GEOLOGICA CARPATHICA, 43, 1, BRATISLAVA, FEBRUARY 1992
21 – 25

GRANITOIDS OF THE MALÁ FATRA AND VEĽKÁ FATRA MTS.: Rb/Sr ISOCHRON GEOCHRONOLOGY (WESTERN CARPATHIANS)

GEVORK P. BAGDASARYAN[1], RAFIK CH. GUKASYAN[1], BOHUSLAV CAMBEL[2], LADISLAV KAMENICKÝ[2] and JURAJ MACEK[2]

[1]Institute of Geological Sciences, Marshal Bagramyan St., 24a, 375019 Yerevan, Armenia, C. I. S.
[2]Geological Institute, Slovak Academy of Sciences, Dúbravská 9, 84226 Bratislava, Czecho-Slovakia

(Manuscript received December 4, 1990; accepted in revised form September 19, 1991)

Abstract: New data, formerly lacking, with exeptions (Dubná Skala, 1990), have been gained from the Western Carpathian core mountain - Malá Fatra and Veľká Fatra by the Rb/Sr method. The isochron based on 13 samples gave the age of 361±10 Ma for Malá Fatra and Veľká Fatra intrusions.

Key words: granitoids rocks Rb/Sr isochron geochronology, Western Carpathians.

There is minima geochronological data available from Malá Fatra and Veľká Fatra granitoids or sediments. According to generally accepted opinion granitoids and metamorphic rocks are of Variscan age. A possibility appeared to fill this gap thanks to Rb/Sr dating carried out by G. P. Bagdasaryan and R. Ch. Gukasyan (Yerevan, Armenia, C. I. S.).

The geological structure and development conditions during metamorphosis and Variscan magmatism differ in the two Fatra ranges. There is no direct relation between them for the Malá Fatra Mts. belong to the outer belt and the Veľká Fatra Mts. to the inner belt of the Tatrides.

Hybrid tonalites to granodiorites, Magura tonalitess to granodiorites, and metasomatically altered hybrid tonalites to granodiorites have been described by Ivanov et al. (1957) and L. Kamenický et al. (1987). The metamorphosed schistose mantle has been regarded as Variscan containing syngenetic basic volcanism. Later, also acid volcanism was described by L. Kamenický (1987b) mainly in the surroundings of Kunerád and Bystrička. Hovorka et al. (1987) expressed the view that these gneisses may be considered as Proterozoic, based on their metamorphic degree, and without geochronological dating. The regional metamorphosis represents here one of the deepest zones recorded in the Western Carpathians with temperatures exceeding 700 °C (Korikovsky et al. 1987).

In contrast the metamorphic mantle in the Veľká Fatra Mts. is developed only in fragments. L. Kamenický supposes a relatively large portion of acid volcanism the basic one being present only in inferior amount. The metamorphosed products of these rocks are at present represented by orthogneisses and amphibolites. The pluton itself developed by differentiation in magmatic pulses from Smrekovica tonalites through Kantor granodiorites and granites up to Lubochňa leucogranites (Macek et al. 1987).

A feature can be seen connecting both mountain ranges, viz. the occurrence of basic granitoid types and leucocratic differentiates, at the margins or upper parts, and in deeper parts of the pluton, respectively. It is a reversed sequence to that suggested in other cores by Hovorka et al. (1987).

A group of samples from the Veľká Fatra Mts. was analysed consisting of the Smrekovica type (Sample 4), pseudo-Kantor type (Sample 6), Lubochňa type (Samples 1, 2) as well as of acid magmatic rocks from metamorphic mantle, viz. leucogranite (Sample 5) which might have been formed via granitization of orthogneisses. The places of origin of samples is presented in the map (Fig. 1), chemical and isotopic analyses are given in Tabs. 1 and 2, respectively, together with a short characterization of the analysed Veľká Fatra samples.

The selection of samples from the Malá Fatra Mts. involves hybrid tonalites to granodiorites (Samples 21, 38, KMF 33), Magura tonalites to granodiorites (Samples KMF 35, ZK 114) and metasomatically altered hybrid tonalites to granodiorites (Samples ZK 98, ZK 99). The place of origin is in the map, Fig. 2.

