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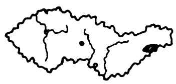
ZIRCONS OF GEMERIC GRANITES (WEST CARPATHIANS – CZECHOSLOVAKIA)

(9 Figs., 3 Tabs.)



Abstract: Morphometric analysis of zircons from the Poproč, Hnilec, Betliar and Súľová Granites carried out by Pupin's (1976) method confirms the opinion that their magma was of crustal-mantle hybrid origin. The conspicuously uniform character of zircons from all four investigated localities suggest joint magma and generally equal conditions under which the Gemeric Granites were formed.

Резюме: Морфометрический анализ цирконов из попрочского, гнилецкого, бетлярского и сульовского гранитов на основе метода Пюпена (Pupin, 1976) подтвердил мнение что их магма имеет гибридное, корово-мантийное происхождение. Резкий единый характер цирконов из изучимых местонахождений указывает на общее происхождение магмы и на одинаковые условия возникновления гемеридных гранитов.

Introduction

The Gemeric Granites have been attracting much attention especially since the mid-1900s. This attention has been due to their petrographic character (more acid, K-rich, less tectonically fractured and faulted) which is different from that of the other West Carpathian granites. The petrography of the Gemeric Granites was studied mainly by087;áková (1954) and J. Kamenický—L. Kamenický (1955).

The concern over the Gemeric Granites is inspired also by their metallogenic importance, either as regards their possible direct association with the neoid hydrothermal mineralization of the siderite formation (in broader terms) (Kordjuk, 1941; Schönenberg, 1949; Ilavský, 1957) or from the viewpoint of indirect relationships important for the dating of the siderite formation. Some authors suppose that the Gemeric Granites antedate the siderite formation (Bernard—Hanuš, 1961; Rozložník, 1976), others think that the granites were formed between the siderite and quartz-sulphide formations (Varček, 1959; Máška, 1956), and furthermore there are also opinions that they were formed as late as in the Neogene (Drnzík, 1974).

The discovery of the fact that the Gemeric Granites are tin-bearing (Baran et al., 1970) triggered detailed researches of their petrological and geochemical properties (Varga, 1975; Gubač, 1977; Tauson et al., 1977; Rub et al., 1977 and others) which their crustal origin and thin-bearing character.

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The age of the Gemeric Granites represents significant datings for the complex geological, tectometamorphic and metallogenic development of the Spišsko-gemerské rudohorie Mts. The young post-Permian age of the Gemeric Granites was established already earlier (B ö c k h, 1905; R o z l o z s n i k, 1912) because of the epigenetic relationship of the granites to the last folding metamorphism of the Gemeric Paleozoicum, which had long been regarded as Hercynian. K a n t o r (1957) determined the geochronological age of the Betliar Granite of 98. m.y. and therefore the Gemeric Granites were long considered as Upper Cretaceous. More abundant data on their isotopic age from various localities and by various methods have recently been obtained: B o j k o et al. (1974), B a g d a s a r y a n et al. (1977), K o v á c h e t al. (1979), K a n t o r — R y b á r (1979), C a m b e l et al. (1980). These indicate Permian, Jurassic and Cretaceous ages. According to these datings the Gemeric Granites should be polyphase intrusions which were subject also to hydrothermal processes.

Based on the investigation of the zircon character, our paper attempts to contribute to the solution of the complicated problems of the genesis of the Gemeric Granites. Our researches have been focused on zircons because this accessory mineral can provide very much information on the petrology of eruptive rocks.

Brief description of samples

The samples were collected in order to provide information on the character of zircons from the occurrences of the Gemeric Granites, at first from the most important ones: Poproč, Hnilec, Betliar and Súľová Granites (Fig. 9). Their petrology and petrochemistry were described mainly by O n č á k o v á (1954), J. K a m e n i c k ý — L. K a m e n i c k ý (1955), G u b a č (1977) and D r n z í k (1982).

Sample No. 1 from the Poproč Massif (exploratory adit Ferdinand) is medium-grained tourmaline-biotite granite which tends to porphyric development. It contains relatively abundant biotite, which is reflected also by its chemical composition.

Sample No. 2 Hnilec—Medvedí potok, Tin adit, some 25 km from the portal, near greisenized contact of the granite with the rocks of the Rakovec Group. It is medium-grained tourmaline-muscovite granite with strikingly abundant tourmaline and also fluorite. Of all studied samples, this one is relatively most leucocratic, which is reflected by its mineralogical as well as chemical composition (Tab. 1).

Sample No. 3 from Betliar (natural outcrop on the western margin of the body) represents porphyric tourmaline-biotite granite typical of this locality. The feldspar phenocrysts are several cm large and also quartz forms phenocrysts in medium-grained matrix.

Sample No. 4 Súľová (summit part, roadcut Súľová—Smrečinka) represents medium-grained tourmaline-biotite-muscovite granite. Muscovite usually prevails over biotite. Apatite is relatively plentiful. Garnet is present as an accessory mineral.

The zircon content in the above-described samples depends on the content of biotite and therefore it is most abundant in the sample from Poproč, less

Table 1

Chemical analyses of rocks from which zircons were separed (contents in %)

Oxides \ Locality	Poproč	Hnilec (adit) (Medvedí potok)	Betliar	Summit of Súľová
SiO_2	70.54	74.60	74.72	76.24
Al_2O_3	13.35	13.71	12.35	12.88
Fe_2O_2	0.41	0.56	0.98	0.14
FeO	2.92	0.95	1.46	0.90
CaO	2.16	0.88	0.88	0.28
MgO	1.22	0.18	0.59	0.28
MnO	0.006	0.024	0.045	—
TiO_2	0.42	0.14	0.34	0.00
P_2O_5	0.15	0.20	0.17	0.11
Spyr.	0.03	traces	traces	—
SO_3	0.04	0.05	0.04	—
H_2O^-	0.23	0.06	0.11	0.14 —
H_2O^+	0.43	0.32	0.56	0.69 +
st.	1.05	0.82	0.70	
Na_2O	2.75	3.70	2.88	4.37
K_2O	4.39	3.84	4.50	4.66
Σ	100.096	100.034	100.325	100.69

Analysed by Geological Survey, Spišská Nová Ves — Laboratory Centre.

plentiful in that from Betliar, whereas in the sample from Hnilec it is very rare. Higher zircon concentrations correspond to accumulations of apatite and some other ore minerals. In addition to the zircons and already mentioned tourmaline, apatite, fluorite and garnet, the Gemeric Granites contain many other accessories, predominantly ore minerals which were described by Veselský et al. (1983).

Results of morphometric analysis

The morphometric analysis yielded results which were unexpected in many respects.

The zircons in all four investigated samples of the Gemeric Granites are fresh, uncorroded, without any manifestations of older cores or visible zonation. They are frequently of long-prismatic habit with the following length-to-width ratios: Poproč 2.4—2.8; Hnilec 2.2—2.4; Betliar 2.4—2.8; Súľová 2.0—2.4 (Tab. 3). Their colour is faint pink to brown-pink. Dark inclusions are abundant. Intergrowths can be observed in the zircons from Betliar and Súľová (Fig. 8).

