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U-Pb AGE OF GRANITOID ROCK FROM THE QUARRY DUBNÁ SKALA – MALÁ FATRA MTS.

(1 Fig., 1 Tab.)

A b s t r a c t : The paper presents the determination of age of tonalite rock from the quarry Dubná Skala. It is the first age determination of granitoids from Malá Fatra Mts. by U-Pb method from separated zircons. The measurements have been carried out in IGFM in Kiev. The obtained age – 353 m.y. – corresponds approximately to the determinations obtained by the Rb-Sr method in most core mountain ranges in the Western Carpathians. The authors point out the fact that U-Pb geochronologic analyses give in comparison with Rb-Sr isochronal determinations from similar rocks and from the same regions in most cases lower ages. There is so far no unambiguous explanation of this phenomenon, but to a considerable extent it is probably caused by geochemical properties of individual elements.

Р е з ю м е : В статье приводится определение возраста тоналитовой породы из каменоломни Дубна Скала. Это является первым определением возраста гранитоидов в Малой Фатре U-Pb методом из сепарированных цирконов. Измерения были сделаны в ИГФМ в Киеве. Полученный возраст – 353 м. л. – соответствует приблизительно возрастам полученным Rb-Sr методом в большой части ядерных горных массивов Западных Карпат. Авторы показывают на то, что U-Pb геохронологические анализы в сравнении с Rb-Sr изохроническими определениями дают в подобных породах из тех же регионов обыкновенно более низкие возрасты. Пока нето однозначного обьяснения для этого, но правдеподобно это способствовали геохимические свойства элементов.

As a result of bilateral cooperation of Geological Institute of the Slovak Academy of Sciences with Institute of Geochemistry and Physics of Minerals of the Ukrainian Academy of Sciences in Kiev, U-Pb analysis was carried out on zircons from a granitoid rock from the quarry Dubná Skala near Vrútky, Malá Fatra Mts. The quarry is situated not far from the road Vrútky–Strečno and the rock exploited here has been characterized on the basis of planimetric modal analysis carried out by M a c e k et al. (1982) as tonalite.

On the basis of chemical analysis (S t r e c k e i s e n – L e M a i t r e, 1979) with the application of calculations after M i e l k e and W i n k l e r (1979) the studied rocks belong to the group of tonalites. Individual varieties belong according to modal composition to biotite tonalites to biotite granodiorites. The tonalites have the following modal composition: Q-29, Pl-63, B-10, accessories – 1.

Malá Fatra Mts. is one of the most important core mountain ranges in Central Slovakia. Granitoid complexes form the main part of the Malá Fatra crystalline complex and metamorphosed sediments occur especially on SW side of the granitoid body. The contacts of

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granodiorites and tonalites with crystalline schists are primary and there are high-metamorphosed schistose derivates, gneisses, amphibolites, migmatites and other hybride rock types. These hybridized schistose complexes form in places continuous zones of migmatites, imbibic gneisses and other products of hybridization and assimilation of sedimentary supercrustal mantle. Generally the granitoids of Malá Fatra Mts. contain numerous schlieren and the minerals are inhomogeneously distributed, and thus according to the opinion of K a m e n i c k ý (1982) they can be considered analogous to Ďumbier granitoid types from the Nízke Tatry Mts. region.

Chemical composition of an average sample of granodiorites and tonalites from Malá Fatra Mts. – quarry Dubná Skala, sample ZK-38 (C a m b e l – W a l z e l , 1982) is the following: SiO_2-68.74, TiO_2-0.58, Al_2O_3-15.19, Fe_2O_3–0.78, FeO-2.62, MnO-0.07, CaO-3.40, MgO-1.12, K_2O-2.48, Na_2O-3.50, H_2O^--0.06, H_2O^+-0.06, P_2O_5-0.21, total 99.81.

The authors I v a n o v – K a m e n i c k ý (1957) distinguished another type of granitoid rocks in the Malá Fatra Mts. – leucocratic two-mica granitoids, in places autometamorphosed, which can be classified with granites to granodiorites. This granite is by the abovementioned authors denominated „Magura" type and they consider it relatively younger than the more frequently occurring granodiorite to tonalite type denominated by K a m e n i c k ý (1982) as „hybrid". The latter is the type represented by rocks of the quarry Dubná Skala.

Although Malá Fatra Mts. is an important mountain range of the Central Slovak part of Western Carpathians, especially as far as its size and surface is concerned, we have only very few geochronological measurements from this region. Therefore we are very grateful to the workers of the Kiev Institute of Academy of Sciences (IGFM), especially to the team of Academician S h c h e r b a k , who, within our bilateral cooperation, carried out the analysis on zircons from granitoids of the quarry Dubná Skala by U-Pb method. This analysis is so far the only geochronological datum from the Malá Fatra Mts. region. Mineralogic description of the analyzed zircons and the results and evaluation of radiometric measurements are as folows:

According to morphologic features of zircons from the studied granite (sample GU-8), two crystal types can be distinguished – hyacinth (50–55 %) and pointed (45–50 %). The first type is formed by a combination of the faces of low bipyramide {111} with the faces of prismatic band. The faces of the prisms {110} and {100} are not equally developed. The most frequent are crystals with prismatic faces {100}, more rare are in the crystals the faces of the prism {110}, however, they are considerably less developed. The sharp-ended-type crystals are formed by the faces of high bipyramide {311} or {211} and {111} with faces of prismatic band {100} and {110}, while the latter is considerably less developed. Prevailing are columnar crystals with an elongation of 2.0–2.5. Grains with and elongation of 1.5–2.0 occur in inferior amounts. The lustre is strong, vitreous, the colour light-pink.

