GEOLOGICA CARPATHICA, 45, 3, BRATISLAVA, JUNE 1994
171 - 183

GEOCHEMICAL CHARACTERIZATION OF GRANITIC ROCK PEBBLES FROM CRETACEOUS TO PALEOGENE FLYSCH OF THE PIENINY KLIPPEN BELT

PAVEL UHER[1], RÓBERT MARSCHALKO[1], EDUARD MARTINY[1], ĽUBICA PUŠKELOVÁ[1], VLADIMÍR STREŠKO[2], BORIS TOMAN[1] and ERNEST WALZEL[1]

[1]Geological Institute, Slovak Academy of Sciences, Dúbravská cesta 9, 842 26 Bratislava, Slovak Republic
[2]Geological Institute, Faculty of Sciences, Comenius University, Mlynská dolina G, 842 15 Bratislava, Slovak Republic

(Manuscript received June 28, 1993; accepted October 5, 1993)

Abstract: Granitoids s.l. belong among typical rocks forming pebbles in conglomerates of Middle Cretaceous to Paleogene flysch in the Slovak part of the Pieniny Klippen Belt (PKB). Predominant are biotite leucogranites to granite porphyries, with metaluminous to peraluminous trend, increased values of K, Zr, Y, REE, Zn and Ga/Al, decreased contents of Al, Ca, Mg, Sr and V (Upohlav type). The two comparative rhyolite samples are geochemically related to this type as well. Less frequent are biotite to two-mica granodiorites and granites, with peraluminous trend, in contrast to the first type with increased contents of above all Ca, Mg, Sr and Ba, but lower values of K, Rb, Zr, Y, Zn and Ga/Al (Krivá type). Partly different geochemical characteristics shows the occurrence of porphyric granite (Lubina type). While the Krivá and probable also Lubina type are comparable with Variscan (above all Carboniferous) orogenic granitoids of the Western Carpathian Tatric and Veporic Units, the Upohlav type has analogues in post-orogenic (above all Permian) intrusions in the broader Alpine-Carpathian and Western Mediterranean region.

Key words: Carpathians,Pieniny Klippen Belt, Cretaceous-Paleogene flysch, granitic rocks, geochemistry.

Introduction

Pebbles of granitic rocks s.l., which occur systematically in conglomerates of the Middle Cretaceous to Paleogene (Eocene) flysch of the Pieniny Klippen Belt (PKB) in the Western as well as Eastern Carpathians, have long attracted the attention of geologists, above all due to abundant occurrence of exotic types, the analogues of which, until recently, have not been described in the Carpathian region. The study of acid magmatic rocks from these pebbles was in the past oriented to accessible petrographic and geochemical studies, i.e. optical study, major and some trace elements (Zoubek 1931; Wieser 1958; Krivý 1969; Kamenický et al. 1974; Šímová 1985; Birkenmajer & Skupinski 1989; Birkenmajer & Wieser 1990; Mišík et al. 1991b). Geochemical classification, petrogenesis, provenience, age and original paleogeographical situation of the PKB granites are important for clarifying the geological evolution of this region situated on the contact of external and central Carpathian units. We attempted thus to contribute to the solving of these problems with the help of the study of accessory zircon (Uher & Marschalko 1993; Uher & Pushkarev, in press), as well as some geochemical characteristics of PKB granitic rocks presented in this paper.

Geological position of the pebbles

Granitoid rocks occur systematically in pebbles of conglomerate bodies within proximal facies of turbidite flysch sequences of Cretaceous-Paleogene age in the Slovak, Polish as well as Ukrainian section of PKB (Zoubek 1931; Wieser 1958; Chernov 1973; Marschalko et al. 1976; Marschalko 1975, 1986; Mišík et al. 1991b). Pebbles of various sedimentary, magmatogenic and metamorphic rock types, granitoids forming in average 4 % (Western Slovak segment - Marschalko 1986), occur in several conglomerate horizons within flysch cycles of the Klape, Pieniny and Manín Units. The age span of the conglomerate bodies in the Western Slovak PKB segment is Upper Albian to Campanian (Marschalko & Samuel 1975; Marschalko 1986), while eastwards (Eastern Slovak and Ukrainian segment) the ages are stratigraphically shifted from Paleocene to Middle Eocene (Chernov l.c., Mišík et al. l.c.). The size of the granitoid pebbles to blocks is very variable, from 0.X cm to 1 - 1.5 m blocks (loc. Považský Chlmec, Zádubnie, Kotrčiná Lúčka). The pebbles are most widespread in the region between Púchov and Žilina, and in the Orava region (NW Slovakia). In our contribution we present a study of the whole Slovak segment, from Podbranč in the west to Inovce in the east, in a length of approx. 350 km (Fig. 1).

Petrographical characteristics

Already with the naked eye, two different granitoid rock types can be distinguished ("exotic" vs. "Tatry" type granites - Zoubek 1931; granites II vs. I - Šímová 1985; Upohlav vs. Krivá type - Uher & Marschalko 1993). On the basis of a study of accessory zircon and unpublished data, at least a part of rhyolite pebbles can be ranged among the Upohlav granitic rocks. Sporadically, a third type has been identified as well: the Lubina type of granitic rocks (Uher & Marschalko l.c.).

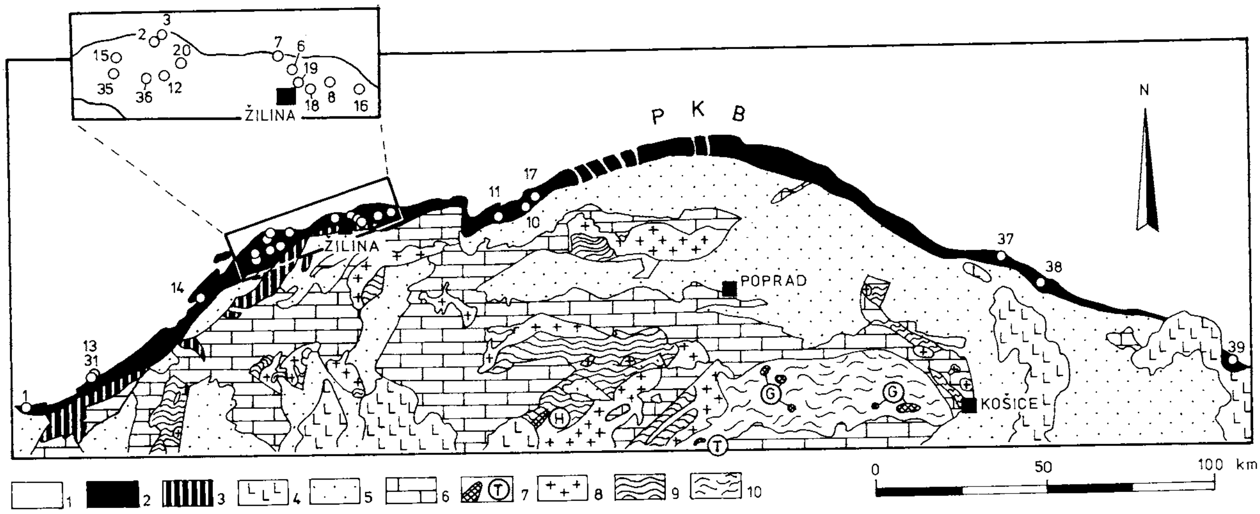

Fig. 1. Geological map of Slovak and Polish section of the Pieniny Klippen Belt (PKB) and adjacent units with marked localization of studied patterns of granitic rocks (numbers indicate the "BP" samples, see sample locations and Tab. 1). **1** - flysch belt (Cretaceous - Paleogene) and Neogene basins of Outer Carpathians; **2** - PKB (Jurassic - Paleogene); **3** - peri-klippen zone: Brezová, Myjava and Manín Units, Súľov Formation (Jurassic - Paleogene); **4** - mostly intermediary volcanic and pyroclastic rocks (Neogene); **5** - clastic Central Carpathian Paleogene and Neogene; **6** - mostly carbonatic less clastic and volcanic sequences of different units (Upper Carboniferous - Cretaceous); **7** - post-orogenic small intrusions of granites (mainly Permian), H - Hrončok, T - Turčok, G - Spiš-Gemer (see discussion); **8** - orogenic granitoids of Tatric and Veporic Units (mainly Carboniferous); **9** - metapelites-metapsammites, local metavolcanics and metacarbonates of Tatric and Veporic Units (mainly Early Paleozoic); **10** - metapelites-metapsammites, metavolcanics and metacarbonates of Gemeric Unit (Paleozoic).

