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Geology

New Data on the Formation and Age of Orthoclase Gabbro of the Dzirula Crystalline Massif (Georgia)

David Shengelia*, Lasha Shubitidze, Sun-Lin Chung**, Han-Yi Chiu**, Peter Treloar§**

* *Academy Member; A. Janelidze Institute of Geology, I.Javakhishvili Tbilisi State University, Tbilisi*
* *A. Janelidze Institute of Geology, I. Javakhishvili Tbilisi State University, Tbilisi*
** *Department of Geosciences, National Taiwan University, Taipei 106, Taiwan*
§ *Centre for Earth and Environmental Science Research, Kingston University, London, GB*

ABSTRACT. Orthoclase gabbro of the Dzirula crystalline massif incorporates the rocks of different genetic groups: protolith of the gabbroic intrusion, hybrid rock – orthoclase gabbro and leucocratic quartz-feldspar bearing formation. The rocks of all three genetic groups are dated by the U-Pb LA-ICP-MS zircon age method. The apparent age of zircon in the protolith of gabbroic intrusive and in hybrid orthoclase gabbro, respectively wt.mean 221±1.9 and 221.9±2.2Ma, records the time of crystallization of the intrusive and the apparent age of zircons (wt.mean 323±2.9Ma) from leucocratic quartz-K-feldspar formations, as well as the inherited Late Variscan age (323±9, 329±8.3, 332±10 and 335±11Ma) of zircons of hybrid orthoclase gabbro corresponds to the age of formation of Late Variscan granitoids widespread in the Dzirula crystalline massif. *© 2012 Bull. Georg. Natl. Acad. Sci.*

Key words: *the Dzirula massif, orthoclase-gabbro, U-Pb zircon age.*

In the Eastern part of the Dzirula crystalline massif stock-like body of orthoclase gabbro (OG), known as “rikotites” is spread. The primary intrusive contact of OG is complicated by Mesozoic-Cenozoic tectonic events. Generally, the contact of the intrusive with the Baikalian quartz-diorite gneisses is tectonic, though locally the contact effects are observed. During the tectonic movements, the country rocks were insignificantly dislocated.

Views of researchers on the genesis and age of OG considerably differ. Some researchers believe that these OG are pre-Variscan or Early Variscan basites, reworked under the influence of Late Variscan [1-3] or Jurassic [4] granitoids. Others associate their formation with the assimilation of Paleozoic granitoids with ultrabasite magma, considering the latter to be a Late Paleozoic formation [5,6].

According to the scheme of I. Khmaladze [7] the OG formed as a result of deep assimilation and belongs to a group of Bathonian intrusions. Khmaladze’s assumption is based on the following facts: a massive structure of OG; OG are considerably less (cataclased) broken down in comparison with the Paleozoic granitoids and gabbroids of the Dzirula massif; presence of anorthoclase in OG that are missing in the pre-Jurassic rocks of the Dzirula massif; absence of vein facies of Paleozoic granitoids in the intrusive body of OG; presence of transformed (assimilated) granitoid xenoliths and also of veins of pyroxenites in OG; occurrence of active contacts of OG with quartz-diorite gneisses.

O.Dudauri [8] related the OG intrusive body to the Khevi-Chalvani intrusive complex. In his opinion, formation of OG was induced with the activity of basic magma of the first phase of Middle Jurassic magmatic processes. He considers that granite material was delivered into the OG by hydrothermal and pneumatolite solutions from the Khevi-Chalvani intrusive that was formed in the Middle Jurassic.

According to A.Okrostsvaridze et al. [9] the Σ_{Nd} parameter of OG varies within the limits of 0.4485 – -0.36936 (mean figure – + 0.05870; and I_{sr} parameter shows the mantle source of magma (I_{sr} = 0.7049476-0.7053333). From the above mentioned they consider that the main source of OG magma is an unexhausted mantle reservoir, from where the K-enriched magma intruded into the Precambrian quartz-diorites.

The age of OG biotite by K-Ar dating was determined by [10] as 163±11Ma, but according to [11] it is 179±6Ma. Isotope-geochemical determinations obtained by [9] is worth mentioning: the $^{40}Ar/Ar^{39}$ dating shows 219±4 Ma for hornblendes and 217±11Ma for biotites. Rb-Sr isochrone for 6 samples of OG drawn by the same authors corresponds to 211±11Ma (MSWO=0.83).

Thus, the age and formation of OG on the basis of the above facts is difficult to solve definitively.

