GEOLOGICA CARPATHICA, 45, 1, BRATISLAVA, FEBRUARY 1994
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METAMORPHISM OF THE JÁNOV GRÚŇ LOWER PALEOZOIC VOLCANO-SEDIMENTARY FORMATION (VEPORIC UNIT, WESTERN CARPATHIANS)

OTO MIKO[1] and SERGEY P. KORIKOVSKY[2]

[1]Dionýz Štúr Institute of Geology, Mlynská dolina 1, 817 04 Bratislava, Slovakia
[2]Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry, Russian Academy of Sciences, Staromonetny er. 35, 109 017 Moscow, Russia

(Manuscript receiced January 13, 1993; accepted in revised form October 5, 1993)

Abstract: Authors present evidence on the low-grade progressive Variscan metamorphism of the Lower Paleozoic Jánov Grúň Formation occurring in the eastern part of the Nízke Tatry Mts. The metamorphic conditions determined indicate temperatures about 340 - 370 °C and pressures 340 - 400 MPa (3.4 - 4 kbar).

Key words: Variscan, low-grade metamorphism, Veporic Unit, Nízke Tatry Mts., Western Carpathians.

Introduction

In 1981 Miko for the first time published data on the Lower Paleozoic low grade metamorphic volcano-sedimentary formation of the Jánov Grúň belonging to the northernmost units of the Veporic crystalline basement.

Brief characteristics of the formation

The Jánov Grúň Formation is situated in the eastern, Kráľova Hoľa part of the Nízke Tatry Mts. It builds a belt about 18 km long and 4 km wide running in the SWW - NEE direction beyond the villages of Beňuš, Bacúch and Polomka (Fig. 1). The formation also comprises a small basement occurrence at Bystrá. A probable continuation of the formation to the southwest is the basement of the Krakľová Formation (Korikovsky & Miko 1992) situated in the Vepor Mts. south of the river Hron.

Amongst older, more important papers dealing with the problems of the studied area, the works of Kettner (1927), Zoubek (1935, also in Maheľ et al. 1964) and Máška & Zoubek in Buday et al. (1961) are to be mentioned.

The structure of the mentioned part of the Nízke Tatry Mts. is Alpine, block-slice (Klinec et al. 1973, 1976; Biely et al. 1992). The position of the formation and its relation to adjacent areas was described by Miko (1981), Miko & Ivanička (in print) an partly by Siegl (1978) and Putiš (1989). The age of rock complex, determined by palynology, is Devonian - Lower Carboniferous (Planderová & Miko 1977). The formation is built up mainly by metapelites, metasandstones, locally metagreywackes which are metamorphosed to phyllites. A characteristic feature is the presence of acid volcanogenic rocks: metarhyodacites, metadacites and their volcanoclastics, in lesser amount also of basic volcanics: metadiabases and basic volcanoclastics matamorphosed to greenschists. The volcanism was calc-alkalic, with rocks belonging to the contrasting spilite-diabase-keratophyre formation (Miko l.c.). Typical is the occurrence of quartz-tourmaline rocks (Miko & Hovorka 1978).

Lithological and petrographical characterization of the rocks and their chemical composition

An important rock type of the Janov Grúň Formation are acidic *meta-eruptives* the abundance of which appears to be a significant distinguishing criterion of the formation compared to other Lower Paleozoic formations and complexes of the Tatric and Veporic basement. Mainly *Phn-Bt-Plg (Ab)-Kfs -Qtz metarhyodacites* and their *metavolcanoclastic analogues* are concerned here. Among magmatic minerals, corroded quartz phenocrysts, plagioclase and K-feldspars along with dark-brown magmatic biotite are preserved (Figs. 2, 3). The magmatic minerals were also observed in the metavolcanoclastic rocks showing distinct features of primary tuffogeneous textures (blasto-crystalloclastic - Fig. 4; blasto-lithoclastic and other). The rocks are in many cases schistose and recrystallized. Phenocrysts and crystalloclasts are often deformed, granular and stretched along dynamofluidal schlieren (Fig. 5). Matrix is metamorphosed into fine-graned, locally folded Phn-Bt-Ab-Kfs-Qtz aggregate (Fig. 6).

Chemically the rocks belong to dacites, less to rhyodacites. The K_2O contents are usually higher than Na_2O, but they can be also lower. The iron content varies widely, X_{Fe} ranging between 0.36 - 0.67 (Tab. 1).

Amphibole-epidote-chlorite-albite greenschists were originally diabases, diorite porphyrites and basic tuffs. Quartz is rare or absent. They often show remnants of magmatic and tuffogeneous textures. Chemical analyses of the metamorphosed products of basic volcanism are given in Tab. 2.

Mineral abbrevations: Ab - albite, Act - actinolite, An - anortite, Bt - biotite, ($_{mag}$ - magmatic, $_{met}$ - metamorphic), Chl - chlorite, Ep - epidote, Hbl - hornblende, Kfs - K feldspar, Ms - muscovite, Ort - orthoclase, Phn - phengite, Plg - plagioclase, Qtz - quartz, Ser - sericite, Ttn - titanite.

Metasediments of the Jánov Grúň Formation are represented by various phyllite varieties. *Ms-Chl-Qtz phyllite* (Fig. 7) with greyish-greenish to dark colour depending on the amount of organic matter is the prevailing rock type. The organic matter