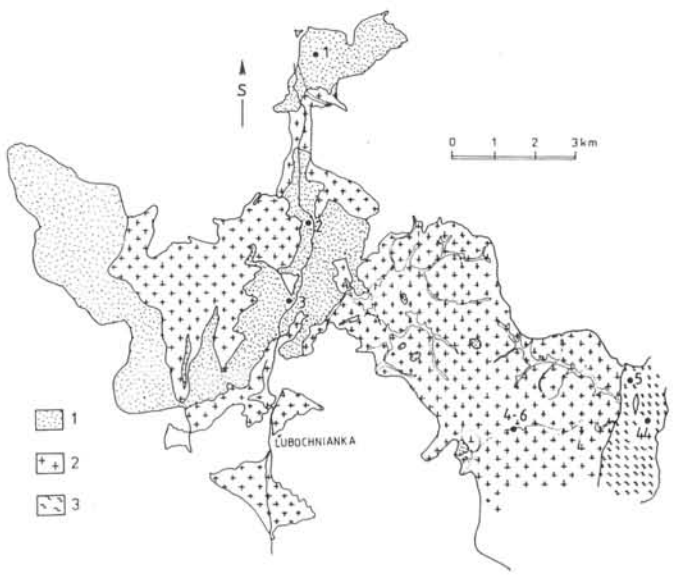

Fig.1. Simplified sketch of the Veľká Fatra geological map 1 : 25 000 after Kubíny (1954).
1 - leucogranites; 2 - other granitoides; 3 - metamorphites.

