capable of forcing magmatic systems to differentiate in the direction opposite to that predicted by liquidus phase equilibria [3]. Our tentative interpretation is that the anomalous compositions trends have been produced by the emplacement of increasingly more primitive magma followed by the recrystallization of the uppermost part of the partly solidified body, under the influence of the Koitelainen layered intrusion.

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STRUCTURE AND CONSTITUTION MAFIC-ULTRAMAFIC MASSIFS AS EVIDENCE OF THEIR POLYGENIC ORIGIN

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In the course of last decades, we discussed various aspects of geology, petrology, petrochemistry, geochemistry, mineralogy and metallogeny of various types of mafic-ultramafic massifs (MUM) that are common in folded regions and mainly considered to be ophiolite associations. Based on those data, polygenic formation model for such massifs [1-17], was proposed. The data in question are summarized and somewhat appended below.

Mafic-ultramafic massifs (MUM) located within both folded regions and platforms, are characterized by wide variations in all their parameters. At the low-scale structure-geological maps one can normally observe more or less linear disposition of MUM; this, in particular, can be clearly seen on the global layout of ophiolitic MUM [18]. This property of MUM is explained by their close structural ties with the zones of long-life abyssal fractures. The majority of MUMs have extended-lens shape, and trace both the main and fledging ruptures. Massifs confined to the nodes of crossing fractures, often have subisometric shape. The initial geometry of many massifs is complicated by later block deformations. MUM linear dimensions vary from hundred meters to hundred kilometers along the long axis, and from dozens of meters to dozens of kilometers along the short axis; areas of exposed MUM portions – from several square kilometers to several thousand square kilometers. Here area ratios can demonstrate variations from 100% ultramafic rocks to 100% mafic rocks.

Contact interrelations between the bodies of mafic and ultramafic rocks that make up the MUM, and those between the above bodies and encompassing strata rocks, are of topical significance as far as MUM petrology is concerned. Ultramafic bodies in MUM, as a rule, have steep (much rarely, slanting) tectonic contacts with the encompassing volcanogenic-terrigenous and metamorphic formations. Contact-edge zones of ultramafic bodies are often subject to intensive dynamo-metamorphism, are often schistose, sometimes the relict slab parting is observed. Mafic bodies in MUM lie normally along their hanging contacts; much less often – along the hanging or both contacts of ultramafic bodies. In the general case, mafic bodies and encompassing strata rocks have intrusive contacts, however, they are often complicated by fracture distortions. Very often, close to the major intrusive mafic bodies in encompassing strata, there occur their satellites represented by sills, stocks and dikes; xenoliths and skialites from encompassing strata rocks are present in mafites. Amphibole- and quartz-bearing gabbro and dorites prevail in the endocontact zones of mafic intrusives formed at substantial depths. Endocontact zones of low-depth mafic intrusives are normally the chilling zones formed by fine-grained gabbroids; here, in their exocontact zones encompassing rocks are often transformed into hornstones.

Contact zones between mafic intrusives and spatially connivent ultramafic protrusions are characterized by different structure and petrography composition. In abyssal gabbroid intrusives Type 1 contact zones predominate in which one can usually observe gradual transitions from mafic to ultramafic rocks. This property is explained by frequent and, normally, uneven alternation of stripe-like bodies varying in length and thickness, consisting of olivine gabbro, troctolites, anorthosites, wehrlites, websterites, clinopyroxenites, their olivine and plagioclase varieties, plagiodunites, plagiolherzolites that widely vary in quantitative-mineral composition. All those rocks very often have taxitic, streaky included, textures; sometimes porphyroblasts of olivine, plagioclase and pyroxenes are present in them. Much rarer are the second type contact zones between mafic and ultramafic rocks. In such cases, ultramafic xenoliths of varying size, shape and petrography composition are present in endocontacts of mafic intrusives. In the exocontact portion of such zones among ultramafites there often occur gabbroid sills and dikes varying in thickness and length and being the satellites of the major mafic intrusive. Ultramafic xenolith sizes vary from the first centimeters to many meters; their shape varies from angular to oval or lens-like and direct borders between xenolith and surrounding gabbroids can fluctuate from rapid to gradual. Geological and petrography observations demonstrate that transitional subtypes exist between the two types of contacts. Mafic-ultramafic contact interrelations within MUM (Type 2 in the first place) allow for the conclusion that mafic bodies are genetically autonomous intrusives that intruded later than ultramafic protrusions spatially connivent with them. Herewith, the latter had undergone both very intensive (abyssal formation conditions) and low-intensive (subsurface conditions) magma-metasomatic transformations under the influence of mafic melts and their fluids. Contact zones with gradual transitions from mafites to ultramafites and with alternation of stripe-like bodies of varying thickness and composition, are interpreted by many scholars as the evidence of genetic unity of ultramafites and gabbroids, i.e., as the result of crystallization-gravitation differentiation of mafic melts, and all ultramafic and mafic varieties forming such contact zones, are defined as cumulates. From our viewpoint, such model poorly correlates with multiple facts that characterize the structure and composition of the MUM.

