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THE PROBLEMS OF GENESIS AND AGE OF TWO-FELDSPAR GRANITOIDS OF THE MOSHCHEVAYA RIVER (NORTHERN CAUCASUS, C. I. S.)

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Abstract: The genesis and age of the two-feldspar gneissic granites from Moshchevaya and Beskes rivers of the Great Caucasus are a key point for the understanding of early periods of magmatic evolution of the province. There are two views on the age of these granites: the first one that they are Paleozoic, the second one - Middle Paleozoic rocks. Data obtained by the authors on the disturbation of the whole-rock Rb-Sr system supports the pre-Paleozoic age of these granites.

Key words: two-feldspar granites, magmatic evolution, Great Caucasus, Rb-Sr dating.

Introduction

Two-feldspar gneissic granitoids of the Moshchevaya and Beskes rivers are by a number of investigators considered to be the oldest on the territory of the Great Caucasus and they have been described as granites, granito-gneisses, gneissic granites etc. The solving of the problems of their age and genesis within the Caucasus orogenic regions is of principal importance for the understanding of the regularity of evolution of continental Earth crust of orogenic zones. The age of these granitoids appears up to now to be discutable and there are opinions on them being Early or Middle Paleozoic rocks. This served as a basis for further studies together with scientists from Germany. On 15 most representative samples from granitoids of the Moshchevaya and Beskes rivers, isotope-geochronologic, geochemical studies were carried out, including the determination of the contents of ore and rare earth elements and fission-track analyses of apatites.

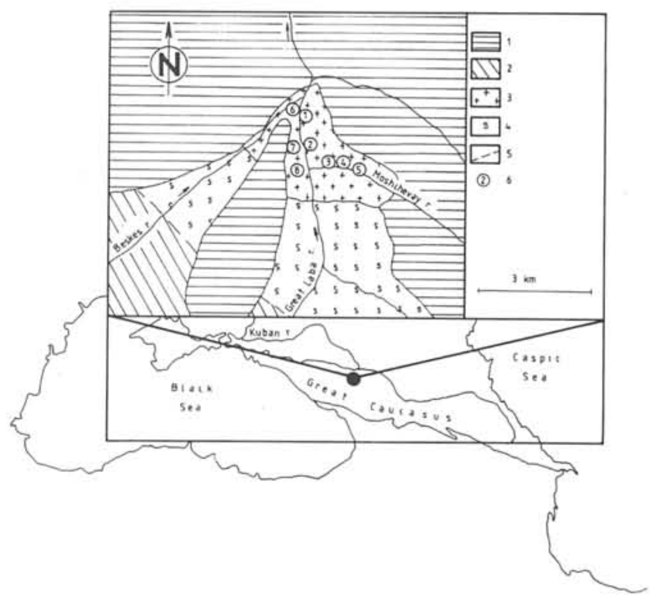

Fig. 1. Geological sketch map of the rivers Bolshaya Laba, Moshchevaya and Beskes.
1 - aleurolites, sandstones (Lower Jurassic); 2 - Upper Devonian metamorphosed terrigene-volcanogenic rocks; 3 - gneissic granitoids of the rivers Moshchevaya, Beskes; 4 - serpentinites of the Bedenskiy Massif; 5 - fault zones; 6 - sampling sites for radiological studies.

Geological setting of the region and petrochemical characteristics of the granitoids

Gneissic granitoids and accompanying gray and pink aplites uncovered in the valleys of the rivers Moshchevaya and Beskes (tributaries of the river Bolshaya Laba) are a part of pre-Jurassic fundament of the Bechasinskaya structural-formational zone of the Great Caucasus (Fig. 1). The granitoids intrude into serpentinites of the Bedenskiy Massif (Moshchevaya river), mica schists and gneisses (river Bolshaya Laba and Beskes). On contacts with serpentinites the granites contain variously oriented xenoliths of reworked serpentinites. In the valley of the Moshchevaya river there are exocontact alterations in granitoids caused by assimilation of green chloritoid schists as well as serpentinite material of the xenoliths. In the ending of the Moshchevaya river valley medium-grained granitoids with marked gneissose texture predominate and 600 *m* upwards in the valley they are replaced by a coarse-grained variety with weak gneissose texture and large quantity of flakes of unaltered biotite. Massive structure of granitoids can be seen also on the left side of the valley of the Bolshaya Laba river, opposite to the mouth of the Moshchevaya river. Granitoids as well as the surrounding rocks are cut by numerous veins and dykes of grey and pink aplites. The studied granitoids and the surrounding mica schists, gneisses and serpentinites are covered by eroded Lower Jurassic sediments.