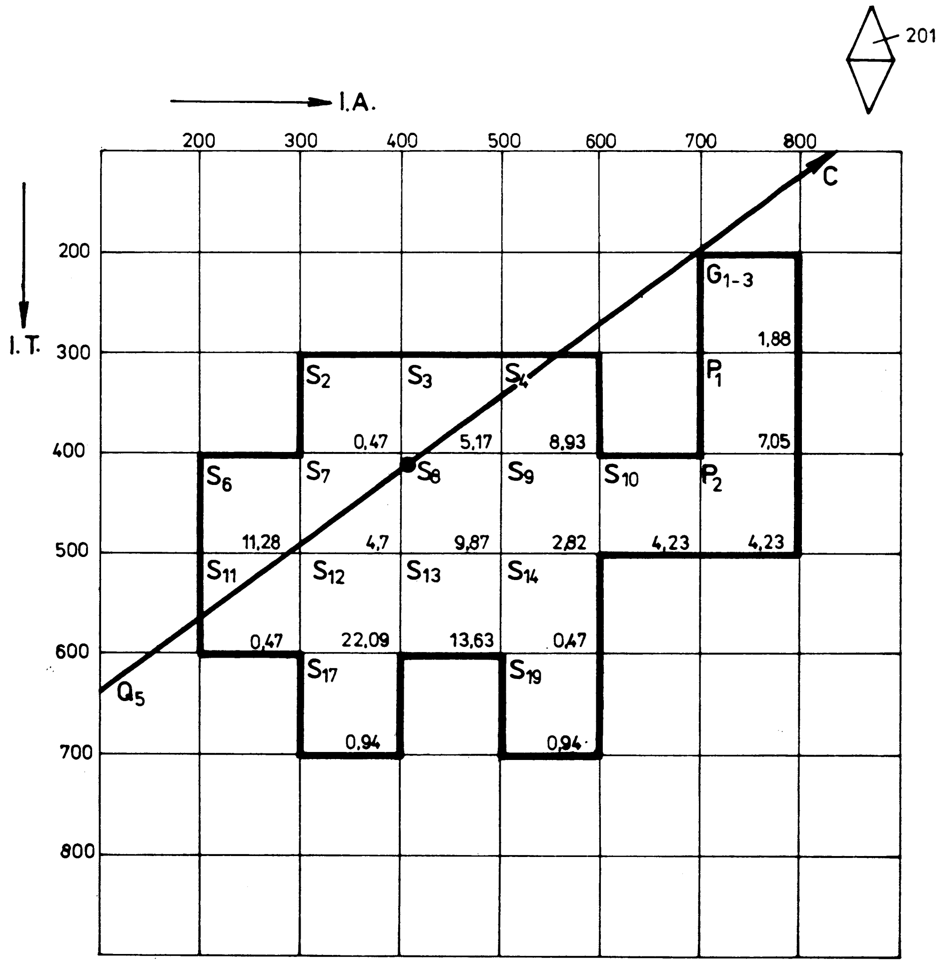


Fig. 1. I.A. and I.T. diagrams of zircon populations from Poproč Granite.

The results of the morphometric analysis are shown in Figs. 1, 2, 3, 4. The typograms are based on the classification of Pupin (1976) and Pupin — — Turco (1981). The analysis indicates that the zircons of the type S_8 from all four localities belong among important types and morphometric mean point of all these four studied populations falls into the field S_8. Between the zircons from the Poproč and Betliar Granites there is a very close correlation because their dominant types S_8, S_{13}, S_{12}, S_3, S_6 are equal. Zircons from the Hnilec and Súľová Granites contain these dominant types: S_8, S_{10}, S_{13}, S_{18}, S_{19}. From the above facts it results that the morphometric mean point of zircons from Hnilec and Súľová is somewhat more excentric to the right, i.e. more alkaline than the near mean points of zircons from Betliar and Poproč.

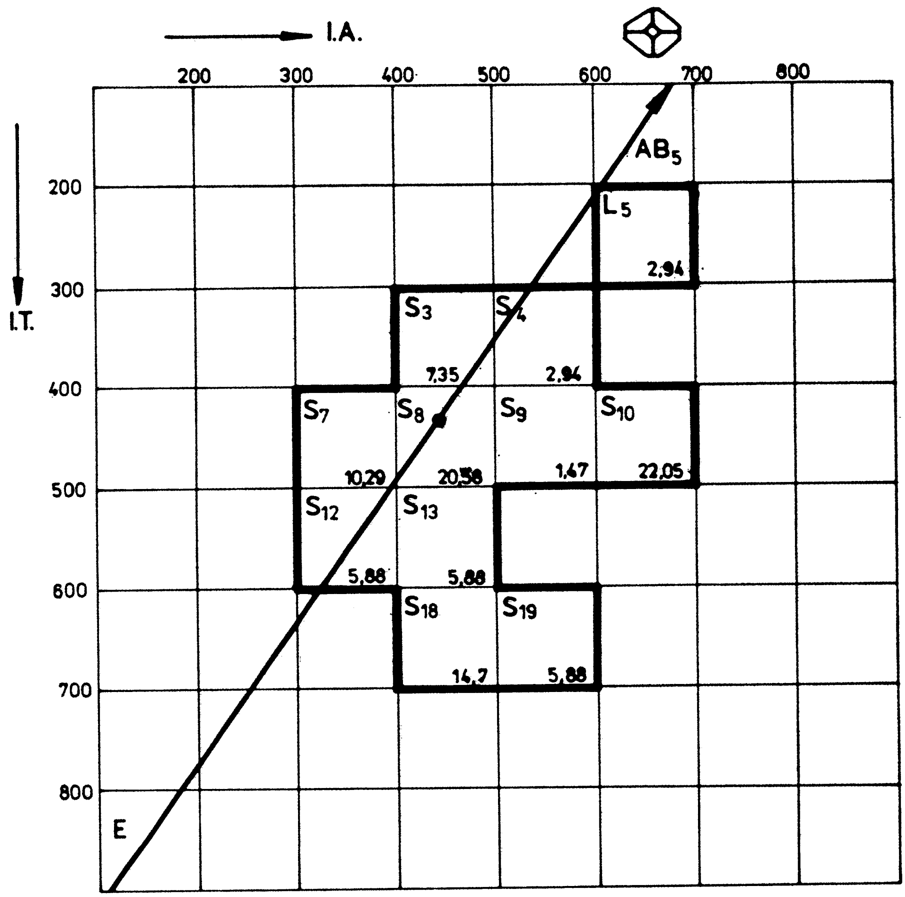


Fig. 2. I.A. and I.T. diagrams of zircon populations from Hnilec Granite.

