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K-Ar DATING OF THE PALEOGENE LATE EXTENSIONAL MAGMATISM IN THE EASTERN RHODOPES

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ABSTRACT. During the Paleogene, as a result of extension, the Central Rhodope, Kesibir and Byala reka domes formed in the Eastern Rhodopes. The East Rhodope depression, a domain of intensive intermediate and acid volcanism, is located between them and Harmanli block. Subvolcanic bodies and dikes occur in the neighboring domes. The conclusions are based on all K-Ar data of the authors (84) and those from accessible literature sources (87) for the discussed magmatism. The results for individual magmatic phases (complexes) are dispersed within an unrealistically large time interval – 7-8 Ma. However, their mean arithmetic values are close to data from more precise (Rb-Sr, Ar-Ar) methods. The time span of the Paleogene late-extensional magmatism is 42.7-25.5 Ma or 39.9.-27.3 Ma as indicated by the mean values for the individual phases. There is a tendency for migration of the magmatism from the intermediate magmatic groups from NW to SE: 39,9-32,3 Ma (Sarnitsa group); 36,8-29,7 Ma (Dambala group); 31,1 Ma (Madzharovo complex); 28,9-27,3 Ma (Byala reka group). The acid magmatic groups show a slightly expressed reverse tendency: 30,8-29,1 Ma (Chamdere group); 34,5-31,1 Ma (Kardzhali group), 33,5-33,1 Ma (Zlatoustovo group).

K-Ar ДАТИРОВКИ НА ПАЛЕОГЕНСКИЯ КЪСНОЕКСТЕНЗИОНЕН МАГМАТИЗЪМ В ИЗТОЧНИ РОДОПИ

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РЕЗЮМЕ. През палеогена, в резултат на екстензия, в Източните Родопи се формират Централнородопски, Кесибирски и Белоречки куполи. Между тях и Харманлийския блок се разполага Изрочнородопското понижение. То е арена на интензивен среднокисел и кисел вулканизъм. В околните куполи се внедряват субвулкански тела и дайки. Обработени са всички наши (84 бр) и достъпни литературни (87 бр.) K-Ar датировки за разглеждания магматизъм. Отделните фази (комплекси) на магматизма се характеризират с нереално голям диапазон на получените резултати – до 7-8 Ma. Средноаритметичните им стойности обаче са близки до получените с по-точни методи (Ar-Ar) данни. Възрастовия диапазон на палеогенския късноекстензионен магматизъм се определя на 42,7–25,5 Ma, а по средните стойности на отделните фази 39,9-27,3 Ma. Наблюдава се тенденция на миграция на магматизма за среднокиселите магмени групи от СЗ на ЮИ: 39,9-32,3 Ma (Сърнишка група); 36,8-29,7 Ma (Дамбалска група); 31,1 Ma (Маджаровски компекс); 31,8-27,3 Ma (Белоречка група). За киселите магматични групи се установява по-слабо изразена обратна тенденция: 30,8-29,1 Ma (Чамдеренска група); 34,5-31,1 Ma (Кърджалийска група), 33,5-33,1 Ma (Златоустовска група).

Geology

During the period latest Late Cretaceous – Oligocene, the Rhodope massif was a domain of crustal extension. As a result, metamorphic core complexes (domes) formed. In the interval Late Cretaceous-Eocene the domes were intruded by granitoids (early extensional stage). During the interval Paleocene-Oligocene, depressions originated between the individual domes. Mainly terrigenous sediments were deposited at the base of the depressions. Upwards follow numerous intermediate and acid volcanic edifices (Eocene-Oligocene, to the south in Greece also Miocene) – late extensional magmatism. The present paper deals only with the late extensional magmatism.

In the Eastern Rhodopes, between the Central Rhodope, Byala Reka and Kessibir domes, formed the Momchilgrad depression, between the Central Rhodope dome and Harmanli block – the Northeastern Rhodope depression, and between Byala Reka dome and Harmanli block – the Zlatoustovo depression. The three depressions join in the area of Kardzhali and together form the East Rhodope Paleogene depression (Ivanov, 1960; Georgiev, 2005). The products of the volcanic activity in these depressions are concentrated in individual domains (Fig. 1) with relatively independent evolution. Each depression hosts groups of intermediate (to acid) volcanic edifices. The Sarnitsa magmatic group is located in the Northeastern depression, the Dambala magmatic group – in Momchilgrad depression, the Madzharovo latite complex – in Zlatoustovo depression. There are also zones of only acid volcanism: Chamdere magmatic group in the Northeasten depression, Kardzhali group in the area of Kardzhali, Zlatoustovo acid group in the eastern parts of Zlatoustovo depression (Georgiev, Milovanov, 2005). The last phases of magmatic activity include acid and intermediate to basic dikes, less commonly extrusions which form dike swarms of dominantly WNW trend. They intrude both the fill of the depressions and their metamorphic framework – the Pcheloyad complex occurs in Momchilgrad depression, the Trimogili complex – in the Northeastern Rhodope depression, the Byala Reka complex – in the Byala Reka and Kessibir domes. It is suggested that the individual magmatic groups

