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PETROCHEMICAL FEATURES OF THE PALEOGENE SARNITSA MAGMATIC GROUP, EASTERN RHODOPES

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ABSTRACT. Sarnitsa Group unites the intermediate magmatic rocks of the late extensional Paleogene magmatism in the Northeastern Rhodope Depression. It includes the successively formed Kolets basalt-andesite, Voinovo shoshonite-latite, Bukovo shoshonite-latite, Nikolovo latite, Bezvoden latite and Dragoina latite complexes. A distinct tendency toward increasing acidity and alkali content (K, K+Na) from earlier to later phases (complexes) is observed. Voinovo and Bukovo complexes have similar composition and close trends in the distribution of main oxides. They probably represent one phase of an evolving magma chamber, but have different spatial distribution and form Voinovo volcano and the base of Dragoina Volcano, respectively. Nikolovo, Bezvoden and Dragoina complexes have also close composition and trends but different from those of Voinovo and Bukovo complexes with respect to the content of K_2O, K_2O+Na_2O, TiO_2, Al_2O_3. The former are probably the result of a common later phase in the development of the magma chamber and form Nikolovo volcano and the late phases of Bezvoden and Dragoina volcanoes, respectively. On the K_2O/SiO_2 diagram, most analyses from Sarnitsa Group plot in the field of the shoshonite series and only single ones – in the field of the high potassium-calc-alkaline and high potassium subalkaline series. Only the trend of Kolets Complex lies in the field of the high potassium-calc-alkaline series.

ПЕТРОХИМИЧНИ ОСОБЕНОСТИ НА ПАЛЕОГЕНСКАТА СЪРНИШКА МАГМЕНА ГРУПА В ИЗТОЧНИТЕ РОДОПИ
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РЕЗЮМЕ. Сърнишката група обединява среднокиселите магмени скали на късноекстензионния палеогенски магматизъм в Североизточнородопската депресия. Тя включва последователно формираните Колецки базалт-андезитов, Войновски шошонит-латитов, Буковски шошонит-латитов, Николовски латитов, Безводенски латитов и Драгойновски латитов комплекси. Наблюдава се отчетлива тенденция на повишаване на киселинността и алкалността (К; К+Na) от ранните към късните фази (комплекси). Войновският и Буковският комплекси имат сходен състав и близки трендове на разпределение на основните окиси. Те вероятно са една фаза в развитието на обща магмена камера, но имат различни ареали на разпространение и изграждат съответно Войновския вулкан и основата на Драгойновския вулкан. Николовският, Безводенският и Драгойновският комплекси също имат близък състав и трендове на разпределение, различни от тези на Войновския и Буковския комплекси по отношение на K_2O, K_2O+Na_2O, TiO_2, Al_2O_3. Те вероятно също са резултат на една обща по-късна фаза в развитието на магмената камера и изграждат съответно Николовския вулкан и късните наставки на Безводенския и Драгойновския вулкани. На диаграмата K_2O/SiO_2 точките на повечето анализи от Сърнишката група попадат в полето на шошонотовата серия и само единични в полетата на висококалиево-калциевоалкалната и висококалиевосубалкалната серия. Единствено трендът на Колецкия комплекс се разполага в по-голямата си част в полето на висококалиево-калциевоалкалната серия.

Introduction

During the Pleogene, as a result of extensional process in the Rhodope massif (Ivanov, 2000), the Northeastern Rhodope Depression developed between the Central Rhodope dome (metamorphic core complex) and Harmanly block (Georgiev, 2005). The base of the section comprises Paleocene-Eocene terrigenous sediments and reefal limestones. In the end of the Priabonian and the Rupelian, the depression was the locus of intense volcanism. The earlier phases (Late Priabonian - Early Rupelian) are of intermediate composition, whereas the later (Rupelian) are acidic. The intermediate phases are included in Sarnitsa Magmatic Group and the acidic – in Chamdere Magmatic Group (Georgiev, Milovanov, 2005a; 2006a; 2006b).

The present paper is focused on the intermediate rocks of Sarnitsa Group. They form Kolets, Yavorovo, Nikolovo, Bezvoden and Dragoinovo volcanoes as well as many smaller volcanic structures. The Sarnitsa Group includes the successively formed (from bottom to top) Kolets basalt-andesite, Voinovo shoshonite-latite, Bukovo shoshonite-latite, Nikolovo latite, Bezvoden latite and Dragoina latite complexes (Fig. 1). The rocks of this group are spatially closely associated and are supposed to have a common magma source (chamber).