Fig. 5 indicates that vectors of TET trends of zircons from Hnilec are directed to the type AB_5, whereas those of zircons from Poproč, Súľová and Betliar point to C. These vectors determine hypothetic, evolutionally initial and evolutionally terminal shape-type of the zircons. Compared to zircons from Betliar, Poproč and Súľová, the vector of TET trends of the Hnilec zircons is also somewhat steeper. There seems to be a closer analogy between the localities Betliar and Poproč. Some differences can also be deduced in the crystallization temperatures of the zircons and course of the magma cooling. Zircons from the Betliar and Súľová Granites began to crystallize at about 850 °C, with the maximum crystallization at approximately 700 °C (Fig. 6) which was followed by quick cooling evidenced by the maximum angle ($\alpha = 55°$) of the vector. The Poproč, but mainly Betliar Granite, contain zircons, most of which crystallized at relatively lower temperatures of 750—600 °C.

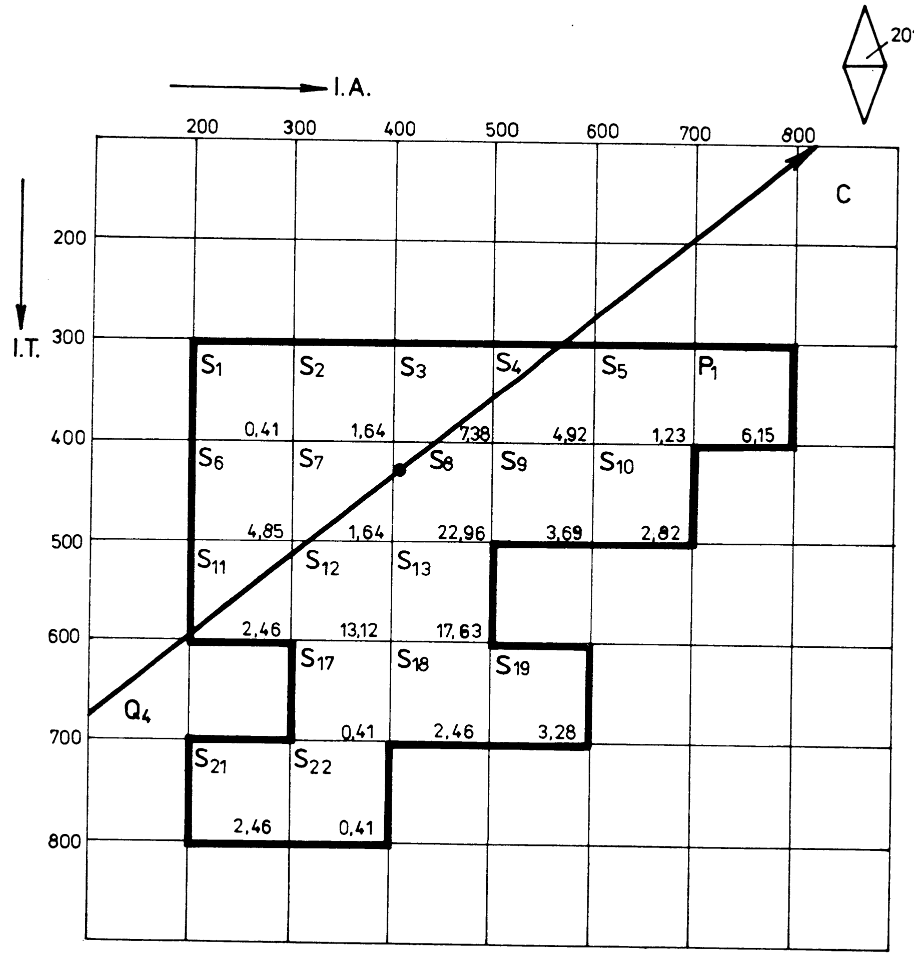


Fig. 3. I.A. and I.T. diagrams of zircon populations from Betliar Granite.

According to Pupin et al. (1978) the prevailing prisms make it possible to determine whether zircons were formed in warmer or colder environment. In our case, prisms 110 prevail over prisms 100 which indicates that the magma concerned was colder and relatively water-rich.

From the above fact it results that there are some differences between the zircon population from Súľová and those from Betliar, Poproč and Hnilec, which suggests that the properties of magma of the Gemeric Granites were not quite equal. Between the Betliar and Poproč Granites these differences are small, whereas between the Hnilec and Súľová Granites they are greater. Interestingly, the most contrast crystallization trend is that of the Hnilec Gra-

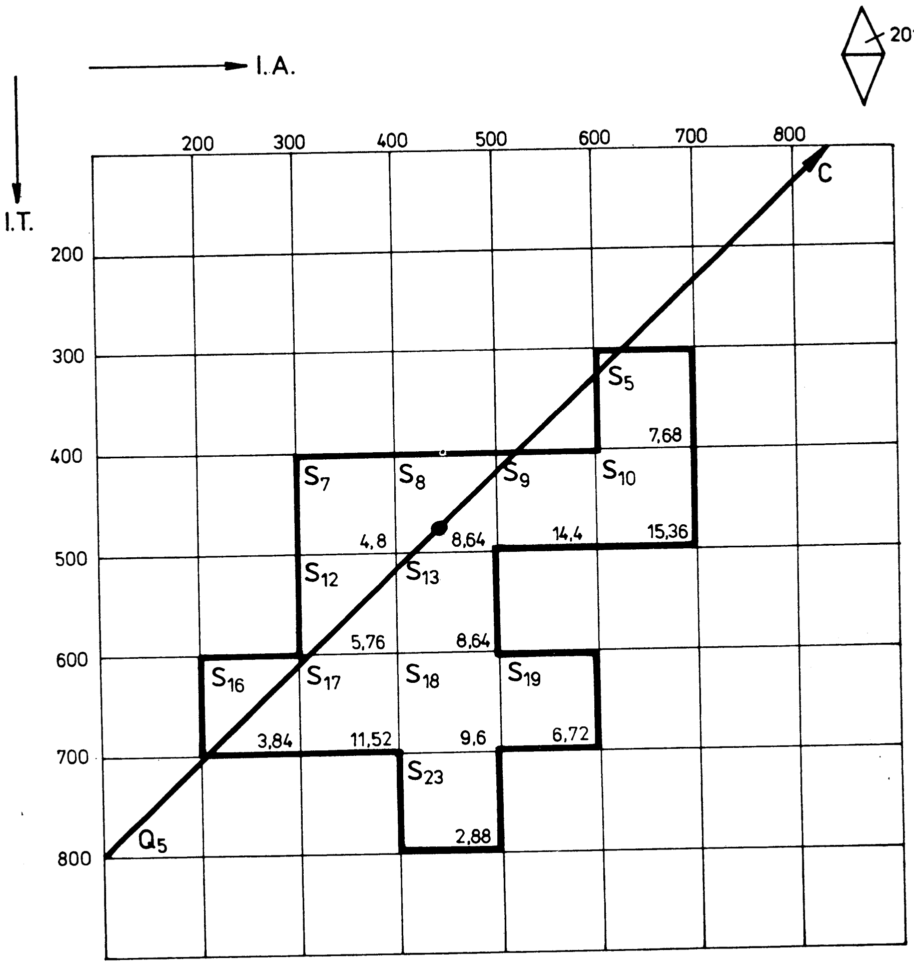


Fig. 4. I.A. and I.T. diagrams of zircon populations from Súľová Granite.