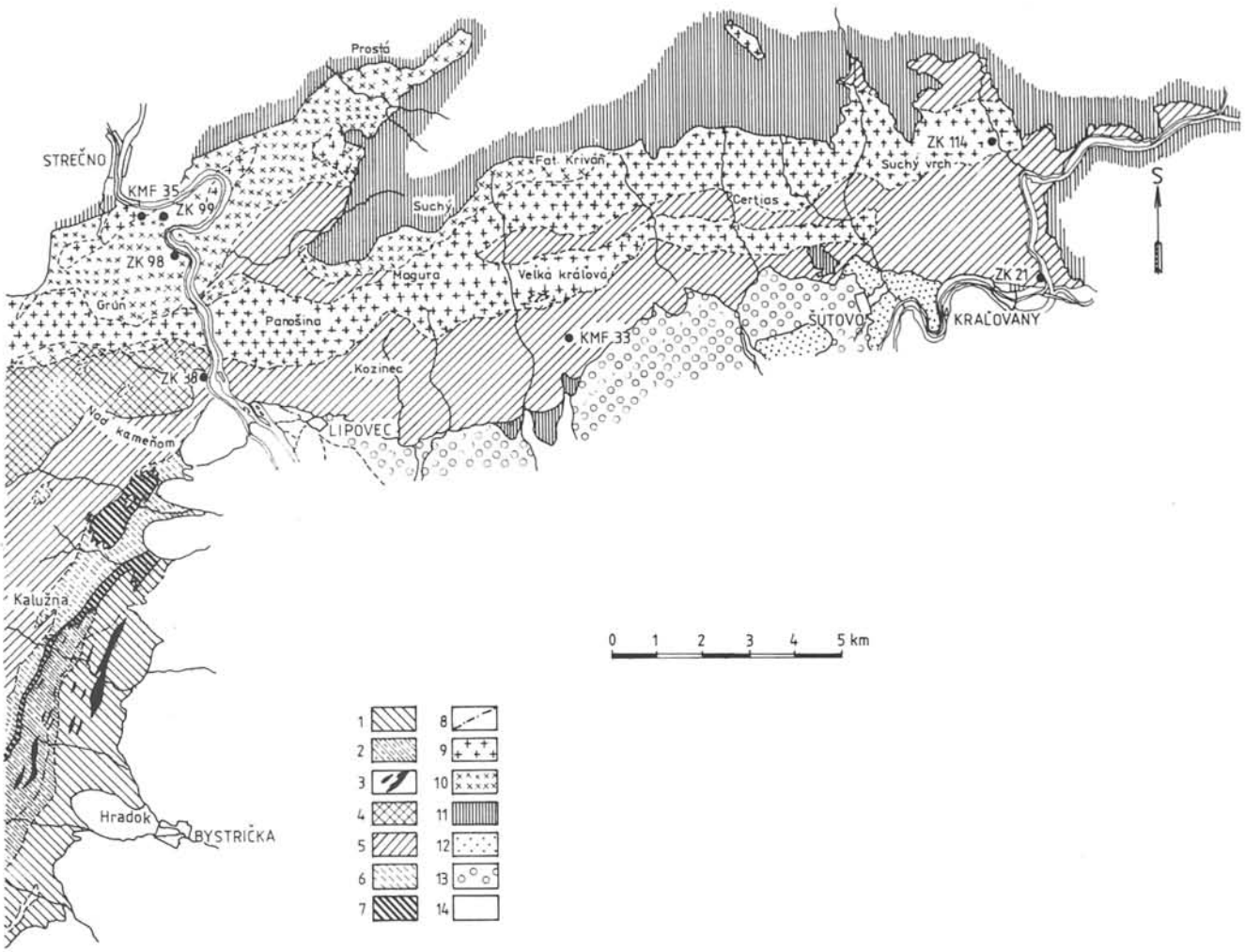

Fig.2. Geological map of the NE part of the Malá Fatra crystalline complex after Ivanov & Kamenický (1957).
1 - quartz paragneisses; 2 - biotite paragneisses; 3 - amphibolites; 4 - oligoclase-biotite granodiorites; 5 - hybrid tonalites; 6 - migmatites with prevailing ortho-component; 7 - migmatites with prevailing para-component; 8 - external boundary of imbibition manifestations; 9 - Magura type tonalites to granodiorites; 10 - metasomatically altered hybrid tonalites; 11 - Mesozoic cover series; 12 - Paleogene; 13 - Neogene; 14 - alluvium.

Geochronological analyses of Veľká Fatra rocks are given in Tabs. 1, 2 and plotted in Fig. 1. The obtained isochron gives the age 361±10 Ma.

Unlike the Veľká Fatra samples, a considerable scatter is seen among Malá Fatra samples making it impossible to define any isochron (Tab. 4, Fig. 2). However, in accord with geological and field studies it follows that the Magura type of tonalites is comparable with the Smrekovica tonalites. A reference line corresponding to the age of the Veľká Fatra is plotted in Fig. 2.

Magura type samples (KMF 35, ZK 114) are close to this line. Although the differentiation in both plutons shows a differing course and it reached a different degree, the geochemical isotopic characteristics are similar.

Therefore it is also possible to point to a correlation of both instrusions on the basis of Rb/Sr isotopic data, in spite of the different geographical position.

The age of the Malá Fatra rocks was also obtained by the U/Pb method on zircons from granitoids from the Dubná Skala quarry - 353±11 Ma (Shcherbak, Cambel et al. 1990).

An approximately contemporary geological development is assumed for Tatric Variscan granitoids, but undoubtedly with a different detailed history, differentiation degree, or post-genetical history.

A group of samples (ZK 21, 38, KMF 33) in Fig. 2 represents the granitised mantle and hybrid tonalites to granodiorites as are present e.g. in the Dubná Skala quarry. They exhibit the relatively high alkali-feldspar content and consequently the high $^{87}Rb/^{86}Sr$ ratio (with the exception of sample ZK 21). The rocks are usually strongly altered.

The samples ZK 98, ZK 99 (Fig. 2) represent metasomatically altered hybrid tonalites with strong alteration of biotites to chlorites and epidotes. Plagioclases are albitised and newly-formed alkali feldspars can also be observed. All the samples from the Malá Fatra are relatively close, in both isotopic ratios and Rb, Sr contents. In addition the relatively low differetiation of the pluton is in accord with field observations.

To conclude we state that the results of geochronological study are in agreement with geological observations and they can be well interpreted. The interpretations are closely comparable with similar development of geological structure outside the C.S.F.R., e.g. the French Massif Central. Jean-Louis Duthou (1977) studied in his work from the northern part of the Limousin Mts. a similar situation by the method of a detailed analysis of samples.

