ГЕОЛОШКИ АНАЛИ БАЛКАНСКОГА ПОЛУОСТРВА ANNALES GÉOLOGIQUES DE LA PÉNINSULE BALKANIQUE	74	47–55	БЕОГРАД, децембар 2013 BELGRADE, December 2013

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Pinite-cordierite from spotted slate of the Brajkovac contact metamorphic aureole (Dudovica locality, central Serbia)

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Abstract. The Paleozoic very low to low-grade metamorphic rocks of the Bukulja-Lazarevac Unit designated as Drina, Golija and Birač formations are contact metamorphosed by the intrusion of the Tertiary Brajkovac granodiorite into spotted slates and hornfelses. In some parts, they are slightly migmatized at the contact. In addition to their outcrops found at the western, eastern and northern parts of the formation, these rocks are also found in boreholes near Dudovica at about 8 km south-west from the pluton. There, at a depth of 110 m, the spotted slates comprise oval to ellipsoid pinite-rich spots which can be regarded as incipient cordierite porphyroblasts (up to 5 mm in diameter) overgrowing the existing regional foliation. They are composed of cryptocrystalline mixture of a very fine sericitic material ± light glassy orange „film“ (some kind of an amorphous gel-like material often mixed with limonite matter) and are abundant in inclusions: minute quartz and dusty ore minerals (magnetite) prevail. In addition, within some spots an increased number of xenotime and monazite inclusions are noted. Minute flakes of neobiotite are formed at the expense of quartz-sericite-chlorite matrix. The secondary chlorite occurring as overgrowths on pinite-cordierite spots shows variable composition (brunsvigite to diabandite). The Mg/Fe+Mg ratio of cryptocrystalline pinitic mixture ranges from 0.14–0.67. The Si vs Al^{IV}+Al^{VI} relations deviate from the ideal muscovite-phengite join due to Tschermak substitution towards chloritic composition or a more complex mixture, including clay minerals (which reflected a decrease of Al_{tot} and Si with increase of Fe^{2+}). Obtained data indicates that the cordierite-pinite spots can be related to contact metamorphic processes that occurred within the temperature range 300–450 °C.

Key words: granodiorite, contact aureole, spotted schist, pinite-cordierite, central Serbia.

Апстракт. Источно од Јадарског Блока, на потезу између Аранђеловца и Лазаревца, издвојена је због врло сложене грађе геотектонска јединица Букуља–Лазаревац која се састоји од врло ниско до ниско метаморфисаних стена палеозојске старости међу којима је, на основу литолошких и структурних карактеристика, издвојено неколико мањих суб-јединица или формација. Под утицајем Брајковачког гранодиоритског тела, утиснутог током терцијера, формације Дрина, Голија и Бирач су контактно метаморфисане у слејтове и различите типове хорнфелса. На непосредном контакту уочене су и врло уске зоне слабе мигматизације (до 1 m). Осим на површини, контактно метаморфни продукти тј. бобичави шкриљци са пинитизираним порфиробластима кордијерита су откривени у језгрима истражних бушотина у подручју Дудовице (око 8 km од Брајковца) на дубини од 110 m. Овални до елипсоидни појкилобласти, у различитом степену пинитисаног кордијерита, величине су до 5 mm. Развијени су на постојећем слабо рекристалисалом и контактно метаморфисаном кварц-серицит-хлоритском (± необиотит) матриксу уклапајући га и не реметећи примарни фолијативни склоп стене. Осим уклопака минерала основе садрже ситне љуспе необиотита, а некад и у већем броју инклузије ксенотима и

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монацита. Пинитске партије у њима састоје се од криптокристаласте мешавине серицитског материјала и стакласте изотропне геласте материје измешане са финодиспергованим лимонитом. У неким порфиробластима уочена су и секундарна нарастања хлорита (брусвингит-диабандит) по пиниту. Криптокристаласте пинитске партије имају Mg/Fe+Mg однос између 0.14–0.67. Однос Si и $Al^{IV}+Al^{VI}$ одступа од идеалног мусковит-фенгит пара и чермакитске супституције ка више хлоритским саставима или чак ка комплексијим мешавинама укључујући и минерале глина: одражава се опадањем Al_{tot} и Si са растом Fe^{2+}. Добијени подаци показују да су пинит-кордијеритски бобичави шкриљци формирани у температурном опсегу између 300–450 °C.

Кључне речи: гранодиорит, контактни ореол, бобичави шкриљац, пинит-кордијерит, централна Србија.