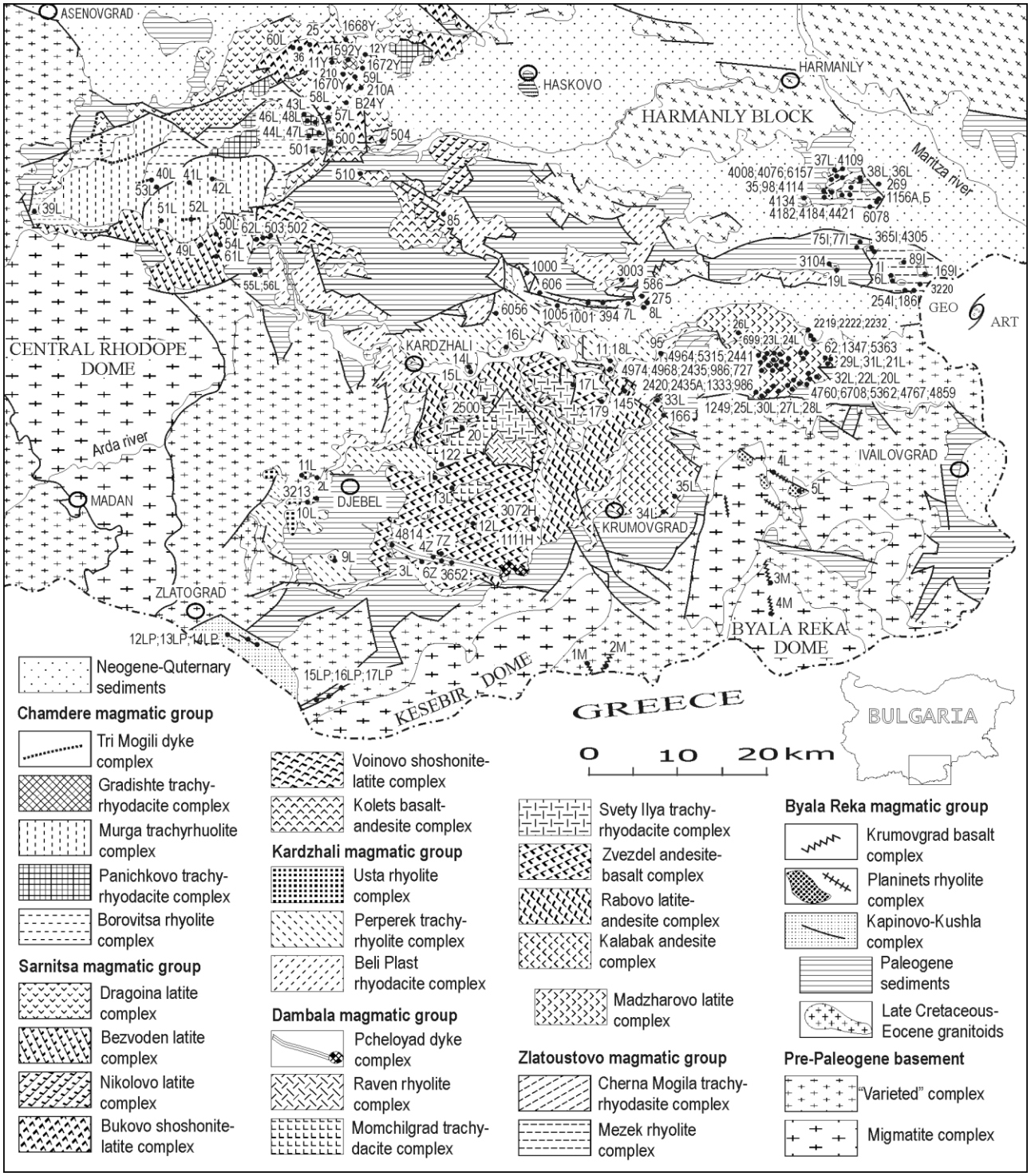

Fig. 1. Geological map of the Eastern Rhodopes

resulted from the evolution of different magma chambers. The magmatic complexes (divided as components of the groups) correspond in the most general case to separate phases in the evolution of the magma chambers.

The Chamdere magmatic group includes (in upwards succession) the Borovitsa rhyolite (Br), Panichkovo trachyrhyolite (Pn), Murgen trachyrhyolite (Mr), Gradishte trachyrhyodacite (Gr) and the Tri Mogili dyke (TM) complexes.

The Sarnitsa intermediate group comprises the Kolets basalt-andesite (Kt), Voinovo shoshonite-latite (Vn), Bukovo shoshonite-latite (Bk), Nikolovo latite (Nk), Bezvoden latite (Bv) and Dragoina latite (Dr) complexes. The Kardzhali acid group is subdivided into Beli Plast rhyodacite (BP), Perperek trachyrhyolite (Pr) and Ustra rhyolite (Us) complexes. The Dambala intermediate group includes the Kalabak andesite (Kl), Rabovo latite-andesite (Rb), Zvezdel andesite-basalt (Zv) complexes (Putocharka intermediate subgroup), Svety Ilya trachyrhyodacite (SI), Momchilgrad trachydacite (Mm), Raven rhyolite (Rv) complexes (Zdravers acid subgroup) and the Pcheloyad dike (Pc) complex.