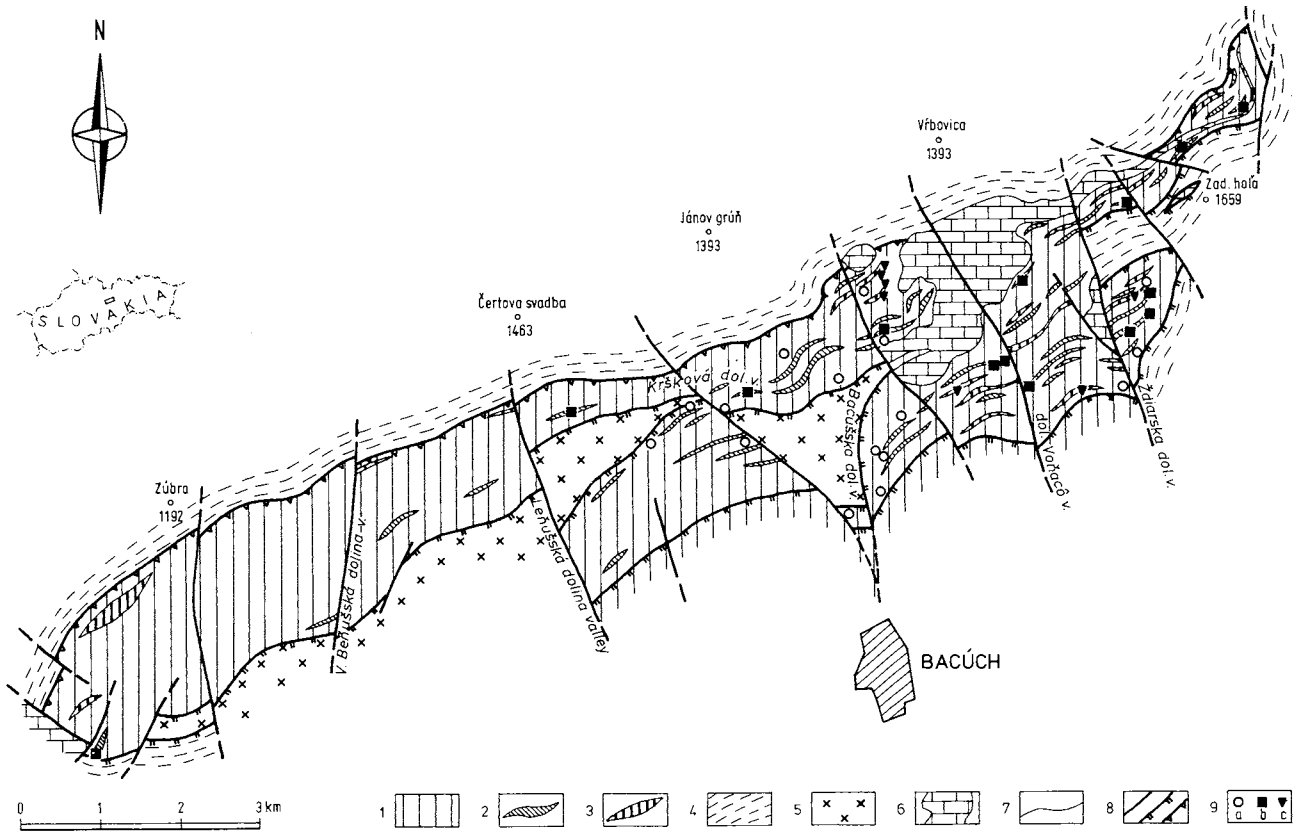

Fig. 1. Sketch of the Jánov Grúň Formation geological position; the Veporic crystalline complex, eastern part of the Nízke Tatry Mts. (drawn by Miko 1988).
Legend: 1-3 Jánov Grúň Formation: 1 - metasediments (total), 2 - metamorphosed products of acid volcanism, 3 - metamorphosed products of basic volcanism, 4 - metamorphosed rocks of the Hron complex (total), 5 - granitoid bodies, 6 - Mesozoic cover (total), 7 - primary geological boundary, 8 - tectonic relations of various categories, 9 - localization of chemically analysed samples, a - metasediments, b - acid Paleovolcanic rocks, c - basic Paleovolcanic rocks.

contents are generally low, the maximum C content is 0.13 wt. %. Tourmaline and ilmenite are abundant in phyllites. A common variety is the spotted *Ms-Chl-Ab-Qtz phyllite* with large porphyroblasts of metamorphic albite bearing the signs of growth rotation (Fig. 8). According to chemical analyses the phyllites belong to the group of Al- and K- rich rocks with increased (X_{Fe} 0.5 - 0.7) and, with some exceptions, also with low Na/(Na+K) ratio indicating the dominance of muscovite rather than albite. This petrochemical characteristics is typical of originally clay-rich sediments with prevailing hydromicas, the rocks from which the phyllites probably originated.

Another abundant member of the formation are *Ms-Chl-Ab-Qtz metasandstones* or *quartz phyllites* with dominating quartz and albite. They often contain remnants of blastopsammitic textures (Fig. 9). Compared to phyllites, they in addition to SiO_2 show increased Na/(Na+K) ratios. In spite of lower Al contents, the Al/(Mg+Fe) ratios and X_{Fe} 0.4 - 0.8 are high in this variety (Tab. 3). *Metagreywackes* of the composition Chl ± Phn ± Ab + Qtz differ form other metasediments by more melanocratic composition with abundant chlorite and often carbonate (calcite).

Mineral assemblages and metamorphic conditions

The evidence has already been presented regarding the low-grade progressive, Variscan (Bretonian phase?) metamorphism of the Jánov Grúň Formation, based on mineralogical, petrographical, geological and stratigraphical data. Relatively well preserved remnants of primary sedimentary and volcanic textures (blastoporphyritic, blastocrystalloclastic, blastopsammitic and other) are present in the rocks. Only low-grade (greenschists facies) metamorphic minerals were found with no relics of high-temperature associations (Miko 1981). The use of the so-called graphite thermometer yielded the maximum metamorphic temperature not exceeding 425 °C (Shengelia et al. 1978). Recently, Sassi & Vozárová (1992) studied the metamorphic conditions based on the b_o values of muscovites from the rocks not influenced by the Alpine metamorphism. They confirmed the low-pressure character of the Variscan metamorphism and temperatures of 350 - 430 °C. The preservation of palynomorphs and quartz-tourmaline rocks may be considered as another indirect evidence.

As noted above, some well preserved primary magmatic minerals were observed in acid meta-eruptive rocks of the studied formation. The primary biotite flakes contain over 3 wt.% TiO_2 (Tab. 4). They, however, are also partly recrystallized and altered to aggregates of lighter metamorphic biotites with abundant secondary titanite or rutile grains. The presence of feldspar phenocrysts, manly plagioclases, is indicated often only by pseudomorphic low-temperature K-feldspars and albite.