1 - The Upohlav type. There are leucocratic granites with biotite, passing into granite porphyries. Granites s.s. have massive confining structure, hypidiomorphic-granular texture. The K-feldspar, forming up to 0.5 cm large phenocrysts, is optically distinguishable as orthoclase-perthite, frequently forming Carlsbad twins. Plagioclase I (An about 10) forms hypidiomorphic, strongly sericitized grains, in contrast to unaltered plagioclase II - albite with An_{01-02}, substituting plagioclase I as well as K-feldspar. Biotite forms characteristic xenomorphic clusters, less hypidiomorphic lamelles of yellow-green to dark green colour, due to high Fe^{2+} contents and partial chloritization (unpublished analyses - Uher & Petrík). From accessory minerals, we observed zircon, allanite and magnetite, sometimes there are frequent veins of secondary calcite. Average modal composition of Upohlav type granites (n = 13) is the following: quartz 34.4 ± 6.7, K-feldspar 36.9 ± 13.2, plagioclase 23.3 ± 11.9, biotite 4.8 ± 2.7 (vol. %).

A typical feature of granite porphyries is porphyric texture with microgranitic matrix or dactylitic (micrographic) intergrowth of K-feldspar with quartz. Pink K-feldspar phenocrysts are again frequent. Rhyolites have aphanitic texture with corroded beta-quartz, locally also albite phenocrysts.

2 - The Krivá type. Among these there are granites, granodiorites to leucotonalites (the later only on the basis of planimetric analysis), local pegmatoid granites to pegmatites (especially loc. Krivá and Široká). Granitoids s.s. have equigranular hypidiomorphic texture with sericitized plagioclase (oligoclase to andesine), gridded microcline-perthite, undulose quartz, brown hypidiomorphic biotite, less muscovite. From accessories there are garnet, apatite and zircon. Average modal composition of Krivá type granitoids is as follows (n = 4): quartz 35.8 ± 1.8, K-feldspar 11.5 ± 5.7, plagioclase 45.5 ± 9.2, biotite 4.4 ± 2.7, muscovite 1.0 ± 0.5 (vol. %). The rocks have sometimes slightly, or even evidently oriented structure.

3 - The Lubina type has been found only sporadically. It is a coarse-grained granite with 1-2 cm long pink K-feldspar phenocrysts, optically orthoclase-perthite, with strongly sericitized plagioclase, clearly undulose quartz and chloritized biotite. The rock bears signs of tectonic reworking.

Analytical methods

Major elements in the form of oxids (SiO_2 to H_2O^-) have been determined in a part of the samples by wet silicate analysis (analyst E.Walzel, analytical conditions see in Cambel & Walzel 1982).

The second part of the samples has been analysed by X-ray fluorescence method (analyst B.Toman) on the X-ray spectrometer Philips PW 1410/20 with Rh-anode. For the determination of Si, Al, Mg and Na, LiF 200 and TIAP dispersion crystals were used, for Fe and Mn a scintillation detector, for Ti, Ca and K a gas proportional detector with Ar/CH_4 = 90/10 filling. The samples were prepared into the form of a $Li_2B_4O_7$ solid solution melted at the temperature of 1050 °C. As comparative materials, the standards of ZGI Berlin were used: granite GM and basalt BM, as well as their mixtures. For the calculation of concentrations, a linear calibration modes was used.

In 3 samples, Nb was determined by the XRF method on the X-ray spectrometer Philips PW 1410 (analyst Janáčková, UNIGEO Brno).

Trace elements Sr, Ba, B, Be, Sn, Ga, Sc, Y, Zr, Mo, Cu, Ni, Cr and V were determined by the optical emission spectrography method - OES (analyst Ľ. Puškelová). The samples were diluted by a spectrochemical admixture (graphite powder Su-602 with comparative elements Ge, Pd and Eu) at a ratio of 1 : 1, the spectra of samples were recorded by the grid spectrograph PGS-2 Zeiss in UV and visual area, with a 6 A power arch as activating source.

Li, Rb and Zn were determined using atomic absorption spectroscopy - AAS (analyst E. Martiny). The spectrometer Perkin-Elmer 303 was used, at working conditions analogous to those mentioned in Cambel et al. (1983).

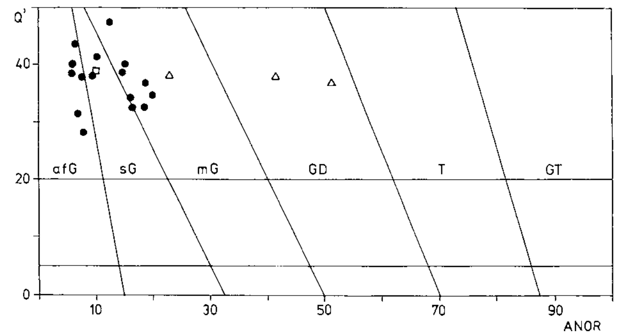

Fig. 2. Mesonormative Q'-ANOR classification (Streckeisen & Le Maitre 1979) of granitoid rock pebbles of Pieniny Klippen Belt. afG - alkali-feldspar granites, sG - syenogranites, mG - monzogranites, GD - granodiorites, T - tonalites, GT - gabbroid tonalites. Upohlav type: granites and porphyries (full circles), Krivá type granitic rocks (open triangles), Lubina type granite (open square).

Rare earth elements were determined by atomic emission spectrometry with induction-coupled plasma - ICP (analysts E. Martiny and V. Streško). Samples in the form of solutions enriched in REE were measured on the atomic emission spectrometer PLASMAKON S 35 KONTRON in sequential arrangement, with a grid of 2400 lines/mm, at the frequency of 27.12 MHz, with Ar/Ar plasma with an output of 1.5 kW.

Fluorine was determined using the hydropyrolithic method in Pt apparatus, the determination itself was carried out using a ion-selective electrode (ISE) on the ION Meter pMX 2000 manufactured by WTW (analyst V. Chalupský, Geological Institute of the AS CR Prague).

In all, 32 samples of acid magmatic rock pebbles were analysed: 22 granitoids, 8 granite porphyries and 2 rhyolites, or 27 Upohlav type rocks, 4 Krivá type rocks and 1 of the Lubina type. All 32 samples were analysed for major elements (wet method, or XRF) and OES, 27 samples by AAS, 4 samples by ICP (REE analyses), 4 samples on ISE (fluorine) and 3 samples by XRF (Nb) - Tab. 1.

Major elements and geochemical classification of rocks

Due to frequent ambiguous distinguishing between plagioclase I and II (albite with An below 05), as well as very fine-grained textures in the matrix of granite porhyries of the Upohlav type, in the majority of cases it was not possible to classify correctly these rocks by planimetry. Thus, a suitable way proved to be mesonormative classification on the basis of chemical composition of the rock (Streckeisen & LeMaitre 1979). From Q'-ANOR diagram of the above classification (Fig. 2) it follows that the analysed granites and granite porphyries of Upohlav type belong without exception to alkali-feldspar granites, syenogranites, less monzogranites. Granitoids of Krivá type can be classified as monzogranites to granodiorites and the Lubina porphyric granite as syenogranite (Fig. 2). However, some rocks, evidently due to subsolidus alterations and above all due to the presence of secondary calcite veinlets, yield anomalous chemical compositions, leading to negative ANOR values.

From the viewpoint of the major element distribution in acid magmatic rocks of Upohlav type, evident are high SiO_2 contents (almost always exceeding 70 %, frequently above 73 %), slightly

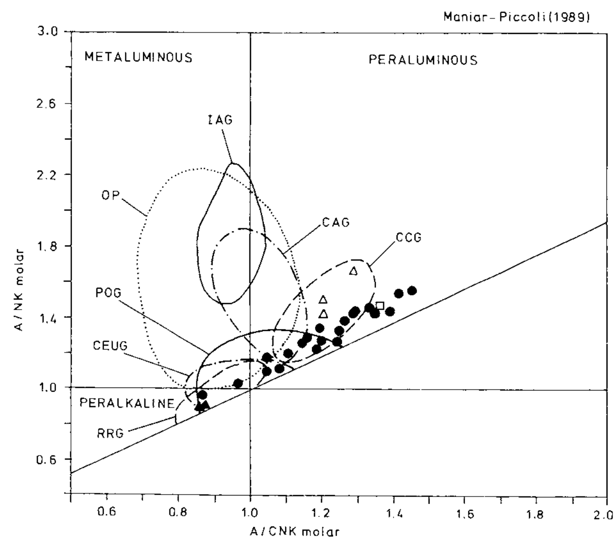

Fig. 3. A/NK [molar $Al_2O_3/(Na_2O + K_2O)$] vs. A/CNK [molar $Al_2O_3/(CaO + Na_2O + K_2O)$] diagram (Maniar & Piccoli 1989) of granitoid rock pebbles of Pieniny Klippen Belt. Granitic rocks: RRG - rift related, CEUG - continental epeirogenic uplift, POG - post-orogenetic, OP - ocean plagiogranites, IAG - island arc, CAG - continental arc, CCG - continental collision, Upohlav type rhyolites (full triangles). Other symbols see Fig. 2.