Introduction

The basic feature of the majority of the outer contact metamorphic zones is the production of spotted slates formed at the expense of argillaceous rocks or their very low to low grade regionally metamorphosed products (slate/schist). Generally, the spotted texture is the result of the metamorphic reactions that take place due to heat released from the adjacent magma body: the quartz-clayish or quartz-sericite-chlorite foliated matrix becomes reactive in this condition. At certain places, the ions mobility can cause it to change into a completely new composition where mineral phases with high activation energy of nucleation (e.g. cordierite) can start to crystallize. At the beginning they will form oval spots up to a few millimeters in size and then, due to temperature increase, they turn into porphyroblasts towards the contact. According to a number of authors (e.g., CHANDLER 1975; HASLAM 1983; NÉDÉLEC & PAQET 1981; CLEMENS & MCMILLAN 1982; OGIERMANN 2002; DEER *et al.* 1962; ÇERNY & POVONDRA 1967; SCHENK & ARMBRUSTER 1985; HASLAM 1983) the composition of these spots is still uncertain. They can represent either the very fine-grained crystalline mixture of phyllosilicates (occasionally accompanied by a light yellowish amorphous isotropic material), formed as the first product of low temperature contact metamorphic reactions (often similar to pinite), or the incipient growth of cordierite. Moreover, there is a doubt whether these pinite-like spots are formed as prograde metamorphic phases or as retrograde products of cordierite porphyroblasts (see DEER *et al.* 1962; PATTISON & TRACY 1991; MIYASHIRO 1994; RUIZ CRUZ & GALAN 2002; OGIERMANN 2002). Also, these pinite-like spots can be composed of hydrous alkali-bearing phyllosilicates (CHANDLER 1975; HASLAM 1983; NÉDÉLEC & PAQET 1981; CLEMENS & MCMILLAN 1982; OGIERMANN 2002) or mixture of chlorite + muscovite ± clay minerals (DEER *et al.* 1962) or clay mineral-bearing assemblages and isotropic alteration products (ÇERNY & POVONDRA 1967; SCHENK & ARMBRUSTER 1985; HASLAM 1983). In addition, it is still uncertain at which P-T-X conditions begin the transformation of cordierite to pinite and whether it is controlled by local fluid-involved reactions.

The focus of this study is to present petrographic characteristics of spotted slates first found in the contact metamorphic aureole of the Brajkovac granodiorite during exploratory drilling at a depth of 110 m in the area of Dudovica (Fig. 1). For this study, we used a combination of macroscopic, microscopic, and SEM data, as well as microprobe major-element mineral analyses to infer the composition and origin of the pinite-cordierite spots. Mineral abbreviations used in this paper follow those recommended by KRETZ (1983).

Geological setting and background

South of the Pannonian basin, within the nothern part of the western branch of the complex Vardar suture zone (see ROBERTSON *et al.* 2009, and references therein), a few Oligocene-Miocene granitic bodies (Cer, Brajkovac, Bukulja) make a NW–SE oriented belt (see KNEŽEVIĆ *et al.* 1994). These 30–25 to 20 Ma old granites (KNEŽEVIĆ *et al.* 1994; CVETKOVIĆ *et al.* 2007) are intruded into a smaller Paleozoic continental block-unit termed Bukulja–Lazarevac (see TRIVIĆ *et al.* 2010) which is built of fragments detached from the Drina–Ivanjica (DIU) and Jadar block (JBU) continental units associated with the Vardar suture (KARAMATA & KRSTIĆ 1996; DIMITRIJEVIĆ 2001; KARAMATA 2006; HRVATOVIĆ & PAMIĆ 2005).

The Bukulja–Lazarevac unit that extends east of the JBU consists of four sub-units or formations (TRIVIĆ *et al.*, 2010): Drina (DF), Golija (GF), Kovilje Conglomerate (KC) and Birač (BF) (Fig. 1A). The 900 m thick series of very low to low grade metamorphics (metasandstone, slate, sericite-chlorite schist, greenschist, muscovite-biotite schist) of the DF represents the lowermost part of Bukulja–Lazarevac Paleozoic Unit. The ~530 m thick GF overlains the DF and mostly comprises slightly metamorphosed argillaceous to arenitic rocks with intercalations of shales and siltstone. The most widespread BF consists of fine- to medium-grained arenites interlayered with shales and siltstone. All these units underwent at least two ductile and one brittle phase of deformation referred as D1, D2 and D3 (see TRIVIĆ *et al.* 2010; MAROVIĆ *et al.* 2007): D1 is recorded by small-scale isoclinals and oblique folds and D2 by m- to dm-sized folds formed