Both volcanic and sedimentary rocks suffered from low-grade progressive metamorphism. The following metamorphic minerals occur in metasediments and metamorphosed acid volcanics:

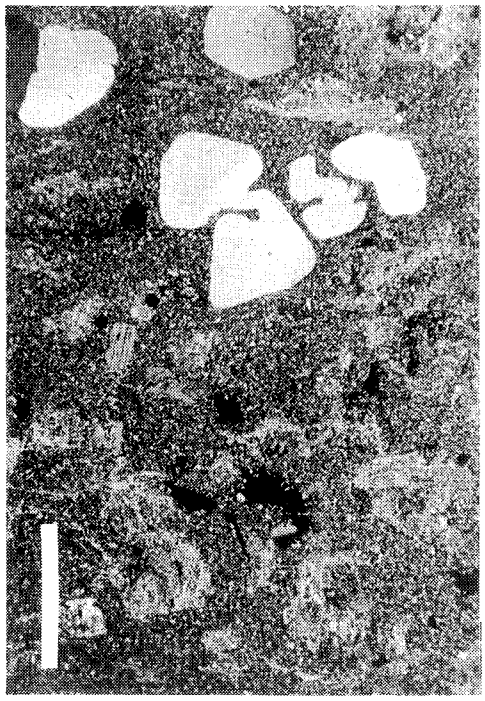

Fig. 2. Metadacite with corroded quartz phenocrysts. Plagioclases are partly replaced by sericite and albite. Sample 56, crossed nicols, the length of scale: 1 mm. The magnification is same in all photomicrographs.

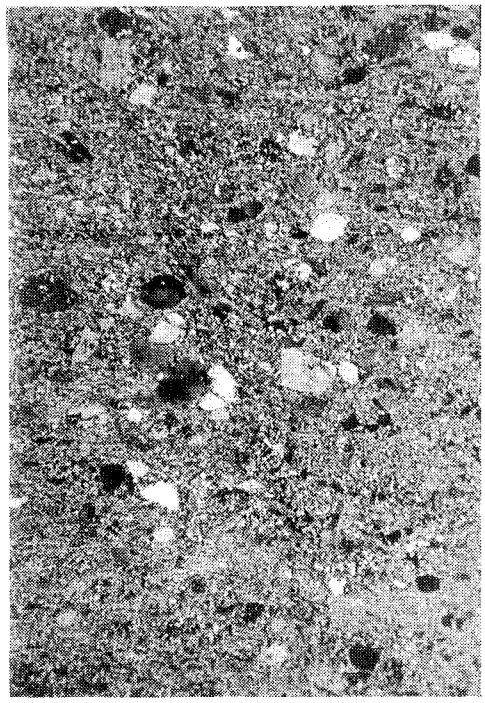

Fig. 4 Relatively well preserved blasto-crystalloclastic texture of a non-schistose, acid metavocanoclastic rock. Sample 150, crossed nicols.

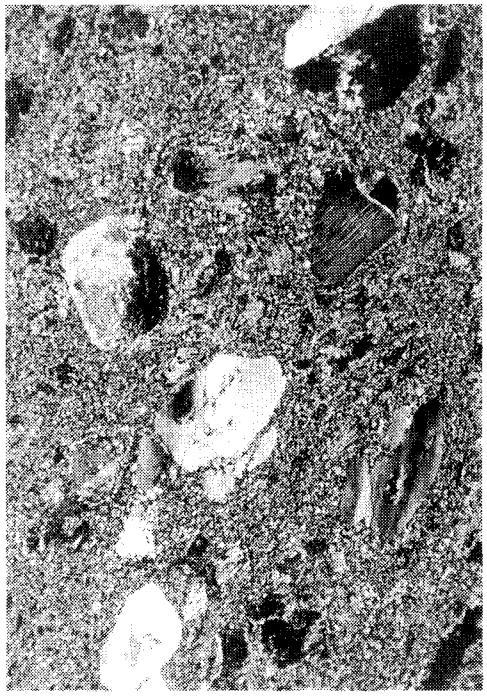

Fig. 3. Blastoporphyric texture of metarhyodacite with quartz, plagioclase and perthitic K-feldspar phenocrysts. Sample 516, crossed nicols.

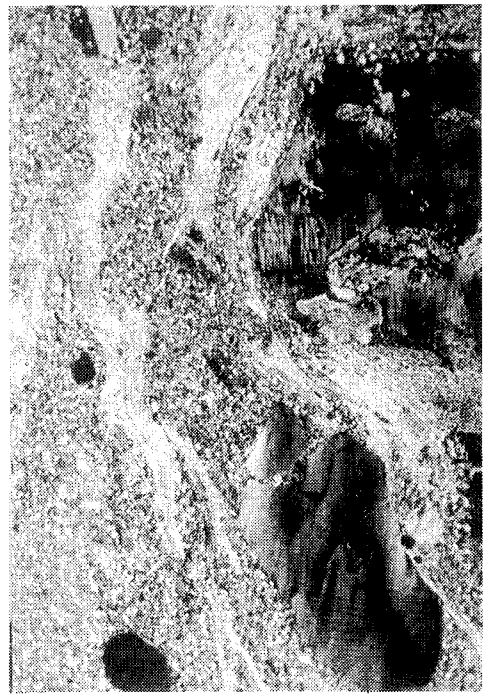

Fig. 5 Intensive deformation of metarhyodacite with cracked quartz and K-feldspar phenocrysts. The phenocrysts are flowed round by thick dynamofluidal schlieren. Sample 206, crossed nicols.