decreased Al_2O_3 contents (in average 13 - 14 %), low MgO (below 0.5 %) and CaO (usually below 1.5 %), but slightly increased contents of K_2O (4 - 5.5 %). The contents of P_2O_5 are also low (below 0.2 %) - Tab. 1. From the position of analyses of Upohlav granites and porphyries on the A/NK vs. A/CNK diagram (Fig. 3) it follows that they are peraluminous, less metaluminous rocks with a consistent trend approaching post-orogenic, or also continental collision granites (POG, or CCG - Maniar & Piccoli 1989). Two rhyolite analyses extend this trend into the peralkaline area, due to very high K_2O contents (above 7 %) and at the same time low Al_2O_3 (below 12 %). The consistent trend of Upohlav magmatites is indicated also by the R1-R2 diagram (Batchelor & Bowden 1985) - Fig. 4, in which these magmatites approach the trend of late orogenic to anorogenic granitoids. The post-orogenic trend of Upohlav-type acid magmatites is clearly documented also by discrimination diagrams of Maniar & Piccoli (1989) - Fig. 5, where the above mentioned two rhyolite samples again diverge from the trend.

Granitic pebbles of Krivá type are characterized as well by higher SiO_2 contents (70 - 73 %), in contrast to Upohlav granites and porphyries they have significantly higher contents of CaO (2 - 3 %), mostly also of MgO, and, on the other hand, the contets of K_2O are lower (below 3 %) - Tab. 1. The trends in the A/NK vs. A/CNK diagram are different as well, Krivá type granitic rocks showing the marked peraluminous trend of continental collision granites (Fig. 3), as well as in the R1-R2 diagram, where increased CaO contents lead to higher R2 parameters, analogous to pre-plate collision granites (Fig. 4). In diagrams of Maniar & Piccoli (1989) they are mostly situated in the field of orogenic IAG+CAG+CCG (Fig. 5).

And, finally, the only pebble of porphyric granite of Lubina type can be characterized as syenogranite, analogus to peraluminous continental collision granites, or syn-collision or orogenic granites s.l. (Figs. 2-5).

Trace elements

Trace element contents show still more significant differences between the granitoid rock types in PKB flysch pebbles. Upohlav type rocks have, in spite of their leucocratic character and higher differentiation grade, relatively high contents of some high-strength elements, especially Zr, Y, REE and Zn, partly Nb, increased are also the ratios 10000xGa/Al and especially Rb/Sr, and, on the other hand, conspiciously low are the contents of V and especially Sr, partly also of Ba (Tab. 1). These signs are typical of A-type granites, as characterized above all by Whalen et al. (1987). The contents of indicative trace elements in relation to the ratio 10000xGa/Al really approach, or are situated in the field of typical A-type suites and are as rule different from S- and I-type granitoids, into fields of which project the analyses of Krivá and Lubina type granitoids (Fig. 6). In the diagrams Nb vs. Y, or Rb vs. Y+Nb (Pearce et al. 1984) the Upohlav granites project into the field of volcanic arc granites, or also syn-collision granites (VAG or syn-COLG), but they are already near the field of within-plate granites (WPG) - Fig. 7. The high total REE contents, especially those of LREE, with marked negative Eu anomalies in the Upohlav granites, strongly remind of normalized REE patterns of A-type granites (Collins et al. 1982; Whalen et al. 1987; Pe-Piper et al. 1991; Fig. 8).

Discussion

On the basis of a geochemical study of major and trace elements, as well as petrographic signs and the character of accessory zircon (Uher & Marschalko 1993), we can distinguish three fundamental genetic types of granitoids rocks s.l. in pebbles of Cretaceous to Paleogene PKB flysch:

1 - The Upohlav type comprises the comagmatic suite granite-granite porphyry. The studied rhyolite rocks are similar: they have the same zircon typology characteristics (Uher & Marschalko l.c.), but also some common geochemical features, especially increased alkalinity and contents of Rb, Zr, Y, and, on the other hand, low concentrations of Sr, Ba and V. The more significant agpaicity (especially K/Al), peralkaline character as well as increased MgO contents in both studied rhyolite samples, in contrast to Upohlav granites and porphyries, can be related to very deep, high-temperature conditions of magma origin (probably lower crust) and higher P-T conditions than in the case of generation of granite and porphyry magma (probably lower to middle part of the crust). Geochemical data on Upohlav type acid magmatites indicate their post-orogenic character and trend similar to A-type granites (cf. Pitcher 1983; Whalen et al. 1987; Maniar & Piccoli 1989). The structural and petrographic features of the rocks (cf. Pitcher l.c.; Bonin 1990), as well as zircon typology (cf. Pupin 1988) support the assumption of post-orogenic, slightly to medium-alkaline and high-temperature character of the Upohlav type granitic rocks and rhyolites.

However, within the group of A-type granites there is a relatively wide range of rocks, from low and medium alkaline, usually peraluminous biotite granites of late- to post-orogenic character, to typical anorogenic alkaline to hyperalkaline granites, monzonites and frequently syenites with alkaline amphiboles and pyroxenes, frequent fayalite, alkaline Zr and Ti silicates (e.g. elpidite, vlasovite, eudialite etc.), of metaluminous to peralkaline character, with enormously increased contents of Zr, Y, REE, Nb and F (Whalen et al. l.c.; Bonin 1988, 1990, Černý 1991 - NYF family). The Upohlav granites, porphyries and rhyolites, considered within this succession, belong without doubt to a weakly developed peraluminous A-type suite, generated in an orogenic belt. In the pebble material from PKB, no specimen of a rock with monzonite or syenite composition has been foud yet, and the Upohlav type itself is represented only by granites and porphyries with biotite, without alkaline amphiboles, pyroxenes, fayalite or alkaline Zr and Ti silicates. Also, the increased, but not enormously, concentrations of indicative trace elements (Zr, Y, REE, Nb, Ga, F) and the position of Upohlav magmatites in discrimination diagrams on the periphery of the main A-type granite field (cf. Whalen et al. 1987), or only near to but already outside the within-plate granite field (cf. Pearce et al. 1984), clearly indicate only moderately developed A-type character of these granitoids (Tab. 1, Figs. 6-8).

As far as analogous post-orogenic granitoids are concerned, it is assumed that they formed in an extension or tension geotectonic environment, in a region of deep and large fault systems, which could be a manifestation of the compensation of tectonic stress and consolidation of a young orogen (cf. Lameyre 1988; Bonin 1990). The most typical period for the generation of similar post-orogenic to early anorogenic acid magmatites of A-type in Europe was the post-Hercynian stage (Permian to Upper Triassic) with large occurrences of acid and at the same time alkaline rhyolite volcanism and granite plutonism (Bonin l.c.). The latest U-Pb isotopic dating of zircons from Upohlav granites has shown their early post-Hercynian, Lower Permian age (274 ± 13, or 294 ± 21 Ma - Uher & Pushkarev, in press). These geochemical and geochronological data are not consistent with the so far presented idea of a Jurassic-Cretaceous magmatic suite of island arc-type or of active (Andean) continental plate margin, which were based on less reliable analytical and geochronological data (scarce trace element analyses, absence of accessory mineral studies, K-Ar dating - Chernov 1973; Marschalko 1986; Mišík & Marschalko 1988, Birkenmajer 1988). However, also the so far available data, especially the petrographic characteristics of "exotic granites" with high contents of K-feldspars, albite and with green biotite, together with increased alkali contents (Krivý 1969; Šímová 1985), increased contents of Zr, Y and Th or Th/U (Kamenický et al. 1974) fully confirm the rather alkaline than calc-alkaline (CA) character of Upohlav type exotic granitoids. This slightly to medium alkaline post-orogenic geochemical trend is not dominant in subduction orogenic regimes, it only accompanies the predominant calc-alkaline magmatism in back-arc or peripheral regions behind the main CA volcanic-plutonic belt, further away from the trench. However, in this case, typical CA granodiorites to diorites with their (sub)volcanic, especially intermediary members, are missing among the pebbles. The lack of tuffogenic rocks in the pebbles has been pointed out already by Mišík & Sýkora (1981), and also in the last time found carbonates with tuffitic admixture are relatively rare, and they represent basic pyroclastic rocks (Mišík et al. 1991a, b). Anyway, the assumed geotectonic environment in the area of the future PKB and surrounding units, mostly with a thin continental, transitional to oceanic crust (cf. Rakús et al. 1990) was in the Jurassic to Lower Cretaceous not suitable for the generation of post-orogenic granitoid types and acid vulcanites. To the contrary, typical of the Mesozoic of the Outer and Central Western Carpathians are alkaline, but more primitive riftogenic basalts (Hovorka & Spišiak 1988). And, finally, new U-Pb zircon ages are undoubtedly more reliable data than the so far available K-Ar data, which, like other where, document only of the uplift or cooling ages of already solidified magmatic rocks.

