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# THE WEST CARPATHIAN GRANITOIDS: I/S CLASSIFICATION AND GENETIC IMPLICATIONS

*(Tabs. 2, Figs. 5)*

Abstract: Geochemical and isotopic characteristic of the West Carpathian granitoids accordingly indicate the predominance of I-affinity of the Tatro-Veporide massifs. In contrast, the Gemeride granites belong to the S-type granitoids. The authors presume the source material of granitoids to have been of a mixed sedimentary-volcanic character. The metasedimentary component contained a considerable proportion of relatively young volcanic mantle-derived material with a low Rb/Sr ratio. The different portions of the volcanic and metasedimentary components were responsible for transitional or mixed I/S characteristics within the individual Tatro-Veporide massifs. The Gemeride granites originated from mature crust material.

Резюме: Геохимическая, как и изотопическая характеристика западнокарпатских гранитоидов тождественно намечает преобладающее I-сродство татровепоридных массивов. Гемеридные граниты, на другой стороне, относятся к S-типу гранитоидов. Авторы предполагают, что материал-источник гранитоидов носит смешанный осадочно-вулканический характер. Метаосадочный компонент содержит значительную долю молодого вулканогенного из мантии дедуцированного материала с низким Rb/Sr отношением. Разная доля их вулканогенного и метаосадочного компонента была ответственна за переходные или смешанные I/S характеристики в рамках отдельных татровепоридных массивов. Гемеридные граниты возникли из более развитого корового материала.

## Introduction

B. W. Chappell and A. J. R. White (1974) differentiated two types of granitoids in the earth's crust, the origin of which is associated with two genetically different environments. The granitoids of I type formed from juvenile, geochemically more primitive material, characterized by a low A/CNK ratio (mol. % $Al_2O_3/K_2O + CaO + Na_2O$). The source material of this granite type is usually interpreted as igneous, i. e. material that did not pass through a sedimentary cycle. The granitoids of S-type are geochemically more mature, their A/CNK ratio is higher and the source material is interpreted as sedimentary. In the course of the sedimentary cycle the A/CNK ratio is increasing. Both the types show many other characteristic features, which are discussed in the text below.

It is of importance that the I-type granitoids are considered to be derived from the originally mantle material, whereas those of the S-type from the matured earth's crust material. The S-type magma has its origin in the crust but the magma of I-type can originate in both the mantle and crust. In ascending the two magmas can be contaminated in the environment of the opposite

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type. By fractional crystallization they may develop each, particularly the I-type, its specific composition spectrum. A number of transitional types, i. e. of granitoids showing mixed characteristics, provides evidence that such contamination is quite frequent. A similar ambiguous type may also be due to a hybrid source material, which contains both sedimentary and magmatic components. The former come from the crust and the latter may be mantle-derived (tholeiites).

From the geodynamical viewpoint the I-types are associated with the subduction zones and the S-types with the collision between continents or between continent and magmatic arc. Typical examples are the Andean batholiths of the I-type, connected with the subduction of the Pacific plate beneath the American continent (M. P. Atherton et al., 1979) and, on the other hand, the granitoid plutons of expressively S-type in the Higher Himalayas, in the Indo-Eurasian collision zone (P. Le Fort, 1981). As the collision between continents is usually preceded by subduction, it is conceivable that the two types often constitute adjacent zones. R. D. Beckinsale (1981) gives the tin belt in SE Asia (Thailand) as an example.

### *Granitoids of the West Carpathians*

The basic data on the I-and S-types have been presented in the papers of J. Klomínský et al. (1981), V. Vilinovič (1981) and B. Cambel – L. Vilinovičová (1981). They have revealed that there is a distinct difference between the granitoids of the Veporides and Tatrides on the one hand and those of the Gemerides on the other. The former show a mixed character with a predominance of I-types and the latter a prominent S-character. The Tatro-Veporide massifs may locally assume the S- or I-character. The massifs of the Little Carpathians were studied most thoroughly in this respect. V. Vilinovič (1981) has characterized the Modra granite massif as of the I-type and the Bratislava massif as a transitional type with a clear affinity to the S-type.

A complementary characterization of the I and S granitoid types in the Little Carpathians is given in the paper of B. Cambel et al. (1981) and concerns the contents of Li, Rb and Cs. The values of these elements are very low and the comparison with their contents in the granitoids of other core mountains (Table 1) has shown analogous results (B. Cambel – E. Martiny – P. Pitoňák, in print). As the elements U and Th in a high degree correlate with the contents of alkalies, the contents of these elements are also listed (B. Cambel – V. Kátlovský – M. Kuhn, 1981; V. Kátlovský, in print). The U and Th contents demonstrate that a deficiency in alkalies is accompanied by the lack of U and Th and that the West Carpathian granitoids (except for the Gemeride granitoids) have a low radioactivity. The approximately equal contents of alkalies and of U and Th elements in the principal types of all Tatro-Veporide mountain ranges indicate that the Variscan granitoids of the West Carpathians belong to one formation (except for the Gemeride granitoids). The increased Cs contents in the regions outside the Little Carpathians are due to the application of different analytical methods in the individual laboratories (INAA, spectral analysis; and flame photometry for the Little Carpathians). The results demonstrate that despite some local deviations, the Variscan granite plutonism