Table 1: Chemical composition of acid metavolcanic rocks (in wt.%).

	metadacites-metaryodacites						metavolcanoclastic rocks							
Sample No.	22	57	15	30	191	217	41	18	34	31	134	27	301	241
SiO_2	65.82	67.69	67.71	67.82	69.94	70.26	66.93	67.41	67.58	68.86	69.31	69.33	70.37	71.24
TiO_2	0.80	0.50	0.80	0.80	0.32	0.31	0.80	0.70	0.70	0.64	0.27	0.80	0.37	0.31
Al_2O_3	16.57	14.98	15.81	15.30	15.56	14.86	15.05	16.06	15.30	16.15	15.14	15.04	14.90	15.13
Fe_2O_3	0.75	1.37	0.35	0.70	1.18	2.09	1.00	1.04	0.64	1.94	1.98	0.28	1.26	1.86
FeO	2.00	2.76	2.73	2.58	0.86	0.08	2.15	2.29	2.29	2.78	1.20	2.43	0.28	0.19
MnO	0.15	0.09	0.10	0.09	0.05	0.13	0.09	0.14	0.09	0.10	0.04	0.09	0.09	0.07
MgO	2.42	1.10	2.01	2.21	1.04	0.68	1.82	1.60	2.21	2.07	0.97	2.01	1.34	0.99
CaO	1.68	2.36	1.68	1.40	1.31	1.15	1.68	0.84	1.12	0.99	1.45	1.68	0.94	0.30
Na_2O	3.00	3.74	3.40	3.00	4.35	0.30	2.10	2.40	2.10	1.81	4.08	3.00	3.46	2.09
K_2O	4.00	3.40	4.00	3.80	2.77	7.04	6.46	5.70	5.20	1.89	3.06	4.00	4.60	4.68
P_2O_5	0.24	0.19	0.20	0.22	0.03	0.04	0.16	0.20	0.16	0.19	0.14	0.16	0.04	0.04
H_2O^+	2.66	1.05	1.06	1.89	2.10	2.59	2.02	1.58	2.11	2.16	2.07	1.15	1.51	2.27
H_2O^-	0.25	0.00	0.22	0.14	0.06	0.00	0.11	0.24	0.18	0.07	0.20	0.14	0.09	0.15
SO_3	-	0.83	-	-	0.14	0.31	-	-	-	-	-	-	0.41	0.25
Sum	100.34	100.06	100.07	99.95	99.71	99.84	100.37	100.20	99.68	99.65	99.91	100.11	99.66	99.57
(X_{Fe}); Fe_{tot}/Fe_{tot}+Mg	0.38	0.67	0.46	0.44	0.50	0.61	0.48	0.53	0.42	0.55	0.63	0.43	0.36	0.51
Na/Na+K	0.53	0.62	0.57	0.54	0.70	0.06	0.40	0.39	0.38	0.59	0.67	0.53	0.53	0.40
K/Al+Mg+Fe_{tot}	0.20	0.19	0.21	0.20	0.16	0.44	0.36	0.30	0.28	0.09	0.18	0.22	0.28	0.29

Localization: **22** - NNW of Polomka, the ridge between L. and P. Ráztoka , 200 m NNW of el.p. 893.3 m. **57** - NW of Bacúch southern slopes of the Krškova valley, 250 m SW of el.p. 969.0 m. **15** - N of Polomka, rock cliffs in the Pravá Ráztoka valley, 600 m NNE of el.p. 893.3 m. **30** - NNE of Bacúch, the ridge SW of Babiná (1515.3 m), 300 m SW of el.p. 1392.2 m. **191** - NNW of Bacúch, N slopes of the Krškova valley, 600 m S of el.p. 1069.1 m. on the Jánov Grúň ridge. **217** - NW slopes of Zadná hoľa (1659.2 m), in the end of Malužiná valley, 550 m NEE of el.p. 1059.2 m. **41** - NW of Zadná Hoľa (1659.2 m), the saddle 350 m S of Kvasná (1423.5 m). **18** - N of Polomka, W slopes of the Pravá Ráztoka, 550 m NE of el.p. 1071.3 m. **34** - NNE of the Zadná Hoľa (1659.2 m), upper part of the Hodruša valley, 100 m NW of el.p. 1291.0 m. **31** - NNE of Bacúch, the ridge between Javorinka (1240.5 m) and Babiná (1515.3 m), near the el.p. 1433.5 m. **134** - E slopes of the Bacúch valley before the confluence with Nemcova valley, 250 m SE of el.p. 840.8 m. **27** - NNW of Polomka, the Voňacô valley, 300 m SWW of el.p. 1293.0 m. **301** - SE slopes of the Sokolova valley, channel 350 m NWW of Babiná (1515.3 m). **241** - E of Mýto pod Ďumbierom, the ridge between Hudák and Ježova valley, near el.p. 729.3 m.
The samples 15, 18, 22, 27, 30, 31, 34, 41 were analysed by V. Dvonč (1973), 57, 191, 217, 241, 301 by V Šaturová (1973, 1977) and 134 by M. Ďuriš (1976), all from the GÚDŠ chemical laboratory staff, Bratislava.

muscovite-phengite micas, biotite, chlorite, K-feldspar, albite, quartz, carbonates, ilmenite and tourmaline. Garnet was not found. Sassi & Vozárová (1992) report also *paragonite*-bearing phyllites. Microprobe analyses of some minerals from typical assemblages are given in Tabs. 4, 5 and Fig. 10. The minerals were analysed by the CAMECA MS-46 microprobe in IGEM Russian Academy of Sci., Moscow.

Mg, Fe-rich and Na-poor *phengites* are present in acid metavolcanics (Tab. 4, sample 24) in the assemblage Phn + Kfs + Bt. On the other hand, Al-rich and Mg, Fe-poor *muscovites* are often found in chlorite-muscovite phyllites (Tab. 5, sample 326).