Petrographic Model of Orthoclase Gabbro Formation

In the process of OG formation tectonic layering of the Earth's crust of the Black Sea – Central Transcaucasian terrane played a significant role.

According to geological [12-15] and geophysical [16] data in the Black Sea–Central Transcaucasian terrane in the Saurian phase of tectogenesis horizontal tectonic layering of the Earth'crust took place. Tectonic layering covers deeper horizons of the Earth's crust. Tectonic doubling of the Earth's crust of the Black Sea–Central Transcaucasian microcontinent takes place (Fig. 1). Thick tectonic nappe of mafic (second layer) and sialic (first layer) layers overlap the sialic basement (third "inversion" layer).

On the basis of the above-mentioned, in the present paper the questions of the formation of OG (original rocks of exotic composition) of the Dzirula massif are considered in a new light [15, 17-19].

The authors deem that the initial magma of OG is high temperature basite-ultrabasite magma. Crystallization products of the latter are represented by pyroxenite and pyroxene-bearing gabbro (with mineral composition – labradorite, bytownite and clinopyroxene). Petrochemical parameters of basite-ultrabasite magma [9, 17-19], most likely attest to its formation in the upper mantle and, perhaps, partially in the "crustal astenolayer", where the protolite of OG was formed. A newly formed high temperature and overheated dry magma with phenocrysts of clinopyroxene and also of basic plagioclase intruded into the third "inversion" sialic layer. From the new realm, it took the volatile components causing the selective fusion of leucocratic material of quartz-feldspar composition and at the same time provoking the intensive transformation of pyroxene to hornblende in the basite magma. The basic magma was admixed to the newly formed acid magma, or it remained partially unmixed. Granitic and partly decrystallized basaltic magmas intruded first into the allochthonous basite (second) layer, apparently, without substantial changes and then into the sialic (first) layer crystallizing at a depth of 7-10 km. The leucocratic granite magma, newly formed in the "inversion" sialic layer, belongs to the S type granites, but its mixing with the initial basite magma enables to include the products of its crystallization in the special hybrid H type granites distinguished by Spanish researchers [20]. At the final stage of magmatic process the gabbroic rock was saturated (impregnated) with high temperature