Table 1

Average Li, Rb, Cs, Th, U contents and Th/U ratios for West Carpathian granitoids. Data according to B. Cambel et al. (1981) and V. Kátlovský (1982, in press)

| TATRIDES AND VEPORIDES | | | ppm | | | | | |
|---|---|---|---|---|---|---|---|---|
| Rock type | n | Li | Rb | Cs | n | Th | U | Th/U |
| leucogranitoids | 9 | 21 | 114 | 5 | 23 | 9 | 4.5 | 3.4 |
| two-mica granites | 36 | 28 | 95 | 3.4 | 27 | 11 | 3.7 | 4.0 |
| granodiorites | 31 | 33 | 81 | 3.7 | 29 | 12 | 2.0 | 7 |
| tonalites | 18 | 28 | 62 | 4 | 16 | 10 | 2.1 | 5.6 |
| Malé Karpaty Mts. | | | ppm | | | | | |
| Bratislava massif | | | | | | | | |
| syenogranites | 5 | 20 | 110 | 1.4 | 23 | 5.4 | 1.5 | 3.5 |
| monzogranites | 24 | 27 | 94 | 1.4 | 88 | 12 | 2.2 | 5.6 |
| granodiorites | 10 | 27 | 83 | 1.4 | 13 | 13 | 2.0 | 6.5 |
| | | | | | Bratislava massif as a whole | | | |
| | | | | | 179 | 9 | 1.9 | 4.6 |
| Modra massif | | | | | | | | |
| monzogranites | 2 | 24 | 65 | 1.1 | | | | |
| granodiorites | 11 | 18 | 58 | 1.4 | 40 | 8.3 | 1.7 | 5.3 |
| | | | | | Modra massif as a whole | | | |
| | | | | | 63 | 9.2 | 1.9 | 5.6 |
| GEMERIDES | | | ppm | | | | | |
| leucogranitoids | 5 | 108 | 379 | 18.8 | 4 | 11 | 13 | 1.6 |

was controlled by regularities and geochemical conditions common to the whole region of the West Carpathian Tatro-Veporides.

The present paper summarizes the available data and information on the West Carpathian granitoids, and infers their genetic interpretation from their I/S classification. The results are based on the examination of 120 selected samples of Tatro-Veporide granitoids (so-called ZK samples) and 54 samples from the Gemerides (M. Štrbianová, 1980).

## *Results*

A basic macrochemical feature that distinguished the I-types from S-types is the relatively high Na content in the I-types and its relatively low content in the S-types. The S-types show a markedly peraluminous character ($A/CNK > 1.1$). The impoverishment of S-types in Na is connected with the partitioning of some Na into sea water during the sedimentary cycle. The sedimentary cycle preceding the genesis of S-type granitoids may cause a decrease of oxygen fugacity during crystallization by the effect of reducing agents, such as graphitic shales; this is manifested by a reduced $Fe_2O_3/FeO$ ratio. As a result, the S-types mostly contain ilmenite, whereas the I-types bear magnetite (S. Ishihara, 1977). This regularity, however, can be disturbed by a change of oxygen fugacity during crystallization (fractionation), as has been shown by M. L. Coleman (1979) on the example of the New England batholith.

The major element chemistry of the granitoids studied is represented in a multicationic diagram, which has been proposed by H. de la Roche (1980). This chemical representation, which associates the coordinates of diagrams with the principal mineral paragenesis of granitoids, is very suitable for the study of the source rocks (for more detailed information see op. cit.).

