GEOLOGICKÝ ZBORNÍK — GEOLOGICA CARPATHICA, 33, 5, BRATISLAVA, OCTOBER 1982, Pp. 623—630

JURAJ MACEK*

PETROGRAPHY OF THE WEST CARPATHIANS GRANITOIDS — ZK SAMPLES

(Figs. 3, Tab. 1)

A total of approximately 112 granitoide samples from the West Carpathians has been examined microscopically until now. The results are obtained also from X-ray studies (triclinity of K-feldspars), atomic absorption spectrometry (potassium content of K-feldspars) and electron microprobe analyses (basicity of plagioclases). According to the IUGS classification (1973), samples under consideration were divided into the following rock groups: leucocratic (i. e. leucocratic granites and granodiorites), muscovitic — biotitic (i. e. muscovitic — biotitic granites and granodiorites), biotitic (i. e. biotitic granites and granodiorites) and tonalites.

Leucogranites to leucogranodiorites

General characteristics of this group is based on examining 24 samples (i e. ZK — 41, 42, 100, 68, 44, 90, 63, 55, 35, 33, 91, 61, 39, 8, 31, 27, 66, 69, 9, 54, 59, 15, 65, 43). Q u a r t z. Modal presence varies within the range 28—46 %. Usually, it is represented by 2 generations with different morphological development, undulatory extinction as well as inclusions. K - f e l d s p a r s. Their content ranges from 15 to 40 %. They are represented mainly by chess-board microcline with triclinity values exceeding 0.80 (2 $V\alpha$ varies within 78—88°). Orthoclase was identified in 4 samples (ZK — 9, 15, 66, 68). P l a g i o c l a s e s are present within the range 19—42 %. The majority of plagioclases is represented by weakly zonal, medium altered, subhedral plagioclase with the basicity An_{10}—An_{22}. The basicity An_{20-28} was found only scarcely (samples ZK — 8, 15, 43, 91). Evidently younger seem to be anhedral individuals with the basicity An_{4-8}. B i o t i t e represents the amount 1—4 %. There are morphologically incomplete relicts of biotites, non-altered or only partly chloritized individuals present. Both mentioned types have not been observed within one single sample. M u s c o v i t e ranges from 2 to 10 %. It is subhedral to adhedral. In certain samples, to a lesser degree, there appear muscovites connected with hydrothermal alterations of feldspars.

Muscovitic — biotitic granites to granodiorites

The characteristics has been worked out on the basis of studying 34 samples (i. e. ZK — 2, 6, 17, 19, 26, 34, 53, 60, 62, 64, 77, 87, 92, 95, 111, 4, 18, 22, 24, 25, 29, 30, 47, 48, 50, 51, 67, 70, 71, 72, 76, 84, 85, 96). Q u a r t z. It occurs within the range 26—39 %. Usually, there are 2 generations present, relatively younger generation evidently penetrates larger, older undulatory quartzs. K - f e l d- s p a r s occur within 7—26 %. They are represented by orthoclase, which is

* RNDr. J. M a c e k, CSc., Geological Institute of the Slovak Academy of Sciences, Dúbravská cesta 9, 814 73 Bratislava.

usually triclinized to the value 0.40 (2 $V\alpha$ varies from 48 to 68°) and chess-board microcline with triclinity over 0.80 (2 $V\alpha$ varies from 74 to 84°). Plagioclase is present within 29–54 %. The main part is represented by subhedral, medium to strongly altered plagioclase with the basicity An_{10} to An_{22} (in acid types) and An_{22-34} (in basic types). Evidently younger are anhedral grains and reaction rims of basicity An_{5-8}. Biotite ranges from 5–11 %. For the most part it is not altered with different inclusions mainly of apatite, zircon and magnetite. There are also present totally baueritized to disintegrated biotites also spatially variously directed. Muscovite represents 3–6 %. It forms subhedral flakes in relation with biotite and quartz on one side and on the other one, also inclusions in plagioclases, originated by hydrothermal alteration.