According to mineral composition, granodiorites, tonalites, granites and aplites can be distinguished among the "granitoids". they are medium- to coarse-grained rocks, greenish-gray in colour and with gneissose structure, which is variously marked in different parts of the massif and sometime even missing. The rocks are to a considerable extent altered by secondary processes. The quantitative mineral composition of the granitoids (in vol. %) is the following: plagioclase - 46 – 60, quartz - 23 – 31, biotite - 3 – 10, K-feldspar - 5 – 15, diopside - up to 1. Accessory minerals are: apatite, brown zoned orthite, sphene, zircon, magnetite and rarely ilmenite. Secondary minerals are represented by chlorite, epidote-zoisite, muscovite, sericite. Large (up to 10 *mm*) and smaller idiomorphic grains, finely polysyntetically intergrown according to the Carlsbad law, are of plagioclase (An_{20-26}) composition. A characteristic feature is the deformation (bending, fracturing) of twin sutures.

It has to be pointed out that the studied granitoids underwent multiple deformations. Primary magmatic minerals, as well as newly-formed ones, have been partly cataclased, partly they acquired oriented distribution corresponding to the schistosity, marked by fine white-mica flakes. During this deformation phase, aggregates of secondary coarse-grained epidote were replaced at the margins by chlorite. Since recrystallization with the formation of fine-grained quartz took place at the same time, the temperature in this phase varied in the range of 290 – 350 °C (Voll 1976, 1980).

Besides tectonic reworking (gneiss-formation with partial schistosity), the granitoids underwent also regional metamorphism. Judging from newly-formed minerals parageneses, regional metamorphism took place in the conditions of greenschist facies at maximal temperature of about 350 °C. In connection with the fact that newly-formed minerals are very coarse-grained and the epigenesis was practically complete we can assume that these temperature conditions had to last for a long period of time.

The classification and nomenclature of the studied rocks has been done on the basis of chemistry and mineralogy with the use of the QAPF diagram (Fig. 2), where it can be seen that predominant rocks of the intrusive massif are granodiorites, a few samples are situated in the field of quartz monzonite and one sample each in the fields of granite and tonalite. Thus, the described massif is basically composed of granodiorites.