Results

Latite varieties prevail in all complexes of Sarnitsa Group (Table 1; Fig. 2, 3, 4). However, basalt varieties (48-52% SiO_2) occur in the earliest Kolets and Voinovo complex. Shoshonite varieties (52-57% SiO_2) are significant in the intermediate in age Voinovo and Bukovo complexes, whereas latite varieties (57-63% SiO_2) dominate in the latest Nikolovo, Bezvoden and

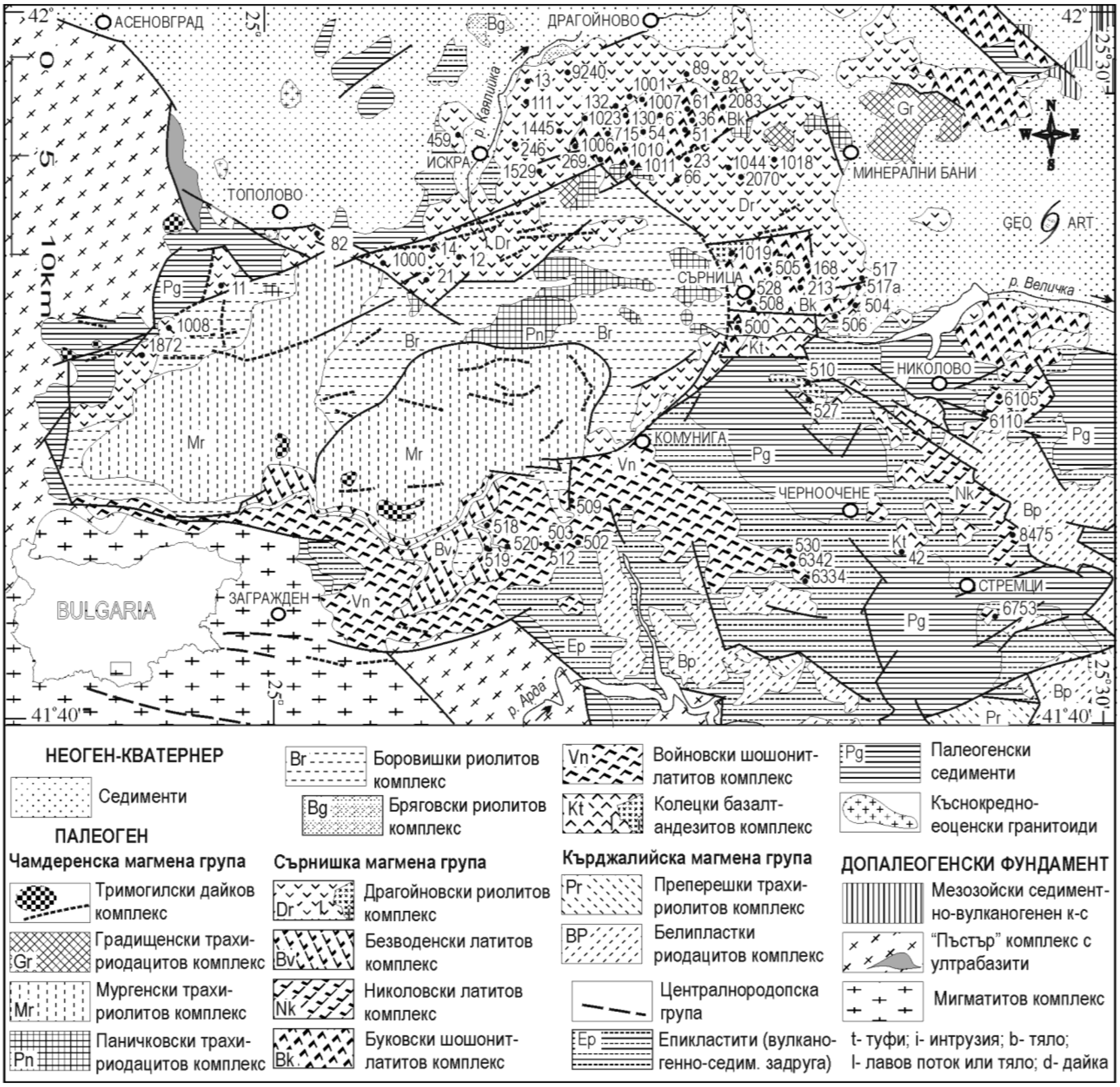

Fig. 1. Map of magmatic complexes in the Northeastern Rhodope Depression

Dragoina complexes. In this way, a well expressed trend to increasing acidity from earlier to later phases is evident.