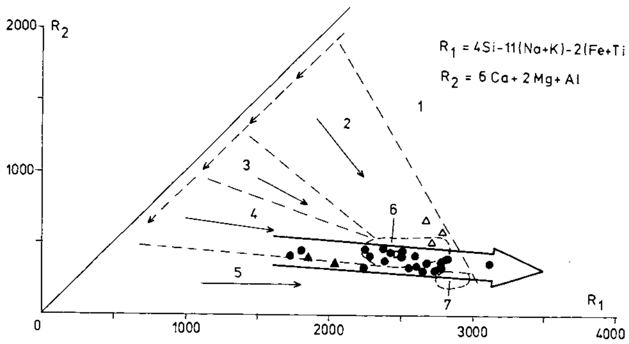

Fig. 4. R1 - R2 diagram (Batchelor & Bowden 1985) of granitic rock pebbles of Pieniny Klippen Belt. Granitic rocks: **1** - mantle fractionates; **2** - pre-plate collision; **3** - post-collisional uplift; **4** - late-orogenic; **5** - anorogenic; **6** - syn-collision; **7** - post-orogenic. Other symbols see Fig. 2 and 3.

Until recently, no analogues of Upohlav type granitoids have been known in the Western Carpathian area, and thus, already since Zoubek (1931), they have been classified as "exotic". However, granitic rocks have been recently identified in the Alpine-Carpathian-Pannonian area, which are in many features similar to the Upohlav granites. They are leucocratic, often porphyric biotite granites, in several cases yielding isotopically determined Permian age. Their common geochemical properties are increased contents of Si, K, often Zr, Y and REE, low contents of Al, Mg, Ca, Sr and V. From the mineralogical viewpoint they have typical zircon typology (high I.A, I.T), indicating higher-alkaline and higher-temperature conditions of origin. From the Western Carpathian area, we can classify in this way especially the Turčok granite in Gemeric Unit (Uher & Gregor 1992), less the Hrončok type granite in Veporic Unit (Fig. 1), perhaps also the Rochovce granite occurring on the boundary of the above units (Határ et al. 1989), if its Permian age should be definitely proved (cf. Kovách et al. 1986; vs. Cambel et al. 1989). Sn-bearing granites of the Spišsko-gemerské rudohorie Mts. (Fig. 1) are evidently also of Permian age (ibid), however, they show a number of specific geochemical properties (Tauson et al. 1977). In the Pannonian block analogous properties are displayed by the Velence Massif in the Hungarian Midmountains (Buda 1969; Gbelský & Határ 1982; Uher & Broska in press), also in the Eastern Alps by several occurrences in the Tauern window of Penninic Unit (Finger et al. 1992). Numerous are the occurrences of Permian alkaline granites of the so-called Western Mediterranean province, especially in the region of Corsica and Esterel (Pupin 1988; Bonin 1988, 1990).

Although the above mentioned occurrences of Permian post-orogenic granites in the broader Middle European area showing a slight A-type trend cannot be considered to have been direct rock sources for the granite and porphyry pebbles of Upohlav type, with some specific structural and geochemical features. On the other hand, we suggest the possibility of a more widespread occurrence of independent post-Hercynian granite plutonism stage in the present Western Carpathian space.

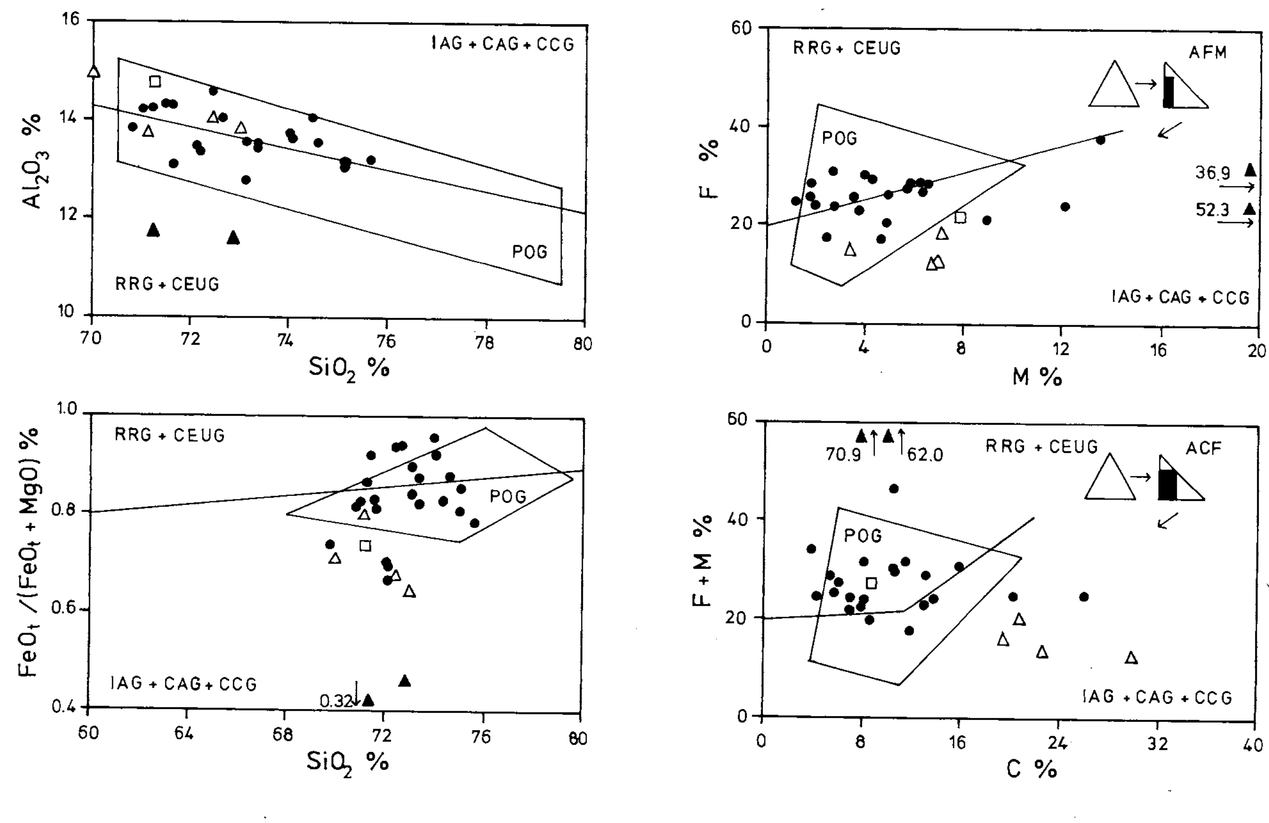

Fig. 5. Discrimination diagrams of the major elements (Maniar & Piccoli 1989). F - FeOt, M - MgO, C - CaO calculated for 100 per cent in AFM and ACF diagram respectivelly. Other symbols see Fig. 2 and 3.

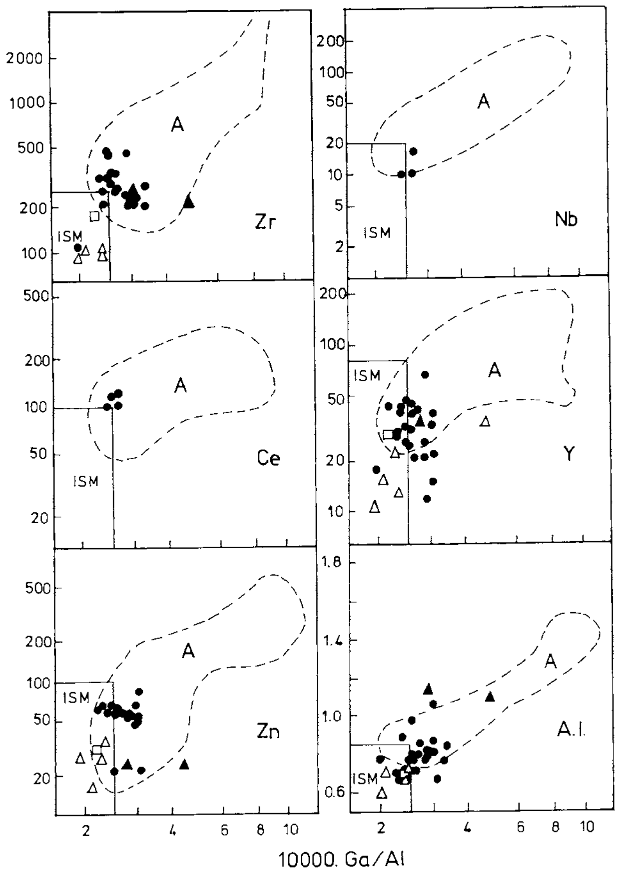

Fig. 6. Zr, Nb, Ce, Y, Zn (ppm) and A.I. [molar ($Na_2O + K_2O$)/Al_2O_3] vs. 10000xGa/Al diagrams (Whalen et al. 1987) granitic rock pebbles of Pieniny Klippen Belt. A: A-type fields; ISM: fields of I-, S- and M-type granitic rocks. Other symbols see Fig. 2 and 3.