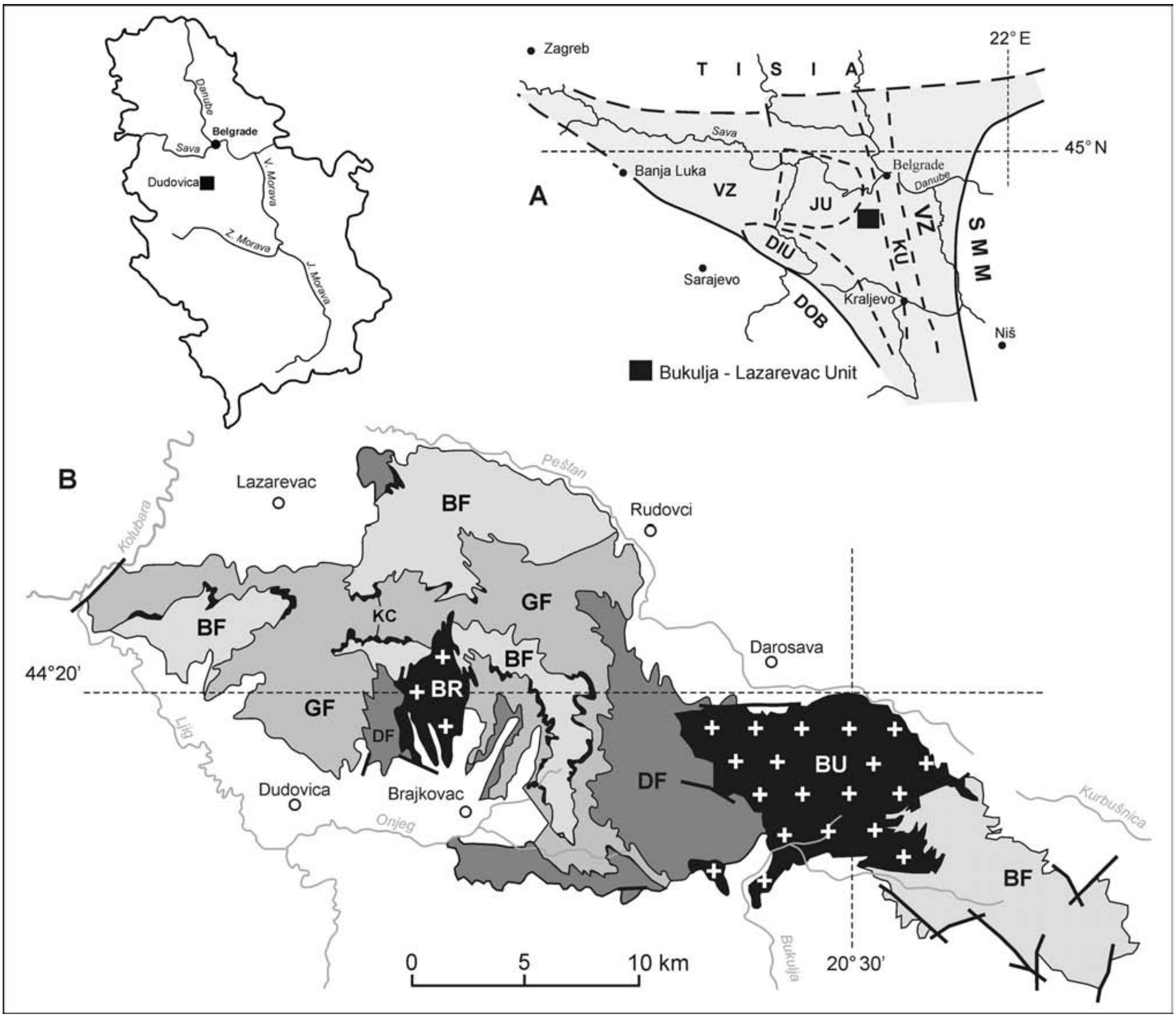

Fig. 1. Geographic position of Dudovica locality in Serbia; **A,** Position of Paleozoic tectonic units within Vardar Zone suture (according to KARAMATA, 2006 and ROBERTSON *et al*. 2009); **B,** Geological position of the Paleozoic sub-units - formations and Tertiary granitoid bodies within the Bukulja–Lazarevac Paleozoic Unit (according to TRIVIĆ *et al.* 2010). Abbreviations: **VZ,** Vardar Zone; **JU,** Jadar Unit; **DIU,** Drina–Ivanjica Unit; **KU,** Kopaonik Unit; **DOB,** Dinaride Ophiolite Belt; **SMM,** Serbo-Macedonian Massive; **DF,** Drina Formation; **GF,** Golija Formation; **KC,** Kovilje Conglomerates; **BF,** Birač Formation; **BR,** Brajkovac granodiorite; **BU,** Bukulja granite.

on the limbs of the larger fold structures; D3 affected D1 and D3 in a brittle manner. It should be stressed out that the age of these sub-units and phases of deformations has not yet been fully resolved (see TRIVIĆ *et al.* 2010; MAROVIĆ *et al*. 2007, and reference there in).