On the K_2O/SiO_2 diagram, most rocks of Sarnitsa Group plot in the field of the shoshonitic series and only some of them – in the field of the high-potassium calc-alkaline and high-potassium subalkaline series (Fig. 3). The distribution trends of the analyses likewise fall within the field of the shoshonitic series. Only the trend of Kolets basalt-latite complex lies in the field of the high-potassium calc-alkaline series but close to the boundary with the shoshonitic series. A distinct tendency to increasing K content is observed from earlier toward later phases (complexes). The K content is lowest in Kolets basalt-latite complex. The next in time Voinovo and Bukovo shoshonite-latite complexes are characterized by intermediate K values. The latest Nikolovo, Bezvoden and Dragoina latite complexes exibit the highest K content.

The rocks of Sarnitsa Group are characterized by higher general alkalinity and on the $(Na_2O+K_2O)/SiO_2$ diagram almost all samples plot in the field of the trachytic varieties (Fig. 4). The same distinct trend toward increasing general alkalinity from earlier to later phases is evident.

Discussion

There is a general trend toward increasing acidity and alkalinity (K_2O, Na_2O+K_2O) from earlier to later phases (complexes).

Voinovo and Bukovo complexes are very close in age (36,2 – 36,9 Ma, Milovanov et al., 2005), composition and trends in the distribution of main oxides (K_2O, K_2O+Na_2O). They probably represent one phase in the evolution of a common magma chamber but have different spatial distribution and form Voinovo volcano and the base of Dragoina volcano.

Nikolovo, Bezvoden and Dragoina complexes are also close in age (33,1–32,2 Ma, Milovanov et al., 2005), composition and trends but they differ from the Voinovo and Bukovo complexes with respect to K_2O, K_2O+Na_2O, TiO_2 and Al_2O_3.