Newly formed metamorphic *biotites* forming fine-grained aggregates were observed only in acid metasediments and metavocanoclastic rocks, in metasediments are absent. Compared to magmatic biotites, they are lighter with lower TiO_2 contents (below 3 wt.%). In the rocks of the Jánov Grúň Complex, similarly as in other areas (Korikovsky 1979; Korikovsky & Miko 1992), the biotite crystallization is determined by the rock composition. It can well be seen in the plot Al-K-(Mg,Fe), in Fig. 10, where almost all metasediments plot in the Chl + Ms + Phn field due to the lower K/(Al + Mg + Fe_{tot}) ratio. This may be accounted for by their chlorite-muscovite composition and the lack of biotite. On the other hand, the acid metavolcanics and metavolcanoclastics with higher K/(Al + Mg + Fe_{tot}) ratios plot in the Bt + Chl + Phn and Bt + Phn + Kfs fields. This explains the crystallization of biotite in these rocks along with muscovite-phengite or chlorite. Moreover, the rocks with compositions close to the Kfs + Ms-Phn join, lack both metamorphic biotite and chlorite. The only mica present is muscovite - phengite. The acid metavolcanics without biotite are very rare in the Jánov Grúň Formation.

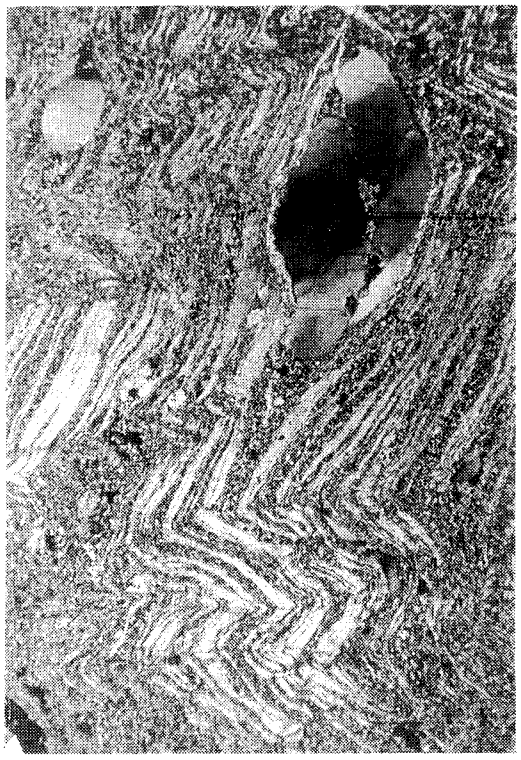

Fig. 6. Folded texture of deformated acid metavolcanoclastic rocks. Sample No. 350, crossed nicols.

Fig. 8. Texture of chlorite-albite phyllite with rotated albite porphyroblasts. Sample 270, plane polarized light.

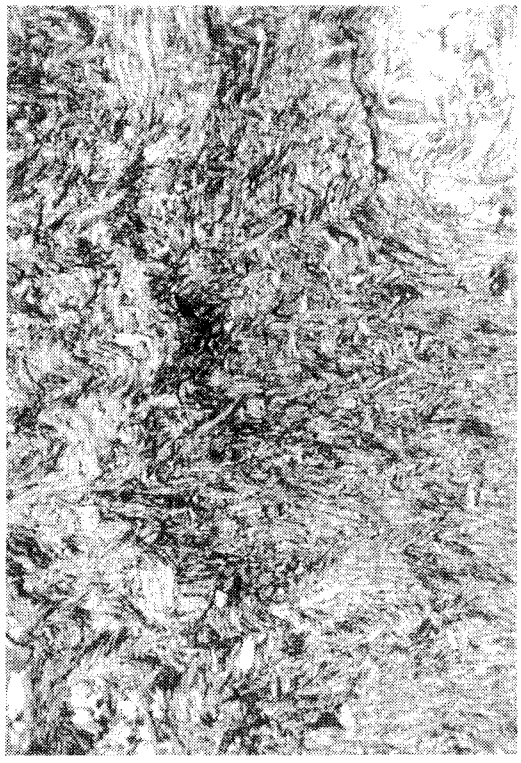

Fig. 7. Finely folded granolepidoblastic to lepidoblastic phyllite texture (without albite). Sample 25, crossed nicols.

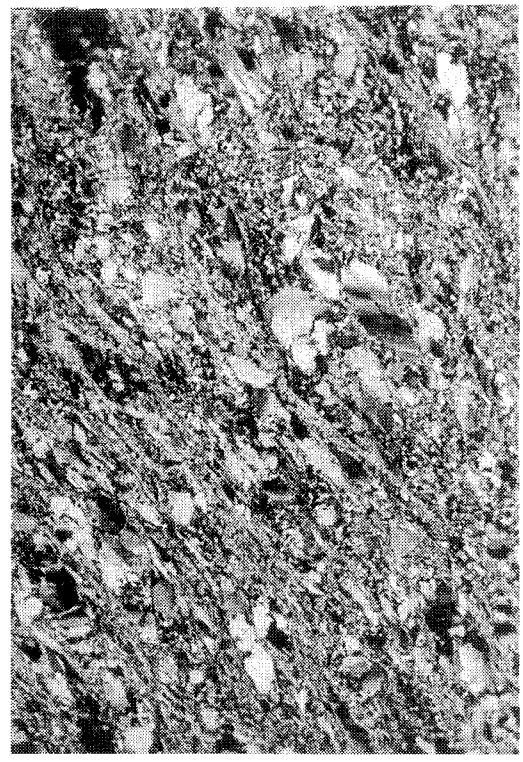

Fig. 9. Blastopsammitic texture of schistose metasandstone. Sample 162, crossed nicols.

Table 2: Chemical composition of basic metavolcanic rocks (in wt.%).