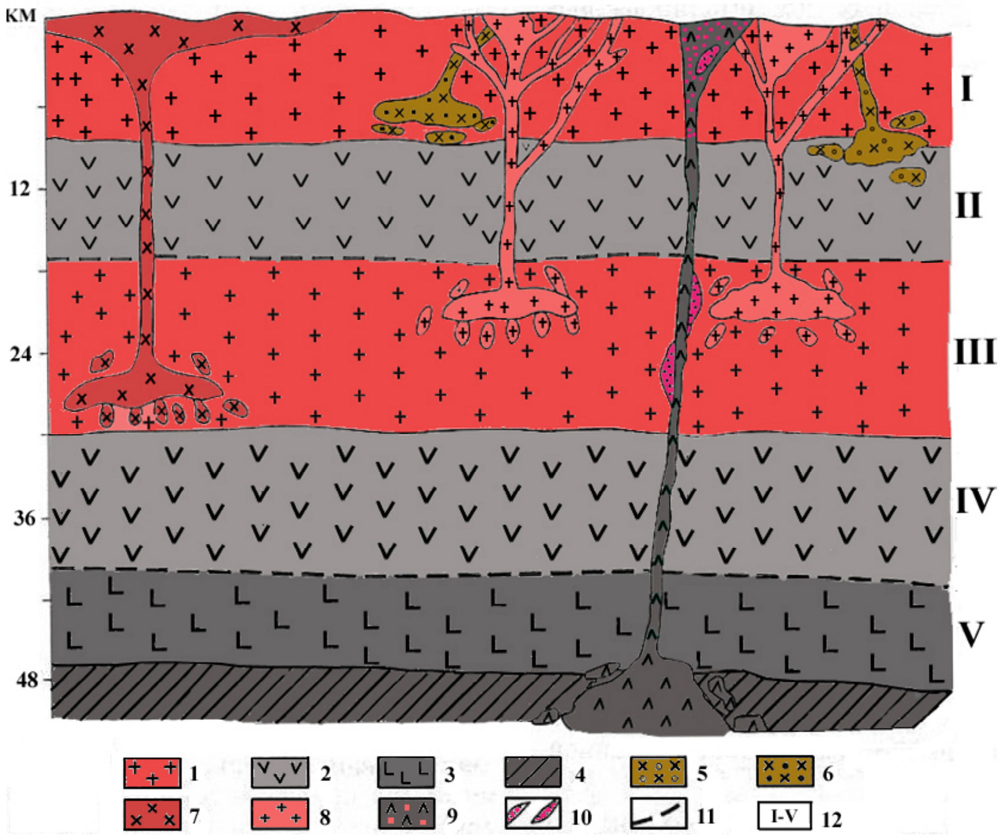

Fig. 1. Scheme of the principle of the formation of magmatic rocks of the Dzirula crystalline massif [15]
1 – sialic layer; 2 – mafic layer; 3 – "crustal astenolayer"; 4 – upper mantle; 5 – gabbro – gabbro-diorite of the Gezrula river gorge; 6 – granitoids of plagiogranite-granite series of the Kvirila and Macharula river gorges; 7 – the Rkvia intrusion; 8 – microcline granite; 9 – orthoclase gabbro (OG); 10 – quartz-feldspar anatectite; 11 - surfaces of tectonic displacement; I-V – geophysical layers.

feldspar material forming anorthoclase or orthoclase.

Thus, the OG unites the rocks of various genetic groups: 1) protolith of the gabbroic intrusion, 2) hybrid rocks - K-feldspar gabbro and 3) leucocratic quartz-feldspar bearing formation.

Protolith of the gabbroic intrusion is a massive, coarse-grained, mainly anchimonomineral (clinopyroxene-bearing diopside enriched with salite molecules) rock; brown hornfels and plagioclase of labradorite-bytownite series is also recorded. Frequently, ingrowths of clinopyroxene with reaction rims of brown hornfels are observed.

Hybrid rock – K-feldspar bearing gabbro also is a coarse-grained massive rock. Its main rock-forming minerals are: K- and Na-bearing feldspar of orthoclase-anorthoclase series, clinopyroxene, brown hornfels and plagioclase of labradorite-bytownite series; secondary biotite occurs as well. K- and Na-bearing feldspar was crystallized (-2VC – 42-60^0; Dp – 0.06-0.5; Do – 0.4) [19, 21] at the final stage of rock formation. It is recorded as xenomorphic grains and fills the space between the minerals.

In the anchimonomineral pyroxenite and in the K-Na-bearing feldspar gabbro the amount of SiO_2 is within the limits of 42.4-56.3, K_2O – 0.5-2.5, Na_2O – 0.5-3%. Geochemical and petrochemical data on hybrid OG and on the protolith of gabbro differ. The hybrid OG is enriched with REE and with other petrogenic elements. The amount of high radius lithosphere elements Ba and Rb is high in them. $(La/Sm)_n$ and $(La/Yb)_n$ ratios in the hybrid OG are 3.21 and 11.16 respectively, that is twice as high as norm ratios of the same elements in the protolith of the OG. Variations of abundance ratios of slightly incompatible elements (Hf/Sm, Ti/Y, Ti/P, Ti/Eu) are also high. Almost the same abundance ratios occur for some noncoherent elements (La/Th, La/Hf, Zr/Y, Ti/Zr). The abundance ratios of some indicator elements (Th/La, Th/Sm, Th/Yb, Zr/Y) are also increased. Eu/Eu* minimum in hybrid OG exceeds 1.0, pointing to the enrichment of this rock with Eu. Total REE in "the protolith" varies within 91.01-96.16 and in the hybrid OG it is 177.0.

In the OG mainly heterogenous leucocratic quartz-feldspar vein bodies of different thickness (from one cm to 2m) or accumulations of various shape spread widely. The rock is mainly fine- and medium-grained, rarely coarse-grained that in places passes into the pegmatitic areas. The main rock-forming minerals are: K-feldspar and acid plagioclase, sometimes quartz. In the K-feldspar (25-70%) grain size reaches 2cm; micropegmatitic aggregates of quartz- and K-feldspar occur. In the rock (12 samples were analyzed) the amount of $Si0_2$ is 61-70 mass%, K_2O – 5.4-11 mass%, Na_2O – 3.5-5.3 mass%. Heterogenous character of the leucocratic formations is conditioned mainly by the variation of partial pressure of water and rate of leucocratic acid and basic magma miscibility [19]. In all three characterized rocks, zircon is observed. Its maximum amount does not exceed 6.3 g/t. Two types of zircons are ascertained [22].