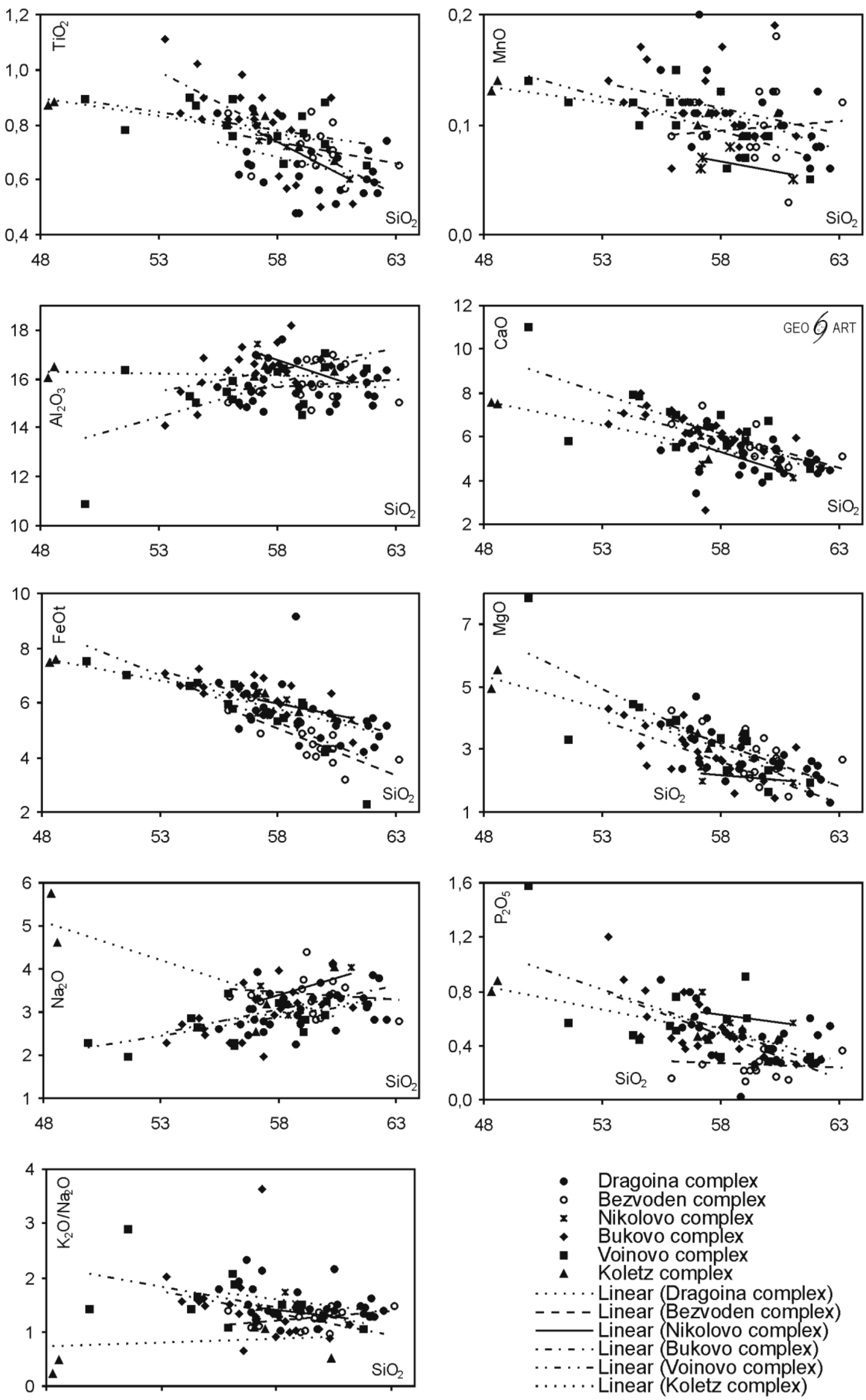

Fig. 2. Harker digrams of main oxides

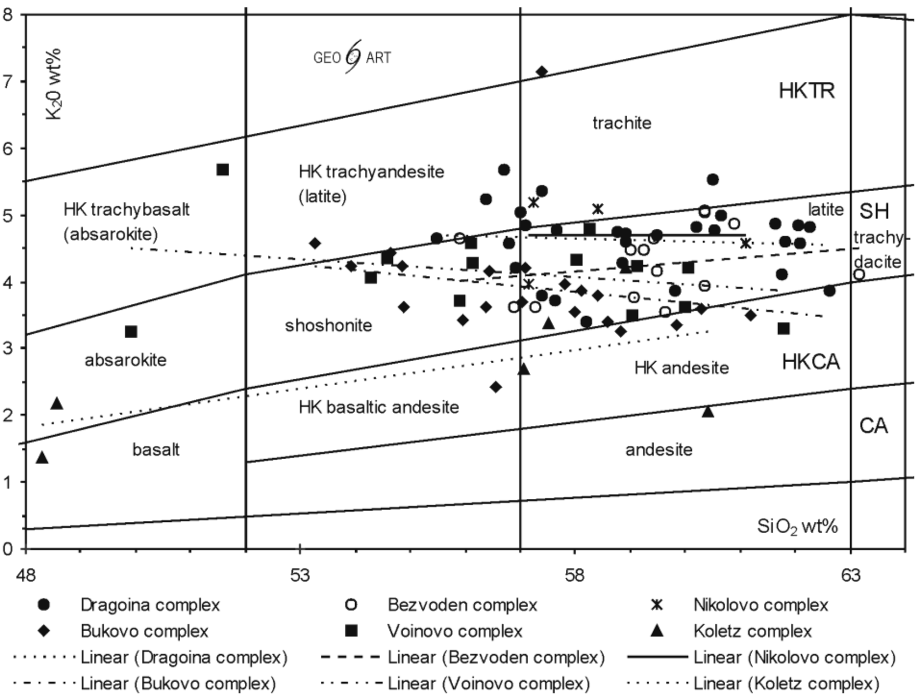

Fig. 3. K_2O/SiO_2 diagram (after Dabowski et al., 1991)