The contact metamorphic changes of various degree, took place due to the intrusion of the Brajkovac granodiorite, are recorded in the DF, GF and BF.

According to KOSTIĆ & PAVLOVIĆ (1978) the effects of contact metamorphism which could be seen even at a distance of 5 to 8 km from the exposed granodiorite mass indicates the existence of a much greater undiscovered body that could be linked to the Bukulja granite. The spread of the Brajkovac granodiorite to the northeast is supported by geophysical exploration in the area between Baroševac and Rudovci (~ 5–6 km from the exposed mass) where it was found at a depth of about 80 m (VUKAŠINOVIĆ 1970). In addition, the discovery of spotted slates in exploration boreholes at a depth of 110 m (Dudovica locality, about 8 km south of the exposed granodiorite; SREĆKOVIĆ-BATOĆANIN *et al.* 2013), also points to its much wider distribution. The above mentioned authors emphasized that the contact metamorphic changes within the basement? rocks took place at moderate P–T conditions recorded in feldspatic biotite-muscovite rich hornfelses with rare porphyroblasts of andalusite adjacent to contact, and feldspatized or metasomatized muscovite-biotite schists at some distance from it. FILIPOVIĆ *et al.* (1978) and FILIPOVIĆ *et al.* (1980) also recognized various types of hornfelses, sericite ± chlorite or biotite-muscovite schist (± andalusite) and feldspatized or metasomatized schists, at similar distance from the contact; data related to the conditions of contact metamorphism are lacking.

The Brajkovac granodiorite is not well studied yet. The available data on its composition and associated contact aureole are very scarce as can be seen from the previous discussion. It is classified as medium- to fine-grained, rarely porphyritic, hornblende-biotite granodiorite with local transition to tonalite (KOSTIĆ & PAVLOVIĆ 1978; FILIPOVIĆ *et al*. 1980; KNEŽEVIĆ *et al*. 1994). Small intrusions of aplitic granite and very rare aplite and pegmatite dykes are also noted. The main rock-type is granodiorite and is composed of quartz, plagioclase (32–38 % An), microcline, biotite and hornblende; accessories are epidote, allanite, titanite, apatite, zircon and Fe-Ti oxides; secondary minerals are calcite, chlorite, sericite and epidote.

Analytical techniques

The samples were examined in thin sections using a Leica DMLSP petrographic microscope with digital camera Leica DC 300. Chemical compositions of mineral phases were identified using a JEOL JSM-6610LV Scanning Electron Microscope that was connected to an X-Max Energy Dispersive Spectrometer. The samples were covered with carbon using a BALTEC-SCD-005 Sputter coating device, and the results were recorded under high vacuum conditions, with an accelerating voltage of 20 kV and a beam current of 0.5–1.8 nA. The scanning electron microscope is also used for imaging of specimens.

Results

The contact metamorphic rocks found at a depth of 110 m in the drillhole at Dudovica locality correspond to porphyroblast-bearing spotted slates (Fig. 2) formed under the influence of Brajkovac granodiorite (30–25 Ma) on low grade regionally metamorphosed argilaceous sediments of Paleozoic age. Their primary metamorphic fabric is completely preserved. The main mineral assemblage is quartz, muscovite (sericite), chlorite, biotite and cordierite-pinite; dusty ore minerals (magnetite), xenotime and monazite are accesories; secondary chlorite is also present. The grain sizes of foliated matrix minerals (white mica +quartz + chlorite ± neobiotite + dusty ores) range from <0.01 mm to 0.15 mm. Cordierite, occurring in oval to ellipsoidal poikilobalsts up to 5 mm in diameter, contains numerous inclusion of matrix minerals (white mica + quartz) ± neobiotite. Within all examined samples cordierite is almost completely altered to a bright yellowish pinite – a mixture of very tiny white micas, chlorite and probably clay minerals. Within some poikiloblasts a small accumulation (up to 0.25 mm) of secondary chlorite was found as overgrowths on pinite (Fig. 2A) Moreover, some porphyroblast are transformed into a bright orange-brown vitreus isotropic material probably formed as a weathering product. The relationships between cordierite poikiloblasts and regional foliation indicate their post-tectonic growth with respect to the Paleozoic (post-Variscan) deformation, i.e. cleavage (Fig. 2 A, B). Quartz, except as matrix mineral, makes small lens-shaped fine-grained mosaic aggregates parallel to schistosity. Biotite occurs in light brown flakes (< 0.3 mm in size) associated with matrix white micas (sericite–phengite) and chlorite. It is also found as inclusion