The geochronological study of Veľká Fatra granitoids leads to conclusion that the main intrusion of granitoid pluton occurred

Table 1. Silicate analyses of Veľká Fatra granitoids

	1	2	3	4	5	6	44
SiO_2	75.58	75.04	70.94	63.38	72.45	71.50	73.76
TiO_2	0.24	0.26	0.25	0.57	0.27	0.33	0.17
Al_2O_3	12.92	12.89	15.31	16.76	15.36	14.91	14.43
Fe_2O_3	1.18	0.63	1.96	2.85	0.92	1.28	0.73
FeO	0.20	0.15	0.50	2.39	0.25	0.94	0.60
MnO	0.04	0.06	0.04	0.08	0.02	0.03	0.03
MgO	0.11	0.32	0.43	1.73	0.41	0.53	0.16
CaO	0.49	1.39	1.12	3.23	0.31	1.35	0.86
K_2O	3.45	4.01	3.56	2.56	4.50	4.29	4.95
Na_2O	3.47	3.35	3.95	3.89	3.40	3.70	3.62
P_2O_5	0.19	0.13	0.10	0.27	0.01	0.14	0.11
H_2O	0.54	0.36	0.36	0.46	0.08	0.10	0.07
LO.I.	1.48	1.44	1.56	1.74	1.48	0.94	0.85
Σ	99.89	100.03	100.08	99.91	99.96	100.04	100.34

Table 2. Rb-Sr isotopic data of Veľká Fatra granitoids.

Sample number	Rb g/g	Sr g/g	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
1	103.55	177.05	1.692±0.025	0.71520±0.00016
2	99.77	148.19	1.914±0.029	0.71512±0.00012
	100.17	154.01	1.91 ±0.029	0.71499±0.00013
3	84.98	319.93	0.768±0.012	0.71036±0.00007
4	103.00	546.62	0.545±0.008	0.70896±0.00006
5	133.28	90.66	4.272±0.064	0.72418±0.00009
	133.57	90.04		0.72357±0.00009
6	113.48	189.88	1.729±0.026	0.71573±0.00013
44	123.70	115.56	3.097±0.046	0.72220±0.00006
				0.72237±0.00017

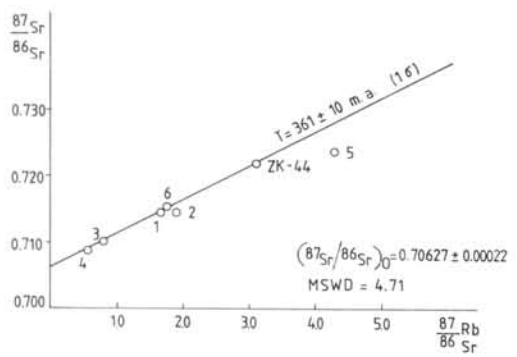

Fig.3. Rb-Sr isochron diagram of Malá and Veľká Fatra Mts. (Western Carpathians), $(^{87}Sr/^{86}Sr)_0 = 0.70627 \pm 0.00022$, MSWD = 4.7.

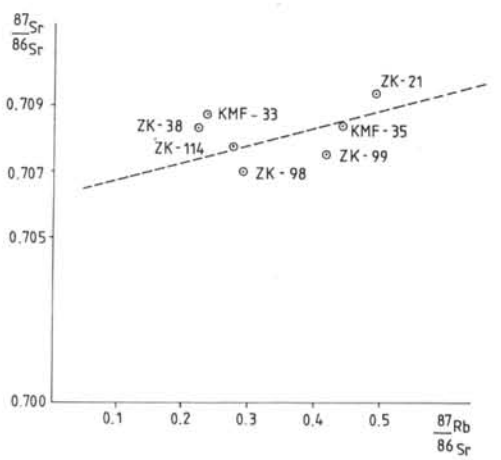

Fig.4. Rb-Sr diagram of Malá Fatra granitoids (Western Carpathians). A reference isochron (361 Ma, V. Fatra) is plotted as dashed line.

Table 3. Silicate analyses of Malá Fatra granitoids.

	ZK 114	KMF 35	ZK 38	KMF 33	ZK 21	ZK 98	ZK 99
SiO_2	67.37	69.15	68.74	71.00	71.81	72.31	72.67
TiO_2	0.42	0.43	0.58	0.39	0.24	0.44	0.34
Al_2O_3	16.04	13.93	15.19	13.90	13.60	13.71	13.51
Fe_2O_3	0.86	1.26	0.78	1.18	2.22	1.53	0.83
FeO	1.78	2.07	2.62	1.54	1.50	1.27	1.54
MnO	0.06	0.02	1.07	0.06	0.06	0.05	0.05
MgO	1.64	1.62	1.12	1.28	0.54	1.51	1.27
CaO	2.31	2.48	3.40	2.70	2.24	0.65	0.56
Na_2O	4.97	3.47	3.50	3.39	4.28	4.12	4.34
K_2O	1.47	2.58	2.48	2.37	3.07	2.85	3.04
H_2O^+	1.76	2.30	1.06	1.52	0.76	1.26	1.60
H_2O^-	0.98	0.16	0.06	0.28	0.01	0.14	0.16
P_2O_5	0.25	0.31	0.21	0.20	0.07	0.13	0.08

Table 4. Rb-Sr isotopic data of Malá Fatra granitoids.