The Madzharovo latite (Md) complex is of independent occurrence and may be discussed as a group. The Zlatoustovo acid group covers Mezek rhyolite (Mz) and Cherna Mogila trachyrhyodacite (CM) complexes. The Byala Reka magmatic group is represented by the Planinets rhyolite (Pl), Krumovgrad basalt (Kg) and Kalinovo-Kushla basalt (KK) complexes. Kalinovo-Kushla basalt complex is included in our discussion conventionally since we do not know this area but there are published analyses (Lilov et al., 1997).

Analytical methods

During the geological mapping of the Eastern Rhodopes almost all of the divided magmatic complexes (phases) have been dated by the K-Ar method (84 analyzed samples). The sampling location have been plotted on 1:25 000 maps (Georgiev et al., 1995, 1996, 1997, 1999, unpublished reports, National Geological Archive). Part of the results has been published by Georgiev at al. (2003). All literature sources (91 datings), where the sampling locations can be sufficiently accurately related to some of the magmatic complexes, have been also used (Lilov et al., 1987; Marchev et al., 1997; Yanev, Pecskay, 1997; Harkovska et al., 1998a, b; Lilov et al., 2000; Ivanova et al., 2001).

Possibly most fresh rock samples were selected for analysis. The samples were crushed, sieved and washed to bulk fraction 0,50-0,25 mm and 0,25-0,10 mm.

The K-Ar dating was done at the laboratory of "Absolute Geochronology and Isotope analysis" at the Enterprise for Laboratory Geological Investigations, Sofia (now Eurotest Ltd.) using the method of the so-called isotopic dilution with ^{38}Ar tracer. The K content of the samples was determined by two and three times repeated measurements in flame photometer "Flapho-4" with a relative error of 2-4%. The content of the so-called radiogenic ^{40}Ar was fixed with a specially constructed installation for extraction and purification of Ar and subsequent isotopic analysis by means of a mass spectrometer МИ-1305 using a two-collector registration method of the Ar isotopes in a semistatic vacuum regime. The parameters of the ionizing source of the mass spectrometer are: current of emission – 1 мА; ionizing voltage – 50 V. The content of ^{40}K, ^{40}Ar and the age of the sample were computed by means of the constants: λ_β=4,962.10^{-10} year^{-1}; λ_K=0,581.10^{-10} year^{-1}; ^{40}K=1,167.10^{-4}.K (%).

The accuracy of the analysis was periodically controlled by calibration of the flame photemeter, isotope analysis of atmospheric argon and calibration of the tracer (with interlaboratory standard sample "Asia 1/65"). The total analytical error is estimated to be 4-5%, but during analysis of samples with large correction for non-radiogenic atmospheric ^{40}Ar (low content of radiogenic ^{40}Ar respectively) the error considerably increases.