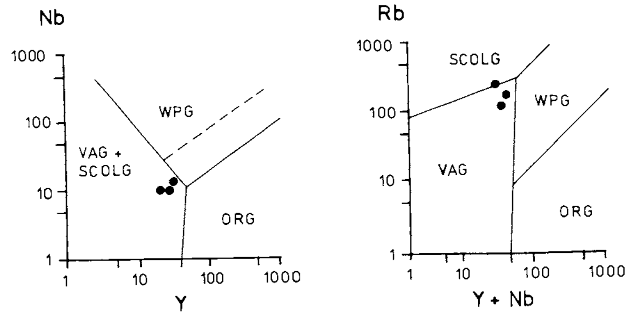

Fig. 7. Nb vs. Y and Rb vs. Y + Nb diagrams (Pearce et al. 1984) of the Upohlav type granites (in ppm).

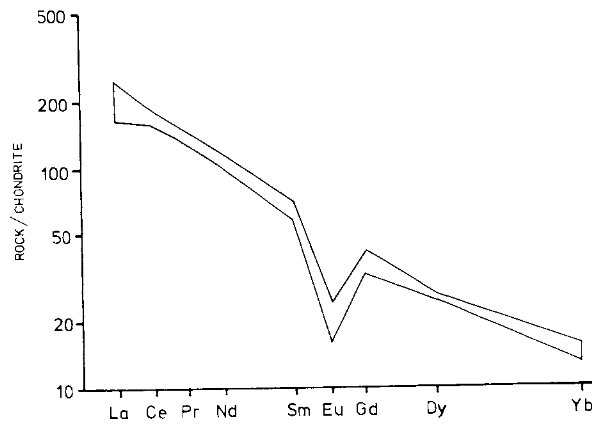

Fig. 8. Chondrite normalized (Evensen et al. 1978) REE pattern of the Upohlav type granites (4 samples).

2 - Granitoids of Krivá type, and 3 - porphyric granite of Lubina type can be well correlated, on the basis of geochemical as well as mineralogical-petrographical properties, with Hercynian calc-alkaline intrusions, especially of Carboniferous age, known from crystalline complexes of Tatric and Veporic Units in the Central Western Carpathians (Cambel & Walzel 1982; Hovorka & Petrík 1992). Although only a small number of analyses is available, fundamental features of Hercynian orogenic CA granitoids (structural signs, evident peraluminous character, increased contents of Ca in relation to K and Na, lower contents of Zr, Y, Rb, Ga), I-S or VAG characteristics of these rocks are evident and allow to correlate them with granitoids of Tatric and Veporic Units. However, this statement again does not mean that the source area of Krivá and Lubina type granitoids must have located in the present Central Western Carpathian space, since similar types of Hercynian granitic rocks are common also in neighbouring regions.

Conclusions

Granitoid rocks s.l., occurring as pebbles in conglomerate horizons of Cretaceous to Paleogene flysch of the Pieniny Klippen Belt (PKB) can be divided into three genetic groups:

1 - The Upohlav type ("exotic") is the most common one, they are pebbles of leucocratic biotite alkali-feldspar granites, syenogranites, less monzogranites, with frequent transitions into granite porphyries. On the basis of similar geochemical features we include here also rhyolites. The Upohlav granitoids trend towards post-orogenic metaluminous, but especially peraluminous suites with slightly increased alkalinity and less developed A-type trend. We consider them to be analogues of Permian alkaline magmatism developed in various regions of the Alpine-Carpathian-Pannonian and Western Mediterranean area.

2 - The Krivá type consists of pebbles of biotite and two-mica monzogranites to granodiorites, with considerably peraluminous character and calc-alkaline I-S trend, analogous to Carboniferous orogenic granitoids of Tatric and Veporic Units in the Western Carpathians.

3 - The Lubina type, found so far only sporadically, is porphyric leucocratic biotite syenogranite with peraluminous calc-alkaline character and evidently it exhibits some similarity with I-S orogenic (Hercynian?) granitoids.

Acknowledgements: The study was supported by the GA SAV Grant 118. The authors are indebted to Dr.Igor Petrík and Dr. Vojtech Vilinovič for precise and critical revision of the manuscript. We thank to Dr. Milan Klečka (Geol. Inst. of the Acad. Sci. of Czech Rep., Prague) for help in acquiring analyses of some trace elements.

Translated by K. Janáková

Table 1. Chemical compositions of the PKB granitoid pebbles in wt. %. (* Samples contamined due to authigene calcite.)

	UPOHLAV TYPE						
	BP-1	BP-2	*BP-3	BP-6.1	BP-6.2	BP-7.1	BP-7.2
SiO_2	74.08	73.10	71.70	71.00	71.43	72.17	69.83
TiO_2	0.17	0.16	0.18	0.24	0.36	0.15	0.27
Al_2O_3	13.63	12.82	12.51	14.20	14.32	13.36	13.45
Fe_2O_3	0.82	0.76	0.70	1.18	3.52	1.92	3.20
FeO	1.06	1.12	0.88	1.52	-	-	-
MnO	0.04	0.03	0.03	0.04	0.05	0.04	0.01
MgO	0.14	0.34	0.22	0.54	0.28	0.86	1.02
CaO	0.67	1.79	3.20	1.45	1.18	1.34	0.90
Na_2O	3.42	3.43	3.23	3.50	3.17	3.45	4.44
K_2O	4.76	4.65	4.58	4.43	4.45	5.41	5.36
P_2O_5	0.17	0.17	0.18	0.21	-	-	-
H_2O^+	0.88	1.38	2.36	1.28	0.95	1.30	0.90
H_2O^-	0.12	0.22	0.16	0.34	0.18	0.13	0.21
TOTAL	99.96	99.97	99.93	99.93	99.89	100.13	99.59
Li	12	26	13	18	16	9	24
Rb	168	141	165	144	134	188	169
Sr	23.0	30.0	49	65	76	40	78
Ba	620	600	540	1120	1430	710	1700
B	6.9	6.9	8.0	25.7	12.1	3.0	5.1
Be	3.2	3.6	3.1	3.7	3.8	2.0	3.1
Sn	4.0	4.2	<3.0	8.9	5.5	<3.0	3.0
Ga	19.8	18.8	19.5	24.8	20.4	21.4	19.1
Sc	6.0	5.9	3.9	7.8	14.1	8.9	16.2
Y	35.5	40	23	36	35	14	20
La	58.9	-	-	-	43.7	-	-
Ce	118.0	-	-	-	100.0	-	-
Pr	14.1	-	-	-	12.6	-	-
Nd	53.2	-	-	-	45.8	-	-
Sm	10.2	-	-	-	8.99	-	-
Eu	0.888	-	-	-	1.41	-	-
Gd	8.44	-	-	-	7.74	-	-
Dy	6.19	-	-	-	6.34	-	-
Yb	2.43	-	-	-	2.46	-	-
Zr	263	234	182	278	330	252	370
Nb	12	-	-	-	-	-	-
Pb	22.9	18.2	27.5	44.0	21.9	11.5	9.6
Zn	72	57	58	87	73	50	68
Mo	1.0	1.0	1.2	1.0	1.3	<1.0	<1.0
Cu	<3.0	<3.0	<3.0	10.2	3.9	<3.0	<3.0
Ni	4.3	4.9	4.3	6.1	6.2	3.2	4.7
Co	7.7	<3.0	4.5	3.4	<3.0	<3.0	4.5
Cr	<3.0	3.3	<3.0	3.5	<3.0	<3.0	4.5
V	<3.0	<3.0	<3.0	10.5	13.2	3.2	7.9
F	190	-	-	-	-	-	-
A.I.	0.79	0.84	0.82	0.74	0.70	0.87	0.97
Rb/Sr	7.30	4.70	3.37	2.21	1.76	4.70	2.17
Ga/Al	2.74	2.77	2.95	3.30	2.69	3.03	2.68

Continuation of Tab. 1.