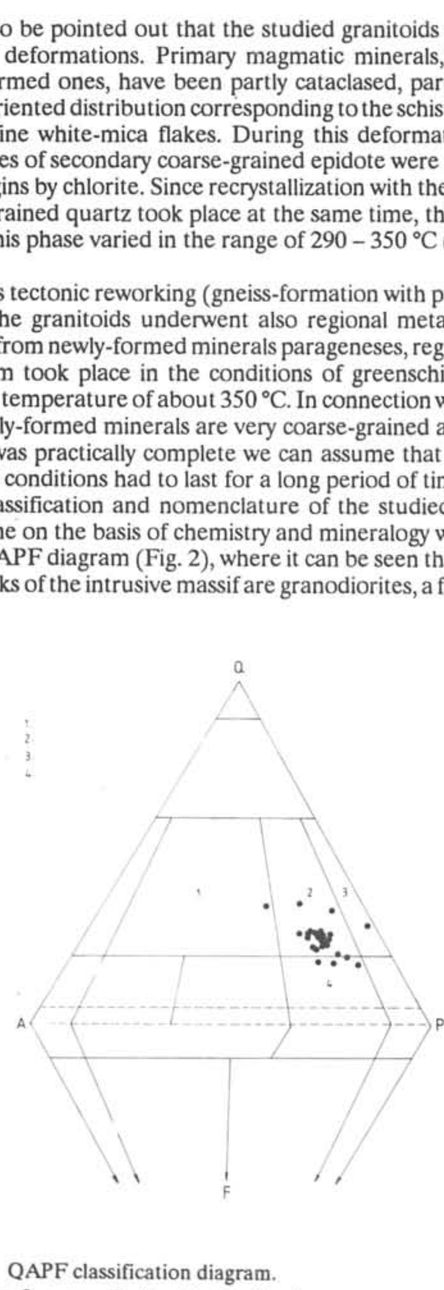

Fig. 2. QAPF classification diagram.
1 - granites, 2 - granodiorites, 3 - tonalite, 4 - quartz monzonite.

Geochemical studies have been done on 15 large (up to 8 *kg*) samples, representing the main varieties of the rocks in the massif. The contents of principal, trace and rare earth elements have been determined (Tab. 1). Characteristic for the granitoids are high contents (in *g/t*) of Sr - up to 952, at relatively low Rb concentrations - up to 90, which explains also the very low values of the ratio Rb/Sr = 0.1. Among the studied granitoids, C-normative rocks are predominant (0.62 – 2.13 %, 0 = 1.39 %), with average molar ratio of Al_2O_3/Na_2O+K_2O+CaO varying from 1.06 to 1.04. The ratio Na_2O/K_2O corresponds in average to 2.1 and the average value of the ratio K/Rb is 287.

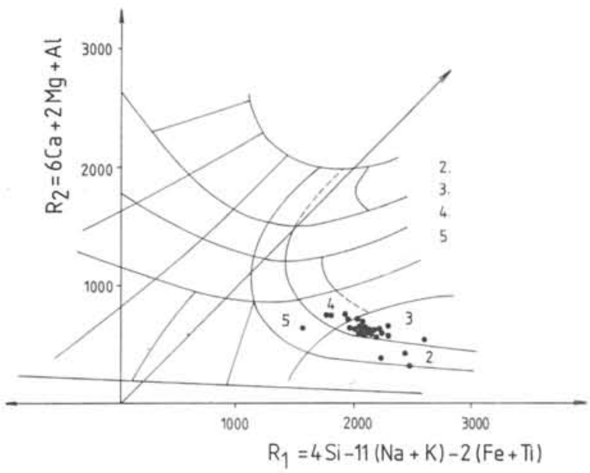

Fig. 3. Projection of studied rock samples in the R_1R_2 diagram after de la Roche (1980).
2 - granites, 3 - granodiorites, 4 - tonalite, 5 - quartz monzonite.

Fig. 3 shows the distribution of chondrite-normative (Evensen et al. 1978) rare earth element average values (from six selected samples). We can see an enrichment (75 - 80 times higher than chondrite concentrations) of LREE and depletion of HREE, e. g. the content of Lu is only 2.8 times higher than in chondrites. The latter can be explained by the fractionation of hornblende and garnet. The chondrite-normative ratio of La/Yb having values of 22 - 31 is an evidence of relatively strong fractionation of rare earth distribution. The negative Eu anomaly is not very marked.

The value of the Al_2O_3/Na_2O+K_2O+CaO ratio equal to 1.1, along with the values of $^{87}Sr/^{86}Sr$ varying between 0.704 and 0.705 (Tab. 2) indicate that the studied rocks belong to the I-type of granite (Chappel & White 1974).

Isotopic-geochronological studies

After the publication of the first potassium-argon data obtained for gneissic granitoids of the rivers Moshchevaya and Beskes, they have been introduced into geological literature (Afanasyev et al. 1969) as an Ordovician granitoid formation, which, in turn, served as an indirect proof of pre-Ordovician age of hyperbasites intruded by these granitoids, and for the distinguishing of the Caledonian tectono-magmatic cycle in the history of the Caucasian orogenic region. Mikheev (1965), on the basis of geological and petrographical data, united the granites-gneisses of the rivers Moshchevaya, Beskes and Bolshoy Blib into one magmatic com-

Table 1. Average chemical composition (in wt. %) of granitoids of the rivers Moshchevaya and Beskes, and the contents of trace and rare earth elements (in *g/t*).