Sample number	Rb g/g	Sr g/g	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
ZK 114	60.74	637.21	0.276±0.004*	0.70780±0.00016*
KMF 35	66.90	446.04	0.439±0.007	0.70848±0.00018
		435.54		
ZK 38	41.68	548.29	0.220±0.003	0.70842±0.00020
KMF 33	47.42	588.73	0.233±0.003	0.70876±0.00007
				0.70883±0.00010
				0.70874±0.00002
ZK 21	67.88	402.72	0.488±0.007	0.70950±0.00045
ZK 98	68.83	689.40	0.289±0.004	0.70715±0.00007
ZK 99	82.44	572.17	0.417±0.006	0.70779±0.00030
				0.70743±0.00034
				0.70745±0.00003

*Squared deviations of mass measurements

app. 360±10 Ma ago. During generating of magma a mantle component as well as the influence of protolith could have taken part, what, together with anatexis and palingenesis of deeper parts of crust, made possible the formation of intruded tonalite under relatively high-temperature conditions. In the following time magma has become differentiated and/or contaminated up to two-mica granodiorites and leucogranites. The latter often form intrusive contact. The acid member of protolith has probably taken part in their formation coming from acid, mainly, magmatic tuffogeneous rocks of the upper parts of the Earth's crust.

Due to the dispersion of measured data obtained from post-genetically altered samples the age of the Malá Fatra granitoids cannot be established directly. However, in accordance with geological knowledge, when correlating with granitoids of the Veľká Fatra, as well as, on the basis of U/Pb zircon data from the Malá Fatra, the similar age for the main intrusions of both mountain ranges can be considered.

(Appendix)

I. The Veľká Fatra Mts.

Sample 1: Leucogranite, Lubochňa type. The Lubochňa valley, Stupecký creek, 500 *m* from the mouth, a small outcrop at right side. The model composition ranges about (vol. %): alkali feldspar 20, plagioclase 35, quartz 35, biotite and accessories 3. It is orthoclase granite with bazicity of plagioclase An_7-An_{15}.FeO_{tot} in biotite ranges between 21 – 23 wt.%. MgO 6 – 7 wt.%. Biotite is to a variable degree baueritized.

Sample 2: Leucogranite, Lubochňa type. The Lubochňa valley, gamekeeper's lodge Raková, a small rocky outcrop behind the gamekeeper's lodge. The modal composition is in the range: alkali feldspar 17, plagioclase 42, quartz 28, biotite 3, muscovite 9, accessory minerals 1. The sample represents orthoclase-microline leucogranite, with plagioclase bazicity An_6-An_{14}. Only bauerite is present in the sample after biotite alteration.

Sample 3: Leucogranite, Lubochňa type. The Lubochňa valley, gamekeeper's lodge Lipová, at the confluence of the Lubochňa and Lipová creeks, left bank outcrop. The modal composition is in the range: alkali feldspar 20, plagioclase 35, quartz 38, chloritized biotite 4, muscovite 2, accessories <1 %. The sample represents microcline granite with plagioclase basicity An_6-An_{14}, except cores which are unmeasurable. Practically, all biotites are chloritized. Muscovite is formed by alteration of plagioclase.

Sample 4: Tonalite, Smrekovica type, the valley Vyšné Matejkovo. The road to Smrekovica, rocky wall in a big curve (1020 *m* elevation). The modal composition is in the range: quartz 32, alkali feldspar 3, plagioclase 47, biotite 16, muscovite and accessories 2. Alkali feldspar is represented by orthoclase. Plagioclase is present in two generations: the older with bazicity An_{28}-An_{40}, and the younger one with An_{14-16}.

The FeO_{tot} in biotite is about 20 %, MgO 9 %, it is commonly chloritized.