nite which is tin-bearing (Fig. 5). Nevertheless, the fact that all four zircon populations have a common morphometric mean point in the field S_8 is surprising. I.T. index of 412—478 (Fig. 7) according to the classification of Pupin et al. (1978), Pupin (1980) indicates that the morphometric mean point falls into the field of muscovite "aluminium" granites of crustal origin. The I.A. index of 406—437 also lies near the field of intrusive aluminium--rich granitoids but it is closer to the field of hybrid granites of crustal-mantle origin of alkali-lime series and within this group it belongs to the position of granodiorites and monzogranites. The morphometric mean point falls into the field of tourmaline granites near the subautochthonous-granitoids/mig-

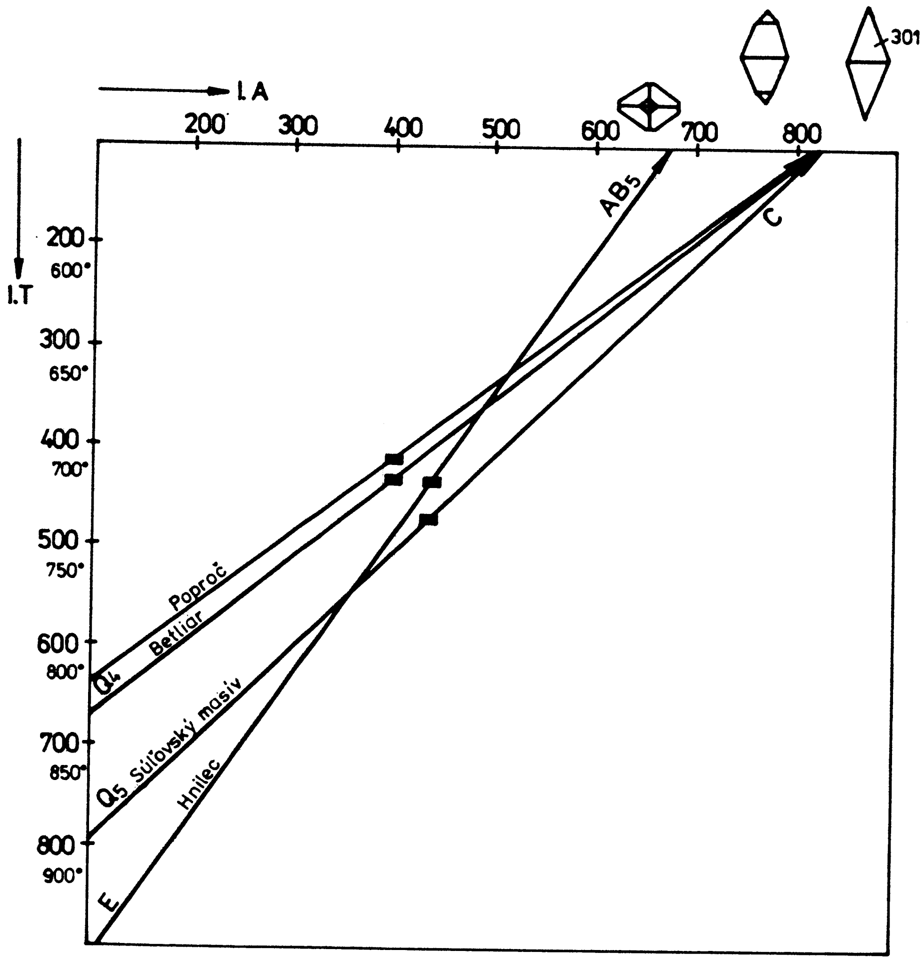


Fig. 5. Combined vectogram of average zircon values from Gemeric Granites.

matites boundary (Fig. 7). In general the above facts confirm earlier views on the anatectic-hybrid origin of the Gemeric Granites. At the same time, the mantle was also involved in their formation.

Research of zircon chemistry

ZrO_2/HfO_2 ratio as well as morphology of zircon crystals depend on the composition of the parent magma and may therefore be useful for the classification of eruptive rocks (P r o s c h e n k o, 1964).

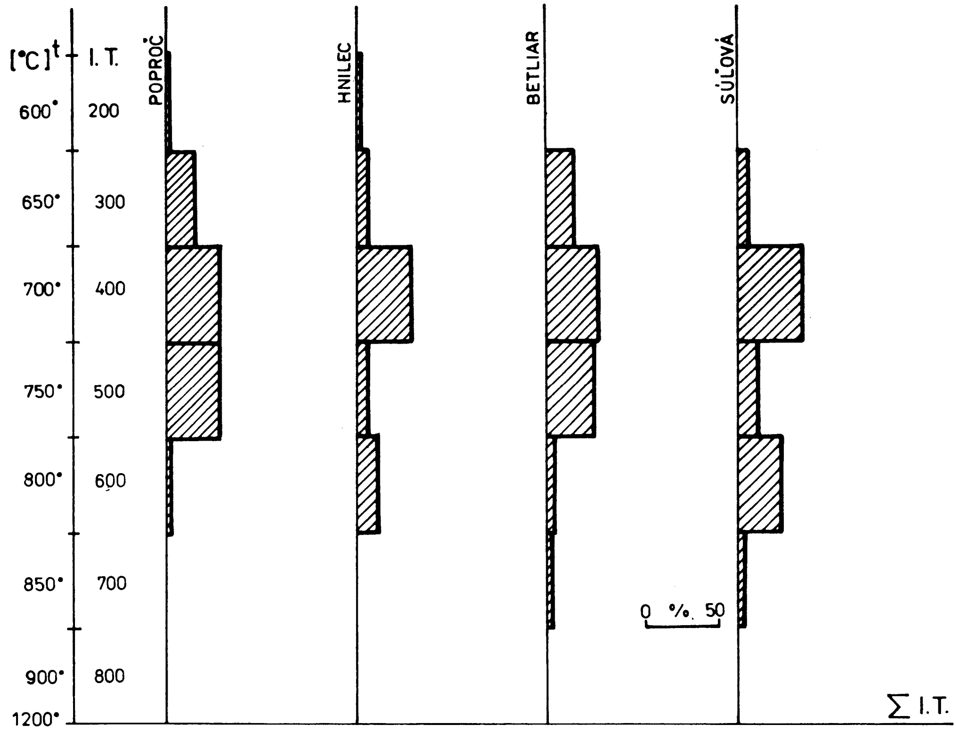


Fig. 6. Frequency diagram of zircons from Gemeric Granites with various total I.T. and correlation of I.T. with the temperature of their formation.