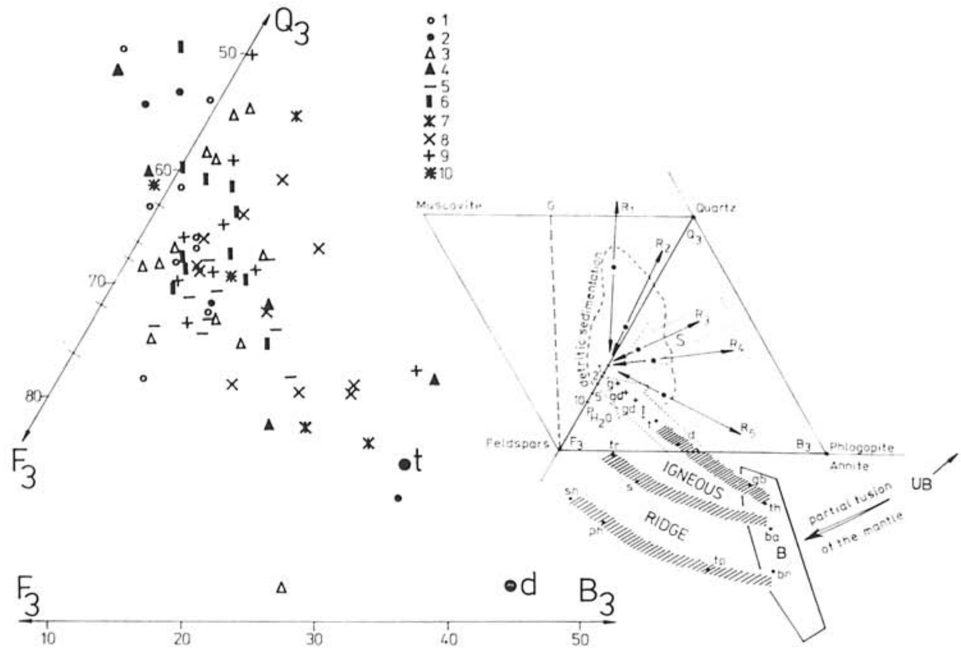
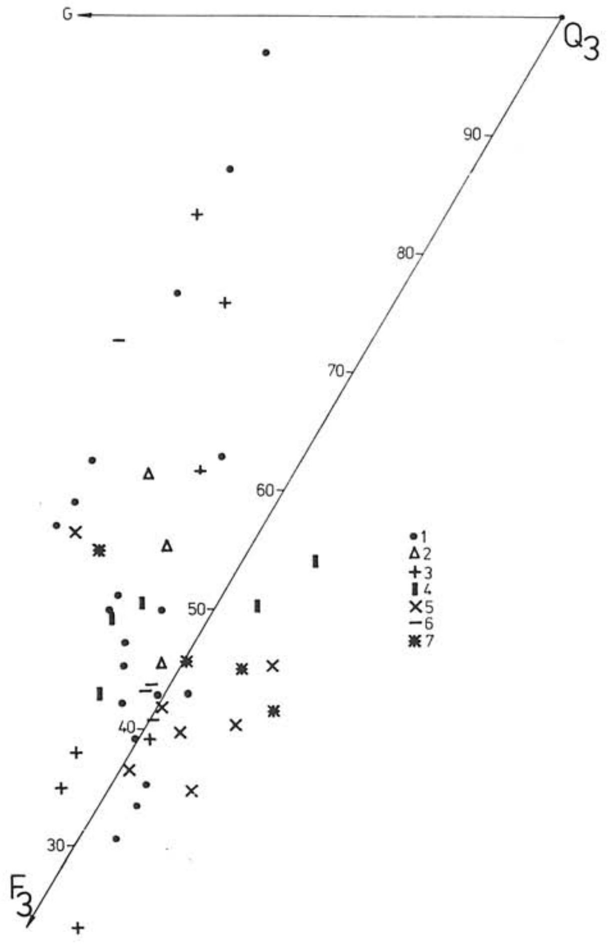



Fig. 1 A. Projection of Tatride and Veporide granitoids in the multicationic diagram of H. La Roche (1980). The quartz-muscovite-feldspars biotite rhombus is extension of the $Q_3B_3F_3$ triangle, where

$$
\begin{aligned}
Q_3 &= Si + 7Al/2 - 9Ca - 13\,(Na + K)/2 \\
B_3 &= \quad - 7Al/2 + 7Ca + 7\,(Na + K)/2 + 8\,(Mg + Fe + Ti)/3 \\
F_3 &= \quad Al + 3Ca + 4\,(Na + K) - 5\,(Mg + Fe + Ti)/3 \\
\hline
Sum &= Si + Al + Ca + (Na + K) + (Mg + Fe + Ti)
\end{aligned}
$$

From the lherzolite upper mantle (UB) basaltic magmas (B) are generated by partial fusion. Fractional fusion of basaltic magmas gives rise to the igneous series along an „igneous ridge". Granites appear as the utmost extension of the igneous ridge being the most differentiated products of the fractional crystallization (I arrow) or as products of partial melting (anatexis) of metasediments (S arrow), or anatectic remobilization of old igneous rocks (underneath $R_5$ arrow). $R_1$ ot $R_5$ arrows are restite com-




positions originated by melting away of granite minimum melts from various source compositions in the field of detritic sedimentation (H. La R o c h e, l. c.).
Abbreviations:
1, 2, 5, 10: Minimum melt compositions of the haplogranitic system for 1, 2, 5, 10 kbars of water pressure.
Rocks: g – granites, gd – granodiorites, ad – adamellites, t – tonalites, d – diorites, gb – gabbros, th – tholeiites, tr – trachytes, s – syenites, ba – alkali basalts, sn – nepheline syenites, ph – phonolites, tp – tephrites, bn – basanites.
G: greisen
West Carpathian granitoid plutons and regional rock types.
Tatrides: 1 – Malé Karpaty Mts. (Bratislava massif), 2 – Tríbeč Mts., 3 – Malá Fatra Mts., 4 – Veľká Fatra Mts., 5 – Nízke Tatry Mts., 6 – High Tatras, 7 – Čierna hora Mts.
Veporides: 8 – Sihla type + Vepor type, 9 – Sinec massif. 10 – Hrončok type.

Fig. 1 B. Projection of Gemeride granites in the $Q_3B_3F_3$ triangle (H. La R o c h e, 1980). Analyses were taken from M. Š t r b i a n o v á (1980).
1 – Hnilec granite, 2 – Delava granite, 3 – Betliar granite, 4 – Poproč granite, 5 – Zlatá Idka granite, 6 – Čučma granite, 7 – Hummel granite.