The zircon of first type, generally recorded in pyroxene gabbros, is represented by well faceted crystals of long-prismatic habitus. In their facet pattern tetragonal prism (110) and tetragonal dipyramid (111) occur. The facets of prism (100) and sharp dipyramid (311) are rarely developed. Zircon crystals are fine (0.05-0.1mm), transparent with light pink coloring; they are fissured and corroded. Elongation is within the limits of 4-5.

Zircon of the second type, being a mineral of hybrid and quartz-feldspar bearing rocks, is represented by metamictic diversity – citrolite. Unlike the zircons, citrolite is larger (0.1-02 mm); it forms dark brown non-transparent crystals of short prismatic habitus with the facets of tetragonal prism (100) and dipyramid and with elongation – 2-2.5.

New data on the U-Pb zircon age of orthoclase gabbro of the Dzirula massif

The results of LA-ICP-MS U-Pb dating of zircons in the protolith of the gabbroic intrusive (sample #1-98), in the hybrid rock (K-feldspar gabbro; samples ##10-06 and GEO127) and in quartz-feldspar bearing formations give significant information for the identification of the petrogenic model of the OG formation.

LA-ICP-MS U-Pb dating was performed at the laboratories of the Department of Geosciences of National Taiwan University, Institute of Earth Sciences of Academia Sinica (samples ##1-98, 10-06 and 12-06) and at the Institute für Geowissenschaften of Johann-Wolfgang-Goethe University (sample # GEO127).

Age determinations performed in 18 zircon crystals (sample # 1-98) of gabbroic intrusive protolith show 216-226±4Ma (wt. mean ≈221.4±1.9Ma; 2σ) (Table 1, Fig. 2). Th/U ratios in the analyzed zircons are high and vary from 2.273 to 0.730, mainly positive value of $\varepsilon_{Hf}(T)$ is from +6.4 to –0.1 (its negative value is fixed in two cases: -0.2 and -1.2) and T_{DM}^{C} vary from 1266 to 847Ma. The crystals are homogenous – in the core and in the peripheral part similar ages were obtained. These data are higher to some extent than those obtained by A.Okrostsvaridze et al. [9] with the Rb-Sr method for OG (211±11Ma) and are nearer to the results of measurements of OG hornfels (219±4Ma) and biotites (217±3Ma) performed by the same authors with $^{40}Ar/^{39}Ar$ dating. From the above it follows that the age of the OG protolith is ≈ 220Ma.

Two samples of hybrid K-feldspar gabbro were analyzed: ##GEO127 and 10-06. In the sample #GEO127 4 zircon crystals were studied (Fig. 3), where the Late Variscan age (323±9; 325±8.3; 332±10 and 335±11Ma) was received. In the fourth crystal, on the edge the Late Variscan age (327±12Ma) and in the core an inherited age (779±21Ma) was ascertained. To our mind, the inherited age of zircon determined in the core, corresponds to the early stage of the Grenville regional metamorphism manifested in

Table 1. U-Pb and Lu-Hf isotopic data of magmatic zircons from orthoclase gabbro of the Dzirula massif