Specific structural features of contact zones between ultramafic and gabbroid bodies in MUM, as well as their petrography composition, were predetermined to a considerable extent by the character of interaction between mafic melt and ultramafic rocks. The intensity of such interaction was in direct relation with such factors as mafic melt crystallization time and their fluid saturation, degree and character of disintegrity in contacting ultramafic rocks, and their serpentinization. Cooling and crystallization time of mafic melts increased under influence of such factors as their initial temperature as well as «thermostattedness» of intrusive chamber; herewith, the latter, evidently, increased when intrusives occurred under abyssal and mesoabyssal conditions. In their turn, origination conditions for Type 2 contact zones took place under short and low-intensive interaction between mafic melt and ultramafic rocks, i.e., formation of mafic intrusives in hypabyssal and subsurface conditions. Banded patterns of hybrid gabbroids and ultramafites from the contact zones between ultramafic bodies and later gabbroid intrusives, are interpreted by us as the consequences of mafic melts and their fluids infiltration along the systems of sub parallel fractures of flaglike parting of ultramafites that initially was intrinsic to peripheral portions of many ultramafic protrusions. To add, we obtained the evidence that chemical composition of rock forming minerals from the banded rocks in contact zones (plagioclases, in particular) does not have distinct dependence on quantitative-mineral composition of the «bands»; this also does not correlate with the cumulative origin model for the rocks with banded textures.

In the majority of cases, we view the MUMs as polygenic and polychronic rock-complexes. In the general case four main structural units should be isolated in MUMs: a) protrusion of ultramafite restites; b) gabbroid intrusives; c) transition (contact-reaction) zone located at the border of ultramafic protrusion and gabbroid intrusive; d) transition (contact-reaction) zone located at the border of gabbroid intrusive and enclosing strata. Protrusions are formed by orthomagmatic ultramafic rocks, i.e., mantle restites that are normally represented by lherzolites, harzburgites and dunites as well as their serpentinized varieties. Gabbroid intrusives are formed by orthomagmatic mafites, i.e., are predominantly represented by olivine-free gabbros and gabbronorites. Contact-reaction zones located at the border between mafic intrusives and ultramafic protrusions, are formed by paramagmatic (hybrid) ultramafic rocks (wherlites, websterites, clinopyroxenites and their plagioclase-bearing varieties), as well as by paramagmatic (hybrid) gabbroids (olivine gabbros and gabbronorites, troctolites, less frequently anorthosites). Contact zones between gabbroid intrusives and the encompassing terrigenous-volcanogenic and metamorphic rocks, are formed by another group of paramagmatic (hybrid) gabbroids: mainly, amphibole- and quartz-bearing gabbros, gabbro-diorites, and diorites.