Relative to the current petrochemical characteristics, this method has the advantage that virtually the whole major element composition of every sample is taken into consideration.

In Fig. 1 (inset) the positions of ultrabasic, basic and acid magmatites and the principal development trends are figured in the quartz-feldspar-muscovite-biotite rhombus (coordinates $Q_3$-$B_3$-$F_3$). The field of granitoids extends about the granite minimum on the tie-line $Q_3$-$F_3$. The arrows I and S indicate the paths along which the granitic composition can be attained. Arrow I corresponds to the I-type granitoids, which is actually a termination of the igneous ridge issuing from basic rocks of the tholeiitic type. Arrows S corresponding to the S-type delineate paths which lead to the minimum composition from different source sediments. $R_1$ to $R_5$ are restite compositions. Point G on the quartz-muscovite connecting line corresponds to the secondary muscovitization of feldspars (greisen).

Diagram in Fig 1 A, B depicts the studied samples from the Tatro-Veporides (A) and the Gemeride (B). As the selected samples represent the principal granitoid types, most of the points are concentrated about the granitoid minimum, but some massifs (Fig. 1 A), for example Tríbeč, Veľká and Malá Fatra or the Sihla type from the Veporides, are obviously linked with the igneous ridge. The distribution of the rock types from the most basic tonalite to biotite-muscovite granites following the calc-alkaline differentiation trend is also well defined. No marked tendency of the S character is manifest. It is evident that to establish or exclude the I or S-affinity of the massifs, each of them must be studied separately. As yet, only the massifs of the Little Carpathians have been investigated in this respect (B. Cambel – J. Veselský – V. Vilinovič, in print). Graphic representation after H. de la Roche (1980) has confirmed the assignment of the Modra granitoids to the I-type, and the predominant affinity of the granitoids of the Bratislava massif to the S-type as well (op. cit.).

The Gemeride granites (Fig. 1 B) differ strikingly from those of the Tatro-Veporides. The greatest part of projection points in the granite field is shifted to the muscovite peak. The Gemeride granites are characterized above all by an intensive greisenization trend, the absolute absence of more basic rocks being another distinctive feature. There is thus no manifestation of either the I or S trend; the monotonous granitic composition results from a total absence of hybrid and transitional rocks.

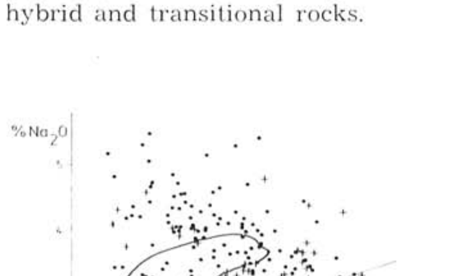



Fig. 2. $Na_2O$ vs. $K_2O$ diagram for Tatride and Veporide (1) and Gemeride (2) granitoid rocks. Fields of I- and S-types according to R. Hine et al. (1978).

The character of the West Carpathian granitoids with respect to the $Na_2O/K_2O$ ratio is depicted in Fig. 2. The fields of I- and S-types are plotted after R. Hine et al. (1978). Fig. 2 confirms the well-known fact that the Tatro-Veporide granitoids are characterized by a predominance of $Na_2O$ over $K_2O$, which implies that granodiorites are there the most frequent rock type. As concerns the alkali ratio, the Tatro-Veporide granitoids show a strong I-affinity.

The position of the Gemeride granites is partly obscured by the presence of Na-metasomatites and greisens. However, a higher $K_2O/Na_2O$ ratio is distinct and the centre of projection points is at the boundary of the S-type field; according to R. Hine et al. (1978), the Gemeride granites have a higher content of $Na_2O$, compared with the S-type granite of the Kosciusko batholith (op. cit.) but they are decidedly of the S-type.

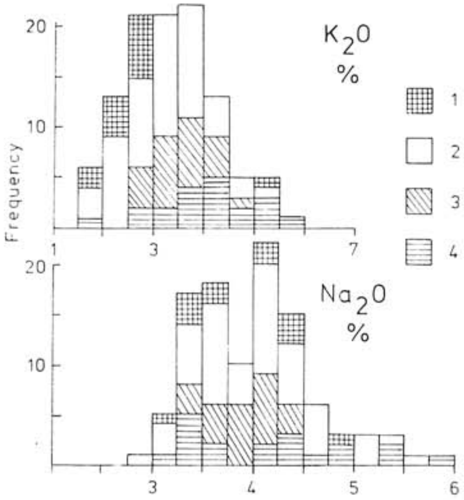



Fig. 3. Histograms of $K_2O$ and $Na_2O$ contents in Tatride granitoids (according to B. Cambel – Ľ. Vilinovičová, 1981).
1 – tonalites; 2 – biotite granitoids; 3 – muscovite-biotite granitoids; 4 – leucocratic granitoids.

