

Geology

New Geological-Petrological Data on the Klich Gabbro-Diorite Intrusion (the Greater Caucasus)

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ABSTRACT. In the paper petrogenic model of the the Klich intrusive formation in the Buulgen metamorphic complex is presented. It is shown that the protolith of the Klich intrusion is represented by hornblende varieties of gabbro-dioritic composition. The intrusion breaks through the Gvandra suite of the Buulgen complex. It was metamorphosed during the Bretonian phase under the staurolite facies conditions. It has a contact-thermal effect on the metamorphites of the Gvandra suite covering the interval of biotite-muscovite gneiss and hornfels facies. Sakeni granitoids in the vicinity of Klich intrusion comprise xenoliths similar to the rocks of Klich intrusion. LA-ICP-MS U-Pb zircon age of the Sakeni intrusion - 325 ± 2.5 Ma corresponds to the Sudetic phase of folding. The Klich intrusion cut by alaskites and aplites that formed at a little depth in ensimathic zones of fold systems of the lithosphere caused neo-mineralization in the rocks of the intrusion and thus quartz, biotite, garnet, cummingtonite, zircon and sphene occurred. It is established that zircon is a newly formed mineral and the authors of the present paper regard that U-Pb zircon age of the Klich intrusion - 320 Ma corresponds to the formation time of Late Variscan veined by alaskites and aplites. The Klich and Sakeni intrusions, veined alaskites and aplites composing an integrated gabbro-diorite - granite series were formed within the range of manifestations of the Bretonian and Sudetic phases of folding. © 2017 Bull. Georg. Natl. Acad. Sci.

Key words: Greater Caucasus, Klich intrusion, contact metamorphism, formation and age of the intrusion

In the Pass subzone of the Greater Caucasus Main Range structural zone the pre-Alpine Buulgen metamorphic complex is intruded by large bodies of Variscan magmatites of gabbro - diorite (Klich intrusion) and quartz-diorite - granodiorite (Sakeni intrusion) composition, as well as by alaskite and aplite veins.

The Klich intrusion is the thickest gabbro-diorite body crops out in the Klich river (left tributary of the river Kodori, Mountainous Abkhazia) basin. Concordant body of the intrusive occurs in the Paleozoic Gvandra unit of the Buulgen metamorphic complex that underwent either the Bretonian [1] or the Sudetic [2] prograde regional metamorphism under staurolite-

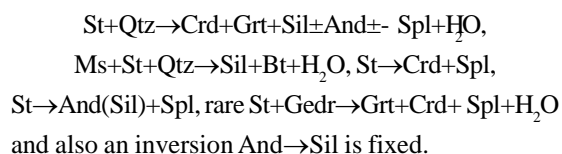
biotite-andalusite and staurolite-sillimanite subfacies conditions. The Klich intrusion, according to its geological position is one of the key formations to specify the age and succession of manifestation of pre-Alpine magmatism and regional metamorphism in the Pass subzone.

Different authors consider the Klich intrusion in different ways: as biotite hornblende bearing gabbro-diorite gneisses [3], augen biotite-hornblende gabbro-diorite orthogneisses [4], hornblende bearing gabbro or gneissized hornblende bearing and weakly biotitized rocks of gabbro-quartz-diorite series [1, 5]. As a result of our researches it turned out that the composition of the Klich intrusion changes from gabbro to quartz-diorite of basic composition, but gabbro-diorites and diorites are most widespread. In the central part of the outcrop generally massive varieties are exposed, while in the peripheries gneissized rocks are dominant. By petrochemical and geochemical features the Klich intrusion corresponds to weakly differentiated low-K gabbro-quartz-diorite series [6]. According to some petro- and geochemical parameters the intrusion formed in the upper part of the depleted mantle, and by other features - at a little depth in ensimathic zone of folded structures of the lithosphere [6].