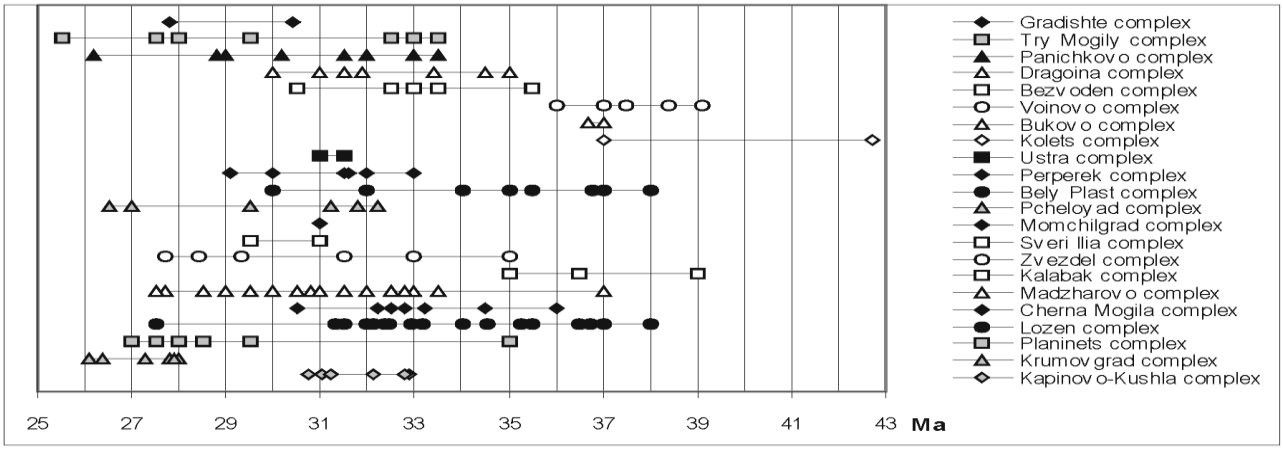

Fig. 2. Chronogram of magmatic complexes

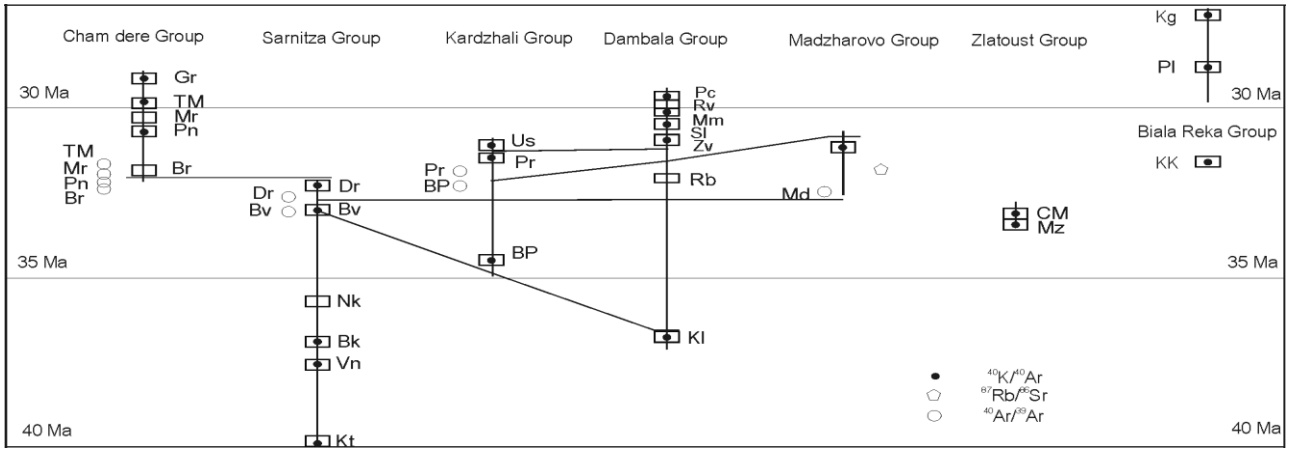

Fig. 3. Chronogram of magmatic complexes (average ages)

Table 1

K-Ar data and ages of magmatic complexes.

No	Rock variety	Locality	K%	rad^{40}Ar	Ma
CHAMDERE MAGMATIC GROUP					
Gradishte trachyrhyodacite complex			average 29.1		
210	TRD dk	Briastvo village	4.11		27.8
1592Y	TRD dm	Gradishteto peak	4.34	5.162	30.4
Try mogily dyke complex			average 29.9		
39L	QT (Kf)	Chetroka village	10.71	1.050	25.5
41L	Sh dk	Tri Mogili village	3.88	4.159	27.5
42L	R dk	Tri Mogili village	4.07	4.490	28.0
40L	Sh dk	Sini vrah reak	4.04	4.690	29.5
52L	R dk	Pakaderesi villadg	3.86	4.890	32.5
51L	QT st	Sakakaya	4.23	5.454	33.0
53L	TD b	Sini vrah reak	4.41	5.770	33.5
Panichkovo trachyrhyolite complex			average 30.8		
501	R dm	Velichka river	3.79	3.800	26.2
12jY	TRD dm	Haskovo Min. Spr. Village	4.39	4.964	28.8
43L	P	Letnitsa peak	5.56	6.340	29.0
511Y	TRD dm	Cheria Kamak peak	4.67	5.509	30.2
48L	TR dm	Letnitsa peak	5.40	6.680	31.5
46L	TR dm	Letnitsa peak	4.85	6.050	32.0
47L	TR dm	Sarnitsa village	4.09	5.280	33.0
44L	TR dm	Sarnitsa village	4.49	5.820	33.0
45L	TR dm	Letnitsa peak	4.50	5.930	33.5
SARNITSA MAGMATIC GROUP					
Dragoina latite complex			average 32.3		
210	QL dk	Briastovo village	5.02		30.0
1668Y	L	Dolni Voden village	4.78	5.808	31.0
57L	QM l	Mechkovets peak	4.52	5.530	31.5
58L	T	Mechkovets peak	5.30	6.530	31.5
B24Y	UPL	Mechkovets peak	5.30		31.5
1672Y	QL	G. Briastovo village	4.79	5.997	31.9
1670Y	UAL	G. Briastovo village	4.88	6.384	33.4
59L	L l.f.	Briastovo village	3.90	5.270	34.5
60L	L l.f.	с. Пилашево	4.00	5.540	35.0
Bezvoden latite complex			average 33.0		
50L	QL dm	Rakaderesi village	4.14	4.876	30.5
55L	L l.f.	Bezdiven peak	2.55	3.250	32.5
56L	L b	Jeliazkivtsi village	3.24	4.210	33.0
49L	QL dk	Ciliaka peak	6.45	8.073	33.0
54L	L l.f.	Goliam Meden peak	3.06	3.990	33.5
61L	Sh l.f.	Bezvodno village	2.44	3.400	35.5
Voinovo shoshonite-latite complex			average 37.6		
62L	L dk	Sivrikaia	3.70	5.230	36.0
63L	SH l.f.	Kadanka village	2.79	4.073	37.0
Ж1	Ab l.f.	Jenda village	2.18		37.5
503	HKBA l.f.	Voinovo village	2.66	2.740	38.4
502	HKA l.f.	Voinovo village	3.18	4.530	39.1
Bukovo shoshonite-latite complex			average 36.9		
25	HKA l.f.	Bukovo village	2.76	2.940	36.7
36	L l.f.	Bukovo village	3.35	4.750	37.0
500	Sh l.f.	Sarnitsa village	2.87	3.270	37.0
Kolets basalt-andesite complex			average 39.9		
510	M l	Karamantsi village	2.75	3.740	37.0
504	HKA l.f.	Kolets village	2.17	2.920	42.7