Nevertheless, it follows from Fig. 2 that criteria based on the $Na_2O/K_2O$ ratio derived by B. W. Chappell and A. J. R. White (1974) and R. Hine et al. (1978) – solid line and I- and S-fields, respectively, in Fig. 2 – from chemistry of Australian plutonic suites do not match West Carpathian granitoids properly because of higher $Na_2O$ values of the latter (Fig. 3).

Normative corundum and diopside contents up to 5–7 per cent and 2–3 per cent, respectively (Fig. 4) suggest the peraluminous character of all West Carpathian granitoids. Gemeride granites do not contain normative diopside at all, and corundum contents reach values of 8 per cent. The distinct peraluminous character ($A/CNK > 1$) is also obvious from the histogram of A/CNK values, Fig. 5. Frequency maxima of Tatro-Veporide and Gemeride granitoids are separated by the $A/CNK = 1.1$, which was used by B. W. Chappel and A. J. R. White to distinguish sedimentary and igneous source rock.

Mineralogical, similarly as chemical characteristic of Tatro-Veporide massifs is not unambiguous. Majority of studied samples contain both magnetite and ilmenite. The latter is often present in more leucocratic varieties (J. G b e l s k ý, 1980).

A very important characteristic of the I/S classification is the initial $^{87}Sr/^{86}Sr$ ratio. Characteristic for the I-type is an initial ratio below 0.706 (according to some authors < 0.708), and for the S-type a high ratio of above 0.708. It is assumed that the source material of the former had a low Rb/Sr ratio so that during isotopic homogenization, which accompanies the generation of the rock from melt, the proportion of radiogenic $^{87}Sr$ was low. Very young source rocks with a somewhat higher Rb/Sr ratio can produce a similar effect. On the contrary, the S-type granitoids are assumed to have formed from a matured crust material having a high Rb/Sr ratio. The increase of initial $^{87}Sr/^{86}Sr$ ratio

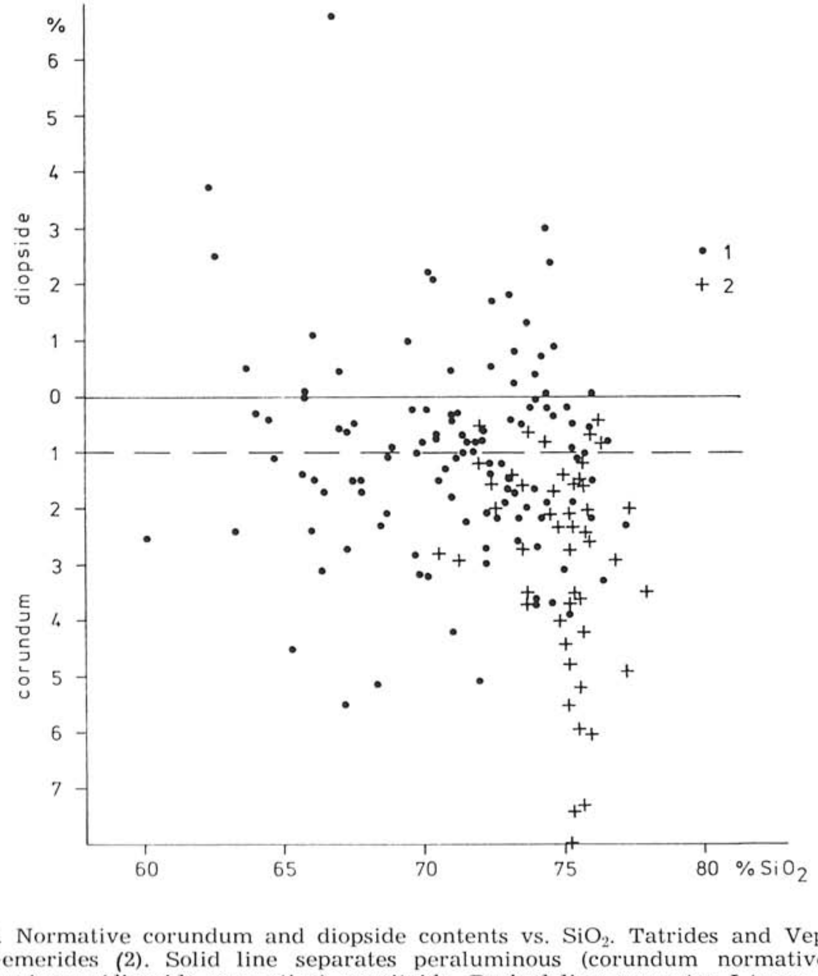
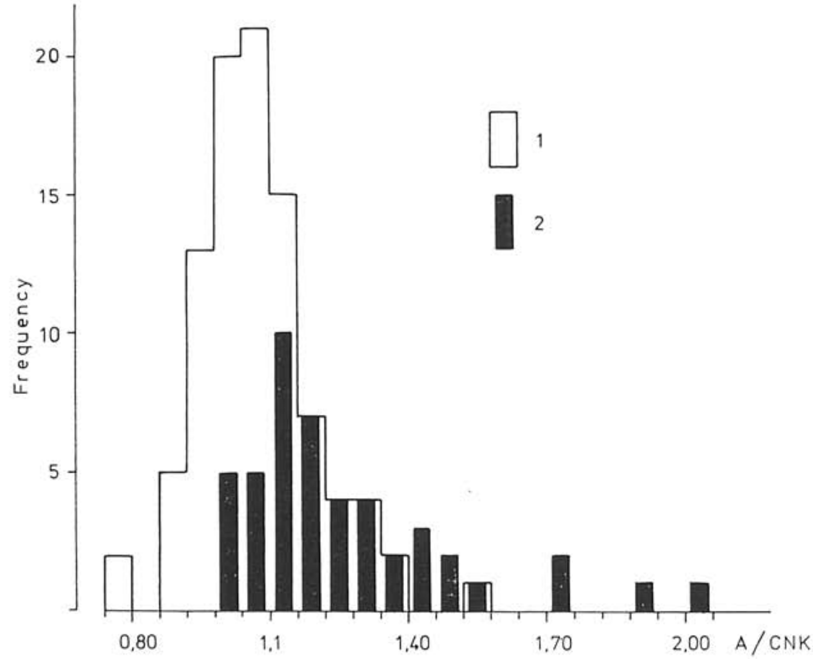