The question on the time of formation of the Klich intrusion is debatable. G.R.Chkhotua [7] attributed the time of formation of the intrusion to the Precambrian, Sh.I. Javakhishvili [3] – to the Lower Paleozoic, G.L.Chichinadze [8] – to the Middle Paleozoic, M.L.Somin [2, 4] connects its formation with the Sudetic orogeny, while I.P. Gamkrelidze and D.M.Shengelia [1] consider it to be the Early Bretonian or the pre-Variscan. At present, the age of the intrusion can be defined only by geological picture: the intrusion cuts the Gvandra unit metamorphosed during the Bretonian orogeny and itself was cut by leucocratic veins of late Variscan aplites and alaskites widespread in the Buulgen metamorphic complex [5].

The Klich intrusion underwent contact-thermal impact over the Gvandra unit rocks metamorphosed

during Bretonian orogeny, [1] covering the interval of the facies of biotite-muscovite gneisses and hornfels with the highest temperature - 620°C. In the exocontact zone of the intrusion very dense, massive metamorphic rocks are spread. Their thick outcrop (10-90m) is established in the confluence area of the river Klich and its right tributary Achapara. Following prograde mineral reactions [9] are established:



Sometimes relicts of staurolites are fringed by monomineral hercynites or occur as inclusions in cordierite or andalusite. In direct contact with the Klich intrusion (1-5m), in exocontact garnet, cordierite, sillimanite, spinel bearing parageneses are spread, where according to graphite [10] and garnet-biotite [11] geothermometers the temperature 600-620°C is established. Remote from endocontact (5-20m) massive $\text{Grt} + \text{Bt} + \text{Sil} + \text{And} \pm \text{Crd}$ bearing rocks occur; then follow staurolite-biotite-andalusite-garnet bearing schists.

Zircons of the Klich intrusion are dated by classic U-Pb method [12]. The obtained age – 320 Ma is interpreted as age of crystallization of magmatic protolith of the Klich intrusion [2, 13]. Running ahead, it should be noted that the authors of the paper consider that the last assumption refers to the rocks of the Klich intrusion hybridized by leucocratic veins of granitoids culminating Late Variscan magmatism of the Pass subzone.

Later of the formation of the Klich intrusion Late Variscan granitoid magmatism of quartz-diorite - granodiorite composition took place. During this process so-called "Sakeni intrusion" was formed. The Sakeni intrusion outcrops over 3.5-5km to the east of the Klich intrusion. Biotite and biotite – hornblende bearing low-K Sakeni granitoids of mixed mantle-crustal type [1,13] contain xenoliths similar to rocks of the Klich intrusion.

Late Variscan age of Sakeni granitoids is com-

pletely confirmed by LA-ICP-MS U-Pb zircon dating. Results of age determinations of 21 zircon crystals show average age 325.5 ± 2.5 Ma, covering the interval of $320\text{--}336 \pm 6$ Ma [14].

All previous researchers [1, 5, 8] believed that the Klich intrusion metamorphosed together with the Gvandra unit. However, based on our researches, the authors consider that the rocks of the intrusion did not undergo regional metamorphism: The minerals such as garnet, cummingtonite, the majority of biotite, zircon and sphene, considered as the products of the Bretonian or the Sudetic regional metamorphism, resulted from the impact of leucocratic granitoid veins over the rocks of the Klich intrusion. These veins are most widespread in the western part of the intrusion. Numerous zircon grains are associated with the newly formed biotite flakes that have occurred due to the replacement of hornblende. It should be specially noted that in the Klich intrusion, in the areas without veined leucocratic granitoids and where the rocks are not affected by the above-mentioned secondary processes, as a rule all above mentioned minerals are absent. Therefore, the authors believe that the U-Pb zircon age of the Klich intrusion - 320 Ma, is the age of the formation of leucocratic granitoid veins, which terminates the Variscan endogenous process of the Pass subzone. Postmetamorphic alaskites and aplites are widespread in the Gvandra suite in the upper reaches of the river Khetskvara and in the interfluvium of the rivers Khetskvara and Achapara. Besides the concordant bodies, they are represented by intersecting bodies with the thickness of some tens of centimeters to several meters. In amphibole bearing schists and amphibolites of the Gvandra unit in the exocontact area with the alaskites and aplites the following processes are observed: biotitization,

cummingtonization of hornblende, saussuritization and epidotization of plagioclase, the reaction hornblende + plagioclase \rightarrow cummingtonite + garnet, silicification of rocks and the formation of sphene.