Concentrations of **$^{40}Ar_{rad}$** *of the present authors and these reported in Lilov et al. (1987); Harkovska et al. (1998b) are in* **nmm^3/gx10^{-3}**, *and the data in Harkovska et al. (1998a); Yanev, Pecskay (1997); Mrchev et al. (1997); Lilov et al. (2000); Ivanova et al (2001) in* **ccSTR/gx10^{-6}**.

Sample number xL is data Lilov et al. (1987); xxxxH - Harkovska et al. (1998b); xZ - Harkovska et al. (1998a); xxxY - Yanev, Pecskay (1997); xxxI - Ivanova et al (2001); xM - Mrchev et al. (1997); xxLP - Lilov et al. (2000).

Shortening: B- basalt; BA- basaltic andesite; Dr- diorite; A- andesite; FD- phenodacite; RD- rhyodacite; R- rhyolite; P- perlite; HKBA- high-K basaltic andesite; HKA- high-K andesite; HKD- high-K dacite; Ab- absarokite; Sh- shoshonite; L- latite; M- monzonite; TD- trachydacite; TRD- trachyrhyodacite; TR- trachyrhyolite; T- trachite; QL- quartzlatite;QT- quartztrachite; QM- quartz-monzonite; UPL- ultrapotassic latite; ATD- alkaline trachydacite; dk- dyke; dm- dome; b- body; I- intrusion; l.f.- lava flow; t- tuff; st- stock.

Table 1

Continuation

No	Rock variety	Locality	K%	rad^{40}Ar	Ma
KARDZHALI MAGMATIC GROUP					
Ustra rhyolite complex			average 31.1		
9	R b	Zli Vrah peak	3,54	4.280	31,0
10L	P dm	Schupena Planina peak	4,13	5.020	31,0
11L	R dm	Mishevsko village	4,13	5.040	31,0
3213	R b	Vodenicharsko village	3,19	1,20	31,5
Perperek trachyrhyolite complex			average 31.4		
145	TR dm	Studen kladenetz	4,80	5.280	29,1
14L	ATD dm	Hisar peak	5,10	6.100	30,0
1005	R dm	Miladinovo village	4.06	4.000	30.0
8L	P	Silen village	4.70	5.830	31.5
6056	R t	Chiflik village	4.53	4.800	31.6
15L	ATD dm	Hisar peak	4,89	6.120	32,0
16L	TRD	Sredna Arda	4,52	5.690	32,0
18L	P l.f.	Cholderen peak	6,45	8.120	32,0
11	TR dm	Svetoslav village	4,84	6.110	33,0
275	R dm	Silen village	3.97	5.080	33.0
Beli Plast rhyodacite complex			average 34,5		
3003	RD b	Zimovina village	6.97	7.360	30.0
7L	P	Patnikovo village	4.25	5.350	32.0
606	RD t	Zvamche village	4.88	5.250	32.0
33L	TR dm	Geren village	4,53	6.100	34,0
1000	RD t	Bashtino village	4.00	3.520	35.0
85	HKD	Minzuhar village	3.75	4.520	35.5
586	TR dm	Liaskovets village	4.85	6.210	36.8
394	RD b	Popovets village	2.01	1.960	37.0
1001	RD b	Sestrinsko village	3.09	4.530	38.0
DAMBALA MAGMATIC GROUP					
Pcheloyad dyke complex			average 29.7		
2L	TR b	Mishevsko village	4,01	4.160	26,5
3L	R dk	Podkova village	4,16	4.420	27,0
4814	RD b	Stareishino village	3,86	4.360	29,5
4Z	Rd dm (Bi)	Kouvandzhic peak	7,16	3.764	31.2
7Z	FD dk	Yapraluk peak	4,68	5.835	31.8
6Z	FD dk	Yapraluk peak	4,46	5.633	32.2
Momchilgrad trahydacite complex					
122	HKA l.f.	Momchilgrad	2,49	2.940	31,0
Sveti Ilia trachyrhyodacite complex			average 30.6		
2500	TD l.f.	Lisicite	4,81	5.370	29,5
17L	TRD l.f.	Sveti Ilia peak	3,20	3.900	31,0
20	TRD l.f.	Chomakovo village	4,94	5.820	31,0
2372	TRD l.f.	Sv. Ilia peak			31.0
Zvezdel basaltic-andesite complex			average 31.0		
1111H	HKBA	Djulgera peak	2.00	3.871	27,7
3072H	HKA l.f.	Zvezdel village	2.00	3.978	28.4
3	HKA l.f.	Sushevo village	1.80	1.120	29.3
12L	M i	Galenit village	2,50	1.100	31,5
3652	Dr l	Metlichka village	1,60		31,5
1	BA l.f.	Bagrianka village	2,45	2.960	31,5
13L	A l.f.	Hubavelka village	2,91	3.812	33,0
179	BA l.f.	Star chal village	3,07	4.140	35,0
Kalabak andesite complex			average 36.8		
34L	BA	Irantepe peak	1,25	1.750	35,0
35L	A	Irantepe peak	2,42	3.490	36,5
166	A l.f.	Geren village	1,84	3.160	39,0