Formation of ultramafic protrusions was accompanied by long and multi-stage upward movement of mantle restite blocks along the zones of long-living abyssal fractures. According to our observations, some ultramafic protrusions, after their wash-out, were tectonically moved to the higher terrigenous strata that contained ultramafite disintegration products. It is assumed, that in the protruding process, initial volume of ultramafic protrusions substantially decreased due to «erosion» of their external zones that previously underwent serpentinization and disintegration under the influence of less flexible block rocks. Predominant localization of gabbroid intrusives along the hanging tectonic contact zones of ultramafic protrusions, most likely, was stipulated by better permeability of those zones for intruding melts as compared to more «condensed» and, thus, less permeable zones along the laying tectonic contacts of protrusions.

The following three features are particularly important evidence of polygenic and polychronic formation of MUM, i.e., later introduction of gabbroids relative to ultramafites: presence of ultramafic xenoliths in gabbroid intrusives; presence of dissecting gabbroid bodies (dikes, apophyses) in ultramafic protrusions; presence of reaction or chilling zones along the contacts between gabbroid and ultramafite bodies. It is assumed that formation of mafic intrusives took place much later than intrusion of ultramafic protrusions to the upper layers of the crust.

The polygenic and polychronic model of MUM formation proposed, is mainly substantiated by the data on massifs being part of ophiolite associations, and, in our opinion, is quite applicable for considering the genesis of many other MUM varieties located in folded regions including those of Urals-Alaska type, as well as concentrically-zonal alkali-ultramafic massifs located within platforms, e.g., Inagli and Conder.

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U-PB AGE CONSTRAINTS ON TEMPORAL EVOLUTION OF THE ORE-BEARING NORIL'SK-1 INTRUSION: EVIDENCE FROM ZIRCON AND BADDELEYITE

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INTRODUCTION

World-class PGE-Cu-Ni sulphide deposits occur in the Noril'sk-1, Talnakh and Kharaelakh areas in the northwestern part of the Eastern Siberia, Russia. They are associated with sill-like ultramafic-mafic intrusions, which are controlled by a long-lived intracontinental paleorift [16]. The first U-Pb data for the Noril'sk-1 intrusion have been restricted to zircon and baddeleyite from pegmatitic leucogabbro of the Noril'sk-1 intrusion (i.e., 248.0 ± 3.7 Ma [1] and 251.1 ± 3.6 Ma [5]). More recent preliminary attempts, based on U-Pb SHRIMP study of zircon from the main lithological units of the Noril'sk-1 intrusion [12], identified two distinct zircon ages (250.7 ± 1.5 Ma and 228 ± 1.4 Ma), indicative of a prolonged temporal evolution of their host rocks. New U-Pb data for about one hundred grains of zircon and baddeleyite shed new light on magmatic evolution of the Noril'sk-1 ore-bearing intrusion.

SAMPLES AND TECHNIQUES

The rocks in the investigated drill core MN-2 comprise (from top to bottom) gabbro-diorite (sample N1-1), leucogabbro (N1-3), olivine-free gabbro (N1-2, N1-4), olivine-bearing gabbro (N1-5), olivine gabbro (N1-6), plagiowehrlite and plagiodunite (N1-7), taxitic-textured rocks comprising melanotroctolite, olivine gabbro with relics of ultramafic rocks (N1-8, N1-9) and contact fine-grained gabbro (N1-10). PGE-Cu-Ni ores are represented by disseminated and low-sulphide types. Disseminated PGE-Cu-Ni ores occur in ultramafic (N1-7) and taxitic-textured (N1-8 and N1-9) rocks, which have thickness of about 17 m, whereas the low-sulphide horizon is about 1 m thick and occurs in the upper part of intrusion (N1-3).

243 grains of zircon and baddeleyite were concentrated using a *ppm-mineralogy* technique at NATI Research JSC (St. Petersburg, Russia). Grains of zircons and baddeleyite from each concentrate were hand picked, imaged by SEM and subsequently mounted in epoxy blocks together with the TEMORA and 91500 reference zircons. Transmitted and reflected light photomicrographs and CL images were made in order to select grains and choose sites for analyses omitting cracks and inclusions. The Sensitive High-Resolution Ion Microprobe (SHRIMP-II) at the Centre of Isotopic Research of the