The zircon population from the Poproč Granite as well as from Hnilec, Betliar and Súľová Granites have been investigated by means of electron microprobe at the Laboratory of Electron Microanalysis of the Geological Institute of Dionýz Štúr by a team under the guidance of J. Krištín and J. Határ to whom we thank for their aid. The results of the analyses are shown in Tab. 2, from which it results that zircons from all localities are of a very similar composition reflected, among other things, also by mutually similar Hf contents and Zr/Hf ratios. The sample from Súľová and Hnilec, however, has a substantially (two-times) higher Y content. Compared to tin-bearing granites (Rub — Loseva, 1973), our granites contain approximately the same amount of Hf, but their La, Ce, Y and Th contents are generally lower. The Zr/Hf ratio ranging from 42 to 49 (Tab. 2) clearly confirms the fact that the zircons are "authigene", fresh. This is supported also by researches of Pigorine — Veniale (1966) which prove that Zr/Hf ratios in metamictized zonal zircons with an older core are extremely low — within the range of 10—25 and with a very high Hf content (4—8 %). Zr/Hf ratio (42—49) in zircons of the Gemeric Granites compared to data given by Chessex — Delaloye (1965) for granodiorites (35—55) and alkali-lime granites (30—45) indicates that our granites

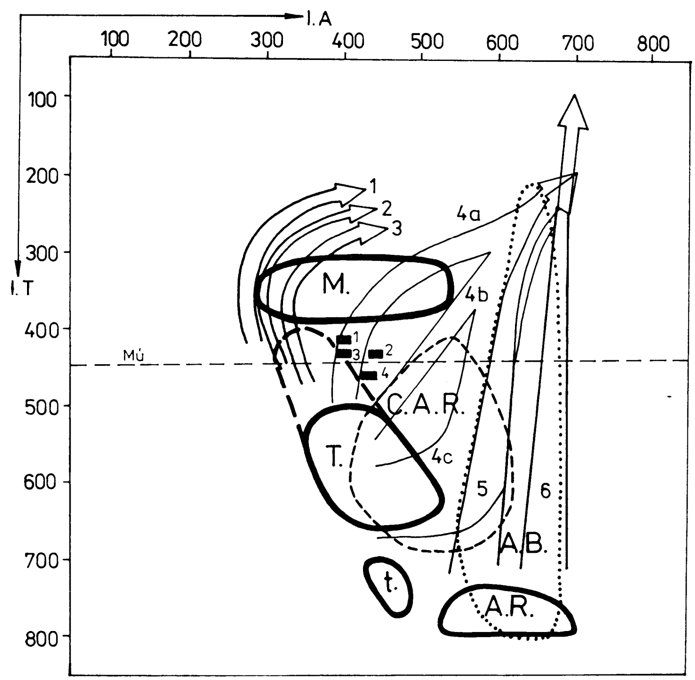


Fig. 7. Evolution trends of some granitic and non-granitic rocks based on zircon data. *Explanations:* area: AB — alkali basalts, AR — rhyolites of alkali series from anorogenic complexes, CAR — rhyolites of alkali-lime series from orogenic complexes, M — migmatites, t — trachyandesites, T — tonalites.
Granites of crustal and/or predominantly crustal origin:
1) aluminium leucogranites; 2) subautochthonous monzogranites and granodiorites; 3) intrusive aluminium monzogranites and granodiorites.
Granites of crustal as well as mantle origin, hybrid granites:
4 a, b, c) granites of alkali-lime series, monzogranites + alkali granites; 5) granites of subalkaline series.
Granites of mantle and/or predominantly mantle origin:
6) granites of alkali series; 7) granites of tholeiitic series; Mu — boundary of muscovite granite.

Fig. 8. Morphological types of zircons from investigated Gemeric Granites.
3967 — zircons from Poproč Granite S_{12}, S_{12}, magn. 200 ×; 3968 — zircon from Poproč Granite S_{13}, magn. 240 ×; 3969 — zircon from Poproč Granite S_{13}—S_{12}, magn. 240 ×. 3964 — zircon from Hnilec Granite S_{17}—S_{13}, magn. 240 ×; 3965 — zircon from Hnilec Granite S_{17}, magn. 240 ×.
4500 — zircon from Betliar Granite S_3, magn. 400 ×; 4582 — zircon from Betliar Granite S_{14}, magn. 280 ×; 4581 — zircon from Betliar Granite S_7, magn. 600 ×; 4583 — zircon from Betliar Granite S_{12}, magn. 300 × and intergrowths S_{12} and L_4; 4598 — zircons from Betliar Granite, intergrowth magn. 320 ×.
2776 — zircon from Súľová Granite S_{19}, magn. 660 ×; 2778 — zircon from Súľová Granite S_{17}—S_{16}, magn. 660 ×; 2781 — zircon from Súľová Granite, intergrowth S_{13}, magn. 1000 ×.