Table 1
Continuation

No	Rock variety	Locality	K%	rad^{40}Ar	Ma
Madzharovo latite complex			average 31.1		
4760	QL dk	Malko Popovo village	8.38		27.5
6708	QL dk	Malko Popovo village	4.08	4.160	27.5
62	QT	Gaberovo village	4.52	4.730	27.7
4964	M i	Madzharovo tawn	4.39	4.870	28.5
2219	TD	Borislavtsi village	5.12	5.700	29.0
1347	QT	Gaberovo village	7.40	8.440	29.0
4859	QT dk	Brusevtsi village	6.74	9.890	29.0
5315	QL	Madzharovo tawn	4.12	4.450	29.0
2441	L dk	Madzharovo tawn	9.30	10.500	29.5
4974	A dk	Madzharovo tawn	5.39	5.850	29.5
2222	TD	Borislavtsi village	4.23	4.650	29.5
5363	QT	Gaberovo village	4.30	5.520	30.0
4968	M i	Madzharovo tawn	4.10	4.580	30.5
2435	M i	Madzharovo tawn	6.43	7.660	30.5
986	QL dk	Madzharovo tawn	7.74	8.820	30.5
2232	TD	Borislavtsi village	5.11	6.150	30.8
20L	QT	Malko Popovo village	5.45	6.539	31.0
22L	P	Malko Popovo village	3.83	4.590	31.0
727	L l.f.	Madzharovo tawn	5.07	6.010	31.0
2420	M i	Madzharovo tawn	4.28	5.280	31.5
2435a	A dk	Madzharovo tawn	3.38	4.070	31.5
31L	Sh	Senoklas village	3.18	3.950	31.5
5362	L l.f.	Malko Popovo village	4.38	5.270	31.5
1249	BA l.f.	Chernichino village	5.36	6.370	31.5
21L	QT	Hisara peak	4.85	6.140	32.0
24L	M i	Madzharovo tawn	4.30	5.375	32.0
1333	L l.f.	Madzharovo tawn	4.25	5.170	32.0
32L	L	Malko Popovo village	3.46	4.350	32.0
26L	L	Baldja village	3.24	4.120	32.5
27L	Sh	Malko Popovo village	3.60	4.560	32.5
4767	Sh dk	Malko Popovo village	3.27		32.8
23L	M i	Madzharovo tawn	4.40	5.720	33.0
28L	L	Malko Popovo village	4.65	6.050	33.0
986	L l.f.	Madzharovo tawn	4.50	5.750	33.0
30L	L	Shishtepe peak	3.23	4.177	33.0
25L	L	Chernichevo village	3.00	3.950	33.5
29L	Sh	Senoklas village	3.02	3.980	33.5
95	QL l.f.	D. Cherkovishte village	4.35	5.710	34.0
699	BA l.f.	Madzharovo tawn	2.19	4.530	37.0

Results

The age range of the Paleogene late extensional magmatism is 42,7-25,5 Ma and based on the average values for individual phases – 39,9-27,3 Ma or around 12 Ma (Table 1, Figs 2 and 3). The peak of the magmatic activity is between 30-33 Ma.

The age of Chamdere magmatic group is 33,5-25,5 or 30,8-29,1 Ma (average for individual complexes). The Sarnitsa intermediate group has an age interval of 42,7-30,0 Ma or 39,9-32,3 Ma (average for individual complexes). The Kadzhali acid group spans 38,0-29,1 Ma or 34,5-31,1 Ma (average values).

The age of Dambala intermediate group (with acid final phases) is 39,0-26,5 Ma or 36,8-29,7 Ma (average values). The Madzharovo latite complex has a time span of 37,0-27,5 Ma or in average 31,1 Ma. The age interval of Zlatoustovo acid group is 38,0-27,5 Ma or in average 33,5-33,1. The Byala Reka magmatic group is datetd 35,0-26,1, or in average 31,8-27,3.