Biotitic granites to granodiorites

The characteristic of this group has been elaborated on the basis of 20 samples (i. e. ZK – 3, 112, 11, 14, 10, 21, 23, 36, 40, 56, 58, 73, 74, 79, 80, 81, 86, 97, 98, 104). Quartz represents 26–38 %. The older generation is represented by anhedral, relatively larger, strongly undulatory individuals, containing inclusions mainly of biotites and plagioclases. Evidently younger is fine-grained, anhedral, non-undulatory quartz without inclusions. K-feldspars occur within the range 5–20 %. With the exception of samples ZK – 11, 14, 23, 81, also orthoclase and microcline are present, at the same time. It is not clear yet, whether the microclines form a distinct generation or the product of orthoclase triclinization. Plagioclase is represented by the amount 40–52 %. The main part is represented by subhedral to euhedral strongly altered plagioclase of basicity An_{22-34} in more acid types, An_{28-42} in more basic types. Evidently younger are anhedral, strongly albite – twinned individuals of basicity An_{4-8}. Also morphologically incomplete, altered relicts of plagioclases with unmeasurable basicity are common. Biotite ranges from 5 to 12 %. Usually, it is not altered, chloritized to a lesser degree, more or less directed in most of them. Also strongly altered biotites of different spatial direction are present quite often. Muscovite is present up to 2 %, usually it forms inclusions in altered plagioclases. It forms only rarely subhedral individuals occurring in relation with biotite and/or quartz.

Leucotonalites to tonalites

The characteristic has been done on the basis of investigating 16 samples (i. e. ZK – 5, 49, 1, 7, 12, 28, 20, 37, 46, 57, 75, 78, 82, 83, 88, 102). Quartz occurs within the range 22–32 %. The older generation is formed by anhedral, variously intensively undulatory quartz with inclusions mainly of biotite and feldspars. Evidently younger is a fine-grained, non-undulatory quartz, sometimes directed even to partially banded texture. K-feldspars are present up to 6 %. It is an orthoclase variously intensively triclinized. With the exception of samples ZK – 28, 78, microcline is not observed. Plagioclase ranges from 50–68 %. Usually it is strongly altered, subhedral to euhedral with basicity An_{28-38} in more acid types and that of An_{36-44} in more basic types. There are also anhedral albite – twinned plagioclases with basicity An_{4-6} present in a lesser extent and or to An_{7-12}. Biotite ranges from 8–24 %. There are non-altered biotites (only partly chloritized) subhedrally shaped on one hand and disintegrated biotites on the other one (mainly the samples ZK – 7, 49, in a lesser degree ZK – 12, 46, 78, 88), usually spatially in different optic orientation towards non-altered biotites. Muscovite occurs only sporadically. Usually it is well-individualized muscovite enclosed in plagioclases according to cleavage surface.

In the given set of granitoide rocks the following characteristics of feldspars have been studied:

1. Data on Na_2O, K_2O, CaO, Sr and Rb contents in K-feldspars from granitoides within the Western Carpathians are listed in Table 1.

Table 1

Potassium feldspars. The average Na_2O, K_2O, CaO contents are defined in wt. per cent and Sr and Rb contents in g/t^{-1}

	Na_2O %	K_2O %	CaO %	Sr g/t^{-1}	Rb g/t^{-1}	N
1	1.61	13.76	0.105	242	380	17
2	1.43	14.04	0.202	422	263	23
3	1.55	13.48	0.206	530	247	16
4	1.17	14.13	0.293	647	212	4
Orthoclase	1.62	13.59	0.143	510	249	14
Microcline	1.57	13.78	0.123	296	350	28
K-feldspars Tatrides	1.33	14.11	0.199	446	250	40
K-feldspars Veporides	1.49	12.39	0.138	480	245	19
K-feldspar Gemerides	2.67	12.09	0.157	63	694	4

Explanations: Group 1 – leucogranites to leucogranodiorites. Group 2 – muscovitic – biotitic granites to granodiorites. Group 3 – biotitic granites to granodiorites. Group 4 – tonalites. N – number of analyzed samples. Analyses were carried out by Ing. E. Martíny, CSc., Geological Institute of the Slovak Academy of Sciences, Bratislava.

2. K-feldspars of leucocratic granitoide rocks are noted for the presence of the generation of high triclinity forms (with triclinity ranging from 0.70 to 0.90). They are forming remarkable individuals to megacrystals commonly subhedrally shaped. For K-feldspars of tonalites, the presence of weakly triclinic to monoclinic forms (triclinity from 0.20 to 0.40) is characteristic. Usually, they are micro- to medium-grained, anhedral, intersticial. From the point of view of the genesis of K-feldspars in the group of muscovitic – biotitic to biotitic granitoides, the relationships are very complicated, conditioned by the presence

of monoclinic forms (with maximum triclinity to 0.40) and triclinic (with triclinity ranging from 0.70 to 0.90). The fact needs to be mentioned that it is not possible to consider in each individual case whether there are two distinct generations of K-feldspars or only some local selective triclinization, of original orthoclase. Furtheron, we assume that certain microclines of leucocratic granitoides form the second generation of K-feldspars in biotitic types and orthoclases of tonalites the first generation of biotitic types of the Western Carpathians granitoides.