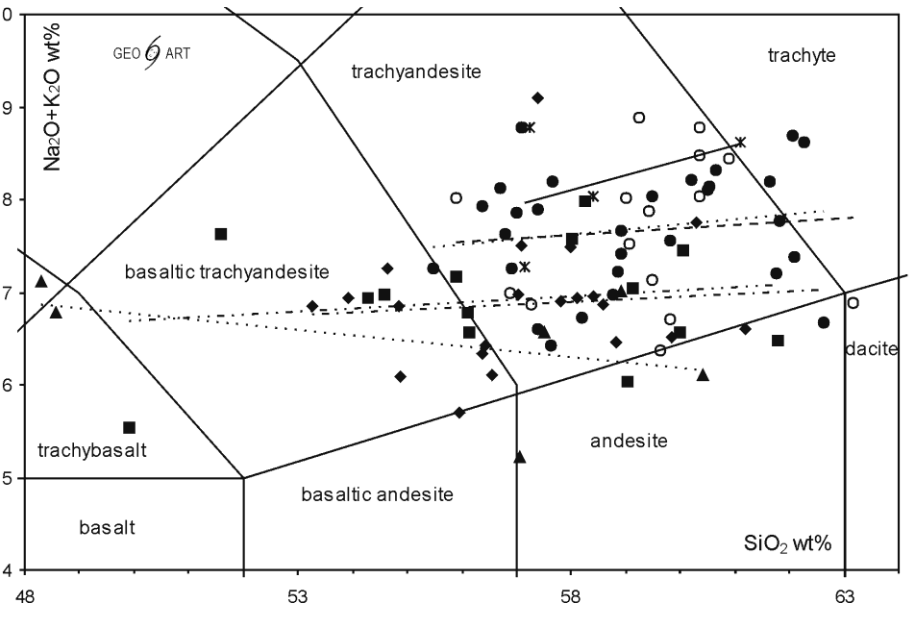

Fig. 4. $(Na_2O+K_2O)/SiO_2$ diagram (after Le Bas et al., 1986). For the key see Fig. 3

They are probably also products of a later phase in the evolution of the magma chamber and form Nikolovo volcano and the later phases of Bezvoden and Dragoina volcano.

The rocks of Sarnitsa Group differ considerably from the intermediate rocks of Dambala Group (Zdravets Subgroup), which show lower K_2O and Na_2O+K_2O values and belong mainly to the high-potassium calc-alkaline series (Georgiev, Milovanov, 2003; 2004). This is another reason to assign them to different magmatic groups – probable products of the evolution of different magma chambers. According to petrochemical features, the rocks of Sarnitsa Group are closer to those of Madzharovo complex (Георгиев, Милованов, 2004, 2005b). However, the considerable distance between the two magmatic areas do not allow to include Madzharovo complex in Sarnitsa Group.

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Table 1.
Representative analyses of Sarnitsa group. Sample number xxM is data after Marchev (1985)