Fig. 4. Normative corundum and diopside contents vs. $SiO_2$. Tatrides and Veporides (1), Gemerides (2). Solid line separates peraluminous (corundum normative) and metaluminous (diopside normative) granitoids. Dashed line separates I-types (above the line) and S-types (below the line) according to B. W. C h a p p e l l and A. J. R. W h i t e (1974).

can again be produced also by a very old rock with a lower Rb/Sr ratio. As concerns the West Carpathians, we suppose that it was clastic material and weathering products of rocks from older Precambrian orogenic cycles that had a share in the formation of Palaeozoic complexes. Another plausible factor which affected the initial isotopic ratio was the relatively young age of granitization and anatexis in the Variscan orogen and a reduced supply of potassium (K-feldspars) characteristic of it. Granitization fluids and solutions as well as low-temperature anatectic melts contributed only slightly to the increase of K and Rb content, which is responsible for the generation of radiogenic $^{87}Sr$.

The resulting initial ratio can also be influenced, for example, by the contamination of the mantle-derived magma by continental crust during its ascent.




Rig. 5. Histogram of A/CNK (mol. % $Al_2O_3/CaO + Na_2O + K_2O$) values. Tatrides and Veporides (1), Gemerides (2).

This may commonly occur e. g. at the subduction of ocean-continent type. The degree of contamination is then proportionate to the thickness of the crust (R. S. Thorpe – P. W. Francis, 1979).

Our knowledge of the strontium isotopes of the West Carpathian granitoids is still meagre. We know only the initial ratios of some Tatride massifs (Bratislava and Modra massifs, G. P. Bagdasarjan – R. Ch. Gukasjan – B. Cambel – J. Veselský, 1982), the pluton of the High Tatra Mts. (J. Burchart, 1968), and two ratios from the Gemeride granites (Kovách et al., 1979). The initial $^{87}Sr/^{86}Sr$ ratios and isochrone ages of the West Carpathian

Table 2
Initial $^{87}Sr/^{86}Sr$ ratios and isochrone ages for the West Carpathian granitoid massifs

| TATRIDES | $(^{87}Sr/^{86}Sr)_0$ | Age (m. y.) | Author |
|---|---|---|---|
| High Tatras | | | J. Burchart (1968) |
| granodiorite WR + M | 0.705 ± 0.001 | 290 ± 10 | |
| granodiorite WR + M | 0.706 ± 0.003 | 300 ± 15 | |
| pegmatite M | 0.708 ± 0.002 | 250 ± 15 | |
| pegmatite M | 0.705 ± 0.002 | 305 ± 15 | |
| Western Tatras | | | |
| leucogranite WR + M | 0.708 ± 0.001 | 290 ± 10 | |
| pegmatite M | 0.731 ± 0.018 | 280 ± 80 | |
| Goryczkowa | | | |
| granodiorite WR + M | 0.706 ± 0.04 | 295 ± 20 | |
| Malé Karpaty Mts. | | | G. P. Bagdasarjan (1982, in press) |
| Bratislava massif | | | |
| granodiorite WR | 0.7076 ± 0.0013 | 347 ± 4 | |
| Modra massif | | | |
| granodiorite WR | 0.7075 ± 0.00032 | 324 ± 18 | |
| GEMERIDES | | | Á. Kovách et al. (1979) |
| Podsúľová granite WR | 0.7339 ± 0.0040 | 145 ± 6 | |
| Hummel granite WR | 0.7195 ± 0.0077 | 250 ± 26 | |

WR — whole rock, M — mineral

granitoid rocks are listed in Table 2. Except for one pegmatite from the High Tatra Mts. no initial ratio exceeds the value of 0.708. The main granitoid body of the High Tatra is characterized by the value 0.705 and the two Little Carpathian massifs by 0.707. The leucogranites and pegmatites of the High Tatra yielded the value of 0.708 with one exception (0.731 ± 0.018).