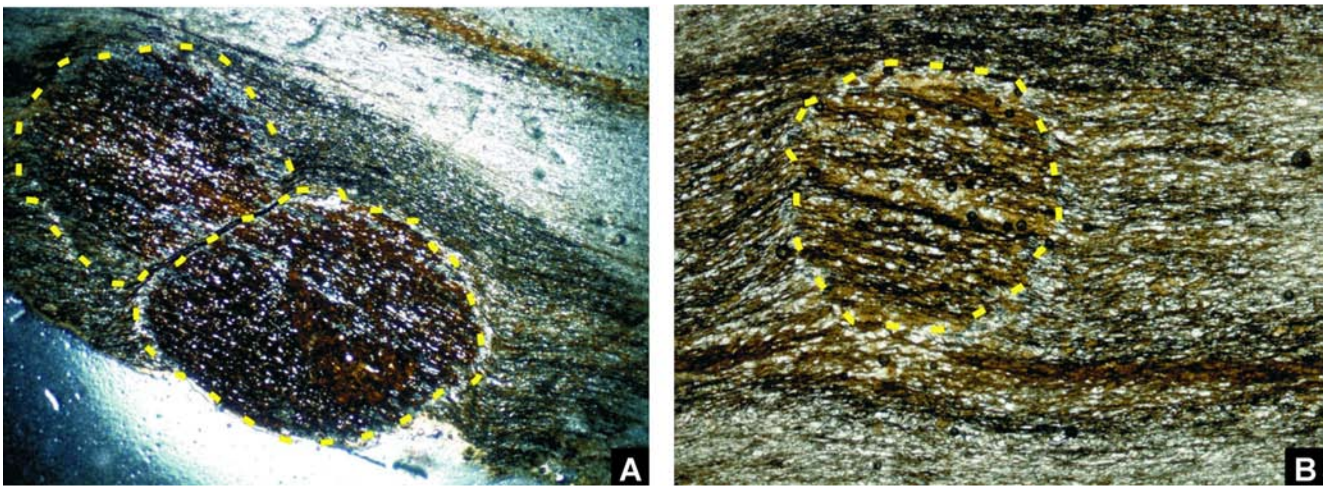

Fig. 2. Microphotographs of spotted slate from the core drilling at the depth interval of 108–110 m. **A,** Pinitized incipient cordierite poikiloblasts overgrowing pre-existing foliated quartz-sericite-chorite-biotite matrix with secondary chlorite overgrowths; **B,** Fine flakes of neobiotite formed at the expense of quartz-sericite-chlorite matrix; cordierite poikiloblast overgrowing the existing crenulated foliation; XPL, long dimension of photo is 6 mm (A) and 3 mm (B).