Spot	Th/U	$^{207}Pb/^{206}Pb$	±1σ	$^{206}Pb/^{238}U$	±1σ	$^{207}Pb/^{235}U$	±1σ	error corr.	$^{206}Pb/^{238}U$ age (Ma ± 1σ)		$^{176}Hf/^{177}Hf$	±1σ	$^{176}Lu/^{177}Hf$	±1σ	$\varepsilon_{Hf}(T)$	±1σ	T_{DM1}	T_{DM}^{C}
1-98	**wt. mean = 221.4 ± 1.9 Ma (2σ)**																	
1-98-01	1.266	0.05459	0.00052	0.03409	0.00060	0.25654	0.00553	0.816	216.0	4.0	0.282803	13	0.002644	4	5.6	0.5	665	899
1-98-02	1.235	0.05513	0.00048	0.03463	0.00061	0.26318	0.00529	0.876	219.0	4.0	0.282769	12	0.002462	15	4.4	0.4	713	976
1-98-03	1.818	0.05157	0.00042	0.03454	0.00060	0.24560	0.00451	0.946	219.0	4.0	0.282793	9	0.004949	20	4.9	0.3	727	943
1-98-04	0.909	0.05138	0.00041	0.03497	0.00061	0.24774	0.00450	0.960	222.0	4.0	0.282650	13	0.005102	14	-0.2	0.5	956	1266
1-98-05	1.124	0.05200	0.00045	0.03546	0.00062	0.25423	0.00500	0.889	225.0	4.0	0.282813	14	0.003115	64	5.9	0.5	659	881
1-98-06	1.587	0.05165	0.00052	0.03450	0.00062	0.24564	0.00552	0.800	219.0	4.0	—	—	—	—	—	—	—	—
1-98-09	1.724	0.05429	0.00043	0.03380	0.00059	0.25302	0.00455	0.971	214.0	4.0	—	—	—	—	—	—	—	—
1-98-10	1.667	0.05127	0.00042	0.03459	0.00060	0.24450	0.00458	0.926	219.0	4.0	0.282734	11	0.003599	6	3.0	0.4	789	1065
1-98-12	0.667	0.04970	0.00233	0.03453	0.00067	0.23661	0.01487	0.309	219.0	4.0	—	—	—	—	—	—	—	—
1-98-13	2.273	0.05118	0.00041	0.03490	0.00061	0.24621	0.00455	0.946	221.0	4.0	0.282696	12	0.006256	7	1.3	0.4	915	1174
1-98-15	0.840	0.05312	0.00047	0.03544	0.00063	0.25954	0.00521	0.886	225.0	4.0	0.282693	16	0.002896	8	1.7	0.5	833	1150
1-98-16	2.128	0.05063	0.00042	0.03511	0.00062	0.24503	0.00464	0.933	222.0	4.0	0.282839	11	0.005687	10	6.4	0.4	669	847
1-98-17	1.111	0.05081	0.00047	0.03508	0.00062	0.24572	0.00513	0.847	222.0	4.0	0.282764	10	0.002705	36	4.2	0.4	724	988
1-98-18	1.000	0.04633	0.00232	0.03551	0.00067	0.22687	0.01435	0.298	225.0	4.0	—	—	—	—	—	—	—	—
1-98-19	1.408	0.05161	0.00043	0.03523	0.00062	0.25071	0.00482	0.915	223.0	4.0	0.282710	12	0.002093	26	2.4	0.4	790	1104
1-98-20	1.754	0.05173	0.00042	0.03568	0.00063	0.25446	0.00471	0.954	226.0	4.0	0.282725	10	0.002605	6	2.8	0.3	780	1075
1-98-22	0.730	0.05095	0.00278	0.03566	0.00079	0.25051	0.01844	0.301	226.0	5.0	0.282605	15	0.001094	7	-1.2	0.5	918	1332
1-98-23	1.163	0.05237	0.00053	0.03534	0.00067	0.25513	0.00586	0.825	224.0	4.0	0.282647	16	0.002531	9	0.1	0.6	892	1250
N12-06	**wt. mean = 323.1 ± 2.9 Ma (2σ)**																	
N12-06-02	0.195	0.05198	0.00086	0.04929	0.00097	0.35323	0.01137	0.611	310.0	6.0	—	—	—	—	—	—	—	—
N12-06-03	0.980	0.05453	0.00050	0.05091	0.00093	0.38269	0.00808	0.865	320.0	6.0	0.282531	10	0.003056	20	-2.1	0.3	1079	1464
N12-06-06	0.402	0.05209	0.00136	0.05117	0.00091	0.36746	0.01470	0.445	322.0	6.0	—	—	—	—	—	—	—	—
N12-06-07	0.301	0.05269	0.00044	0.05167	0.00093	0.37533	0.00712	0.949	325.0	6.0	0.282483	7	0.001769	5	-3.5	0.2	1109	1554
N12-06-09	0.336	0.05369	0.00044	0.05122	0.00092	0.37913	0.00701	0.971	322.0	6.0	0.282487	8	0.002708	8	-3.6	0.3	1134	1559
N12-06-10	0.565	0.05310	0.00045	0.05116	0.00093	0.37451	0.00726	0.938	322.0	6.0	0.282500	9	0.002212	40	-3.0	0.3	1098	1522