No	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	CO	S	H_2O^-	LOI	H_2O^+	∑
DRAGOINA COMPLEX																	
130	62,05	0,63	14,88		5,44	0,08	4,96	2,17	4,85	3,84	0,27				0,82	0,00	99,99
1872	58,77	0,48	15,40	2,35	7,02	0,07	4,25	2,36	4,74	2,24					0,72	0,80	99,20
11	62,10	0,59	15,27	2,66	1,96	0,13	4,32	2,46	4,57	2,81	0,48	0,28	0,01	0,45		1,40	99,49
132	60,54	0,68	15,30		5,31	0,10	4,95	2,60	4,76	3,39	0,27				1,75	0,00	99,65
66	60,20	0,71	14,68		5,61	0,13	5,87	2,65	4,83	3,39	0,38				1,55	0,00	100,00
12	57,10	0,81	16,99	5,28	0,92	0,20	4,36	2,60	4,84	3,93	0,53	0,03	0,01	0,79		1,20	99,59
1008	56,71	0,70	14,84	5,29	1,54	0,12	6,15	3,67	5,67	2,45	0,79	0,18	0,01	0,45		1,20	99,77
459	58,92	0,61	15,67	4,43	1,31	0,10	5,33	3,32	4,61	3,06	0,51	0,04	0,02	0,22	1,60	1,70	101,45
1000	56,90	0,65	15,50	3,24	2,41	0,11	5,56	3,33	4,20	3,06	0,61	1,23	0,01	0,20		2,70	99,71
1001	56,80	0,66	15,75	4,84	1,08	0,08	5,45	3,38	4,57	3,06	0,56	0,02	0,04	0,75		2,70	99,74
246	61,83	0,71	15,35		5,18	0,09	4,82	2,65	4,60	3,17	0,26				0,85	0,00	99,51
1529	59,47	0,70	15,82		5,77	0,09	4,47	2,74	4,70	3,33	0,26				2,14	0,00	99,49
82a	57,40	0,76	16,00	2,92	3,20	0,15	6,70	4,00	3,80	2,80						0,00	97,73
13	58,20	0,83	17,60		6,70	0,11	5,90	2,00	3,40	3,33	0,50				1,36	0,00	99,93
111	58,85	0,66	16,72	2,81	2,73	0,10	5,61	3,06	4,29	2,94	0,02			0,55		1,47	99,81
1445	57,63	0,75	16,85	3,66	2,34	0,11	6,41	3,57	3,72	2,70	0,33			0,64	1,03	1,26	101,00
9240	57,65	0,74	16,38	3,05	2,75	0,11	5,83	3,24	4,76	3,44	0,48			1,76	1,40	0,00	101,59
4674	61,76	0,60	15,85	2,78	2,78	0,06	5,27	1,57	4,10	3,10	0,60			0,90	0,42	0,00	99,79
1018	62,27	0,55	16,02		4,78	0,08	4,55	2,04	4,82	3,80	0,29				0,69	0,00	99,89
1044	60,49	0,51	14,95		5,14	0,11	4,56	2,45	5,54	2,56	0,44				2,90	0,00	99,65
1019	61,65	0,55	16,20		4,20	0,07	4,84	2,38	4,88	3,32	0,29				0,69	0,00	99,07
2070	60,66	0,56	16,48	3,67	1,10	0,10	4,29	2,81	5,00	3,31	0,49	0,04	0,34	0,28	0,63	0,00	99,76
508	57,00	0,86	15,11	3,61	3,34	0,11	3,41	4,70	5,04	2,81	0,75	0,50	0,02	0,80		2,06	100,12
528	55,49	0,84	15,65	4,02	3,05	0,15	5,35	3,83	4,65	2,61	0,88	0,38	0,01	0,77		2,10	99,78