Oxids	average	minimum	maximum	element	average	minimum	maximum	element	average	minimum	maximum
SiO_2	69.6	66.8	76.6	Co	5.0	2.0	8.0	La	19.3	17.0	24.4
TiO_2	0.33	0.03	0.56	Cr	12.0	5.0	29.0	Ce	41.0	34.2	50.3
Al_2O_3	15.9	13.9	16.5	Cu	3.0	1.0	6.0	Nd	17.4	14.2	20.9
Fe_2O_3	1.2	0.2	1.8	Ga	20.0	19.0	23.0	Sm	3.4	2.9	3.7
FeO	0.8	0.2	1.4	Nb	5.0	1.0	8.0	Eu	0.77	0.70	0.84
MnO	0.04	0.01	0.05	Ni	12.0	3.0	24.0	Gd	2.2	1.8	3.2
MgO	1.1	0.2	1.8	Pb	24.0	16.0	49.0	Tb	0.32	0.26	0.43
CaO	2.1	0.5	2.8	Rb	69.0	13.0	90.0	Dy	1.6	1.2	2.0
Na_2O	5.2	4.5	7.5	Sr	693.0	129.0	952.0	Er	0.7	0.3	0.9
K_2O	2.35	0.42	3.1	Th	9.0	7.0	16.0	Yb	0.6	0.2	0.9
P_2O_5	0.13	0.01	0.22	Y	9.0	5.0	23.0	Lu	0.07	0.02	0.13
CO_2	0.14	0.03	0.30	Zn	39.0	6.0	66.0				
H_2O^+	1.1	0.3	1.6	Zr	106.0	18.0	140.0				

plex of Middle Paleozoic age. Analogous conclusions on Middle Paleozoic age of metaplagiogranites of the Bolshoy Blib type including the granitoids of the rivers Moshchevaya and Beskes, have been made by Chesnokov et al. (1985), who obtained from these rocks by the potassium-argon method on micas the values of 350 ± 15 Ma. The same authors obtained for metaplagiogranites of the Bolshoy Blib river by the Rb-Sr method on 6 points an isochron corresponding to the age 376 ± 40 Ma and initial strontium ratio of about 0.703 (Chesnokov et al. 1985). These values were interpreted by the cited authors as the age of metaplagiogranites. Our assumption has been confirmed by the results of radiologic investigations (K-Ar method) on newly-formed muscovites separated from gneissic granitoids of the rivers Moshchevaya, Beskes and Bolshoy Blib. The obtained values - 350 – 368 Ma (Tab. 2) - correspond most probably to the age of Variscan regional metamorphism and they are consistent with geological data.

Later on, an attempt has been made (Somin et al. 1985) to determine the age of the Moshchevaya river granites by studying individual zircon grains by the thermoisochron method. The obtained three groups of values - 1200, 570 and 200 Ma - do not allow to make an unambiguous conclusion on the age of the granites.

More recently, a first attempt has ben made (Chernishev et al., 1987) by U-Pb zirconometry to determine the age of gneissic granites of the Moshchevaya river on magmatic zircon grains. The geochronological interpretation of U-Pb data on zircon from the granitoids has been based on the extrapolation of three experimental points by a straight line (discordia). Its lower intersection with concordia corresponding to an age of 285 Ma allows to date the beginning of concentration of the young component of radiogenic lead and the time of the closing of the U-Pb system in zircon. The upper intersection (approx. 1.3 bilion years) gives an estimate of the minimal age of the ancient lead component, or of the minimal age of relic zircon. The following interpretation of these data has been presented: *1* - the material of the granites originated as a result of processes of melting of Proterozoic rocks; *2* - the granites underwent deep metamorphic changes in the Late Paleozoic period - 285 Ma ago. However, on the basis of the obtained results it is not possible to make an unambiguous conclusion on the Proterozoic age of magmatic zircons and, correspondingly, of their host granites.