Therefore, we can assume with great certainty that the Klich and Sakeni intrusions and leucocratic granitoids form gabbro-diorite–granite series, which formed during the Bretonian and Sudetic orogenies.

Thus, the results of our research are as follows:

- Protolith of the Klich intrusion is presented by hornblende bearing gabbro-diorite formed in the upper part of depleted mantle;
- The intrusion breaks through the rocks of the Gvandra unit metamorphosed in the Bretonian orogeny under the staurolite facies conditions.
- The intrusion has an intensive contact-thermal effect on metamorphites of the Gvandra unit, covering the interval of biotite-muscovite gneisses and hornfels facies;
- Sakeni granitoids of mantle-crustal type outcrop close to the Klich intrusion; they comprise xenoliths similar to the rocks of Klich intrusion. LA-ICP-MS U-Pb zircon age of the Sakeni intrusion - 325 ± 2.5 Ma corresponds to the Sudetic orogeny;
- The Klich intrusion was cut by alaskites and aplites causing neo-mineralization in the rocks of the intrusion. In particular formation of quartz, biotite, garnet, cummingtonite, zircon and sphene took place;
- U-Pb age of the newly formed zircon of the Klich intrusion - 320 Ma corresponds to the time of formation of Late Variscan veined alaskites and aplites;
- Klich and Sakeni intrusions and veined alaskites and aplites, forming an integrated gabbro-diorite–granite series, formed during the Bretonian and Sudetic orogenies.

გეოლოგია

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სტატიაში მოცემულია კავკასიონის საუდელტეხილო ქვეზონის ბუულგენის მეტამორფულ კომპლექსში განვითარებული კლიჩის გაბრო-დიორიტული ინტრუზივის ფორმირების პეტროგენული მოდელი. ნაჩვენებია, რომ კლიჩის ინტრუზივის პროტოლითი წარმოდგენილია გაბრო-დიორიტული შედგენილობის რქატყუარაიანი სახესხვაობით. ინტრუზივი კვეთს ბუულგენის კომპლექსის გვანდრის წყებას, რომელიც დანაოჭების ბრეტონული ფაზისის დროს მეტამორფიზებულია სტავროლიტული ფაციესის პირობებში. იგი იწვევს გვანდრის წყების მეტამორფიზების კონტაქტურ - თერმულ გარდაქმნას ბიოტიტ-მუსკოვიტთან გენიზებისა და რქაულების ფაციესის პირობებში. კლიჩის ინტრუზივის მახლობლად მდებარე საკენის გრანიტოიდები შეიცავს კლიჩის ინტრუზივის ანალოგიურ ქსენოლითებს. საკენის ინტრუზივის LA-ICP – MS U-Pb ცირკონული ასაკი – $325 \pm 2,5$ მლნ. წელია და შეესაბამება დანაოჭების სუდეტურ ფაზისს. კლიჩის ინტრუზივის გამკვეთი ალიასკიტები და აპლიტები, რომლებიც ფორმირებულია ლითოსფეროს ნაოჭა სისტემის ენსიმატური ზონის მცირე სიღრმეზე, იწვევს კლიჩის ინტრუზივის ნეომინერალიზაციას: ჩნდება კვარცი, ბიოტიტი, გრანატი, კუმინგტონიტი და სფენი. დადგინდა რა, რომ ცირკონი ახლადგაჩენილი მინერალია, ავტორებს მიაჩნიათ, რომ კლიჩის ინტრუზივის ცირკონების კლასიკური მეთოდით განსაზღვრული U-Pb ასაკი – 320 მლნ. წ. ეთანადება გვიანვარისკული ძარღვული ალიასკიტებისა და აპლიტების ფორმირების დროს. ავტორების მონაცემებით, კლიჩის და საკენის ინტრუზივები და ძარღვული ალიასკიტები და აპლიტები, ქმნის ერთიან გაბრო-დიორიტ – გრანიტულ სერიას, რომლის ფორმირება მოხდა დანაოჭების ბრეტონული და სუდეტური ფაზისების გამოვლენის დროს.

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