N12-06-14	0.365	0.05533	0.00046	0.05211	0.00095	0.39749	0.00738	0.982	327.0	6.0	0.282536	8	0.003386	27	-2.0	0.3	1082	1459
N12-06-15	0.389	0.05458	0.00046	0.05144	0.00094	0.38702	0.00732	0.966	323.0	6.0	0.282552	8	0.002249	28	-1.2	0.3	1024	1406
N12-06-16	0.455	0.05456	0.00046	0.05109	0.00093	0.38431	0.00738	0.948	321.0	6.0	0.282484	7	0.001688	10	-3.4	0.2	1106	1552
N12-06-17	0.671	0.05181	0.00242	0.05061	0.00109	0.36148	0.02311	0.337	318.0	7.0	—	—	—	—	—	—	—	—
N12-06-18	0.433	0.05447	0.00048	0.05114	0.00094	0.38402	0.00773	0.913	322.0	6.0	0.282504	7	0.001216	14	-2.6	0.3	1064	1500
N12-06-19	0.526	0.05343	0.00045	0.05172	0.00094	0.38099	0.00726	0.954	325.0	6.0	0.282479	7	0.001337	6	-3.5	0.3	1102	1557
N12-06-20	0.562	0.05309	0.00046	0.05179	0.00095	0.37909	0.00745	0.933	326.0	6.0	0.282494	7	0.002297	24	-3.2	0.2	1109	1536
N12-06-21	0.775	0.05815	0.00050	0.05127	0.00096	0.41096	0.00810	0.950	322.0	6.0	0.282455	23	0.004364	47	-5.0	0.8	1236	1652
N12-06-22	0.490	0.05546	0.00048	0.05162	0.00097	0.39468	0.00780	0.951	324.0	6.0	0.282392	16	0.001405	9	-6.6	0.6	1228	1753
N12-06-23	0.057	0.09764	0.00084	0.10069	0.00191	1.35546	0.02928	0.878	618.0	11.0	0.282318	15	0.001477	15	-3.0	0.5	1335	1749
N12-06-24	0.275	0.05371	0.00046	0.05339	0.00100	0.39532	0.00773	0.958	335.0	6.0	0.282430	16	0.002018	15	-5.4	0.6	1194	1678
N12-06-25	0.813	0.05459	0.00048	0.05222	0.00099	0.39295	0.00785	0.949	328.0	6.0	0.282421	12	0.002600	13	-5.9	0.4	1226	1705
10-06[a]	**wt. mean = 221.9 ± 2.2 Ma (2σ)**																	
10-06-01	1.408	0.05079	0.00048	0.03406	0.00064	0.23848	0.00513	0.874	216.0	4.0	0.282673	15	0.001871	18	1.1	0.5	840	1187
10-06-02	1.538	0.05229	0.00047	0.03464	0.00065	0.24970	0.00510	0.919	220.0	4.0	0.282635	13	0.002100	10	-0.3	0.5	901	1275
10-06-03	1.613	0.05153	0.00046	0.03536	0.00067	0.25116	0.00519	0.917	224.0	4.0	0.282637	14	0.001121	13	-0.1	0.5	874	1260
10-06-04	1.408	0.05311	0.00051	0.03410	0.00065	0.24972	0.00550	0.865	216.0	4.0	0.282623	17	0.002475	39	-0.7	0.6	926	1303
10-06-05	2.174	0.05146	0.00046	0.03491	0.00066	0.24768	0.00510	0.918	221.0	4.0	0.282653	14	0.001747	9	0.4	0.5	865	1230
10-06-06	1.471	0.05111	0.00048	0.03545	0.00067	0.24979	0.00538	0.878	225.0	4.0	0.282641	20	0.002137	34	-0.1	0.7	892	1260
10-06-08	1.695	0.05167	0.00048	0.03537	0.00068	0.25194	0.00542	0.894	224.0	4.0	0.282652	21	0.001860	40	0.3	0.7	870	1234
10-06-09	1.010	0.05271	0.00055	0.03471	0.00067	0.25226	0.00594	0.820	220.0	4.0	0.282650	25	0.003191	73	0.1	0.9	905	1250
10-06-10	1.587	0.05102	0.00049	0.03633	0.00070	0.25551	0.00560	0.879	230.0	4.0	0.282627	23	0.002172	65	-0.6	0.8	913	1293
10-06-11	1.333	0.05477	0.00058	0.03470	0.00068	0.26203	0.00625	0.822	220.0	4.0	0.282657	16	0.001185	18	0.6	0.6	846	1215
10-06-13	2.273	0.05247	0.00048	0.03521	0.00067	0.25472	0.00529	0.916	223.0	4.0	0.282679	13	0.002400	24	1.2	0.5	843	1177
10-06-14	1.136	0.05102	0.00050	0.03528	0.00068	0.24820	0.00551	0.868	224.0	4.0	0.282613	15	0.001083	7	-0.9	0.5	906	1313
10-06-15	1.695	0.05126	0.00047	0.03506	0.00067	0.24778	0.00521	0.909	222.0	4.0	0.282733	17	0.002142	7	3.2	0.6	759	1054