Simultaneously with our studies, investigations have been made (Bagdasaryan et al. 1987) aimed as well at the explanation of the age of the studied granites using potassium-argon and Rb-Sr methods. It has been determined that the strontium ratio

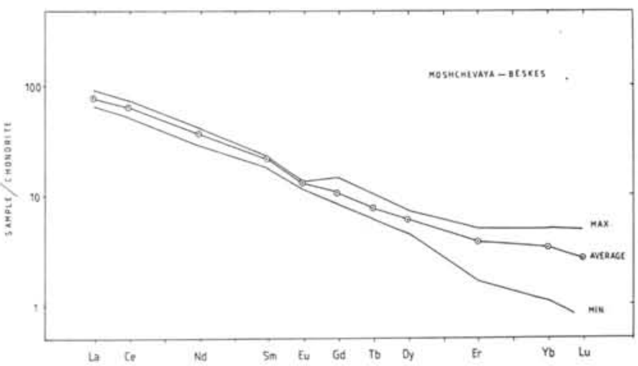

Fig. 4. Diagram of the distribution of rare earths in granitoids of the rivers Moshchevaya and Beskes.

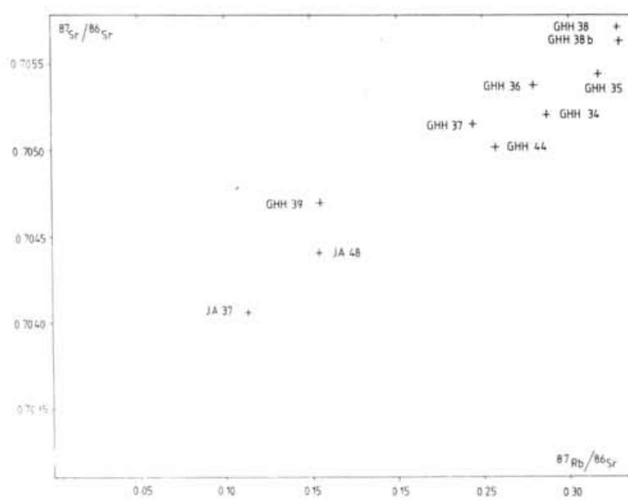

Fig. 5. Diagram of the distribution of strontium isotopes in granitoids of the rivers Moshchevaya, Beskes and Bolshoy Blib.

Table 2. Results of radiologic studies of the granitoids (of the rivers Moshchevaya and Beskes).

Method	mineral, rock on which dating has been made	age in Ma	author of the material
K-Ar	phlogopite on contact of granite and serpentinite	450-470	1
K-Ar	as above	439±9	1
Rb-Sr	as above	300-345	3
K-Ar	biotite from gneissic granite	415±12	1
K-Ar	biotite from gneissic aplite	406±16	1
K-Ar	biotite from plagiogranite	377±16	2
K-Ar	muscovite from plagiogranite	335±9	2
K-Ar	muscovite from plagiogranite	367±11	2
K-Ar	muscovite + biotite from plagiogranite	397±11	2
K-Ar	feldspar from granite	372±20	1
K-Ar	muscovite from granite	365±20	2
K-Ar	whole-rock sample, serpentinite	555 ?	1
K-Ar	biotite from granodiorite	368±11	
K-Ar	muscovite from granodiorite	350±11	
K-Ar	muscovite from granodiorite	365±11	

Note: All in the Table presented granitoid varieties have gneissose structure; authors of the material:
1 - Afanasyev et al. 1968; 2 - Afanasyev et al. 1969; 3 - Rubinstein 1874; 4 - Gurbanov.