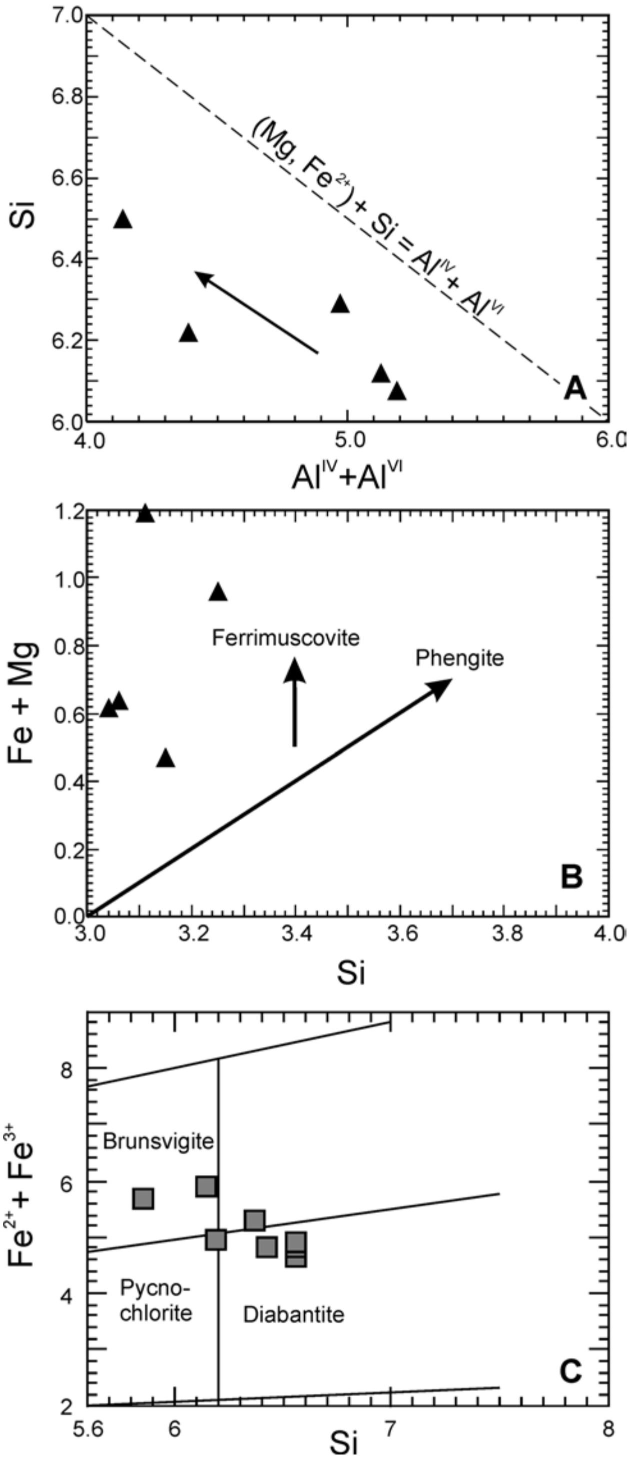

Fig. 3. Chemical composition of pinitic mixture phases in Si *vs*. Al^{IV}+Al^{VI} (A) and Fe+Mg *vs*. Si (B) diagram; (C) composition of secondary chlorite overgrowths on pinitized cordierite poikiloblasts in the classification diagram of HEY (1954).

in cordierite. Coarse calcite grains (up to 1 mm in size) are noted in some samples.

For the purpose of the present work only pinitized cordierite poikiloblasts and secondary chlorite overgrowths on pinite were analyzed; the results of the chemical analyses are shown in Table 1.

Pinite as a cordierite breakdown product is almost represented by a mixture of hydrous phyllosilicates i.e. phengite + chlorite + clay mineral phases (smectite?). The mixture of chlorite-white mica pinite is a known assemblage (e.g. DEER *et al*. 1962). The involvement of clay minerals is also reported (e.g. ÇERNY & POVONDRA 1967).

Generally, the Mg/Fe+Mg ratio of the micro- to crypto-crystalline pinitic mixture (phengite prevails) ranges from 0.14 to 0.63. The Na-free mixture (see analyses S2 & S3) with the Mg/Fe+Mg range of 0.27–0.35 shows deficiens in Al_{tot} (4.14–4.38 p.f.u.) as compared with mixture having Na (0.287–0.361 p.f.u.) – there Al_{tot} range varies between 4.97–5.19 p.f.u. The Si vs Al^{IV}+Al^{VI} relations deviate from the ideal muscovite-phengite join due to Tschermak substitution towards chloritic composition or more complex mixture including clay minerals which is reflected in the decrease of Al_{tot} and Si with increase of Fe^{2+} (Fig. 3A, B). The K content varies from 1.385 to 1.759 p.f.u.

The secondary chlorite overgrowths on pinite correspond to brunsvigite-diabandite (Fig. 3C, 4). The Mg/Mg+Fe ranges from 0.34 to 0.43.

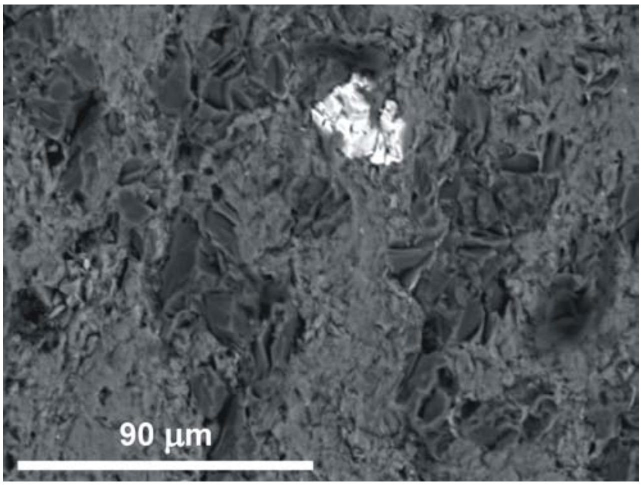

Fig. 4. BSE image of secondary chlorite overgrowths on pinitized cordierite poikiloblast and anhedral monazite crystal (white).

Disscusion and Conclusions

In exploration boreholes, at a depth of 110 m, pinite-cordierite spotted slates were found at Dudovica locality, about 8 km south of the Brajkovac granodiorite. Mineral assemblage (white mica + neobiotite + cordierite ± chlorite) and textural features indicate that these rocks were formed probably from low regionally metamorphosed argillaceous rocks of the DF in the temperature range 350–450 °C.

Pinite fractions within cordierite porphyroblast are composed of micro- to cripto-crystalline mixtures of

Table 1. Representative microprobe analyses of secondary chlorite and mixture phases from pinitized cordierite poikiloblasts.