	7g	7i	293	87	7j	4a	19
SiO_2	45.70	47.37	48.64	48.99	49.13	49.54	54.37
TiO_2	1.61	2.01	0.92	1.09	1.48	1.61	1.47
Al_2O_3	14.78	14.91	16.30	17.09	14.61	15.04	16.62
Fe_2O_3	3.99	7.76	4.87	4.66	4.62	4.34	6.71
FeO	8.37	8.77	6.50	5.73	9.05	9.81	5.06
MnO	0.16	0.22	0.18	0.16	0.22	0.24	0.10
MgO	9.58	5.54	7.20	6.48	6.85	6.45	3.97
CaO	10.51	4.07	5.24	11.25	8.13	6.17	5.03
Na_2O	2.07	4.26	3.75	0.57	3.08	4.65	1.83
K_2O	0.42	0.10	3.17	0.17	0.40	0.24	0.18
P_2O_5	0.15	0.20	0.24	0.19	0.16	0.17	0.66
H_2O^+	2.27	4.28	2.53	3.03	2.07	1.50	3.58
H_2O^-	0.13	0.20	0.15	0.15	0.12	0.15	0.06
SO_3	0.10	0.34	-	-	0.20	0.03	-
Sum	99.84	100.03	99.69	99.56	100.12	99.94	99.64

Localization: **7g** - N of Bacúch, Jančíkova valley, N of el. p. 840.8 m, metadiabase. **7i** - see sample 7g, **293** - NNE of Bacúch, upper part of the Sparistá valley, 650 m NW of Javorinka (1240.5 m),Chl-Ep±Bt-Hbl_{Mg}-Ttn-ore-Ab±Qtz basic metatuff (greenschist). **87** - NNW of Polomka, W slopes of Ždiarska valley, 500 m SE of el.p. 1293.0 m, Hbl_{Mg}-Chl-Ep-Carb-Ttn-Ab-Qtz basic metatuff (greenschist). **7j** and **4a**, see sample 7g. **19** - N of Polomka the ridge between L. and P. Ráztoka, 250 m NE of el.p. 1071.3 m., Chl-Ep-Carb-ore (much)-Ttn-Ab-Qtz metadiorite - porphyrite. Bt_{mag}-Chl+Ser±Ttn.
Note: Samples 7g, 7i, 7j, 4a: material and rock name in: Bajaník (1980). Samples 7g, 7i, 7j, 4a were analysed by E. Gromová and M. Tulinská, laboratory of Geological Survey, Turčianske Teplice, 1976. Samples 19, 87, 293 were analysed by M. Ďuriš, chemical laboratory GÚDŠ, Bratislava

The chemical composition of *feldspars* also reflects low-grade conditions of metamorphic recrystallization. K-feldspars have very low Na content (X_{Na} = 1.2 %) and plagioclases are represented by almost pure albite (Tab. 4).

In the greenschists of the Jánov Grúň Complex are present light green *amphiboles, chlorite, epidote, carbonate, albite, ilmenite and titanite*. Ca-amphiboles with moderate Al_2O_3 (8.7 wt.%) represent a transitional type, edenitic hornblende.

The basic rocks and their minerals from Tab. 2 and 5 are plotted in the Ca-Al-(Mg, Fe) diagram, Fig. 11. All the points lie in the Hbl(Act) + Ep + Chl (+Ab ±Qtz) field confirming their origin from a basic magmatogenic or tuffogenic material.

The chemical composition of minerals points to low temperature conditions of progressive metamorphism in the biotite subfacies. The temperature of metamorphism was estimated on the basis of petrogenetic grid (Korikovsky 1979). The progressive Variscan metamorphism occurred at temperatures 340 - 370 °C.

The Phn-Bt-Kfs-Qtz geobarometer (Massonne & Schreyer 1987) was used for pressure determination. The maximum content of Si^{4+} in phengites of the studied rocks is 3.2 - 3.23, which, at estimated temperatures, corresponds to the pressures of P_s = 340 - 400 MPa (3.4 - 4.0 kbar).

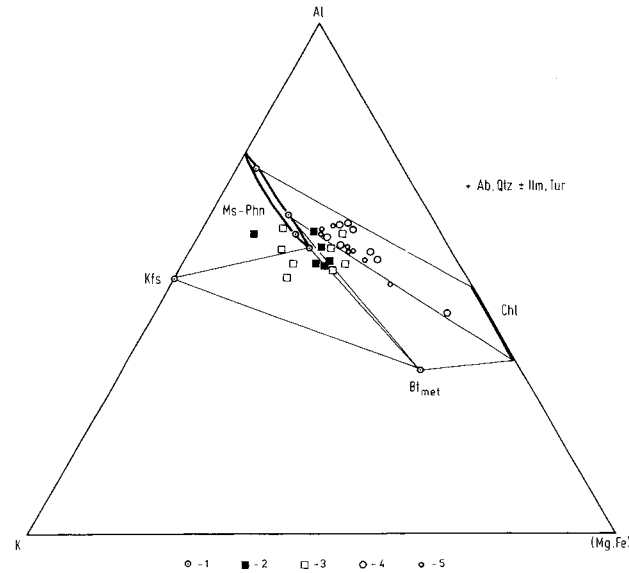

Fig. 10. Phase diagram of equilibrium mineral associations in metamorphosed acid Paleovolcanic rocks and metasediments of the Jánov Grúň Formation.
1 - composition of minerals (microprobe analyses, Tabs. 4-5), rock compositions (Tabs. 1 and 3), 2 - metadacites and metarhyodacites, 3 - metamorphosed acid volcanoclastic rocks, 4 - phyllites, 5 - metasandstones.

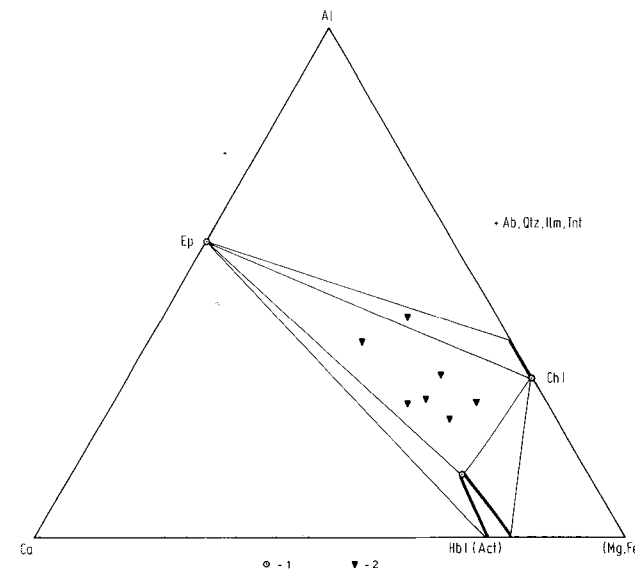

Fig. 11. Phase diagram of equilibrium mineral associations in metamorphosed basic Paleovolcanic rocks and metasediments of the Jánov Grúň Formation.
1 - composition of minerals (microprobe analyses Tab. 5), 2 - rock compositions (Tab. 2).