	UPOHLAV TYPE					
	BP-12.1	*BP-12.2	BP-14.1	BP-14.2	BP-14.3	BP-14.4
SiO_2	72.65	66.85	72.42	74.01	75.65	73.34
TiO_2	0.19	0.21	0.45	0.14	0.20	0.23
Al_2O_3	14.03	11.97	14.63	13.78	13.26	13.55
Fe_2O_3	1.02	0.99	3.31	2.15	1.55	3.06
FeO	1.17	1.27	-	-	-	-
MnO	0.03	0.04	0.03	0.04	0.01	0.04
MgO	0.14	0.22	0.19	0.09	0.38	0.59
CaO	1.29	5.78	0.61	0.58	0.78	0.38,
Na_2O	3.44	3.03	2.71	3.22	2.15	2.56
K_2O	4.84	4.29	4.63	4.78	4.69	4.79
P_2O_5	0.18	0.19	-	-	-	-
H_2O^+	0.78	5.02	0.84	0.79	1.23	1.01
H_2O^-	0.34	0.06	0.21	0.11	0.10	0.15
TOTAL	100.10	99.92	100.03	99.69	100.00	99.70
Li	18	11	28	15	13	33
Rb	154	86	131	169	144	183
Sr	36	81	43	17.4	14.1	31.6
Ba	980	930	1480	690	550	650
B	5.0	5.0	30.9	15.1	26.3	10.2
Be	2.9	3.0	3.8	3.0	3.5	1.8
Sn	4.3	<3.0	5.9	4.7	4.7	<3.0
Ga	19.3	19.5	18.8	19.5	21.4	16.4
Sc	9.1	9.4	13.5	7.1	6.8	10.1
Y	29.5	30	35.5	46	65	40
La	45.9	-	40.0	-	-	-
Ce	114.0	-	97.5	-	-	-
Pr	13.6	-	12.3	-	-	-
Nd	50.0	-	47.3	-	-	-
Sm	9.76	-	9.13	-	-	-
Eu	1.12	-	1.32	-	-	-
Gd	7.00	-	6.93	-	-	-
Dy	6.00	-	6.31	-	-	-
Yb	2.16	-	2.03	-	-	-
Zr	410	229	450	282	191	302
Nb	-	-	-	-	-	-
Pb	12.3	3.0	22.9	20.0	10.1	7.4
Zn	59	21	66	60	67	63
Mo	1.0	1.2	1.2	1.1	1.1	<1.0
Cu	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Ni	5.5	4.1	6.9	6.2	6.3	5.4
Co	<3.0	<3.0	3.0	29.5	29.5	<3.0
Cr	<3.0	3.8	<3.0	<3.0	<3.0	<3.0
V	<3.0	<3.0	11.0	4.6	7.8	11.2
F	-	-	-	-	-	-
A.I.	0.78	0.80	0.65	0.76	0.65	0.69
Rb/Sr	4.28	1.06	3.04	9.71	10.2	5.79
Ga/Al	2.60	3.08	2.43	2.67	3.05	2.29

Continuation of Tab. 1.

	UPOHLAV TYPE						
	BP-14.5	*BP-15	BP-16	BP-17.1	BP-17.2	BP-18	BP-19
SiO_2	74.58	65.83	71.26	71.63	75.11	72.93	73.12
TiO_2	0.13	0.24	0.14	0.14	0.17	0.17	0.15
Al_2O_3	13.54	12.96	11.71	13.09	13.04	11.59	13.55
Fe_2O_3	1.44	0.36	1.36	1.44	1.66	1.50	1.84
FeO	-	1.69	-	-	-	-	-
MnO	0.02	0.05	0.05	0.05	0.02	0.01	0.02
MgO	0.18	0.37	2.63	0.30	0.25	1.56	0.19
CaO	1.01	5.66	0.41	1.69	0.40	0.46	1.07
Na_2O	2.69	3.35	3.18	4.84	2.94	3.02	3.88
K_2O	4.93	4.18	7.36	5.07	5.36	7.25	4.52
P_2O_5	-	0.21	-	-	-	-	-
H_2O^+	1.39	4.84	1.82	1.39	0.79	1.20	1.22
H_2O^-	0.11	0.26	0.14	0.11	0.12	0.20	0.13
TOTAL	100.02	100.00	100.06	99.75	99.86	99.89	99.69
Li	10	15	26	14	9	28	10
Rb	164	111	231	150	181	263	159
Sr	18.6	135	7.0	57	17.0	25.0	45
Ba	530	1680	30	390	214	174	410
B	22.4	6.3	56	9.1	3.8	115	6.3
Be	2.8	2.6	2.5	2.2	1.7	5.7	2.0
Sn	<3.0	8.7	<3.0	<3.0	<3.0	6.3	<3.0
Ga	18.4	17.6	17.8	20.0	22.9	29.5	20.9
Sc	8.5	10.2	7.2	5.5	8.1	4.9	7.9
Y	37	26	35	12	21	35	21
La	-	-	-	-	-	-	-
Ce	-	-	-	-	-	-	-
Pr	-	-	-	-	-	-	-
Nd	-	-	-	-	-	-	-
Sm	-	-	-	-	-	-	-
Eu	-	-	-	-	-	-	-
Gd	-	-	-	-	-	-	-
Dy	-	-	-	-	-	-	-
Yb	-	-	-	-	-	-	-
Zr	295	316	252	191	190	209	209
Nb	-	10	-	-	-	-	-
Pb	<3.0	12.6	<3.0	25.1	19.6	15.5	10.4
Zn	21	64	24	55	51	23	43
Mo	<1.0	1.4	<1.0	<1.0	<1.0	<1.0	<1.0
Cu	4.9	38	<3.0	<3.0	<3.0	<3.0	<3.0
Ni	5.5	8.6	<3.0	3.2	4.9	3.7	<3.0
Co	<3.0	14.5	<3.0	<3.0	<3.0	3.6	<3.0
Cr	<3.0	4.1	3.5	<3.0	<3.0	4.0	<3.0
V	4.0	11.5	<3.0	<3.0	<3.0	<3.0	3.8
F	-	220	-	-	-	-	-
A.I.	0.72	0.77	1.13	1.03	0.82	1.11	0.83
Rb/Sr	8.82	0.82	33.0	2.63	10.6	10.5	3.53
Ga/Al	2.57	2.57	2.87	2.89	3.32	4.81	2.91

Continuation of Tab. 1.

	UPOHLAV TYPE						
	BP-20	BP-31	BP-35	BP-36	BP-37	BP-38	BP-39
SiO_2	71.60	74.46	72.10	75.09	70.79	73.35	71.23
TiO_2	0.26	0.16	0.26	0.08	0.39	0.19	0.33
Al_2O_3	14.32	14.06	13.51	13.14	13.84	13.50	14.23
Fe_2O_3	3.28	1.87	2.29	1.70	2.84	1.82	3.27
FeO	-	-	-	-	-	-	-
MnO	0.04	0.02	0.04	0.03	0.02	0.03	0.04
MgO	0.60	0.34	0.87	0.35	0.58	0.23	0.44
CaO	0.91	0.64	1.45	0.34	1.15	0.42	1.22
Na_2O	2.90	2.70	5.31	3.16	3.65	4.25	3.30
K_2O	4.68	4.97	1.83	4.67	4.48	4.68	4.20
P_2O_5	-	-	-	-	-	-	-
H_2O^+	0.85	0.60	1.96	0.66	1.32	0.65	0.94
H_2O^-	0.28	0.18	0.16	0.38	0.37	0.41	0.37
TOTAL	99.72	100.00	99.78	99.60	99.43	99.53	99.57
Li	13	10	-	-	-	-	-
Rb	180	191	-	-	-	-	-
Sr	91	25	55	26	59	22	59
Ba	1700	620	178	630	1120	200	550
B	13.0	9.1	<3.0	30	34	36	36
Be	3.4	3.2	1.7	1.6	1.7	1.8	2.6
Sn	3.4	3.0	5.8	<3.0	<3.0	<3.0	<3.0
Ga	19.1	20.0	20.0	14.1	20.4	17.4	18.2
Sc	16.2	6.2	14.5	<3.0	6.9	<3.0	5.8
Y	40	24	43	17	29	25	29
La	-	-	-	-	-	-	-
Ce	-	-	-	-	-	-	-
Pr	-	-	-	-	-	-	-
Nd	-	-	-	-	-	-	-
Sm	-	-	-	-	-	-	-
Eu	-	-	-	-	-	-	-
Gd	-	-	-	-	-	-	-
Dy	-	-	-	-	-	-	-
Yb	-	-	-	-	-	-	-
Zr	340	224	410	98	339	204	251
Nb	-	10	-	-	-	-	-
Pb	14.1	23.4	<3.0	12.6	<3.0	18.2	11.0
Zn	58	56	-	-	-	-	-
Mo	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cu	<3.0	<3.0	<3.0	3.5	10.7	4.0	4.2
Ni	5.9	<3.0	5.4	7.6	9.6	9.1	6.5
Co	<3.0	<3.0	<3.0	<3.0	3.4	<3.0	3.8
Cr	<3.0	<3.0	<3.0	-	-	-	-
V	7.6	<3.0	8.0	<3.0	14.8	5.9	11.7
F	-	210	-	-	-	-	-
A.I.	0.69	0.70	0.79	0.78	0.78	0.89	0.70
Rb/Sr	1.98	7.64	-	-	-	-	-
Ga/Al	2.52	2.69	2.80	2.03	2.78	2.43	2.42

Continuation of Tab. 1.