No of analysis	Chlorite									Mixture phase spectrum				
	1	2	3	4	5	6	7	8	9	S1	S2	S3	S4	S5
SiO_2	31.51	28.00	27.07	31.37	30.23	30.08	31.82	29.69	31.01	43.85	46.37	44.38	46.36	44.29
TiO_2	0.00	0.93	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.62	0.00	0.00	0.00
Al_2O_3	17.87	16.10	18.07	19.07	17.44	18.39	16.75	18.16	18.66	31.79	25.06	26.58	31.08	31.50
FeO	26.61	32.07	31.43	27.67	29.95	26.86	28.52	28.45	27.89	8.71	11.31	12.53	2.93	8.03
MnO	0.45	0.48	0.54	0.43	0.47	0.46	0.44	0.47	0.51	-	-	-	-	-
MgO	10.83	9.43	10.24	8.94	10.45	11.39	11.85	11.43	10.40	0.83	2.40	3.82	2.79	1.43
CaO	0.79	0.30	0.38	0.36	0.00	0.75	0.46	0.74	0.78	-	-	-	-	-
Na_2O	-	-	-	-	-	-	-	-	-	1.07	0.00	0.00	1.37	1.14
K_2O	0.34	0.26	1.46	0.54	0.78	0.41	0.47	0.00	0.00	8.31	9.27	7.91	10.16	7.86
Total	88.40	87.57	89.22	88.38	89.32	88.34	90.31	89.37	89.25	94.56	95.03	95.22	94.69	94.25
	Based on 28 (O)									Based on 22 (O)				
Si	6.562	6.142	5.856	6.554	6.373	6.373	6.554	6.195	6.426	6.076	6.500	6.220	6.292	6.119
Al^{IV}	2.944	2.301	2.495	3.246	2.703	2.703	1.446	1.805	1.574	1.924	1.500	1.780	1.708	1.881
Sum_T	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
Al^{VI}	2.944	2.301	2.459	3.246	2.703	2.703	2.617	2.659	2.980	3.264	2.637	2.607	3.260	3.244
Ti	-	0.153	-	-	-	-	-	0.068	-		0.065			
Fe^{2+}	4.634	5.883	5.686	4.834	5.280	5.280	4.913	4.966	4.834	1.009	1.326	1.469	0.333	0.928
Mn	0.079	0.089	0.099	0.076	0.084	0.084	0.077	0.083	0.090	-	-	-	-	-
Mg	3.362	3.084	3.302	2.784	3.284	3.284	3.639	3.557	3.213	0.171	0.502	0.798	0.565	0.295
Ca	0.176	0.071	0.088	0.081	-	-	0.102	0.165	0.173	-	-	-	-	-
Na	-	-	-	-	-	-	-	-	-	0.287	-	-	0.361	0.305
K	0.090	0.073	0.403	0.144	0.210	0.210	0.124	-	-	1.469	1.658	1.414	1.759	1.385
Cations	19.285	19.654	20.037	19.165	19.561	19.561	19.472	19.498	19.290	14.200	14.188	14.288	14.278	14.157
Mg/Mg+Fe	0.42	0.34	0.37	0.37	0.38	0.38	0.43	0.42	0.40	0.14	0.27	0.35	0.63	0.24

phengite, chlorite, clay minerals (smectite?) and quartz as well as of some amorphous gel-like material mixed with fine limonite material. Their formation could be considered as a retrogressive process involving hydration reaction caused by fluid infiltration released during the heating of the aureole (e.g. transformation of mixed-layered clay minerals into chlorite and rearrangement of illite into sericite i. e. phengite due to coupled substitution of Si and Fe^{2+} or Mg for 2Al), or from the intrusion of the granitic body. This water with dissolved ions leached from the unstable clay and phyllosilicate minerals, or fluids released during the cooling of the granitic body can cause occurrence of various retrogressive products within the cordierites.

The brunsvigite-diabandite chlorite overgrowths on pinitized cordierite are probably formed in the temperature range 250–350 °C due to circulation of still hot hydrothermal K-bearing fluids according to the reaction:

$$Crd + K^+ + OH^- + H_2O \rightarrow \text{K-bearing White Mica} + Chl$$

So far, the composition of pinite and its petrological significance has not been resolved yet. The SEM analyses done in this study are not sufficient for complete identification of pinitic phases. Detailed model reaction can only be done using more sophisticated methods as for example, TEM (Transmission Electron Microscopy), RS (Raman spectroscopy), and FTIR (Fourier Transform Infrared spectroscopy).

The first finding of pinite-cordierite spotted slates within the contact metamorphic aureole of the Brajkovac granodiorite contributes to a better understanding of granodiorite history as well as of its relationship with Paleozoic formations.