The Jánov Grúň Formation was, along with other Variscan metamorphic crystalline basements, granite bodies, and the so-called Bacúch Mesozoic, metamorphosed by Alpine deformation - recrystallization processes. Their intensity, however, was lower than that of Variscan progressive metamorphism. The Alpine dislocation metamorphism is bound to narrow belts in immediate vicinity of fracture zones and tectonic contacts.

Table 3: Chemical composition of metasediments: Chl + Ms-Phn ± Ab + Qtz + Ilm ± Tur phyllites, Chl + Ms-Phn + Ab + Qtz ± Ilm ± Tur metasandstones.

	phyllites								metasandstones							
Sample No.	354	393	153	25	63	499	205	103	367	270	164	289	253	267	154	67
SiO_2	52.26	55.08	56.56	56.68	56.70	59.53	61.20	64.70	69.70	72.86	74.13	75.68	79.30	79.60	82.81	84.74
TiO_2	1.28	1.24	0.98	1.00	0.86	1.07	0.95	0.81	0.85	0.65	0.97	0.89	0.70	0.58	0.74	0.55
Al_2O_3	23.42	15.50	19.81	21.35	20.85	20.42	18.72	17.00	14.77	14.60	12.80	10.27	9.90	9.35	7.55	6.65
Fe_2O_3	2.61	3.09	1.37	1.99	2.37	1.03	1.78	3.93	3.61	0.79	2.39	< 0.01	0.90	1.19	0.84	0.27
FeO	6.02	8.80	7.75	5.28	5.25	5.28	5.08	2.45	1.83	2.27	1.53	5.52	2.46	2.66	2.30	1.90
MnO	0.06	0.08	0.08	0.04	0.10	0.04	0.05	0.06	0.05	0.02	0.03	0.04	0.03	0.03	0.04	0.02
MgO	2.66	6.25	2.68	2.45	2.15	2.35	2.25	1.23	1.14	1.84	0.70	0.72	1.04	1.04	0.54	1.78
CaO	0.15	0.51	0.27	0.22	0.51	0.29	0.20	0.07	0.09	0.23	0.16	0.16	0.20	0.22	0.65	0.26
Na_2O	1.15	1.17	1.30	0.96	4.78	0.80	0.65	1.20	0.62	1.70	1.59	1.17	1.13	1.57	0.88	1.03
K_2O	4.81	2.17	3.93	5.25	2.82	4.05	4.96	4.87	4.24	2.75	3.17	2.15	2.15	1.69	1.69	1.49
P_2O_5	0.12	0.17	0.14	0.14	0.14	0.19	0.13	0.15	0.15	0.15	0.16	0.14	0.12	0.10	0.12	0.11
H_2O^+	5.20	5.85	5.09	4.10	3.41	4.45	4.02	2.96	2.65	1.44	2.03	2.19	1.74	1.95	1.58	1.45
H_2O^-	0.12	0.09	0.41	0.09	0.15	0.05	0.09	0.22	0.09	0.15	0.13	0.62	0.08	0.06	0.01	0.03
CO_2	0.10	0.24	0.20	0.10	0.10	0.05	0.05	0.13	0.10	0.05	0.16	0.01	0.05	0.04	0.26	0.04
C	0.10	<0.01	0.05	<0.01	<0.01	0.05	<0.01	0.13	0.06	0.06	0.04	0.12	0.06	0.04	<0.01	<0.01
Sum	100.06	100.24	100.62	99.65	100.19	99.65	100.13	99.91	99.95	99.56	99.99	99.68	99.86	100.12	100.01	100.32
(X_{Fe}); $Fe_{tot}/Fe_{tot}+Mg$	0.63	0.51	0.63	0.62	0.66	0.60	0.62	0.73	0.67	0.48	0.75	0.81	0.64	0.66	0.75	0.40
Na/Na+K	0.27	0.45	0.34	0.22	0.72	0.23	0.16	0.27	0.18	0.48	0.44	0.46	0.45	0.58	0.45	0.51
K/Al+Mg+Fe_{tot}	0.16	0.07	0.14	0.19	0.11	0.16	0.20	0.23	0.23	0.16	0.21	0.15	0.17	0.14	0.18	0.16

Localization: **354** - N of Bacúch, E slopes of Bacúch valley, the ridge between main valley and Ryzna valley, 900 m SE of el.p. 713.1 m. **393** - N of Polomka, W slopes of the Pravá Ráztoka valley, 550 m NE of el.p. 1071.3 m. **153** - N of Bacúch, E slopes of Bacúch Valley, 500 m SEE of el.p. 713.1 m. **25** - NNW of Plomka, W slopes of Ždiarska valley, 250 m S of el.p. 893.3 m. **63** - NW of Bacúch, Ďurčíkova valley, near el. p. 915.8 m. **499** - NNW of Bacúch, the ridge S of Kriváň valley, 300 SE of el.p. 769.2 m. **205** - W slopes of Bacúch valley, 800 m N of 713.1 m, **103** - N of Bacúch, the ridge between Jančíkova and Ramžova valleys, 450 m NW of el.p. 840.8 m. **367** - N of Bacúch, the ridge projection S of Sparistá valley, 750 m NEE of el.p. 713.1 m. **270** - NNW of Bacúch, the Jánov Grúň ridge, 200 m W of el.p. 1069.1 m. **164** - N of Bacúch, 350 m SE of el.p. 840.8 m, the confluence of Nemcova, Sokolova and Jančíkova valleys. **289** - NW of Bacúch, the ridge between Krškova and Ďurčíkova valleys, 450 m NNW of el.p. 915.8 m. **253** - NW of Bacúch, SW slopes of Krškova valley, 600 m SE of el.p. 915.8 m. **267** - NW of Bacúch, E slopes of Zamrzlá valley 450 m NE of Vrchbanský grúň (1434.4 m). **154** - 100 m NWW of sample 153. **67** - N of Polomka, E slopes of Ždiarska valley, 400 m SWW of el.p. 1043.0 m.
The samples were analysedby O. G. Unanova, chemical laboratory of IGEM RAV Moscow, Russia, 1992.