$^{87}Sr/^{86}Sr$ varies in the granitoids within the range of 0.7072 to 0.8378 and only in one sample in reached 0.7058, and according to the Rb-Sr isochron their age is 341 ± 22 Ma. It is important to point out that phlogopite, formed at the contact of granites with the intruded serpentinites, yielded by Rb-Sr method values corresponding to Lower Carboniferous age, and the same phlogopite, using K-Ar method, yielded values by 130 Ma higher, which has been explained by possible presence of surplus argon. On the basis of the above mentioned data it has been assumed that the formation of these granitoids is connected most probably with the Variscan tectono-magmatic cycle.

We shall now return to the analysis of results presented in Tab. 2. The earliest value (555 Ma) has been obtained from serpentinites enclosed in gneissic granodiorites; most probably it does not correspond to their age. Contradictory data have been obtained from the granitoids. Thus, values obtained from phlogopite, formed on the contact of granodiorite and serpentinite, using K-Ar method, vary in the range of 450 to 439 Ma, and values obtained from micas of the same granodiorites vary from 415 to 335 Ma. It is also important that only values obtained by Rb-Sr method are considerably younger (300 – 345 Ma) than the determinations by K-Ar method. This allowed us to suggest that the Rb-Sr system has been disturbed. The study of the character of the distribution of uranium in apatites carried out by the authors and its dating confirmed this suggestion. The apatite samples from gneissic granodiorites are not homogeneous, as far as the age of uplift as well as the concentration and distribution of uranium are concerned. It has been determined that apatites from the studied rocks differ in their uranium contents by 10 times. It is very important that the apatites differ not only in uranium contents, but also by the type of distribution (Kráľ & Gurbanov 1988), which could be an evidence of different conditions of formation of the rocks. In this way, rocks crystallizing in different depths were positioned on the same hypsometric level, and therefore homogenization of strontium isotopes cannot be observed in them, which is also the cause of the disturbance of the Rb-Sr system. The distribution of strontium isotopes in the studied rocks is shown on Fig. 4.Since the Rb-Sr system has been disturbed, the

Table 3. Strontium ratios and contents of Rb and Sr in granitoids of the rivers Moshchevaya, Beskes and Bolshoy Blib.

Sample No.	ratios		Contents in *g/t*	
	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	Rb	Sr
GHH 34	0.287±4*	0.70523±4	84.3±0.5	849.9±0.2
GHH 35	0.317±4	0.70547±3	80.8±0.6	738.7±0.2
GHH 36	0.279±4	0.70540±3	68.0±0.7	705.9±0.2
GHH 37	0.244±3	0.70517±2	63.9±0.7	759.7±0.2
GHH 38	0.328±5	0.70574±3	89.1±0.5	786.3±0.2
GHH 38B	0.329±4	0.70566±2	77.6±0.6	683.0±0.2
GHH 39	0.155±2	0.70471±1	53.2±0.8	995.8±0.1
GHH 44	0.257±3	0.70504±3	66.1±0.7	745.3±0.2
Bolshoy Blib				
JA 37	0.113±2	0.70407±3	46.0±1.0	1186.6±0.1
JA 48	0.154±2	0.70442±4	54.1±0.8	1014.4±0.1

Note: * - value of the 2δ error. Analysed in the Geochronological Laboratory, University of Heidelberg.

K-Ar age determinations can be considered geologically probable. This assumption is confirmed by the fact that higher values have been obtained from biotite (415 – 377 Ma) than from muscovite (367 – 335 Ma). These data are not usual, since muscovite is characterized by higher radiogenic argon-loss temperatures (350 °C) than biotite (300 °C). It is well known that in relation to argon-loss biotites should, at slow cooling as well as at secondary thermal effects on the host rock, yield lower age values than coexisting muscovites, but in our case the situation is reverse. The younger ages of muscovite, on one hand, can be explained by its secondary origin, and, on the other hand, by the possibility of its having been formed during "decolouring" of biotite as a result of superimposed processes of rock alteration. Relatively low age determinations, from 365 to 360 Ma, have been obtained from whole-rock granodiorite sample as well as from separated mono-mineral fractions. These values are consistent with the time of Variscan regional metamorphism manifestations, which probably caused the process of granitoid rejuvenation. Except this, we can assume that in the case of K-Ar age determinations we are dealing not with the primary age of cooling, but with to an unknown extent rejuvenated argon age affected by the Variscan orogeny (Chernishev et al. 1987). Therefore the obtained values are an evidence of "mixed" ages.