Table 1
Continuation

No	Rock variety	Locality	K%	rad^{40}Ar	Ma
ZLATOUSTOVO MAGMATIC GROUP					
Cherna Mogila trachyrhyodacire complex			average 33.1		
4109	R b	Cerna mogila village	5.60	6.860	30.5
6157	Dr i	Cerna mogila village	4.11	4.370	32.2
4076	RD b	Cerna mogila village	5.80	6.360	32.5
4134	RD b	Huksana river	5.70	5.980	32.8
4008	RD b	Cerna mogila village	5.00	6.830	33.2
6078	D i	Lozen village	2.55	3.390	34.5
37L	TRD (Kf)	Cerna mogila village	9.40	13.160	36.0
Mezek rhyolite complex			average 33.5		
6L	R dk	Sheinovets peak	4.00	4.260	27.5
4421	R t	Malko Gradishte village	3.96	4.100	31.3
4182	R dm	Malko Gradishte village	6.20	7.380	31.5
19L	R dm	Sv. Marina peak	4.52	5.678	32.0
4184	TRD	Malko Gradishte village	3.60	4.560	32.0
11566	R b	Lozen village	5.70	7.010	32.0
77I	R dk (Bi)	Malko Gradishte village	6.56	8.261	32.1
186I	R dk	Karatepe peak	3.81	4.840	32.4
254I	R dk	Karatepe peak	3.81	4.849	32.5
1I	T dm	Seinovets peak	4.55	5.881	32.9
169I	R dm	Goliama Chuka peak	3.75	4.882	33.2
4305	TRD	Cherno Bardo peak	4.18	3.800	34.0
75I	R dk (Bi)	Malko Gradishte village	6.49	8.798	34.5
365I	R dm	Malko Gradishte village	3.77	5.216	35.2
3220	R t	Tastepe peak	3.68	4.400	35.5
38L	R	Cerna Mogila village	4.28	6.150	36.5
89I	R dm	Malko Gradishte village	3.85	5.554	36.7
1156a	R b	Lozen village	5.80	8.300	37.0
3104	R dm	Sv. Marina peak	3.70	5.470	38.0
BYALA REKA MAGMATIC GROUP					
Planinets rhyolite complex			average 28.9		
5L	R b	Planinets village	4.30	4.550	27.0
4114	R b	Cerna Mogila village	4.85	5.120	27.0
4L	R dk	Popsko village	8.54	9.180	27.5
35	R b	Cerna Mogila village	5.00	5.380	28.0
269	R b	Lozen village	5.61	6.050	28.5
98	R b	Cerna Mogila village	6.94	7.690	29.5
36L	R dk	Cerna Mogila village	6.30	8.650	35.0
Krumovgrad basalt complex			average 27.3		
4M	B dk	Strajevets village	2.62	2.672	26.1
3M	B dk	Parjenaka	1.97	2.036	26.4
2M	B dk	Egrek village	2.01	2.153	27.3
1652	B b	Planinets village	5.04		27.8
1M	B dk	Egrek village	2.24	2.115	27.9
1653	B b	Planinets village		2.590	28.0
Kapinovo-Kushla basalt complex			average 31.8		
17LP	B dk	Dolno Kapinovo village	2.92	3.518	30.7
14LP	B dk	Djerovo village	2.17	2.640	31.0
13LP	B dk	Gorski Izvor village	2.41	2.949	31.2
12LP	B dk	Gorski Izvor village	1.64	2.066	32.1
16LP	B dk	Dolno Kapinovo village	2.78	3.582	32.8
15LP	B dk	Dolno Kapinovo village	2.49	3.214	32.9

Discussion

The individual magmatic complexes are characterized by an unrealistically large age interval – up to 7-8 Ma. Furthermore, the age intervals of the magmatic complexes from one group overlap in an interval of about 4-5 Ma, despite of the fact that the spatial relationships between them are generally clear – the later complexes intersect or cover the earlier ones. There are no lateral transitions between them and an overlapping in time is not possible. Such a large dispersion of age data is

characteristic both of results from our laboratory and the cited literature data. The results of ATOMKI, Hungarian Academy of Sciences (Marchev et al., 1997; Yanev, Pecskay, 1997; Harkovska et al., 1998a; Lilov et al., 2000; Ivanova et al., 2001) show a lesser dispersion (2 to 4,3 Ma for one phase) but in this case a small number of samples has been analyzed (Table 1). The usual error of K-Ar dating is 4-5%. The analysis of our and literature data shows that the error for this method is about 15%.

The average values obtained for the individual complexes (phases), however, are close to those determined by the Ar-Ar method (Table 2). These average values characterize well the succession of formation of the individual complexes and do not contradict the observed field relationships. They may be used with a certain degree of confidence for characterization both of the age interval of the magmatism as a whole and of the individual groups.

Table 2
Ar-Ar ages (data: Marchev, Singer, 1999; Singer, Marchev, 2000; Moskovski et al., 2004)

Magmatic complex	Age Ar-Ar (Ma)
Try mogily dyke complex	31.75-31.76
Murga trachyrhyolite complex	31.86
Panichkovo trachyrhyolite complex	32.17
Borovitsa rhyolite complex	31.93-32.16
Dragoina latite complex	32.30-32-92
Bezvoden latite complex	32.82
Perperek trachyrhyolite complex	31.82-32.00
Beli Plast rhyodacite complex	32.28-32.44
Madzharovo latite compleks	32.06-32.72

The assignment of individual bodies, for which no clear spatial relationships are available, to one or other phase on the basis of single K-Ar data is incorrect and may lead to unrealistic interpretations.