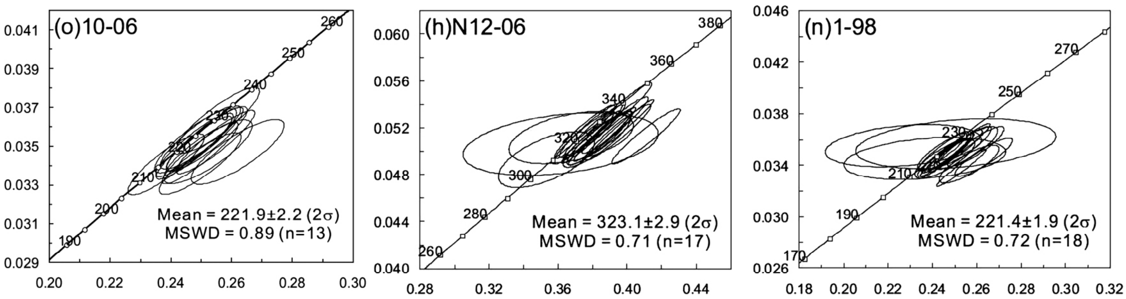

Fig. 2. Concordia diagrams of zircon U-Pb LA-ICP-MS dating results for the protolith of gabbro intrusive (sample #1-98), hybrid K-feldspar gabbro (sample # 10-06) and leucocratic quartz-potassium-feldspar formations (sample #12-06)

the Dzirula massif that is verified by the age of zircon in the Neoproterozoic gneiss-migmatitic complex dated by the La-ICP-MS U-Pb method [23, 24]. In the sample #10-06 13 crystals of zircon were analyzed. The obtained age – 221.9±2.2Ma (σ) corresponds to the zircon age of protolith of the gabbroic intrusive (sample #1-98) (see Fig.1). In the zircon crystals of sample #10-06 the Th/U ratio varies from 2.273 to 1.01, values of $\varepsilon_{Hf}(T)$ in seven cases are positive (3.2-0.1) and in six cases are negative (-0.1- -0.9) and T_{DM}^{C} varies from 1313 to 1054Ma.

18 zircon crystals from the quartz-K-feldspar leucocratic nests of OGs (sample #12-06) have been analyzed. The age of 17 crystals vary within 310-

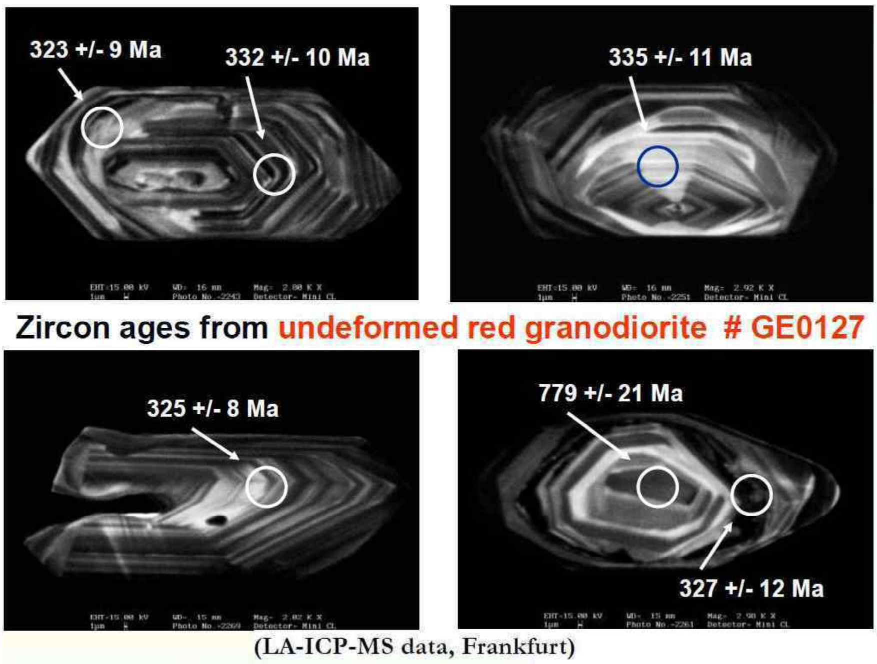

Fig. 3. Zircons from orthoclase gabbro (sample #GEO127) of the Dzirula massif

335±6Ma (wt. mean=323±2.9Ma) (2σ) (see Table 1 and Fig.2), where (Th/U is in the interval of 0.980-0.195, $\varepsilon_{Hf}(T)$ varies from -1.2 to -6.6 and T_{DM}^{C} – from 1753 to 1406 Ma) the inherited age 618±11 Ma (Th/U=0.057, $e_{Hf}(T)$=-3.0 and T_{DM}^{C}=1749Ma) only in one crystal is fixed. It corresponds to the crystallization age of the Baikalian quartz-diorite orthogneisses widespread in the Dzirula massif. The age of the last one is also corroborated by the findings of La-ICP-MS U-Pb zircon dating [23, 24].

