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Mineralogical characteristic of pegmatoid and metasomatic zones in Svidnya pluton, Bulgaria

Минераложка характеристика на пегматоидни и метасоматични зони в Свидненския плутон, България

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The Svidnya pluton outcrops in the Western Stara Planina (Balkan) mountain as small stock-like and dyke-like intrusions. The Svidnya pluton covers area of ~ 2.5 km^2 situated between the localities called Pessoko-Lilyako and Rogo-Padalishte. These magmatic bodies are intruded in Ordovician shales, radiogenic isotopes (K-Ar and U-Pb) data indicate Carboniferous age of the pluton: 340–305 Ma. Trace element and isotopes characteristics are in favour of an orogenic setting of formation of the rocks (Dyulgerov, 2005). Several facial varieties are presented with gradual transition between them; they range from clinopiroxene and biotite-bearing melasyenite to quartz syenites with aegirine and Na amphibole. The whole spectrum of plutonic rocks is observed only in the two biggest outcrops – in the west slope of the hill between Pessoko and Lilyako, and between the localities Rogo and Padalishte. Magmatic activity ends with the introduction of strongly peralkaline syenite porphyritic and granite porphyritic dykes. The rocks from the Svidnya pluton are strongly weathered and contain abundant evidences for postmagmatic alterations and metasomatism.

The initial magma of Svidnya pluton was hydrous saturated (biotite is an early liquidus phase) with estimated minimal water content ~3 wt% (Dyulgerov, Platevoet, 2013). The host rock shales provided an impermeable screen that disabled the fluids separation from the crystallizing magma. This resulted in a high fluid concentration in the magma chamber at the final stages, which predetermined abundant late- to postmagmatic fluid induced pegmatoids formations and overprinted metasomatic alterations on plutonic rocks. The field evidences do not permit always to discriminate unequivocally the pegmatoid zones from postmagmatic alterations due to the limited outcrops and intensive weathering.

The previous study depicted complex picture of hydrothermal alterations (Stefanova, 1986). This author attributed a very important role of the residual fluids, considering them responsible for the change of petrographic composition in several rock types. Later studies (Dyulgerov, 2005; Dyulgerov, Platevoet, 2013) showed that facial diversity of rocks can be explained with evolution of magma composition and changes of cotectic during the crystallization of the Svidnya pluton. In this paper as pegmatites and hydrothermal altered zones are described those formations which have:

1. Contacts with host rocks. These are pegmatite dykes, which characterize with zonal distribution of minerals – salbands are composed of mafic minerals (amphibole) growing perpendicular to the contact plane, and inner zones composed dominantly of K-feldspar and quartz (aegirine and amphibole are scarce). The texture of the rock is coarse grained, with crystals reaching up to 2–3 cm. Thickness of these dykes is up to 20–30 cm. This type of dykes are more abundant in the localities between Rogo and Padalishte, and in Padezh, below the peak Lilyako.

2. Different facial and mineral composition, with rapid transition from the host rocks. These represent pegmatoid zones with extremely variable textures and composition. Two main types can be remarked – one has leucocrate composition and blob and pocket-like shapes with dimension usually between 5 and 20 cm. The second one represents mafic segregations composed of amphiboles (up to 2–4 cm) with minor quartz and feldspar. The texture of these zones and segregations is coarse grained.

Table 1. Amphibole composition

SiO_2	54.96	53.48	55.04	54.34	53.71
TiO_2	3.10	3.11	1.74	2.81	3.28
Al_2O_3	0.48	0.64	0.38	0.70	0.64
FeOt	13.98	15.64	15.68	13.75	14.55
MnO	0.73	0.64	0.49	0.64	0.74
MgO	13.06	12.54	13.75	14.07	12.79
Cr_2O_3	0.04		0.08	0.00	0.04
CaO	1.27	1.43	0.96	1.46	1.39
Na_2O	8.08	7.79	7.86	7.70	8.01
K_2O	2.07	2.17	1.49	2.14	2.15
F	0.03	0.00	0.00	0.00	0.00
Cl	0.01	0.02	0.01	0.01	0.00
Total	97.79	97.45	97.48	97.62	97.30
Si	7.969	7.822	7.873	7.824	7.861
Al^{IV}	0.031	0.110	0.064	0.119	0.110
Ti	0.000	0.068	0.063	0.057	0.028
T	8.000	8.000	8.000	8.000	8.000
Al^{VI}	0.051	0.000	0.000	0.000	0.000
Ti	0.338	0.274	0.124	0.247	0.333
Fe^{3+}	0.256	0.500	1.069	0.631	0.334
Fe^{2+}	1.439	1.414	0.807	1.024	1.447
Mn	0.090	0.079	0.059	0.078	0.092
Mg	2.822	2.733	2.931	3.019	2.790
Cr	0.005	0.000	0.009	0.000	0.005
C	5.000	5.000	5.000	5.000	5.000
Mg	0.000	0.000	0.000	0.000	0.000
Ca	0.197	0.224	0.147	0.225	0.218
Na	1.803	1.776	1.853	1.775	1.782
B	2.000	2.000	2.000	2.000	2.000
K	0.383	0.405	0.272	0.393	0.401
Na	0.469	0.433	0.327	0.375	0.491
[A]	0.852	0.838	0.599	0.768	0.893
F	0.014	0.000	0.000	0.000	0.000
Cl	0.002	0.005	0.002	0.002	0.000
OH*	1.984	1.995	1.998	1.998	2.000

3. Very irregular trails of minerals with parts enriched in quartz-feldspar or in aegirine-amphibole. They are imposed on all rock types as trails or form networks of late-stage aegirines and quartz in syenite and granite porphyries. In the later zones aegirines sometimes form dense monomineral aggregates of felt crystals.