517	62,63	0,74	16,35	4,92	0,68	0,06	4,43	1,30	3,87	2,81	0,54	0,13	0,02	0,60	0,82	0,80	100,70
89	58,92	0,48	14,87	2,55	2,12	0,09	4,71	2,52	4,71	2,70	0,46	3,35	0,03	0,50		5,14	103,15
82	57,40	0,59	14,66	3,83	2,05	0,09	6,53	2,44	5,37	2,53	0,66	2,11	0,07	0,50		2,33	101,16
14	56,37	0,62	15,05	0,92	4,19	0,12	5,73	2,40	5,23	2,70	0,53	2,99	0,01	0,44		1,80	99,10
21	59,80	0,56	15,38	3,50	1,50	0,12	3,93	2,12	3,87	3,69	0,47	1,89	0,01	0,83		2,60	100,27
BEZVODEN COMPLEX																	
214M	55,91	0,84	15,02	5,15	1,05	0,09	6,59	4,26	4,64	3,37	0,16			0,96		1,65	99,69
3M	57,26	0,77	15,49	2,55	2,54	0,09	7,43	3,92	3,61	3,25	0,26			0,65		1,74	99,56
225M	56,88	0,61	15,55	3,23	3,22	0,12	6,29	3,31	3,61	3,38	0,61			0,92		1,81	99,54
188M	59,48	0,68	15,65	3,17	1,60	0,08	6,58	3,04	4,17	2,96	0,22			0,32		2,55	100,50
152M	59,62	0,65	16,81	2,49	1,77	0,13	5,53	1,79	3,55	2,83	0,28	2,00		0,32		2,55	100,32
193M	59,00	0,73	15,36	5,07	0,68	0,07	5,22	2,24	4,47	3,54	0,22			0,82		3,13	100,55
185M	59,06	0,66	15,76	2,89	2,26	0,09	6,08	3,68	3,77	3,75	0,14			0,23		1,18	99,55
225M	59,82	0,76	15,80	3,69	0,96	0,10	5,47	3,36	3,86	2,84	0,38			1,66		0,99	99,69
194M	59,42	0,85	14,75	4,90	0,55	0,07	5,13	2,26	4,64	3,24	0,24			1,46		3,12	100,63
7M	59,24	0,75	16,82	2,16	2,14	0,08	5,50	2,10	4,47	4,41	0,22			0,25		1,48	99,62
8M	60,34	0,71	16,97	1,72	2,26	0,07	5,38	2,36	3,93	4,10	0,28			0,23		1,53	98,16
195aM	60,34	0,69	15,29	3,50	1,15	0,18	4,98	2,95	5,07	3,71	0,17			0,41		1,03	99,47
200M	60,36	0,81	15,29	3,91	1,28	0,13	5,42	2,72	5,03	3,44	0,29			0,63		1,17	100,48
159M	60,88	0,57	16,58	2,02	1,32	0,03	4,62	1,49	4,87	3,58	0,15			0,48		3,85	100,44
198M	63,15	0,65	15,02	2,48	1,64	0,12	5,09	2,70	4,10	2,79	0,36			0,60		0,68	99,38
NIKOLOVO COMPLEX																	
4851	57,24	0,74	16,92	3,36	3,36	0,07	4,72	2,01	5,18	3,59	0,79			1,24	0,63	0,00	99,85
8475	58,40	0,72	16,21	4,93	1,64	0,08	5,70	2,26	5,09	2,94	0,57	0,04	0,04	0,66	0,62	0,85	100,75
6753	57,14	0,80	17,43	4,90	1,13	0,06	6,00	2,42	3,96	3,31	0,55	0,08		1,00		1,03	99,81
6105	61,10	0,60	15,96	5,20	0,63	0,05	4,10	1,94	4,57	4,05	0,57	0,43		0,63	0,50	0,25	100,58