	KRIVÁ TYPE				LUBINA TYPE
	BP-8	BP-10.1	BP-10.2	BP-11	BP-13
SiO_2	72.99	71.11	70.00	72.45	71.23
TiO_2	0.15	0.18	0.30	0.17	0.31
Al_2O_3	13.86	13.73	14.98	14.04	14.81
Fe_2O_3	0.56	0.54	0.93	0.11	0.89
FeO	0.50	0.67	1.32	0.98	1.43
MnO	0.02	0.03	0.03	0.03	0.04
MgO	0.55	0.26	0.83	0.50	0.78
CaO	1.91	3.25	3.08	2.64	0.95
Na_2O	2.94	3.21	3.64	3.60	3.03
K_2O	4.55	4.25	2.69	3.11	4.80
P_2O_5	0.30	0.27	0.32	0.28	0.30
H_2O^+	1.71	2.38	1.86	1.80	1.26
H_2O^-	0.12	0.06	0.18	0.32	0.18
TOTAL	100.16	99.94	100.16	100.03	100.01
Li	15	48	20	33	16
Rb	86	85	98	73	146
Sr	155	282	316	186	96
Ba	1070	930	1510	870	465
B	13.0	13.0	11.0	12.9	6.9
Be	2.8	3.1	2.8	3.1	3.5
Sn	<3.0	3.1	<3.0	3.4	7.1
Ga	15.5	18.0	16.0	18.2	18.8
Sc	<3.0	5.0	3.0	3.2	6.6
Y	16	12	10	23.5	30
La	-	-	-	-	-
Ce	-	-	-	-	-
Pr	-	-	-	-	-
Nd	-	-	-	-	-
Sm	-	-	-	-	-
Eu	-	-	-	-	-
Gd	-	-	-	-	-
Dy	-	-	-	-	-
Yb	-	-	-	-	-
Zr	102	102	64	79	180
Nb	-	-	-	-	-
Pb	28.8	16.4	30.0	22.9	10.5
Zn	16	37	26	25	32
Mo	1.1	1.0	1.2	1.0	1.0
Cu	<3.0	<3.0	<3.0	<3.0	<3.0
Ni	5.3	6.2	4.1	6.5	7.8
Co	12.9	10.5	4.3	3.4	7.1
Cr	4.2	7.2	3.5	5.1	6.6
V	10.0	28.0	12.0	14.6	19.7
F	-	-	170	-	-
A.I.	0.70	0.72	0.59	0.66	0.69
Rb/Sr	0.55	0.30	0.31	0.39	1.52
Ga/Al	2.11	2.48	2.02	2.45	2.40

List of samples.

Sample	Locality
BP-1	uG Podbranč, 50 m/350° from el. p. Starý hrad (455 m above sea level);
BP-2	uG Stupné, 800 m/211° from el. p. Žeravica (530 m);
BP-3	uG Brvnište, 600 m/318° from el. p. Žeravica (530 m);
BP-6.1	uP Považský Chlmec, 1300 m/129° from el. p. Hora (626 m);
BP-6.2	uG loc. as BP-6.1;
BP-7.1	uG Divinka, 100 m/115° from el. p. Veľký vrch (530 m);
BP-7.2	uG loc. as BP-7.1;
BP-8	kG Zástranie, 1500 m/322° from el. p. Straník (769 m);
BP-10.1	kG Krivá, 1000 m/164° from el. p. Vysoký grúň (849 m);
BP-10.2	kG loc. as BP-10.1;
BP-11	kG Široká, 1700 m/284° from el. p. Turíkov Žiar (851 m);
BP-12.1	uG Vrtižer, 2200 m/287° from el. p. Malý Manín (812 m);
BP-12.2	uP loc. as BP-12.1;
BP-13	lG Lubina, 500 m/296° from el. p. Lipovec (585 m);
BP-14.1	uG Vršatské Podhradie, 1800 m/160° from el. p. Chmeľová (925 m);
BP-14.2	uG loc. as BP-14.1;
BP-14.3	uP loc. as BP-14.1;
BP-14.4	uP loc. as BP-14.1;
BP-14.5	uP loc. as BP-14.1;
BP-15	uG Upohlav, 800 m/307° from el. p. Veľký Žiar (474 m);
BP-16	uR Dolný Vadičov, 1600 m/97° from el. p. Kučerovka (744 m);
BP-17.1	uG Podbiel, 1000 m/2° from el. p. Biela skala (750 m);
BP-17.2	uG loc. as BP-17.1;
BP-18	uR Teplička n. V., 2900 m/253° from el. p. Straník (769 m);
BP-19	uG Zádubnie, 1400 m (191° from el. p. Brodenec (621 m);
BP-20	uG Beňov, 1200 m/86° from el. p. Dúbrava (497 m);
BP-31	uG Cetuna, 700 m/140° from el. p. Lipovec (585 m);
BP-35	uG Nimnica, 600 m/212° from el. p. Holíš (583 m);
BP-36	uP Považské Podhradie, 300 m/86° from el. p. Vysoké (575 m);
BP-37	uP Proč, 900 m/133° from el. p. Haľagoš (642 m);
BP-38	uG Prosačov, 2100 m/194° from el. p. Havranív. (419 m);
BP-39	uP Inovce, 1000 m/280° from el. p. Hôrka (661 m).

Note: **u** - Upohlav type, **k** - Krivá type, **l** - Lubina type, **G** - granite, granodiorite, **P** - granite porphyry, **R** - rhyolite.

References

Batchelor R. A. & Bowden P., 1985: Petrogenetic interpretation of granitoid rock series using multicationic parameters. *Chem. Geol.* 48, 43 - 55.

Birkenmajer K., 1988: Exotic Andrusov ridge: its role in plate-tectonic evolution of the West Carpathian foldbelt. *Studia Geol. Polon.* 91, 7 - 37.

Birkenmajer K. & Skupinski A., 1989: On some volcanic and plutonic exotic rock fragments from the Upper Cretaceous of the Pieniny Klippen Belt, Carpathians, Poland. *Studia Geol. Polon.* 97, 69 - 89 (in Polish with English summary).

Birkenmajer K. & Wieser T., 1990: Exotic rock fragments from Upper Cretaceous deposits near Jaworki, Pieniny Klippen Belt, Carpathians, Poland. *Studia Geol. Polon.* 97, 44 - 53 (in Polish with English summary).

Bonin B., 1988: Peralkaline granites in Corsica: some petrological and geochemical constrains. *Rend. Soc. Ital. Miner. Petrol.*, 43, 281 - 306.

Bonin B., 1990: From orogenic to anorogenic settings: evolution of granitoid suites after a major orogenesis. *Geol. J.*, 25, 261 - 270.

Buda G., 1969: Genesis of the granitoid rocks of the Mecsek and Velence Mountains on the basis of the investigation of the feldspars. *Acta Geol. Acad. Sci. Hung.*, 13, 131 - 155.

Cambel B., Bagdasaryan G. P., Gukasyan R. C. & Veselský J., 1989: Rb-Sr geochronology of leucocratic granitoid rocks from the Spišsko-gemerské rudohorie Mts. and Veporicum. *Geol. Zbor. Geol. Carpath.*, 40, 323 - 332.

Cambel B., Martiny E. & Pitoňák P., 1983: Alkalies in the granitoids of the West Carpathians. *Geol. Zbor. Geol. Carpath.*, 34, 15 - 44.

Cambel B. & Walzel E., 1982: Chemical analyses of granitoids of the West Carpathians. *Geol. Zbor. Geol. Carpath.*, 33, 573 - 600.