Comparison of the Jánov Grúň Formation with the Krakľová Formation

When comparing both formations, a particularly typical feature - the greater abundance of acid volcanics products in the Jánov Grúň Formation, is the only marked difference at the first sight.

Based on similar mineral and chemical compositions, mineral assemblages (e.g. increased contents of ilmenite and tourmaline), textures and deformation degrees, we can state that metasediments of both formations are similar. The Krakľová Formation metasediments contain less chlorite, but have higher Al contents which is reflected by abundant muscovite, and even paragonite. Fe-carbonates were found in the Krakľová Formation rocks from the Kamenistá dolina Valley (Spišiak et al. 1992).

The mineral assemblages in all the studied types of metamorphic rocks of both formations are identical, and belong to the biotite sub-facies. Metamorphic biotite in both units formed only in acid metavolcanics, in metasediments it was not found. Temperature and pressure parameters are similar:

Jánov Grúň Formation T = 340 - 370 ^{0}C, P_s = 340 - 400 MPa
Krakľová Formation T = 340 - 350 °C, P_s = 340 - 400 MPa.

Table 4: Microprobe analyses of metadacites minerals (in wt.%).

Sample No.	56			24							116					
Mineral	Bt_{mag}	Bt_{met}	Ms-Phn	Bt_{mag}	Bt_{met}	Phn			Kfs	Ab	Bt_{met}	Phn	Cal		Kfs	Ab
Analysis No.	1	2	3	4	5	6	7		8	9	10	11	12		13	14
SiO_2	36.19	38.32	49.09	34.16	35.42	45.64	46.95		66.12	65.41	37.05	48.12	-		65.13	67.96
TiO_2	3.32	2.91	0.75	3.27	2.92	0.64	0.87		0.05	0.02	2.75	0.17	-		-	-
Al_2O_3	16.56	17.92	29.39	16.87	16.42	27.40	27.08		18.69	21.41	15.63	25.22	-		17.62	19.01
FeO	22.28	21.45	3.85	25.21	24.21	8.37	5.51		-	0.17	21.74	7.57	-		0.03	0.01
MnO	0.08	0.13	-	0.22	0.26	0.06	0.05		-	-	0.03	-	2.42		-	-
MgO	7.79	7.31	2.30	7.46	7.53	2.97	2.59		-	-	9.27	3.39	0.96		-	-
CaO	-	-	0.04	0.03	0.07	0.03	-		0.01	0.03	-	-	52.78		-	0.09
Na_2O	0.04	0.11	0.08	0.03	-	0.05	0.03		0.08	11.69	0.03	0.12	-		0.55	12.28
K_2O	8.97	8.52	10.16	9.40	8.35	10.70	10.75		15.76	0.25	9.89	10.87	-		16.83	0.07
Sum	95.23	96.67	95.66	96.65	95.35	95.88	93.83		100.71	98.98	96.45	95.46	57.04		100.16	99.41
Si	2.86	2.96	3.23	2.69	2.80	3.05	3.20	Ort	99.2	1.4	2.90	3.23		Ort	95.3	0.4
Al_{IV}	1.14	1.04	0.77	1.31	1.20	0.95	0.80	Ab	0.8	98.5	1.10	0.77		Ab	4.7	99.3
								An	-	0.1				An	-	0.3
Al_{VI}	0.41	0.59	1.51	0.26	0.33	1.21	1.38				0.34	1.23				
Ti	0.20	0.17	0.04	0.19	0.17	0.03	0.04				0.16	0.01				
Fe	1.47	1.39	0.21	1.66	1.60	0.47	0.32				1.42	0.42				
Mn	-	0.01	0.01	0.01	0.02	-	-				-	-				
Mg	0.92	0.84	0.22	0.88	0.89	0.29	0.26				1.08	0.34				
Ca	-	-	-	-	-	-	-				-	-				
Na	-	0.02	0.01	-	-	0.01	-				-	0.02				
K	0.90	0.84	0.86	0.95	0.84	0.91	0.93				0.99	0.93				
X_{Fe}	0.62	0.62		0.65	0.64						0.57					
Na/Na+K			1.2			0.7	0.3		0.8	98.6		2.1			4.6	

Conclusions

A great deal of rocks cropping out in the NW part of the Veporic Unit, in the so-called Krakľová zone, was traditionally considered as Alpine, or Variscan, diafthorites formed after originally high grade metamorphic rocks. Relatively well preserved metavolcanics were believed to be hypabyssal, Permian. Lot indirect and direct evidence, however, contradicts these opinions. It was found out that in the NW Veporic Unit are present sedimentary and volcanic rocks of Lower Paleozoic age. These were progressively metamorphosed (during Bretonian phase?) under P-T conditions not exceeding those of the middle part of greenschist facies (chlorite to biotite zone). Similar conditions were identified also in the Krakľová Formation (Korikovsky & Miko 1992).

Table 5: Microprobe analyses of some phyllite (sample 326) minerals (in wt.%).

Sample No.	326	
Mineral	Ms	Chl
Analysis No.	1	2
SiO_2	48.22	25.36
TiO_2	0.20	0.08
Al_2O_3	36.91	22.95
FeO	1.27	27.72
MnO	-	0.17
MgO	0.48	11.62
CaO	-	-
Na_2O	1.00	-
K_2O	9.46	-
Sum	95.54	87.91
X_{Fe}		0.57
Na/Na+K,%	13.1	

Acknowledgemnet: This publication was prepared by the finantial support of the Foundation for Fundamental Research of the Russian Academy of Sciences, Project No. 93-05-833.

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