In general, the data are scarce and some of them (from the Gemerides) are rather uncertain. From the I/S characteristics it can be inferred the following: except for the pegmatite mentioned above (the West Tatra Mts.) no Tatride rock has a higher initial ratio than 0.708, which is distinctive for the S-type. Most ratios (Little Carpathians and High Tatra) are of 0.706—0.708 value, i. e. somewhat above the 0.706 boundary for the I-type. Only the High Tatra granitoid body shows a typical I-character (0.705). Both initial ratios of the Gemeride granite unambiguously confirm an outstanding S-affinity.

## *Discussion and conclusions*

The results obtained have shown a good agreement between the geochemical and isotopic data. The geochemical character, the $K_2O/Na_2O$ ratio, small contents of Rb and Cs, contents of accessory minerals (magnetite ilmenite), and the definite igneous trend of several Tatro-Veporide massifs (the Modra massif in the Little Carpathians, Tribeč, Malá Fatra, High Tatra, Sihla type, etc.), are consistent with the range of the initial ratio of 0.705—0.708. The geochemical and isotopic data on the Gemeride granites also agree with the characteristic of the S-type. The Tatro-Veporide massifs may be labelled as transitional with I-affinity, whilst the Gemeride granites as being of S-type. The initial $^{87}Sr/^{86}Sr$ ratios suggest crustal processes that led to the formation of West Carpathian granitoids.

The nowadays accepted model of the origin of the West Carpathian granitoids presumes anatexis of prevalently sedimentary complexes (B. Cambel, 1980), at the boundary between the upper and lower earth's crust (D. Hovorka, 1979). The source rocks had probably the composition of greywackes. In the sense of this model the Tatro-Veporide granitoids belong rather to the S-than I-type (D. Hovorka, 1980).

The frequent occurrence of metabasites in the granitoid plutons, however, led already in the past years to the conception of a hybrid sedimentary-volcanic character of the source material. The study of alkalies in the Little Carpathian granitoids (B. Cambel et al., 1981) gave rise to the conclusion that the source rocks were not at all pure clayey-siliceous sediments, but that they contained a considerable amount of volcanites of the tholeiitic type. From the petrochemical survey of the selected granitoids of the West Carpathians, as given by B. Cambel — L. Vilinovičová (1981), it follows that by their major element and minor element chemistry they belong chiefly to the latite type, according to the classification of L. Tauson (1977). This type comprises extremely acid members of the basaltoid series of the tholeiitic type. Only a minor part is ranked with the palingenetic granitoids, but the authors believe that this geochemical pattern need not be regarded as a direct results of the differentiation of basaltoid magma. They consider it to be rather a product of anatexis of the volcanic and sedimentary crustal derivatives.

From the standpoint of this knowledge the predominating I-affinity of the Tatro-Veporide massifs is not surprising, on the contrary, it makes it possible to complement the existing conception. The source material of the Tatro-Veporide massifs contained a large amount of mantle-derived volcanic material, which possessed a low Rb/Sr ratio and was relatively young. Its presence caused a decrease of the initial $^{87}Sr/^{86}Sr$ ratio. For example, the value of 0.705 of the High Tatra granitoid body (J. Burchart, 1968) belongs, after G. Faure and J. L. Powell (1972), into the "basalt field". According to these authors, granites with the initial ratio equal to 0.702—0.706 are derivatives of the primary basalt magma. The other established ratios that are of 0.706—0.707 value indicate an admixture of more mature crust material with a higher Rb/Sr ratio. Cambel (in B. Cambel — L. Vilinovičová, 1981) presumes it to be clastics of gneiss or higher metamorphosed older (Precambrian) complexes, which after being disintegrated sedimented in the pre-Variscan geosyncline. During the granite plutonism of the Variscan orogeny this unsorted and petrogenetically diverse source material was granitized and reworked by anatexis. The palingenetic magmas originated in this way and the products of their consolidation — the Variscan granitoids of the West Carpathians — display a definite I-affinity.

A good analogue to the Tatro-Veporide granitoids of the West Carpathians is the Uralla Plutonic suite of the New England Batholith, Eastern Australia (S. E. Shaw and R. H. Flood, 1981). The authors characterized five plutonic suites of the batholith: S-type Hillgrove and Bundarra Plutonic suites, I-type Moonbi and Clarence River Plutonic suites, and the Uralla Plutonic suite with transitional I — S characteristics. The last one resembles Tatro-Veporide granitoids with its $^{87}Sr/^{86}Sr$ initial ratio 0.705—0.707 and I-type affinity S. E. Shaw and R. H. Flood presented three explanations, however, favoured the mixed-source model. This model implies partial melting of pelitic metasedimentary rocks of the type that gave rise to the S-type suites and meta-igneous source region that gave rise to the I-type Moonbi and/or Clarence River Plutonic suites.

As far as the West Carpathian granitoids are concerned, we suppose that the different proportions of volcanic and sedimentary components account for the variations in the geochemical characteristics of some of the massifs.

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REFERENCES

ATHERTON, M. P. — McCOURT, W. J. — SANDERSON, L. M. — TAYLOR, W. P., 1979: The geochemical character of the segmented Peruvian Coastal Batholith and associated volcanics. In: Origin of granite batholiths: Geochemical evidence, eds.: M. P. Atherton and J. Tarney, Orpington, Shiva Publishing, pp. 45—64.