The type 1 and 2 pegmatoid formations are most widespread. They usually appear in the middle and upper parts in the presumed magma chambers (in the sense of Dyulgerov and Platevoet, 2013) within the Aeg-Au + Amph syenite and quartz syenite. Type 3 hydrothermal alterations are imposed on all rock-types in the pluton.

Minerals from all rock-types present limited variation and their composition can be systemized as follows.

Feldspars. Only potassium feldspar is presented in described zones. It characterizes with limited evolution with $Or_{98–85}$ and $Ab_{2–15}$, and low Ba and Sr contents. Very rare are albite-rich zones in K-feldspar probably result of very late-stage fluid infiltration.

Amphibole. Amphiboles from pegmatoid and hydrothermal zones are magnesio-arfvedonites, with no other species presented (Table 1). [A]-site in magnesio-arfvedsonite is filled between 0.9 and 0.6 *apfu* which attests for relatively elevated temperature of formation. A marked difference in amphibole composition is the Ti content: magnesio-arfvedsonite from pegmatoid zones is enriched in TiO_2 with content between 2.5 and 3 wt%. Amphiboles from hydrothermally altered zones present marked enrichment in Fe^{3+}. In both petrographic varieties magnesio-arfvedsonites have low F and Cl content implying that water was the dominant fluid during the late stage crystallization.

Pyroxene. Pyroxenes from studied rocks are aegirines with limited presence of aegirines-augites in the core of the crystals (Table 2). A marked difference in the composition is the Ti content, as aegirines from hydrothermally altered zones have TiO_2 between 3 and 7 wt%, whereas pyroxenes from pegmatoid zones have TiO_2 in the range 1–3 wt%. All studied aegirines have moderate to low Zr content.

Accessories. Apatite is the main accessory phase. In pegmatoid zones it is a rock-forming mineral, medium to coarse grained, with modal proportion 1–3%. In the metasomatic zones it is restricted to the groundmass. All studied apatites are enriched

Table 2. Clinopyroxene composition

SiO_2	53.06	52.44	52.97	52.26	53.34
TiO_2	2.96	1.48	1.88	6.68	4.97
Al_2O_3	0.20	0.28	0.12	0.15	0.13
ZrO_2	0.29	0.26	0.49	1.80	0.44
FeOt	22.22	22.71	21.50	21.19	23.10
MnO	0.12	0.29	0.29	0.72	0.21
MgO	3.35	4.53	4.59	1.73	2.44
CaO	3.25	7.00	7.55	1.05	1.74
Na_2O	12.01	9.44	9.68	12.57	12.47
K_2O	0.01	0.00	0.01	0.00	0.00
Total	97.47	98.43	99.08	98.15	98.84
Si	2.00	1.98	1.99	2.00	2.00
Al^{IV}	0.00	0.01	0.01	0.00	0.00
Ti	0.08	0.04	0.05	0.19	0.14
Al^{VI}	0.01	0.00	0.00	0.00	0.01
Zr	0.01	0.00	0.01	0.03	0.01
Fet	0.70	0.72	0.67	0.68	0.72
Mn	0.00	0.01	0.01	0.02	0.01
Mg	0.19	0.26	0.26	0.10	0.14
Ca	0.13	0.28	0.30	0.04	0.07
Na	0.88	0.69	0.70	0.93	0.91
K	0.00	0.00	0.00	0.00	0.00

Table 3. Baotite composition

SiO_2	15.13	15.06
TiO_2	38.15	38.82
ZrO_2	0.12	0.03
Al_2O_3	0.21	0.11
FeOt	0.19	0.14
SrO	0.5	0.46
BaO	38.73	38.59
Nb_2O_3	3.18	3.18
CaO	0.04	0
Na_2O	0.02	0.09
Cl	2.14	2.15
Total	98.45	98.65
Si	3.672	3.633
Ti	7.959	8.050
Zr	0.015	0.004
Al	0.040	0.021
Fe	0.039	0.028
Sr	0.070	0.064
Ba	3.683	3.648
Nb	0.265	0.264
Ca	0.010	0.000
Na	0.005	0.021
Cl	0.880	0.879

in F (fluorapatite) with marked Sr content, as apatites from pegmatoid zone have up to 7–9 wt% SrO. Ilmenite is main opaque mineral and it is presented in all studied rock types. Some ilmenites have disturbed chemical composition attesting for the circulation of low-T residual fluids. Zircon is widespread accessory phase, in metasomatic hydrothermal zones it shows yellow-brown colour and deviation from ideal stoichiometry. This fact implies on the presence of other cations (Th, U, Hf) or metamictization processes. In pegmatoid dykes for a first time was established the extremely rare mineral baotite. It forms platy tetrahedral crystals closely associating with apatite. Baotite's stoichiometry is close to the ideal (Table 3).

The mineral particularities in the studied rocks show that in spite of the different type of emplacement (as dykes, irregular trails or pocket-like segregations) the late-stage magmatic activity shears some common features: the mafic minerals reflect the strong peralkaline character of the residual fluids with pronounced sodic enrichment (i), water was the main fluid during late-stage crystallization (ii), apatite, zircon and baotite are not the main REE carrier and other accessory phases should be expected in the rocks.

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