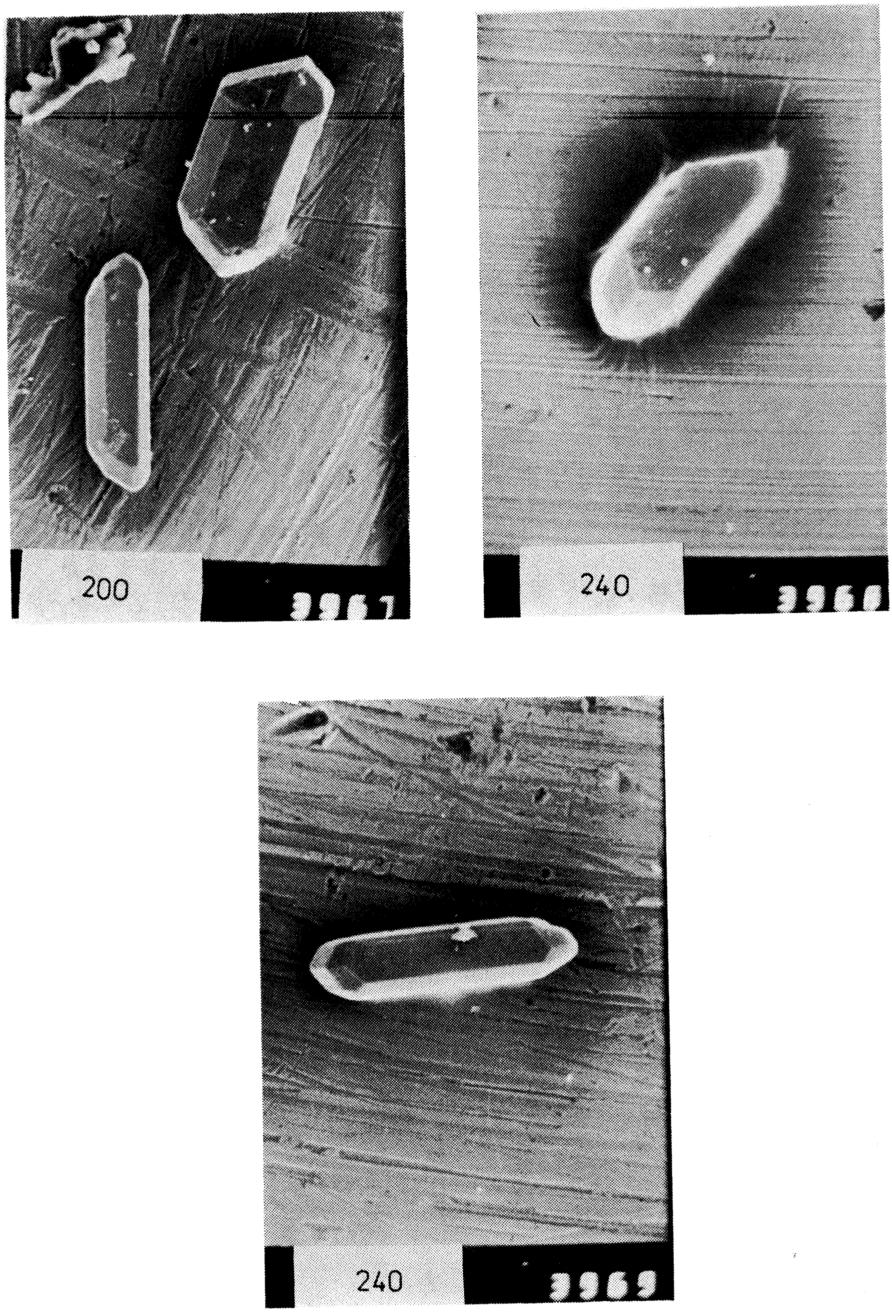
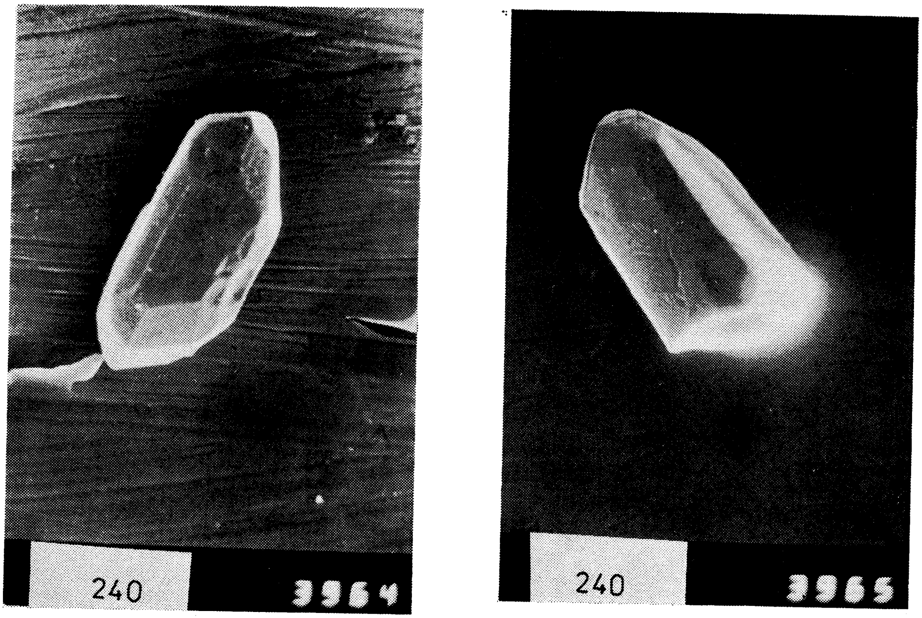


Fig. 8



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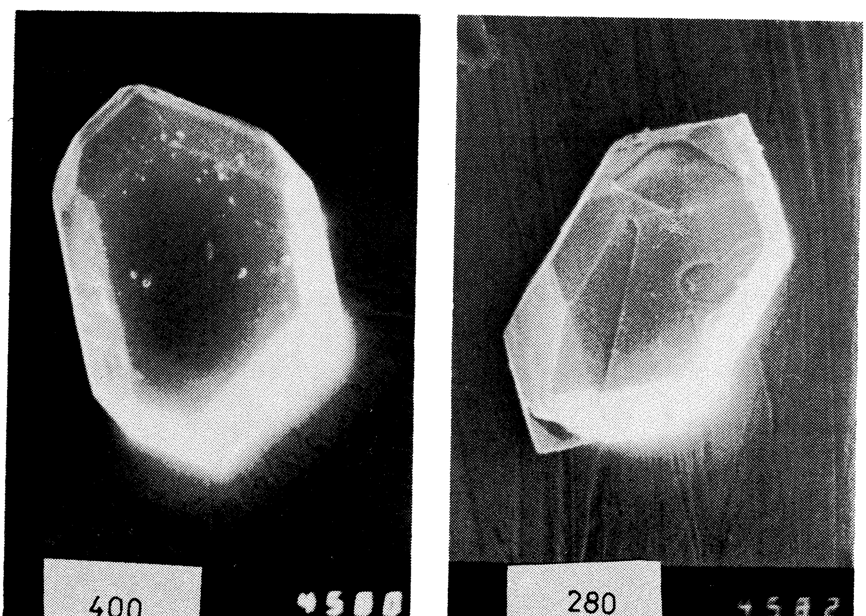