In connection with the fact that the age of the Moshchevaya river granitoids, in accordance with the above mentioned data, remains disputable, additional investigations have been carried out by the authors, aimed at the possibility of using Rb-Sr isochron method. It has been determined (Tab. 3) that granodiorites are characterized by low strontium ratios varying in the range of 0.70471, while the 2δ error is contained in the fifth figure after the decimal point. Since granitoids have high Sr and low Rb contents, we decided to refrain from the correction of isotopic strontium ratios to ^{87}Rb-decay "in situ". The results of isotopic studies are presented on the diagram $^{87}Sr/^{86}Sr$ - $^{87}Rb/^{86}Sr$ (Fig. 4), from the analysis of which it can be seen that they all do not remain within the limits of permitted errors and they cannot be related to one isochron.

Various combinations of results from individual samples allows to construct hypothetic and not strictly defined "isochrons" for which the age values appear to lie between 385 and 599 Ma. However, for all ten samples we obtain an "errochron" with an age of 470 Ma. The from "isochrons" obtained initial Sr ratios vary in the range of 0.70311 to 0.70385 and,consequently, they fall into the area of non-contamined or weakly contamined mantle melts (Tab. 4). The above mentioned data, together with the results of U-Pb zirconometry (Chernishev et al. 1987) allow to make an assumption on the pre-Variscan age of the Moshchevaya and Beskes rivers granitoids.

It is necessary to point out that the results obtained by the authors substantially differ from data presented in the work of Bagdasaryan et al. (1987), although samples for the study of the age of granitoids were collected practically from the same outcrops. Thus, according to data of Bagdasaryan, the granitoids are characterized by high Rb contents and $^{87}Sr/^{86}Sr$ ratios varying in the range of 0.7072-0.8378, and the Rb-Sr isochron corresponds to the age 341 ± 22 Ma. According to our data, the granitoids are characterized by low Rb contents and lower (0.70471 – 0.70574) values of strontium ratios, and instead of an isochron for all ten samples, an "errochron" has been obtained with the age of 470 Ma. When analysing the figure 341 ± 22 Ma obtained by Rb-Sr isochron method and interpreted (Bagdasaryan et al. 1987) as the age of the Moshchevaya river granitoids, we notice that it corresponds to the Visean stage of the Early Carboniferous, when Variscan regional metamorphism ended, accompanied in the concluding stage by manifestations of diastrophism. Since the studied granitoids have gneissose structure, they should have crystallized before the appearance of diastrophism and correspondingly before Variscan regional metamorphism, the results of influence of which have been discussed earlier in this paper. If we consider the value of 341 Ma to be the age of the granitoids, then, considering the above presented data, there remains no geological time for their formation.

Table 4. Rb-Sr isochron ages for different combinations of whole-rock samples.

Sample combination	initial Sr ratios	age in Ma
GHH 34, 35, 44	0.70319	503
GHH 36, 37, 38, 39	0.70377	415
GHH 36, 37, 39	0.70385	385
GHH 38, 39	0.70379	419
JA 37, 48	0.70311	599
general "errochron"	0.70344	470

Genesis of the Moshchevaya and Beskes rivers granitoids

Principially, the formation of granitoid melt producing the studied rocks, could have occurred in the following, principially differing ways: during uninterrupted fractionation of primary magmas with basic compositon; during anatectic melting of continental crust rocks; during assimilation of crustal rocks by mantle melts.