Conclusions

OG integrates the rocks of different genetic groups: 1 – protolith of gabbroic intrusive, 2 – hybrid rock (K-feldspar gabbro) and 3 – leucocratic quartz-feldspar bearing formations.

In the protolith of the gabbroic intrusive and in the zircons of hybrid K-feldspar gabbro the Th/U ratios are high and insignificantly differ from each other. $\varepsilon_{Hf}(T)$ value is mainly positive, though its negative value is also recorded and T_{DM}^{C} is almost identical. Th/U ratio is fairly high in the zircons of quartz-K-feldspar bearing rocks but lower than in the zircons of two previous genetic types of rocks. T_{DM}^{C} value is comparatively high and $\varepsilon_{Hf}(T)$ is always negative in all crystals of the zircon.

The apparent age of zircon in the protolith of gabbroic intrusive and in hybrid K-feldspar gabbro, respectively wt.mean 221±1.9 and 221.9±2.2Ma, records the time of crystallization of the intrusive and the apparent age of zircons from leucocratic quartz-K-feldspar formations wt.mean 323±2.9Ma, as well as the inherited Late Variscan age (323±9, 329±8.3, 332±10 and 335±11Ma) of zircons of hybrid K-feldspar gabbro corresponds to the age of formation of Late Variscan granitoids widespread in the Dzirula crystalline massif.

Thus, the age of formation of the OG of heterogenous composition is not defined explicitly. The Late Variscan age of zircons from orthoclase gabbro and leucocratic quartz-K-feldspar formations reflect the age of zircon of hard-to-melt relic mineral from the formations appearing as a result of selective melt during the injection of gabbro intrusive into the sialic crust.

გეოლოგია

ახალი მონაცემები ძირულის კრისტალური მასივის (საქართველო) ორთოკლაზიანი გაბროს ფორმირებისა და ასაკის შესახებ

დ. შენგელია*, ლ. შუბითიძე*, ს.-ლ. ჩუნგი, ჰ.-ი. ჩიუ**, პ. ტრელუარი§**

** აკადემიის წევრი, ი.ჯავახიშვილის სახ. თბილისის სახელმწიფო უნივერსიტეტი, ა. ჯანელიძის გეოლოგიის ინსტიტუტი, თბილისი*
** ი.ჯავახიშვილის სახ. თბილისის სახელმწიფო უნივერსიტეტი, ა. ჯანელიძის გეოლოგიის ინსტიტუტი, თბილისი*
*** ტაივანის ეროვნული უნივერსიტეტი, თაიპეი, ტაივანი*
§ კინგსტონის უნივერსიტეტი, ლონდონი, დიდი ბრიტანეთი

ძირულის კრისტალური მასივის ორთოკლაზიანი გაბრო (რიკოთიტი) აერთიანებს სხვადასხვა გენეტური ჯგუფის ქანს: გაბროული ინტრუზივის პროტოლითს, ჰიბრიდულ ქანს - კალიშპატიან გაბროს და ლეიკოკრატულ კვარც-მინდვრისშპატიან წარმონაქმნებს. სამივე გენეტური ჯგუფის ქანი დათარიღებულია ცირკონების U-Pb LA-ICP MS მეთოდით. გაბროული ინტრუზივის პროტოლითში და ჰიბრიდულ კალიშპატიან გაბროში განვითარებული ცირკონების ასაკი, შესაბამისად 221.4±1.9 Ma და 221.9±2.2 Ma აფიქსირებს ინტრუზივის კრისტალიზაციის დროს, ხოლო ლეიკოკრატული კვარც-მინდვრისშპატიანი წარმონაქმნების ცირკონების ასაკი 323±2.9 Ma, ასევე ორთოკლაზიანი გაბროს ცირკონების მემკვიდრეობითი გვიანვარისკული ასაკი - 323±9, 329±8.3, 332±10 და 335±11 Ma უპასუხებს ძირულის კრისტალურ მასივში ფართოდ წარმოდგენილი გვიანვარისკული გრანიტოიდების ფორმირების ასაკს.

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