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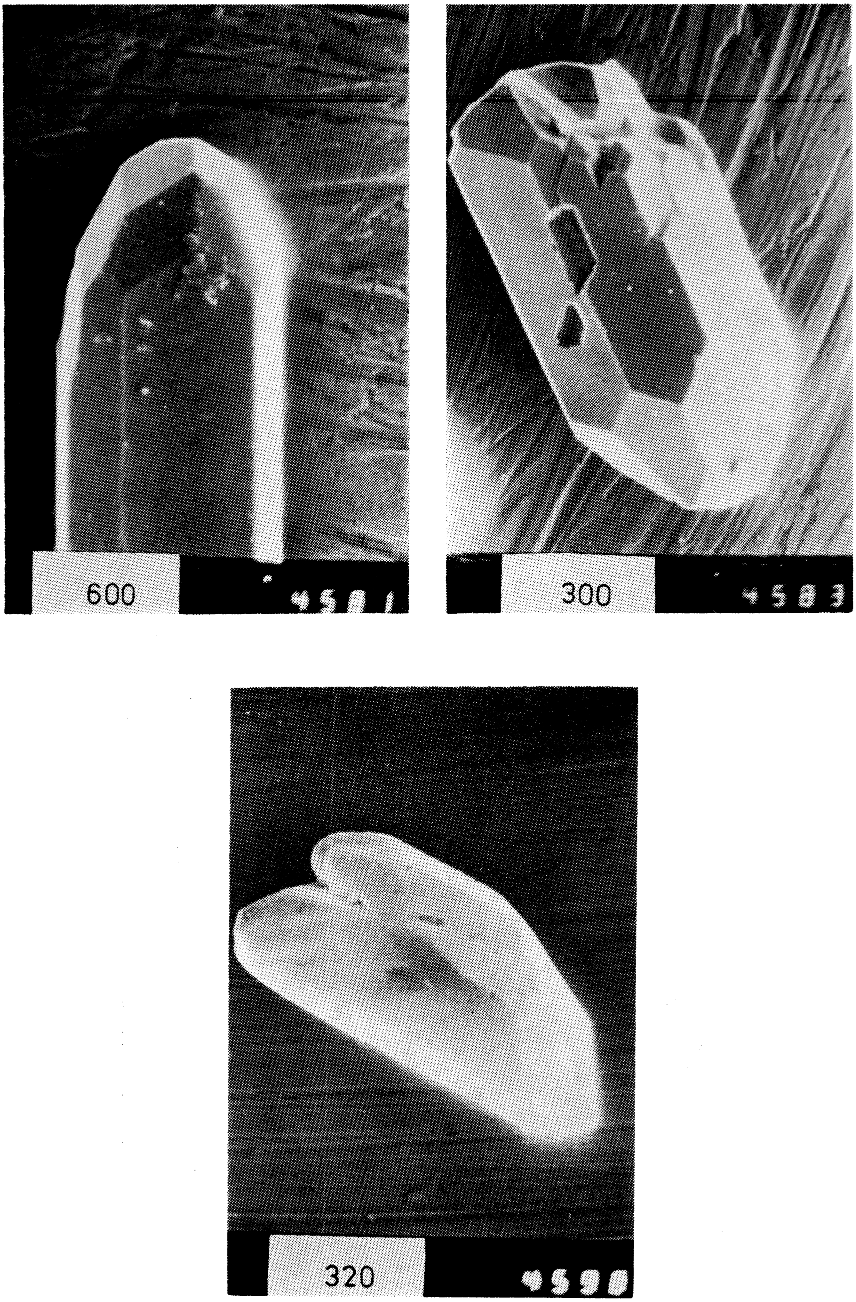

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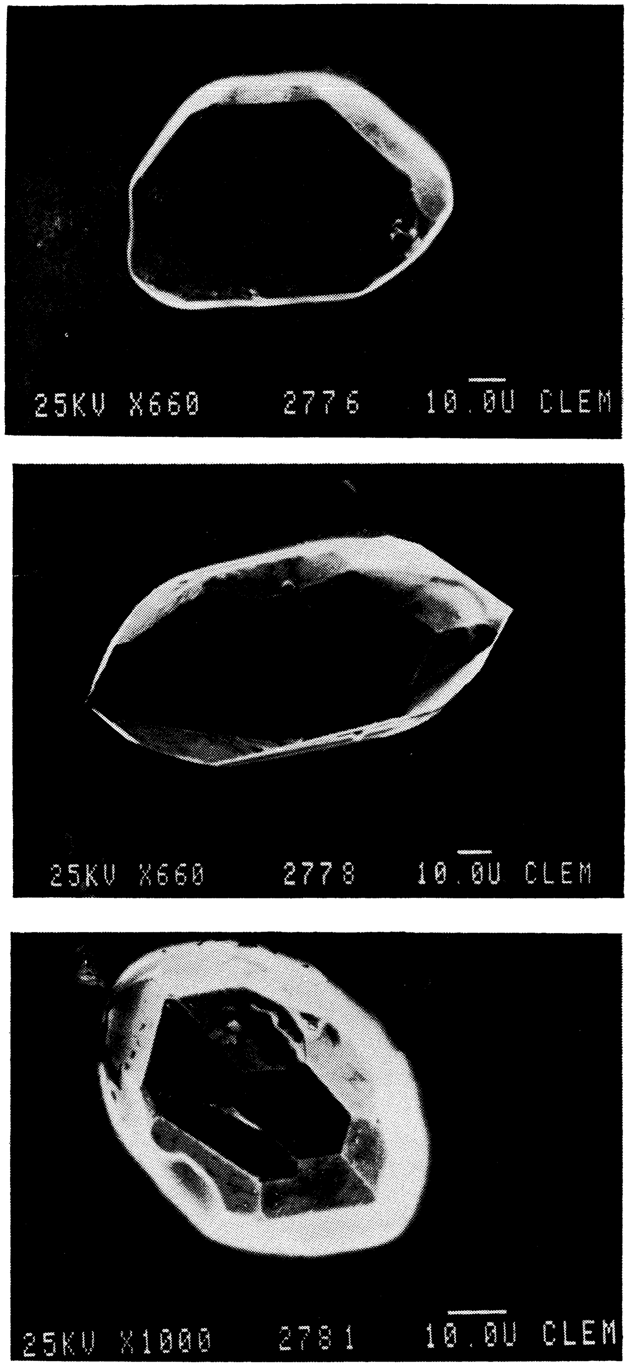
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Fig. 8

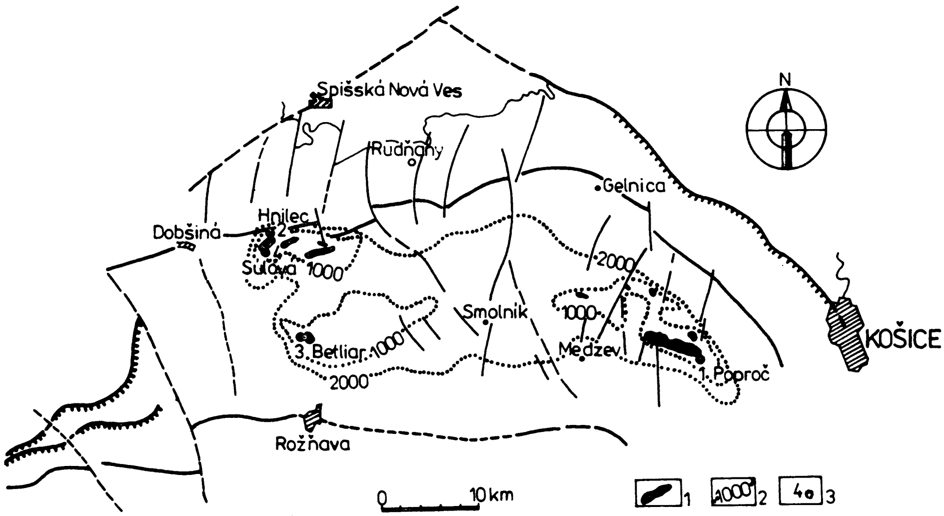

Fig. 9. Schematic geological map of the Spišsko-gemerské rudohorie Mts. with marked occurrences of Gemeric Granites and places of sampling — by R o z l o ž n í k, 1988. *Explanations:* 1 — outcrops of Gemeric Granites; 2 — isohyphs of granite relief determined by Š e f a r a in P l a n č á r et al. 1977; 3 — number of sample.

fall into the alkali-lime-granite/granodiorite boundary. A good correlation between chemistry and petrographic character of the host rock and zircon microchemistry can be observed also here (compare Tab. 1 and Tab. 2).