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Резиме

Пинитизирани кордијерит у бобичавим шкриљцима из контактног ореола Брајковца (Дудовица, централна Србија)

Хорнбленда-биотитски гранодиоритски масив Брајковца, са локалним прелазима ка тоналитима и леукогранитима је средњо- до ситнозрнасте, ређе порфироидне структуре. Испресецан је ретким танким жицама аплита и пегматита. Интрузијом гранодиорита Брајковца (30–25 мил. год.) стене из формација Дрина, Голија и Бирач (издвојене на основу литолошких и структурних карактеристика у оквиру геотектонске јединице Букуља–Лазаревац) контактно су метаморфисане у различите типове слејтова, бобичавих шкриљаца и хорнфелса. На непосредном контакту уочене су и врло уске зоне слабе мигматизације (до 1 m). Ефекти контактног метаморфизма уочени на удаљеностима између 5–8 km од гранодиоритског тела геофизичким испитивањима у подручју Барошевца и Рудоваца указују на постојања веће, неоткривене интрузије која је највероватније повезана са гранитом Букуље. У складу са овом претпоставком је и налазак бобичавих шкриљаца са пинитизираним порфиробластима кордијерита који су окривени у истражним бушотинама у подручју Дудовице (око 8 km јужно од Брајковца) на дубини од 110 m. Ове контактнометаморфне стене су изграђене од кварца, мусковита (серицита), хлорита, биотита и кордијерита-пинита. Прашкасти метални минерали (магнетит), ксенотим и монацит су акцесорни, а као секундарни састојци појављују се хлорит и крупнозрни калцит (до 1 mm) у виду нагомилања. Овални до елипсоидни појкилобласти (порфиробласти) кордијерита, величине до 5 mm у пречнику, у свим испитиваним узорцима замењени су пинитом (мешавином ситнољуспастог серицита , хлорита и евентуално минерала глина) у различитом степену.

Састав пинита, ако се узму у обзир расположиви литературни подаци, још увек није потпуно дефинисан. Може да се састоји од: а) врло финозрних агрегата минерала из групе филосиликата и/или аморфне оптички изотропне материје; б) хлорита, мусковита и минерала глина, као и мешавине минерала глина; ц) изотропних алтерационих продуката. Нејасно је, такође, да ли је пинит представља само фазу у развоју кордијерита у току прогресивног метаморфизма или резултат ретроградних процеса и при којим P-T-X условима почиње трансформација?

У испитиваним стенама пинит је развијен на рачун слабо рекристалисалог и контактно метаморфисаног кварц–серицит–хлоритског (± необиотит) матрикса; уклапајући га не ремети примарни фолијативни склоп стене. Осим уклопака минерала основе порфиробласти садрже и ситне љуспе необиотита, а некад и у већем броју инклузије ксенотима и монацита. Пинитске партије у њима састоје се од криптокристаласте мешавине серицитског материјала и стакласте изотропне геласте материје измешане са финодиспергованим лимонитом. У неким порфиробластима уочена су и секундарна нарастања хлорита. Криптокристаласте

пинитске партије (преовлађује фенгит) имају Mg/Fe+Mg однос између 0.14–0.63. У фазама без Na (анализе S2 и S3, Табела 1) Mg/Fe+Mg однос јесте 0.27–0.35, а садржај Al_{tot} (4.14–4.38 p.f.u.), и знатно је нижи него у фазама са Na (0.287–0.361 p.f.u.). Однос Si и Al^{IV}+Al^{VI} одступа од идеалног мусковит-фенгит пара и чермакитске супституције ка више хлоритским саставима или чак ка комплексијим мешавинама укључујући и минерале глина: одражава се опадањем Al_{tot} и Si са растом Fe^{2+}. Садржај калијума износи 1.385–1.759 p.f.u. Секундарни хлорит настао по пиниту одговара по саставу брусвингиту идиабандиту. Вероватно је настао на температурама 250–350 °C у фази кретања још топлих флуида богатих калијом, по следећој реакцији:

$$\mathrm{Crd} + K^{+} + OH^{-} + H_2O \rightarrow \text{K-лискун} + \mathrm{Chl}$$

Добијени подаци показују да су пинит-кордијеритски бобичави шкриљци формирани у температурном опсегу између 300–450 °C на рачун слабо регионално метаморфисаних глиновитих седимената из Дрина формације. Пинитске партије у кордијериту могле су бити образоване или ослобађањем флуида у фази загревања околних стена при процесима трансформације минерала глина у хлорит или илита у серицит (фенгит) при чермакитској субституцији S или пак под утицајем флуида ослобођених при хлађењу гранодиорита Брајковца.

Важно је истаћи да је ово први налазак пинита у контактном ореолу гранодиорита Брајковца и да су добијени резултати, сходно коришћеним методама, само први корак у испитивањима која следе уз примену далеко осетљивијих метода како би се идентификовале све минералне фазе.