The zircons can be characterized in immersion preparations by high birefrigence, they are clear, transparent. Rare transparent inclusions are spherical or elongated. Sometimes there are black dot-like segregations. An insignificant amount of grains is slightly clouded.

For the purpose of geochronologic studies the zircons have been separated into fractions differing in their grain-size and magnetic properties. These characteristics of fractions as well as the results of the determinations of isotopic composition of lead and contents of uranium and lead in individual fractions of zircons are presented in Tab. 1. All quantitative determinations of the contents of uranium and lead have been carried out by the mass-spectrometric method of isotopic dilution, on the mass-spectrometers MI-1320 and MI-1201T.

Table 1

Zircon samples from the rock GU-8 — Malá Fatra Mts., quarry Dubná Skala

Points	Fraction	Content %		Isotopic composition in %				Isotopic ratios and age in m.y.					
		Lead	Uranium	204	206	207	208	206 / 238		207 / 235		207 / 206	
1	0.04-0.056 electromag.	0.00310	0.0671	0.031	86.059	5.138	8.772	0.04592		0.34473	300	0.05444	389
2	0.04-0.056 non-elmag.	0.00352	0.0685	0.063	84.286	5.496	10.154	0.04967	312	0.3718	320	0.05428	383
3	<0.04 non-elmag.	0.00409	0.0744	0.024	86.181	4.962	8.833	0.0548	343	0.40429		0.0535	
4	<0.04 electromag.	0.00488	0.0892	0.044	85.397	5.248	9.311	0.05381	337	0.40008	341	0.05392	367

The dispersion (2σ) of the determination of uranium and lead does not exceed ± 1 %. Isotopic composition of lead has been measured by the mass-spectrometer MI-1320, the error of measurement was ± 0.1 %. The table shows also the calculated values of isotopic ratios and corresponding isotopic ages. Considering that the studied zircon fractions are characterized by sufficiently low contents of common lead, we can assume that the error imported by the calculation of isotopic ratios, as a result of correction to the content of common lead, is insignificant. Thus, the summary error for the calculation of isotopic ratios has been estimated at ± 2 %.

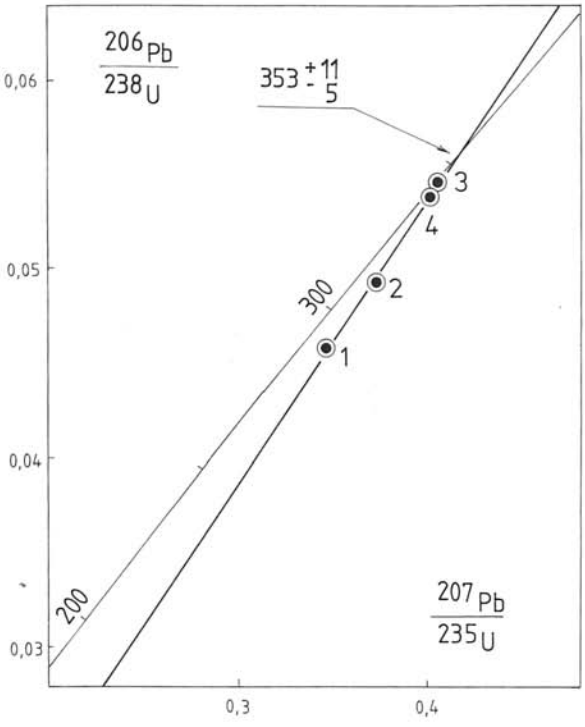

Fig. 1. Discordia plot with U-Pb data on the zircons of granodiorite rocks from the quarry Dubná Skala (Malá Fatra Mts).

The points on Fig. 1 corresponding to lead-uranium isotopic ratios of different zircon fractions constitute a trend for which we can construct linear correlation and calculate its equations. The obtained discordia corresponds to the equation

$$Y = (0.1484 \pm 0.0053)X + (-0.0058 \pm 0.0019)$$

and it intersects the concordia in the point corresponding to the age 353 + 5 (−11) m.y.

In connection with the age determination of tonalites and biotite granodiorites of 353 m.y. in the Malá Fatra Mts. it is necessary to point out a problem which increases with gradual increase of the number of geochronological data obtained by three basic methods – K-Ar, Rb-Sr and U-Pb. It concerns model ages as well as isochronal ages. It is very interesting to compare the results of the abovementioned three methods applied to similar or identical rock samples, or minerals, especially from same mountain ranges.