3. The basicity of plagioclases of the given sample set in a broader sense represents the whole basicity of the rock. It is evident that leucocratic and muscovitic types of granitoides only rarely contain plagioclases of the relict character, and vice versa, for biotitic granitoides and tonalites their presence is frequent.

4. On the whole, three generations of plagioclases have been identified within the granitoide set. The oldest one comprises relict plagioclases, usually of unmeasurable basicity with imperfect morphology. In certain measurable cases the basicity varied within An_{34} to An_{46}. Two populations can be assigned to the main generation of plagioclases: acid plagioclases (with basicity within An_{24}—An_{38}). The youngest generation comprises plagioclases anhedrally shaped, forming newly-formed rims but also distinct individuals with basicity An_{4-6} to An_{12}. Therefore, it can be assumed that the mentioned generation represents secondary alterations of granitoide rocks.

On the whole, it can be stated that the studied set of samples is noted for differences both in modal and chemical compositions as well as for the whole characteristics of the individual minerals. There are several types of generations of biotites (with differences in Mg content), plagioclases (with various basicity), K-feldspars (with various potassium content), and quartz (different undulatory extinction). One of the most important information gained from this study is the discovery that practically none of the samples under consideration represents a continuous crystalline scheme. This fact gave rise to the hypothesis claiming the stage development of the studied rocks. On the basis of a detailed investigation, we have been able to identify even 3 crystalline stages in certain massifs. The origin of individual, easily observable mineral associations which correspond to the mentioned stages of development. Apart from this, there are obviously disintegrated plagioclases of unmeasurable basicity and certain disintegrated biotites, which have not been assigned to this crystalline scheme and they are considered to be the relict ones.

The 1st crystallization stage includes subhedral to euhedral plagioclases with basicity An_{34-44}, chloritized to baueritized biotites (spatially distinctly directed), furtheron intersticial, anhedral, triclinized orthoclase and strongly undulatory anhedral quartz, sometimes even with observable bipyramidal development. The interval of the crystallization temperature determined by two feldspar thermometer varies within 610—680°. Their crystallization temperatures were determined with the use of biotite — scandium thermometer and obtained values fall within the range of 650—730 °C.

The 2nd stage is of various development in samples from different mountain ranges. In certain samples from granitoides mainly from the Tatrides it occurs only as a potassium metasomatosis with the origin of subhedral, maximum triclinic microclines, accompanied by weakly undulatory quartz II, sporadically

