0.32226	0.09487	0.01348	0.58	1909.3	28.0	2027.3	44.4
13oc31e07	17' cr	0.06040	0.00397	0.04361	0.00076	0.36322	0.02341	0.01307	0.00197	0.56	275.2	4.7	314.6	17.4
13oc31e08	19' c	0.11801	0.04502	0.04533	0.00296	0.73771	0.27761	0.01124	0.00300	0.54	285.8	18.3	561.1	162.2
13oc31e09	21' c	0.03838	0.02050	0.04570	0.00223	0.24183	0.12871	0.01343	0.00259	0.52	288.0	13.8	219.9	105.2
13oc31e10	20' r	0.06350	0.00453	0.08977	0.00167	0.78609	0.05486	0.03499	0.00631	0.56	554.2	9.9	589.0	31.2
13oc31e11	23' cr	0.06150	0.00439	0.06331	0.00114	0.53693	0.03748	0.02623	0.00515	0.56	395.7	6.9	436.4	24.8
13oc31e12	24' c	0.09465	0.02518	0.04532	0.00207	0.59149	0.15525	0.01689	0.00366	0.54	285.7	12.7	471.8	99.1
13oc31e13	25' r	0.06212	0.00959	0.03510	0.00116	0.30070	0.04549	0.04398	0.01332	0.55	222.4	7.2	266.9	35.5
13oc31e14	25' c	0.06375	0.00561	0.08493	0.00180	0.74661	0.06419	0.02958	0.00719	0.56	525.5	10.7	566.3	37.3

Abbreviations refer to: r – rim; c – core; rc – rim and core part; Rho – correlation coefficient $^{206}\text{Pb}/^{238}\text{U} - ^{207}\text{Pb}/^{235}\text{U}$

A2-subtype indicating that the magmatism is more likely to be connected to an orogenic extensional environment than to an intra-plate rifting. Interpretations for the tectonic setting of the granites on the Bulgarian side of the Serbo-Macedonian Massif are in favor of a volcanic-arc to syn-collisional environment (Zidarov *et al.*, 2007; Peytcheva *et al.*, 2009). Drakoulis *et al.* (2013) suggest a similar setting for the Papikion pluton from the Eastern Rhodopes.

A detailed discussion on the geodynamic setting of the magmatism in the entire region is beyond the

scope of this report. Our single age is not enough to unravel the tectonic setting of the magmatism in the Eastern Rhodopes. However, age similarity and subduction-related signatures of both the metagranitoid from Drangovo and the nearby Papikion granitoids can be interpreted in favor of origin in a similar tectonic setting. On the other hand, the large amount of xenocrystic zircons from the underlying basement suggest the presence of a comparatively thick crust at the time of this magmatism and do not offer support for crustal thinning accompany-

ing rifting. Additional studies are needed to better clarify the geodynamic setting of the region during the P-T transition.

Genesis

Different suggestions have been made for the genesis of the P-T granitoids in the Serbo-Macedonian and Rhodope Massifs: (1) crustal melting caused by underplating of basaltic melts below the incipient rift (Poli *et al.*, 2009; Peytcheva *et al.*, 2009; Himmerkus *et al.*, 2009); (2) extensive crustal contamination of juvenile mafic magma that originated from depleted mantle (Zidarov *et al.*, 2007; Antić *et al.*, 2016); and (3) fluid-absent melting of a biotite-rich tonalitic source (Christofides *et al.*, 2007).

The suggestions for the origin of P-T granites from crustal melting caused by basaltic melts is based on the relatively high initial Sr isotopic ratios obtained for the Kerkini granite (0.7112 to 0.7202 – Christofides *et al.*, 2007; 0.7136 to 0.7187 – Himmerkus *et al.*, 2009) and the Arnea granite (0.7142 – Himmerkus *et al.*, 2009). Poli *et al.* (2009) attributed the high initial Sr isotopic ratios to hydrothermal alteration and post-intrusive metamorphic and deformational processes of the Arnea granite. They argued that the very high Rb/Sr ratio, and an aberrant age used by Himmerkus *et al.* (2009), led to calculation of the very high initial ratios for the Kerkini granite. Nevertheless, Poli *et al.* (2009) proposed crustal melting by mantle melts penetrating or underplating the crust. A similar origin was proposed for the nearby Igralishte pluton by Peytcheva *et al.* (2009). Unlike the previous suggestions, however, these authors proposed a mixed mantle-crustal origin of the granite on the basis of the lower initial Sr isotopic values of the rocks (0.7078).

The hypothesis for crustal contamination of the juvenile mafic magma is based mostly on the pres-

ence of the large number of xenocrystic zircons, and highly positive ϵ_{Hf} (+0.4 to +3.5) of the autocrystic zircons in the Skrut pluton (Zidarov *et al.*, 2007). Involvement of a mantle component in the genesis and evolution of the Papikion pluton was also proposed by Drakoulis *et al.* (2013) based on the presence of basic rocks in the pluton.

Our preliminary data for the Drangovo metagranitoid are too limited to discuss in detail the genesis of the rock. However, we note that the presence of large amount of xenocrystic zircons rules out the pure mantle-derived origin of the magmas and demonstrates the extensive involvement of older basement rocks for the Permian-Triassic metamorphosed granitoids.

CONCLUSIONS

- 1) Ages of metagranitoid from the Bulgarian part of the Kessebir dome, along with the Papikion pluton from the Greek part, suggest that Permo-Triassic magmatism is present in the Eastern Rhodopes.
- 2) The Drangovo metagranitoid and Papikion granitoids have subduction-related signatures and were more likely formed in a volcanic-arc to syn-collisional tectonic setting.

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