The authors of the papers Burchart – Cambel – Kráľ (1978), Cambel – Kráľ – Burchart (1990) and Cambel – Kráľ (1989), Kráľ (1977) devoted a great deal of attention to the differences in the results of analyses obtained by different methods and they dealt also with possible causes of the variances. They suggested that the principal factor of the differences are postgenetic processes caused by geologic development, tectonics, the change of thermodynamic conditions, time of cooling of the complexes, as well as the character and intensity of alterations of the studied geological materials.

It has been determined in several cases that U-Pb method provides lower values of zircon datings that those obtained by the Rb-Sr isochrone method. An example of this are the results of measurements on Kohút granitoids in Veporicum and Tríbeč Mts. (Bibikova et al., 1988; Broska – Bibikova et al., 1990). Lower values have been obtained by the U-Pb method from Modra granitoid samples (Malé Karpaty Mts.) by Shcherbak et al. (1988) compared with the results of Rb-Sr analysis of Bagdasaryan et al. (1982, 1983), similarly as in Nízke Tatry Mts. (Bagdasaryan et al., 1985 Boyko et al., 1974), Cambel et al., 1977), Tríbeč Mts. (Bibikova et al., 1990 Bagdasaryan et al., 1990), Sihla-type granitoids from Veporides (Bibikova et al., 1990; Bagdasaryan et al., 1986; Cambel et al., 1988, 1989).

In several cases it could be thus assumed that more basic varieties (biotite granodiorites or tonalites) are according to the U-Pb method relatively younger that granitoids of the same mountain ranges dated by Rb-Sr method. We know that in the past this was not in accordance with classical opinions based on magma differentiation producing more leucocratic magmas. In present this fact rather supports the opinions that basic magmas have their origin in another, or strongly contamined source.

On the other hand, several analyses (e.g. from Nízke Tatry Mts.) obtained by Rb-Sr method are approximately equal (365–367 m.y.), regardless of the rocks being more basic (biotite granodiorite of the Prašivá or Králička type) – Bagdasaryan et al. (1985). The U-Pb method (Boyko et al., 1974; Shcherbak et al., 1974; Cambel et al., 1974), using model analysis on zircons and monazites based on the ratio $^{206}Pb/^{238}U$ gave also lower ages of granitoids (310–325 m.y.).

It is necessary to note that model analysis of biotite granodiorite (Shcherbak et al., 1974) from Janova Ves presented in this paper gave the age 295 m.y. A new analysis of granodiorite from an old quarry near the village Kostoľany pod Tríbečom carried out by Broska – Bibikova et al. (1990) resulted in almost the same value, i.e. 306 ± 10 m.y., which is also low in comparison with Rb-Sr analysis (Bagdasaryan et al., 1990) – 351 ± 4.5 m.y.

Recently obtained results indicate that basic rock varieties are according to U-Pb method a little younger in comparison with Rb-Sr method. This assumption is in places contradicted, e.g. tonalites of Malá Fatra Mts. dated by U-Pb analysis of zircons are of the same age (351 m.y.) as the one determined usually by the Rb-Sr method on granitoids from several core mountains of the Western Carpathians.

This means that it is not possible to accept the opinion that in Western Carpathians basic granitoid varieties are always younger than more acid ones. We should rather consider the

question, why these two different methods of dating (Rb-Sr and U-Pb) give different results and which of them are more accurate, as well as why Rb-Sr analysis as a rule gives higher ages than U-Pb method.

The abovementioned discrepancies in the results cannot be explained unambiguously or by same causes for all analysed materials. There are several factors affecting the age determination of rocks, since various geological processes can postgenetically influence the value of age, which is nevertheless the age of the process or of a combination of processes not related to the primary age of the rocks.

In our opinion the variations in the results and the dispersion of geochronological data, as well as the variance of the IR value, or the inequilibrium state of isotopes and the conditions of chronometer closure depend to a considerable extent not only on thermodynamic conditions but also on chemical properties of elements or the properties of their isotopes. It is known that argon is more mobile thant strontium, but the content of strontium depends on the migration capability of K, Rb, Ca, Sr. It seems that in common geological-petrogenetic processes the contents of U, Pb, Th in accessories are least affected by migration. In the Western Carpathian region, where two most intensive orogenic processes – Variscan and Alpine – combined and where there are possibilities of recycling and contamination of rock material even in the pre-Variscan period, it is necessary to take into account an increased influence of postgenetic processes on the dispersion of values and data determinative for the calculation of age of rocks and minerals.

It seems that if we can determine sufficiently accurately the alterations of minerals in rocks and if we obtain information on accessories analysed in our Western Carpathian region, the U-Pb method on zircons remains very important. Its importance increases in the view of the fact that it provides also other indications of genetic history of minerals from studied rocks. However, without Rb-Sr analyses we cannot solve geochronologic problems and verify some petrogenetic and minerogenetic theories.

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