Sample 5: Leucogranite from the metamorphic belt W of Bukovina, 450 *m* from elev. p., road cut in dextral curve. The modal composition is: alkali feldspar 21, plagioclase 25, quartz 45, muscovite incl. some bauerite 8, accessories < 1. It is microcline leucogranite with plagioclase bazicity An_{4-7}. The rock has partly oriented fabric.

Sample 6: Granodiorite, pseudo-Kantor type. The V. Matejková valley, locality as the Sample 4. Contact of the Smrekovica type with an equivalent of the Kantor type. The modal composition is: alkali feldspar 16, plagioclase 39, biotite 7, muscovite 6, accessories 1. The alkali feldspar is represented by microcline. The bazicity of plagioclase is about An_{10-16}. The total iron content in biotite (FeO_{tot}) is 22 %, MgO is about 7 %. The albitization is common.

Sample 44: Leucocratic orthogneiss. Vyšné Matejkovo village, the road cut near the outcrop of baryte veins. It is light-grey, fine-to medium-grained showing indications of parallel fabric. The modal composition is: quartz 28, alkali feldspar 33, plagioclase 32, biotite 3, muscovite 3, accessories 1. The signs of caciritic texture can be seen.

II. The Veľká Fatra Mts.

KMF 33: Tonalite. M. Fatra, the ridge, elev. p. Chleb, SW of Hlasná skala. Light-grey granitoids with hypidiomorphic texture and inhomogeneous fabric. Brown biotite is locally completely baueritized, plagioclase is strongly sericitezed. The modal amount of biotite and muscovite is 7 and 18, respectively. The normative composition is (wt.%) ap-0.43, il-0.75, or-13.9, ab-28.85, an-12.25, cor-1.22, hy-4.52, mt-1.62, q-34.45.

KMF 35: Biotite granodiotite, M. Fatra. Rocky outcrops in the cut on the Strečno-Vrútky road approx. 150 *m* N of the railway tunnel mouth. The rock is medium-grained light-grey to greenish with hypidiomorphic to porphyritic texture, with signs of orientation. Brown biotite is locally partly altered, plagioclase is sericitized. The modal amount of biotite and muscovite is 6 and 2 %, respectively. The normative composition: ap-0.68, il-0.82, or-15, ab-29.4, an-10.3, cor-1.74, mt-1.86, hy-6.08, q-31.5.

ZK 21: Biotite granodiorite, M. Fatra the large quarry in Kráľovany at the confluence of the Orava and Váh rivers. It is light-grey, medium to coarse-grained rock with white K-feldspar porphyroblasts. The modal composition is (vol.%): quartz 35, K-feldspar 19, palgioclase 40, biotite 5, accessories 1.

ZK 38: The sample is a mixture of samples *ZK 36* and *ZK 37*. *ZK 36* is biotite granodiorite, it is light-grey with pink K-feldspar porphyroblasts. *ZK 37* is biotite tonalite light-grey, fine-to medium-grained. The texture is hypidiomorphic. Both samples are from the Dubná Skala at Vrútky, from the upper and lower part, respectively. The modal composition is respectively *ZK 36* and *ZK 37*, mean) : quartz 29, 27,5, 28,3, K-feldspar 13, 6.5, 9.75, plagioclase 45, 54, 49,5, biotite 11. 10.5, 10.75, muscovite 1, 0.5, 0.75, accessories 1.

ZK 98: Biotite granodiorite. Malá Fatra, a cut on the Strečno-Vrútky road, approx. 250 *m* N of the southern tunnel mouth. The locality is in the area of autometamorphic granites. It is light-grey, medium-to coarse-grained, without visible orientation. The fabric is hypidiomorphic to porphyritic. The modal composition: quartz 28, K-feldspar 20, plagioclase 41, biotite 8, muscovite 2, accessories 1.

ZK 99: Biotite granodiorite, Malá Fatra, outcrops on the Strečno-Vrútky road near the mouth of the northern railway tunnel. It is an autometamorphic variety of medium grain.

ZK 114: Biotite leucotonalite. The quarry in the Bystrička valley in the E part of the Malá Fatra Mts. It is light-grey, fine-to medium grained rock. K-feldspar is intersticial among plagioclases. The modal composition: quartz 32, K-feldspar 5, plagioclase 49, biotite 12, muscovite 1, accessories 1.

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