BECKINSALE, R. D., 1979: Granite magmatism in the tin belt of South East Asia. In: Origin of granite batholiths: Geochemical evidence, eds.: M. P. Atherton and J. Tarney, Orpington, Shiva Publishing, pp. 34—44.

BURCHART, J., 1968: Rubidium-strontium isochrone ages of the crystalline core of the Tatra Mountains, Poland. Amer. J. Sci. (New Haven), 266, pp. 895—907.

CAMBEL, B., 1980: K probleme granitoidnych porod Zapadnych Karpat. Acta geol. geogr. Univ. Comen. (Bratislava), 35, pp. 101—110.

CAMBEL, B. — MICKIEVIČ, B. F. — VESELSKÝ, J. — VILINOVIČ, V., 1981: Alkalies in the granitoid rocks of the Malé Karpaty Mts. Geol. Zborn. — Geol. carpath. (Bratislava), 32, 6, pp. 643—669.

CAMBEL, B. — KÁTLOVSKÝ, V. — KHÚN, M., 1981: Geochémia uránu, tória, uhlíka a ďalších prvkov v tmavých bridliciach kryštalinika Malých Karpát. Mineralia slov. (Spišská Nová Ves), 13, 5, pp. 423—441.

CAMBEL, B. — VILINOVIČOVÁ, Ľ., 1981: Petrochemistry and geochemistry of selected granitoid samples from the West Carpathians region. Geol. Zborn. — Geol. carpath. (Bratislava), 32, 5, pp. 517—546.

CHAPPELL, B. W. — WHITE, A. J. R., 1974: Two contrasting granite types. Pacif. Geol. (Tokyo), 8, pp. 173—174.

COLEMAN, M. L., 1979: Isotopic analysis of trace sulphur from some S- and I-type granites: Heredity or environment? In: Origin of granite batholiths: Geochemical evidence, eds.: M. P. Atherton and J. Tarney, Orpington, Shiva Publishing, pp. 129—133.

FAURE, G. — POWELL, J. L., 1972: Strontium isotope geology, 1st ed. Springer Verlag. Berlin-Heidelberg-New York, 188 pp.

GBELSKÝ, J., 1980: Akcesorické minerály v niektorých typoch granitoidných hornín Západných Karpát, Manuscript, Geofond — Bratislava, 102 pp.

HINE, R. — WILLIAMS, I. S. — CHAPPELL, B. W. — WHITE, A. J. R., 1978: Contrasts between I- and S-type granitoids of the Kosciusko batholith. J. Geol. Soc. Australia (Sydney), 25, pp. 219—234.

HOVORKA, D., 1979: Genéza variskych magmatitov Západných Karpát. Geol. Práce, Správy (Bratislava), 72, pp. 131—147.

HOVORKA, D., 1980: The West Carpathians crust origin and plutonite formations. Geol. Zborn. – Geol. carpath. (Bratislava), 31, 4, pp. 523–535.
ISHIHARA, S., 1977: The magnetite-series and ilmenite-series granitic rocks. Mining Geol. Tokyo (Tokyo), 27, pp. 293–305.
KLOMÍNSKÝ, J. – PALIVCOVÁ, M. – CAMBEL, B. – GURBANOV, A. G., 1981: Petrochemical correlation and I/S classification of variscan granitoids from the Czech Massif, West Carpathians (Czechoslovakia) and the Caucasus Mts. (USSR). Geol. Zborn. – Geol. carpath. (Bratislava), 32, 3, pp. 307–315.
KOVÁCH, Á. – SVINGOR, É. – GRECULA, P., 1979: Nové údaje o veku gemeridných granitov. Mineralia slov. (Spišská Nová Ves), 11, 1, pp. 71–76.
LA ROCHE H. de, 1980: Granites' chemistry through multicationic diagrams. Sci. de la Terre, série Informatique Géologique, (Nancy), 13, pp. 65–88.
LE FORT, P., 1981: Manaslu leucogranite: A collision signature of the Himalaya a model for its genesis and emplacement. J. Geophys. Res. (Richmond), 86, Bll, pp. 10545–10568.
SHAW, S. E. – FLOOD, R. H., 1981: The New England Batholith, Eastern Australia: Geochemical variations in time and space. J. Geophys. Res. (Richmond), 86, Bll, pp. 10530–10544.
ŠTRBIANOVÁ, M., 1980: Petrochemicko-geochemické a petrografické štúdium gemeridných granitov, Manuscript – Geofond, Bratislava, 77 pp.
TAUSON, L. V., 1977: Geochimičeskije tipy, potenciaľnaja rudonosnosť granitoidov. 1st ed. Moscow, Nauka, 280 pp.
THORPE, R. S. – FRANCIS, P. W., 1979: Petrogenetic relationship of volcanic and intrusive rocks of the Andes. In: Origin of granite batholiths: Geochemical evidence, eds.: M. P. Atherton and J. Tarney, Orpington, Shiva Publishing, pp. 65–75.

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