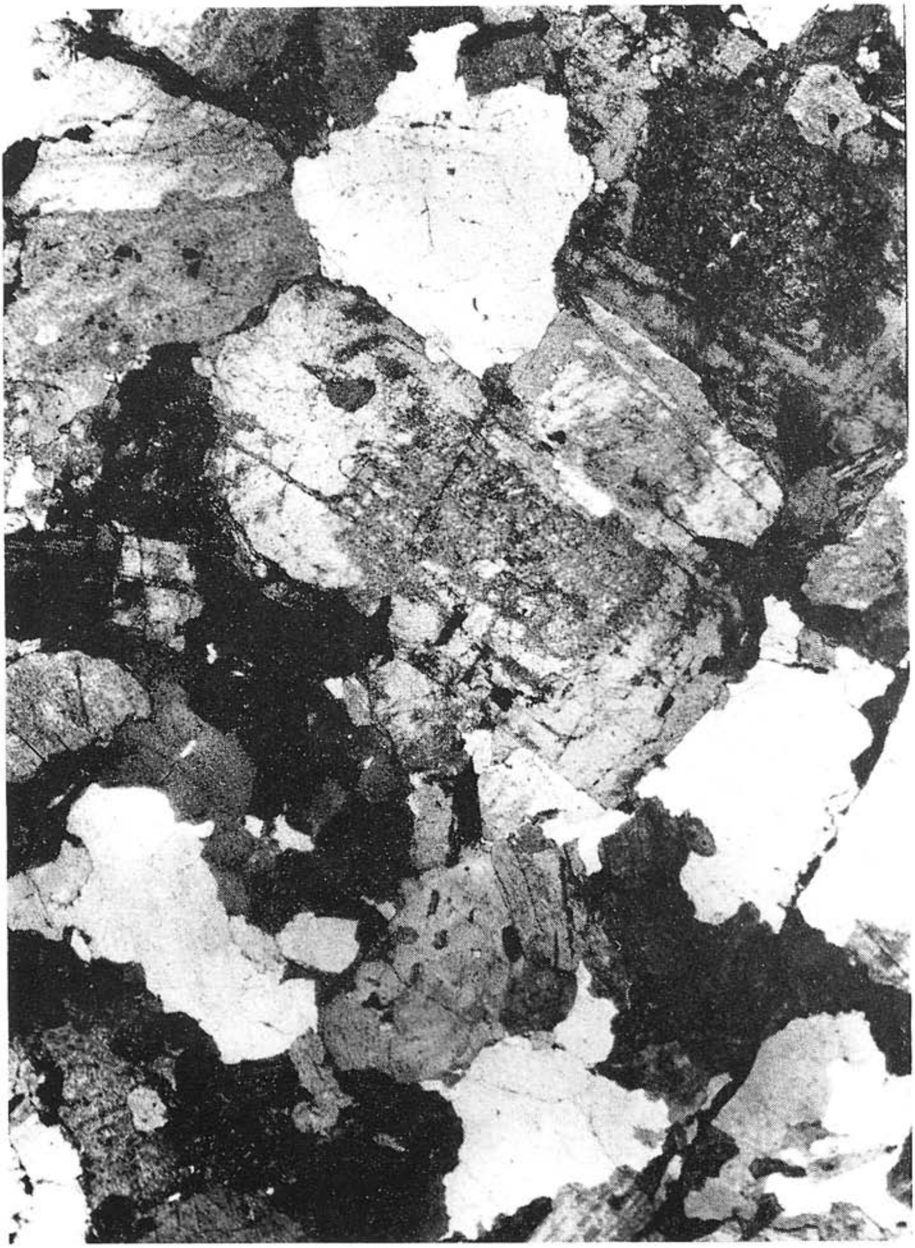

Fig. 1. Minerals of the 1st crystallization stage.
P_1 = plagioclase. B = biotite. Or = orthoclase. Q_1 = quartz. Crossed nicols. 25 × magn. Photo H. Brodnianská.

Fig. 2. Orthoclase (Or) of the 2nd crystallization stage. Plagioclase (P_1). Quartz (Q_1) strongly crushed and recrystallized. Crossed nicols, 25 × magn. Photo H. Brodnianská.