In our opinion the research of the zircon chemistry has resulted in data, although only preliminary for the time being, indicating that the zircons in the Gemeric Granites can be interpreted as regards their morphometry as well as geochronology.

Discussion on petrology of Gemeric Granites

The above data make it possible to express the following conclusions:

1. According to P u p i ń s (1976) classification, typological mean points of zircons from the investigated localities of the Gemeric Granites fall into the field S_8 which corresponds to hybrid-mantle-crustal and/or "aluminium-rich crustal granitoids". This confirms views about the role of palingenesis by the formation of the Gemeric Granite magma (V a r g a, 1975; T a u s o n et al., 1977). Nevertheless, the mantle seems to have participated, too. The researches have proved that the zircons come from intrusive granitoids, which is evident also from their geological position and character of contact effects.

2. Despite some differences, the investigated zircons from the Poproč, Hnilec and Betliar Gemeric Granites and Súľová Granite are remarkably similar to each other. This similarity suggests that former views about the uniform — common leucocratic, potassium and boron-rich magma of all Gemeric Granites might be true. The views on the uniform characters of magma of all Gemeric

Table 2

Average microprobe analyses and derived parametres of investigated zircons (contents in %)

Locality / Oxides	Poproč	Hnilec (adit) (Medvedí potok)	Betliar	Summit of Súľová
Al_3O_2	0.0089	0.1915	0.0000	0.1785
ZrO_2	63.4467	64.0144	63.4267	63.1267
HfO_2	1.1294	1.3261	1.2005	1.2289
La_2O_3	0.0064	0.0083	0.0075	0.0009
Ce_2O_3	0.0218	0.0338	0.0090	0.0331
Y_2O_3	0.2319	0.4221	0.3451	0.6511
FeO	0.0069	0.0138	0.0111	0.1189
SiO_2	34.9409	34.8471	34.3300	33.8924
CaO	0.0032	0.0073	0.0140	0.0403
ThO_2	0.0065	0.0347	0.1281	0.0533
Σ	99.8025	100.8991	99.4720	99.3241
$\overline{I.A}$	406	444	402	437
$\overline{I.T}$	412	437	432	478
Zr/Hf	48.896	42.016	45.984	44.707
ZrO_2/HfO_2	56.1773	48.2726	52.8335	51.3684
Zr	46.9695	47.3898	46.9547	46.7326
Hf	0.9606	1.1279	1.0211	1.0453
Y	0.0912	0.1661	0.1358	0.2563
Ce	0.0093	0.0144	0.0038	0.0141
La	0.0027	0.0035	0.0032	0.0004
Th	0.0057	0.0304	0.1125	0.0468
Al	0.0023	0.0506	0.0000	0.0472

Remark: The analyses are reliable up to hundredths of per cent. Further decimal numbers only characterize the accuracy of correction calculations.
Analysed at Laboratory of Electron Microanalysis, Geological Institute of D. Štúr, Bratislava by RNDr. J. Határ, CSc., RNDr. J. Krištín, CSc., Gregorová.
Morphometric analysis by Eng. K. Jakabská, CSc.

Granites is supported also by the finding of common remarkable spherical ferrosilicum accesories in samples from the localities: Betliar, Hnilec and Súľová (Jakabská — Rozložník, 1988). This would confirm the common substation as well as the same age. At the same time, however, the zircons reflect also some above-mentioned differences between the Hnilec Granite on the one hand and the other granites on the other hand, with the differences resulting from petrochemical (Varga, 1975) or radiometric data (Kantor — Rybár, 1979). Undoubtedly, the zircons of the Betliar and Poproč Granites are virtually identical, whereas those of the Hnilec Granite have some differences — morphological as well as chemical.

Table 3

Frequency distribution of length/width values (R.M.A.) of investigated zircons.

Poproč		Hnilec		Betliar		Summit of Súľová	
class	f (%)	class	f (%)	class	f (%)	class	f (%)
0—0.4	5.94	0—0.4	0	0—0.4	0	0—0.4	0
0.4—0.8	2.16	0.4—0.8	0	0.4—0.8	0	0.4—0.8	6.12
0.8—1.2	0	0.8—1.2	0	0.8—1.2	3.15	0.8—1.2	10.2
1.2—1.4	1.08	1.2—1.4	0	1.2—1.4	5.6	1.2—1.4	3.06
1.4—1.8	9.18	1.4—1.8	19.04	1.4—1.8	15.75	1.4—1.8	11.22
1.8—2.0	7.56	1.8—2.0	9.52	1.8—2.0	13.3	1.8—2.0	7.14
2.0—2.2	7.56	2.0—2.2	9.52	2.0—2.2	10.85	2.0—2.4	23.46
2.2—2.4	10.8	2.2—2.4	23.8	2.2—2.4	9.1		
2.4—2.8	21.6	2.4—2.8	19.04	2.4—2.8	17.5	2.4—2.8	18.36
2.8—3.2	10.26	2.8—3.2	14.28	2.8—3.2	8.75	2.8—3.2	6.12
3.2—3.4	2.16	3.2—3.4	4.76	3.2—3.4	4.55	3.2—3.6	4.08
3.4—3.6	5.4	3.4—3.6	0	3.4—3.6	2.1	3.6—4.0	1.02
3.6—4.0	8.1	3.6—4.0	0	3.6—4.0	2.8	4.0—4.4	3.06
4.0—4.4	1.08	4.0—4.4	0	4.0—4.4	2.1	4.4—5.0	4.08
4.4—5.0	2.7	4.4—5.0	0	4.4—5.0	2.45	> 5.0	2.04
> 5.0	4.86						

image MOPAN 03 by Eng. K. Jakabská, CSc.
R.M.A. measurements carried out on semiautomatic analyser of

3. The Gemeric Granites is undoubtedly a special geological phenomenon, not only within the West Carpathians but within the whole Alpine system. What makes the granites remarkable is the associated tin, which, as indicated by all geological and geochronological evidence, dates back to the period when the Alpine mountain-building processes culminated on the territory of the Inner West Carpathians. This fact itself is a rarity because tin-bearing granites are usually "late orogenic" and not "synorogenic" (Rozložník, 1976). The Gemeric Granites tectonically follow the pre-existing heteroaxial structure of the Spišsko-gemerské rudohorie Mts.: some of them — Poproč and Delava Granites are E-W, others — Súľová Granites SW-NE and Zlatá Idka bodies are NW-SE trending. This suggests that the Gemeric Granites intruded as late as after the principal Alpine tectonic processes (Rozložník — Sasvári, 1985). The presence of siderite veins as well as quartz-sulphide and quartz-antimonite mineralization (Rozložník, 1976; Rozložník — Slavkovský, 1980) indicates that the Gemeric Granites generally antedate the so-called siderite formation.

4. The investigation of properties of zircons of the Gemeric Granites suggests that these granites were formed from a common crustal-mantle source and at the same time. The mutually contradicting radiometric data might have resulted from the fact that the granites have an anatectic substance, strongly hybridized by paleosome.

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