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Tabe. 1

Continuation

No	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	CO	S	H_2O^-	LOI	H_2O^+	∑
BUKOVO KOMPLEX																	
54	54,63	1,02	14,52	7,95		0,17	7,98	3,11	4,42	2,84	0,47				2,67	0,00	99,78
1007	54,84	0,82	15,84	3,95	2,96	0,11	6,98	3,74	4,24	2,61	0,81	0,22	0,01	1,11		1,70	99,94
269	56,55	0,98	17,28	3,39	3,20	0,12	6,14	3,18	2,41	3,69	0,37			0,36		2,00	99,67
6	58,60	0,78	18,16		6,62	0,10	5,86	1,60	3,40	3,46	0,45				0,81	0,00	99,84
715	57,81	0,81	16,55	4,18	1,86	0,11	6,53	2,75	3,96	2,94	0,33	0,57		0,60		0,80	99,80
1023	58,00	0,84	17,52		6,08	0,13	5,98	2,70	3,54	3,95	0,30				0,68	0,00	99,72
1006	53,91	0,84	15,50	3,93	3,06	0,12	7,05	4,13	4,24	2,70	0,89	0,40	0,02	1,27	1,74	1,00	100,80
1010	56,38	0,82	16,79	4,60	2,30	0,11	6,78	3,30	3,63	2,70	0,42	0,04	0,05	0,90	1,00	1,00	100,82
1011	54,88	0,90	16,84	3,40	3,27	0,16	7,43	2,50	3,63	2,45	0,61	1,89	0,04	0,50		1,00	99,50
6679	58,82	0,58	15,86	2,71	2,71	0,08	6,25	2,51	3,25	3,21	0,38			1,11	1,21	0,00	98,68
4743	61,18	0,51	16,07	2,37	2,37	0,09	5,95	3,05	3,50	3,10	0,26			0,65	0,73	0,00	99,83
61	59,85	0,50	16,80	3,40	1,62	0,09	5,29	1,97	3,34	3,18	0,32	0,13	0,03	0,50		2,90	99,92
36	58,10	0,61	16,58	3,26	2,96	0,17	6,17	2,63	3,87	3,06	0,53	0,60	0,10	0,32		1,80	100,76
23	57,02	0,82	16,63		7,03	0,11	6,38	2,92	3,70	3,28	0,40				1,71	0,00	100,00
2083	60,30	0,90	16,54		6,33	0,19	5,46	1,43	3,60	4,15	0,28				0,72	0,00	99,90
168	57,39	0,90	15,43	6,82	0,68	0,14	2,60	2,38	7,14	1,96	0,45	1,22	0,02	0,98		1,87	99,98
519	56,44	0,90	14,92	5,84	1,33	0,11	6,84	4,09	4,15	2,28	0,79	0,25	0,02	0,90		1,10	99,96
517	62,63	0,74	16,35	4,92	0,68	0,06	4,43	1,30	3,87	2,81	0,54	0,13	0,02	0,60		0,80	99,88
500	55,96	0,82	16,35	4,80	1,90	0,06	7,21	2,39	3,42	2,28	0,45	1,81	0,01	0,49		1,76	99,71
505	57,10	0,80	16,25	5,90	0,93	0,12	4,53	2,71	4,20	3,31	0,70	1,81	0,01	0,51		1,29	100,17
213	53,25	1,11	14,10	5,43	2,14	0,14	6,55	4,28	4,57	2,28	1,20	2,94	0,01	0,80		0,81	99,61
51	58,40	0,57	16,30	3,59	2,26	0,11	5,64	2,40	3,78	3,18	0,46	1,25	0,01	0,94		2,20	101,09
VOINOVO COMPLEX																	
6342	60,00	0,88	17,06	3,35	1,13	0,09	6,70	1,62	3,63	2,94	0,37	0,39		1,33		1,05	100,54
6334	58,25	0,66	16,40	4,56	1,28	0,06	5,60	2,31	4,80	3,18	0,59	0,34	0,08	1,18		1,12	100,41
509	49,90	0,89	10,87	5,17	2,84	0,14	10,99	7,83	3,26	2,28	1,58	1,09	0,01	0,98		1,90	99,73
518	56,14	0,89	15,16	5,72	1,48	0,10	7,00	3,93	4,29	2,28	0,76	0,42	0,01	0,80		1,00	99,98
520	56,10	0,76	15,89	3,29	2,76	0,15	5,55	3,98	4,57	2,21	0,51	0,04	0,01	1,22		2,88	99,92
503	61,78	0,65	16,40	0,05	2,22	0,05	4,56	1,94	3,30	3,18	0,32	0,04	0,01	1,30		2,30	98,10
502	59,12	0,77	15,00	4,82	1,51	0,09	6,21	3,27	4,24	2,81	0,60	0,04	0,01	0,65	0,68	0,83	100,65
530	59,05	0,83	14,54	4,82	1,59	0,07	5,82	3,50	3,51	2,53	0,91	0,08	0,03	0,87	1,75	1,88	101,78
512	51,58	0,78	16,35	4,32	3,09	0,12	5,79	3,30	5,67	1,96	0,57	2,22	0,01	1,54		2,70	100,00
143M	55,90	0,80	15,50	4,23	2,07	0,12	7,15	3,86	3,72	3,44	0,54			1,05		1,43	99,81
209M	60,06	0,73	16,50	3,66	0,99	0,09	4,15	2,32	4,21	3,25	0,28			1,18		2,20	99,62
160M	58,02	0,76	16,30	3,05	2,56	0,13	7,03	3,35	4,34	3,23	0,32			0,46		0,62	100,17
121M	54,29	0,90	15,30	5,26	1,83	0,12	7,90	4,44	4,07	2,86	0,48			0,81		1,21	99,47
121'M	54,57	0,87	15,04	4,51	2,63	0,10	7,88	4,35	4,35	2,63	0,44			0,80		1,35	99,52
KOLETZ COMPLEX																	
6110	48,56	0,88	16,51	5,75	2,36	0,14	7,48	5,55	2,17	4,60	0,87	0,13		3,58		3,68	102,26
42	48,30	0,87	16,07	5,20	2,72	0,13	7,58	4,93	1,37	5,74	0,80	0,04		4,62		4,85	103,22
510	58,93	0,72	15,58	3,98	2,05	0,09	5,18	3,54	4,20	2,81	0,52	0,04	0,01	0,95	1,02	1,24	100,86
527	57,50	0,83	16,53	4,46	2,26	0,11	4,96	3,04	3,38	3,18	0,44	0,84	0,03	0,87		1,34	99,77
504	57,05	0,85	16,13	5,45	1,40	0,10	6,35	3,50	2,70	2,53	0,47	0,04	0,01	2,00		1,47	100,05
506	60,40	0,67	16,30	3,49	2,26	0,11	4,80	2,48	2,06	4,05	0,44	0,04	0,01	0,70		2,24	100,05

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