Černý P., 1991: Fertile granites of Precambrian rare-element pegmatite fields: is geochemistry controlled by tectonic setting or source lithologies ? *Precambrian Res.*, 51, 429 - 468.

Chernov V. G., 1973: The Paleogene conglomerates of the Pieniny zone of Soviet Carpathians and their paleogeographic significance. *Soviet. Geol.*, 5, 144 - 152 (in Russian).

Collins W. J., Beams S. D., White A. J. R. & Chappell B. W., 1982: Nature and origin of A-type granites with particular reference to Southeastern Australia. *Contrib. Mineral. Petrol.*, 80, 189 - 200.

Evensen N. M., Hamilton P. J. & O'Nions R. K., 1978: Rare-earth abundances in chondritic meteorites. *Geochim. Cosmochim. Acta*, 42, 1199 - 1212.

Finger F., Frasl G., Haunschmid B., von Quadt, Schermaier A., Schindlmayr A. & Steyer H. P., 1992: Late Paleozoic plutonism in the Eastern Alps. In: *ALÇAPA - Field guide. IGP/KFU* Graz, 37 - 45.

Gbelský J. & Határ J., 1982: Zircon from some granitoid rocks of the Velence and Mecsek Mountains (Hungary). *Geol. Zbor. Geol. Carpath.*, 33, 343 - 361.

Határ J., Hraško Ľ. & Václav J., 1989: Hidden granite intrusion near Rochovce with Mo-(W) stockwork mineralization. *Geol. Zbor. Geol. Carpath.*, 40, 621 - 654.

Hovorka D. & Petrík I., 1992: Variscan granitic bodies of the Western Carpathians: the backbone of the mountain chain. In: *Spec. Vol. IGCP Proj. 276. GÚDŠ* Bratislava, 57 - 66.

Hovorka D. & Spišiak J., 1988: Mesozoic volcanism of the Western Carpathians. *VEDA* Bratislava, 1 - 264 (in Slovak with English summary).

Kamenický L., Kátlovský V., Marschalko R. & Medveď J., 1974: Contribution to characterization of acid magmatites of exotic rocks of the Klippen Belt and other tectonic units of the West Carpathians. *Miner. slovaca*, 6, 311 - 321 (in Slovak with English summary).

Kovách A., Svingor E. & Grecula P., 1986: Rb-Sr isotopic ages of granitoids from the Spišsko-Gemerské Rudohorie Mts., Western Carpathians, Eastern Slovakia. *Miner. slovaca*, 18, 1 - 14.

Krivý M., 1969: The exotic pebbles of magmatic rocks from western part of the Klippen Belt. *Acta geol. geogr. Univ. Comen. Geol.* 18, 165 - 197 (in Slovak with German summary).

Lameyre J., 1988: Granite settings and tectonics. *Rend. Soc. Ital. Miner. Petrol.*, 43, 215 - 236.

Maniar P. D. & Piccoli P. M., 1989: Tectonic discrimination of granitoids. *Geol. Soc. Amer. Bull.*, 101, 635 - 643.

Marschalko R., 1975: Depositional environment of conglomerates as interpreted from sedimentological studies (Paleogene of Klippen Belt and adjacent tectonic units in East Slovakia). *Náuka o Zemi, Geol.*, 10, 1 - 148 (in Slovak with English summary).

Marschalko R., 1986: Evolution and geotectonic significance of the Klippen Belt Cretaceous flysch in the Carpathian megastructure. *VEDA* Bratislava, 1 - 140 (in Slovak with English summary).

Marschalko R., Mišík M. & Kamenický L., 1976: Petrographie der Flysch-Konglomerate und Rekonstruktion ihrer Ursprungzonen (Paläogen der Klippenzone und der angrenzenden tektonischen Einheiten der Ostslowakei). *Západ. Karpaty, Sér. Geol.*, 1, 7 - 124.

Marschalko R. & Samuel O., 1975: Sedimentology and stratigraphy of coarse-clastic flysch near Nosice (the dam Priehrada Mládeže). *Geol. Práce, Spr.*, 63, 105 - 114 (in Slovak with English summary).

Mišík M., Jablonský J., Ožvoldová L. & Halásová E., 1991a: Distal turbidites with pyroclastic material in Malmian radiolarites of the Pieniny Klippen Belt (Western Carpathians). *Geol. Carpathica*, 42, 341 - 360.

Mišík M. & Marschalko R., 1988: Exotic conglomerates in flysch sequences: examples from the West Carpathians. In: Rakús M., Dercourt J. & Nairn A. E. M. (Eds.): Evolution of the Northern margin of Tethys, Vol. I. *Mém. Soc. Geol. France, Nouv. Sér.*, 154, 95 - 113.

Mišík M. & Sýkora M., 1981: The Pieniny exotic ridge - reconstruction from pebbles of carbonate rocks of the Klippen Belt and Manín Unit Cretaceous conglomerates. *Západ. Karpaty, Sér. Geol.*, 7, 7 - 111 (in Slovak with German summary).

Mišík M., Sýkora M., Mock R. & Jablonský J., 1991b: Paleogene Proč conglomerates of the Klippen Belt in the West Carpathians, material from the Neopieninic Exotic Ridge. *Acta geol. geogr. Univ. Comen., Geol.*, 46, 9 - 101.

Pearce J. A., Harris N. B. W. & Tindle A. G., 1984: Trace element discrimination diagrams for the tectonic interpretation of granitic rocks. *Jour. Geol.*, 25, 956 - 983.

Pe-Piper G., Piper D. J. W. & Clerk S. B., 1991: Persistent mafic igneous activity in an A-type granite pluton, Cobequid Highlands, Nova Scotia. *Canad. J. Earth Sci.*, 28, 1058 - 1072.

Pitcher W. S., 1983: Granite type and tectonic environment. In: Hsü K. (Ed.): Mountain building processes. *Acad. Press*, London, 19 - 40.

Pupin J. P., 1988: Granites as indicators in paleogeodynamics. *Rend. Soc. Ital. Miner. Petrol.*, 43, 237 - 262.

Rakús M., Mišík M., Michalík J., Mock R., Ďurkovič T., Koráb T., Marschalko R., Mello J., Polák M. & Jablonský J., 1990: Paleogeographic development of the West Carpathians: Anisian to Oligocene. In: Rakús M., Dercourt J. & Nairn A. E. M. (Eds.): Evolution of the Northern margin of Tethys, Vol. III, Pt. 1. *Mém. Soc. Geol. France, Nouv. Sér.*, 154, 39 - 62.

Šímová M., 1985: Magmatic rocks of the Cretaceous conglomerates from western part of the Klippen and Manín zone in the Western Carpathians. *Západ. Karpaty, Sér. Miner. Petrogr. Geochem. Metalogen.*, 10, 9 - 110 (in Slovak with German summary).

Streckeisen A. & Le Maitre R. W., 1979: A chemical approximation to the modal QAPF classification of the igneous rocks. *N. Jb. Mineral. Abh.*, 136, 169 - 206.

Tauson L. V., Kozlov V. D., Cambel B. & Kamenický L., 1977: Geochemistry and questions of ore-bearing specialization of the Gemeric granites (Slovakia). *Geol. Zbor. Geol. Carpath.*, 28, 261 - 267.

Uher P. & Broska I., in press: The Velence Mts. granitic rocks: geochemistry, mineralogy and comparison to Variscan Western Carpathian granitoids. *Acta Geol. Hung.*

Uher P. & Gregor T., 1992: The Turčok granite: product of post-orogenic A-type magmatism ? *Miner. slovaca*, 24, 301 - 304 (in Slovak with English abstract).

Uher P. & Marschalko R., 1993: Typology, zoning and geochemistry of zircon from main types of granitic and rhyolitic pebbles in conglomerates of the Pieniny Klippen Belt Cretaceous flysch (Western Slovak Segment, Western Carpathians). *Geol. Carpathica*, 44, 113 - 121.

Uher P. & Pushkarev Y. D., in press: Granitic pebbles of the Pieniny Klippen Belt, Western Carpathians: U-Pb zircon ages. *Geol. Carpathica.*

Whalen J. B., Currie K. L. & Chappell B. W., 1987: A-type granites: geochemical characteristics, discrimination and petrogenesis. *Contrib. Mineral. Petrol.*, 95, 407 - 419.

Wieser T., 1958: Magmatic and metamorphic exotic rocks from the Cretaceous and Paleogene of the Pieniny Klippen Belt, Carpathians. *Inst. Geol. Biul.*, 135, 97 - 150 (in Polish).

Zoubek V., 1931: Caractéristique de quelques roches cristallophylliennes et éruptives des galets exotiques des conglomérates sénoniens at paléogénes des Carpathes Occidentales. *Knih. SGÚ*, 13, 353 - 358.