There is a tendency of migration of the late extensional magmatism from the intermediate magmatic groups from NW to SE (after the average values of the component complexes): 39,9-32,3 Ma (Sarnitsa group); 36,8-29,7 Ma (Dambala group); 31,1 Ma (Madzharovo complex); 31,8-27,3 Ma (Byala Reka group). For the acid magmatic groups there is a less well-expressed reverse tendency: 30,8-29,1 Ma (Chamdere group); 34,5-31,1 Ma (Karzgali group); 33,5-33,1 Ma (Zlatoustovo group).

References

Georgiev, V., P. Milovanov, P. Monchev. 2003. K-Ar dating of the magmatic activity in the Momchilgrad volcanotectonic depression. – *Compt. Rend. Acad. Bulg. Sci., 56,* 8, 49-54.

Georgiev, V. 2005. Late Alpine tectonic and magmatism in the Eastern Phodopes. – *Compt. Rend. Acad. Bulg. Sci., 58,* 1, 47-52.

Georgiev, V., P. Milovanov. 2005. Late alpine magmatic groups and komplexes in the Eastern Rhodopes . – *Compt. Rend. Acad. Bulg. Sci., 58,* 1, 53-58.

Harkovska, A., Z. Pecskay, P. Marchev, M. Popov. 1998a. How old the dykes of the Zveadel swarm (Eastern Rhodopes, Bulgaria) are. – *Geologica Balc., 28,* 1-2, 69-70.

Harkovska, A., G. Pe-Piper, K. Stoykova, R. Nedyalkov, S. Moskovski. 1998b. Late Oligocene (Early Chattian) epiclastics and lava bodies of intermediate composition from the Eastern Rhodpes (Bilgaria). – *Compt. Rend. Acad. Bulg. Sci., 51,* 7-8, *53-56.*

Ivanov, R. 1960. Magmatism in the East-Rhodopian depression: I. Geolody. – *Trudove Geol. Bulg., Ser. Geochim. Pol. Izkop, Part I, Geology,* 311-387 (in Bulgarian with German abstract).

Ivanova, R., Z. Pecskay, Y. Yanev. 2001. K-Ar ages of the volcanic rocks from the Paleogene Sheinovets caldera, Eastern Rhodopes (Bulgaria*). – Compt. Rend. Acad. Bulg. Sci., 54,* 3, 59-62.

Lilov, P., Y. Yanev, P. Marchev. 1987. K-Ar dating of the Eastern Rhodope Paleogene magmatism. – *Geologica Balc.,17,* 6, 49-58.

Lilov, P., Z. Pecskay, A. Goranov, I. Boyanov. 2000. Preliminary data on th K-Ar dating of the basic rocks ftom the region southerly of Momchigrad, Eastern Rhodopes, Bulgaria. – *Geol. Balc., 30,* 1-2, 13-17.

Marchev P., A. Harkovska, Z. Pecskay, O. Vaselli, H. Downes. 1997. Natureand age of the alkaline basaltic magmatism southeast of Krumovgrad, SE-Bulgaria. – *Compt. Rend. Acad. Bulg. Sci., 50,* 4, 77-80.

Marchev, P., B. Singer. 1999. Timing of magmatism, alteration-mineralization, and caldera evolution in the Spahievo ore field, Bulgaria' from laser-fusion 40Ar/39Ar dating. – In: *Stanley et al. (Eds). Mineral Deposits: Processes to Processing, Balkema, Rotterdam,* 1271-1274.

Marchev, P., B. Singer. 2002. $^{40}Ar/^{39}Ar$ geochronology of magmatism and hydrothermal activity of the Madjarovo base-precious metal ore district, eastern Rhodopes, Bulgaria. – In: *Blundell, D., Neubauer, F., von Quadt, A. (Eds), The Timing and Location of Major Ore Deposits in an Evolving Orogen. Geol. Soc., London, Spec. Publ., 204,* 137-150.

Moskovski, S., V. Karloukovski, Z. Milakovska, A. Harkovska, M. Pringle. 2004. Litological and magnetostratigraphic correlation of Paleogene sections in the Eastern Rhodopes (SE Bulgaria*). – Geologica Carpathica, 55,* 3, 251-260.

Singer, B., P. Marchev. 2000. Temporal evolution of arc magmatism and hydrothermal activity, including epithermal gold veins, Borovitsa caldera, Southern Bulgaria. – *Economic Geology, 5,* 1155-1164.

Yanev, Y., Z. Pecskay. 1997. Preliminary data on the petrology and K-Ar dating of the Oligocene volcano Briastovo, Eastern Rhdopes – *Geochem. Mineral. Petrol., 32,* 59-66.

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