The granitoids of the rivers Moshchevaya and Beskes can be considered to be the products of basic magma differentiation, however, having mantle source, while garnet and clinopyroxene occurring in granodiorites are probably restite minerals. However, the absence of large volumes of tonalites, gabbros, as well as the small (up to 12 square *km*) size of the studied intrusive massif are evidence against the formation of these granitoids by differentiation of pure mantle magmas. At the same time, low strontium ratios (0.70407 – 0.70574) exclude the possibility of primary material for the formation of the melt being earlier existing granite crust or graywackes and they indicate in principle an ultrabasic or basic source. On the basis of an analysis of SiO_2 contents it can be assumed that the melted material came from ultrabasic or silica-undersaturated rocks, since their partial melting, notwithstanding the high pressure of P_{H_2O}, can lead to the formation of derivative magmas, undersaturated in quartz (Kushiro 1972). Thus, as primary material can be considered quartz-saturated amphibolite or quartz eclogite. In association with granitoids of the river Bolshoy Blib, considered (Chesnokov et al. 1985) to be analogues of the Moshchevaya river granodiorites, together with amphibolites there are also retrograde-reworked eclogite bodies, which, according to coexisting mineral parageneses (garnet + omphacite + quartz + hornblende and rutile) belong to high-pressure varieties - 20 *Kbar* (Green & Ringwood 1967; Ito & Kennedy 1970). However, the composition of garnet (Tatrishvili 1970) from eclogite, represented basically by almandine (in mol.%: almandine - 51.2, andradite - 23.5, pyrope - 19.1, spessartite - 3.9, grossular - 2.3), is an evidence against its formation at such high pressure. The formation of eclogite took place most probably in the conditions of lower crust. Similar silica saturated eclogites (e.g. amphibole-bearing ones) together with garnet amphibolites or amphibole-garnet granulites could be considered to be primary rocks for the formation of the granodiorites.

Considering the chemistry and isotopes we can assume that a part of the primary rocks could have been metamorphically and metasomatically reworked tholeiitic island-arc rocks with approximately ten-fold chondrite content of rare earths, the partial melting of which, maybe, was connected with intrusions of basic or intermediary mantle magmas into lower part of the crust, which led to the origin of quartz-normative melt. The in the studied granodiorites observed depletion of heavy rare earth elements (HREE) can be explained by the presence of residual or crystallizing garnet in which HREE concentrated. Low MgO (1.1 – 3.0 wt.%) and Ni contents (12 – 18 ppm) could indicate that strong fraction of olivine could play a role in the evolution of the primary melt. High concentrations of incoherently behaving Sr (693 – 967 ppm), increased Al_2O_3 contents (15.9 – 16.4 wt.%) as well as the absence or weak manifestation of negative Eu anomaly allow to exclude the assumption of the presence of substantial amount of residual or crystallizing plagioclase in the melt.

Besides this, according to the summary REE contents of up to 88 ppm and the value of the ratio of light and heavy rare earth elements of 32, these granitoids are analogous to granodiorites formed in the conditions of continental margins.

Considering the above mentioned facts, we suggest the following variant of paleotectonic reconstructions for the Early Paleozoic-Proterozoic (?), as well as of the mechanism of formation of the Moshchevaya river granitoids: In the Early Paleozoic, as a result of convergent plate movement, the in the northern part of the Paleotethys existing oceanic crust have been subducted. Partial melting of this crust, according to the extent of reaching the determined P-T parameters,or under the infuence of fluids, in the surrounding mantle peirdotites (?), could have led to the formation of tholeiitic island-arc volcanites and, subsequently, to the formation of an island arc. As a result of underthrust fault in the region of such island arc, Earth crust should have thickened. The following advance of large quantities of mantle melts could, apparently, cause in the lower part of continental crust partial or total melting of amphibolites and (or) eclogites. In this case the melted matter could, according to its composition, correspond to tholeiite with initial strontium ratios of 0.703-0.704. After an interaction of mantle melts and rocks of the upper mantle on one side and lower continental crust on the other side, basic or intermediary melt could form. This melt, during its movement to higher horizons of the crust, had to undergo an evolution, and, in the process of its differentiation, the studied granitoids could have formed, having characteristic low initial strontium ratios, specific geochemical features and rare earth distribution.

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