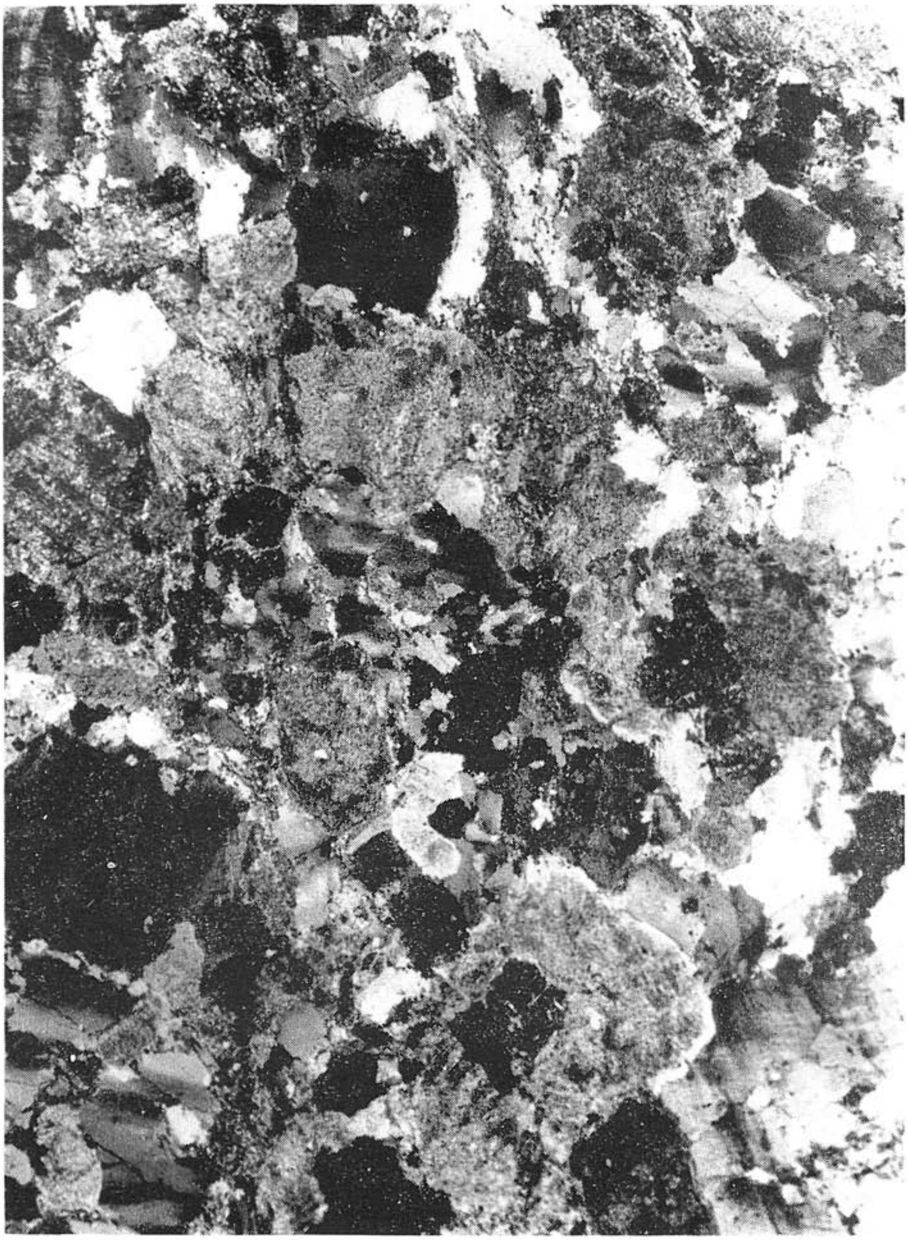

Fig. 3. Coexistence of maximum microcline (Mr) with triclinity 0.88 ($2\ V_\alpha = 82°$ to $85°$) and sometimes even euhedral orthoclase (Or) with triclinity to 0.20 ($2\ V_\alpha = 48°$). Crossed nicols, 25 × magn. Photo H. Brodnianská.

also muscovite. This mineral assemblage occurs usually in the form of thin veinlets (quartz — muscovite), disseminated, sometimes they form nests and aggregates of different size. The crystallization temperature of these microclines ranges from 420—470 °C (determined by two feldspar thermometer). In some other mountain ranges, but mainly in the Veporides, this stage was even more pronounced and it resulted in the origin of dark-brown to yellow biotites (the temperature of their origin ranging from 570—640 °C — the scandium thermometer), subhedral plagioclases, the basicity An_{18-28}, and/or weakly perthitic orthoclase. The temperature of feldspars was determined by two feldspar thermometer and it ranged from 570 to 610 °C. Also fine-grained to medium — grained weakly undulatory quartz and muscovite are included into this stage. This development is locally superseded by lower — temperature association, represented by plagioclase with basicity An_{10-14}, maximum microcline without the presence of biotite.

Relatively youngest crystallization stage within granitoides includes the mineral assemblage represented by non-undulatory fine-grained quartz and albite with the basicity An_{4-8}. This anticipates that the mentioned stage corresponds to alpine metamorphically — recrystalline processes in granitoides.

The outline of the petrography of chosen samples from the Western Carpathians granitoides, presented above, anticipates a very complicated development of solidification of intruding magmatic substances during the development of the Variscan orogene. The complicated and ambiguous interpretation of certain events, which has been stated in the petrography presentation, can be understood fully only if superposed processes which could have taken place towards the end of the Variscan orogene and during the Alpine orogene, are taken into consideration. Therefore, it is clear that the mentioned interpretations must coincide with geological knowledge gained from mapping.

Acknowledgements: Let me express my gratitude to Ing. M. Vondrovic, Geological Institute of the Slovak Academy of Sciences, Bratislava (for carrying out the analyses of K-feldspar triclinity), Ing. E. Martíny, CSc., Geological Institute of the Slovak Academy of Sciences, Bratislava (for stating the potassium content in K-feldspars) and RNDr. J. Krištín, CSc., D. Štúr's Geological Institute, Bratislava (providing the microprobe analyses of plagioclase basicity).

Translated by H. Budajová
Review by D. HOVORKA

Manuscript received April 20, 1982