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PETROSTRUCTURAL TYPIFICATION OF THE KANSKIY GREENSTONE BELT ULTRAMAFITES

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Two types of ultramafites have been distinguished in the Kanskiy greenstone belt (NW of the Eastern Sayan): magmatic of the dunite-wehrlite-picrite composition and restitic of the dunite-harzburgite composition. They are united into Kingashskiy and Idarskiy complexes, correspondingly.

Introduction

Within the limits of the Kanskiy block located in a regional southwest part of the Siberian platform and limited by the Main Eastern-Sayanskiy and Kansko-Agulskiy deep fractures, the numerous fine massifs of ultramafites are mapped, formational accessory of which remains debatable. Ultramafite massifs are mainly concentrated in greenstone belts allocated within the limits of the Kanskiy massif, which are composed of metamorphic rocks (gneisses, crystal slates, amphibolites, marble) [1]. The carried out detailed petrologic research has allowed establishing an accessory of ultramafites of the investigated region to two complexes: Kingashskiy magmatic dunite-wehrlite-picrite and Idarskiy restitic dunite-harzburgite.

Ultramafites of dunite-wehrlite-picrite compose hypabissal magmatic bodies, which in structurally-mineralogical structure are similar to rocks of the Kingashskiy massif [2] which is an ore-bearing deposit of the same name Pt-Cu-Ni deposits [3]. This association unites dunites, wehrlites, their serpentinous differences and metapicrites with characteristic to them cumulative and blastporfiric structures. The cumulous mineral phase is usually represented by subisometric, hypidiomorphic, less often idiomorphic grains of olivine, or formed by them pseudomorphs of lizardite. Clinopyroxene and tremolitic amphiboles play a double role in the most part of dunites, wehrlites, and picrites. They are minerals of the intercumulous phases, however in some species of wehrlites and picrites they are observed in the form of minerals of the cumulous phase. Minerals of the intercumulous phase in these rocks are mainly presented by secondary tremolite, chlorite, and ore minerals, less often by brucite and phlogopite. The heterogeneity of structurally-mineralogical features of ultramafites of the Kingashskiy complex is, probably, caused by a various degree of differentiation of the primary magmatic melt.

Ultramafites of the dunite-harzburgite association are observed in the form of lenticular, olistolithic bodies composed of restitic dunites, harzburgites, and their serpintinous differences. The following structures, peculiar to metamorphic rocks, are characteristic to fresh rocks of this association: granoblastic, porphyroclastic, and recrystallized mosaic. The extended individuals of olivine and enstatite often find ostrict preferable mineral orientation. They have a non-uniform wavy starvation. The strips of plastic break, borders of which are usually focused diagonally to the direction of schistosity, are marked. Such petrostructural features of dunites and harzburgites testify to their involvement into the plastic current which was carried out by means of shift deformations in conditions of the active dynamic condition. Similar dunites and harzburgites compose the large Ospinskiy ultramafitic massif located in the southeast par of Eastern Sayan, and representing a fragment of the bottom part of the ophiolite cover [4].

Research technique

Petrostructural researches were mainly carried out in unoriented samples, and the main task consists in revealing the parity of mineral orientations by the internal structure and the form. In the studied samples (samples 13039; 13039-1; 23025-1; 23032; 23031-1) the petrostructural patterns of olivine and pyroxenes were reduced to the uniform horizontal plan, so the mineral flatness in them had a subvertical location and was focused in the meridional direction. Diagrams of оливина and clinopyroxene from the rocks selected from the wells (C-38-218,3; C-102-27,3), are in the horizontal plane, perpendicularly to the axis of the core, their spatial orientation is conditional, the mineral flatness is also focused in the meridional direction. Diagrams of olivine from the oriented sample of dunite of the Kingashskiy massif (sample Кн-4/1) are spatially oriented in relation to cardinal points and located in the horizontal plane. For construction of the diagrams the results of measurements of spatial orientation of the crystallooptic axes of olivine, ortopyroxene, and clinopyroxene were used, and 100 of definitions were carried out for the all. For each axis, the results of measurements of its spatial orientation were placed onto the equal-area Schmidt's stereographic grid in the form of points. Then, by means of a special pallet, the density of points was counted up. Orientations of the crystallooptic axes with defined type of patterns were obtained. Interpretation of these patterns allows receiving the information on conditions of ultramafite formation [2].

Results and discussion

Petrostructural researches of olivine and pyroxenes were carried out in ultramafites of the Kingashskiy and the Idarskiy complexes with the purpose to identify their petrostructural patterns and to reveal thermodynamic conditions of formation.

Ultramafites of the Kingashskiy complex

Petrostructural studying of olivine and clinopyroxene in dunites and wehrlites has been carried out in the Kingashskiy complex (Fig. 1).

Olivine in the investigated samples, discovers complex petrostructural patterns (Fig. 1, sample C-102-27,3; 23031-2; 23032), analysis of which is represented in the following generalized kind. Crystallooptic axes Ng, Nm and Np have close orientations by the character of the pattern. Heteronymic axes form maxima and belts. Maxima and belts of all three axes are spatially combined. Mineral flatness is located normally to the belts of axes concentration and passes through the combined maxima of axes with which the mineral linearity is spatially combined. Local maxima, subnormal to mineral flatness, are marked in the belts. Similar optical orientations were established in dunites and wehrlites of the Kingashskiy massif. Thus, the greatest interest is of the similar optical orientation of olivine in the oriented sample of dunite (Fig. 1, sample Кн-4/1), which finds a close connection with deposition of the massif. It is characterized by presence of the vertical mineral flatness focused along the prodeleting of the massif, where subvertical maxima of axes Ng, Nm and Np, are located, spatially combined with the mineral linearity abruptly plunging in the southeast direction. The maximum density is possessed by the maxima of the axes Nm (10 %), and maxima of other axes are characterized by weak density. The combined subhorizontal belts of concentration of axes Ng, Nm and Np are normally located to the mineral linearity. Local maxima of axes, oriented almost perpendicularly to the mineral flatness, are marked in these belts the. Thus, orientations of olivine in the studied sample of by the internal structure and the form are closely connected among themselves and are supervised by deposition of the ultramafite body.

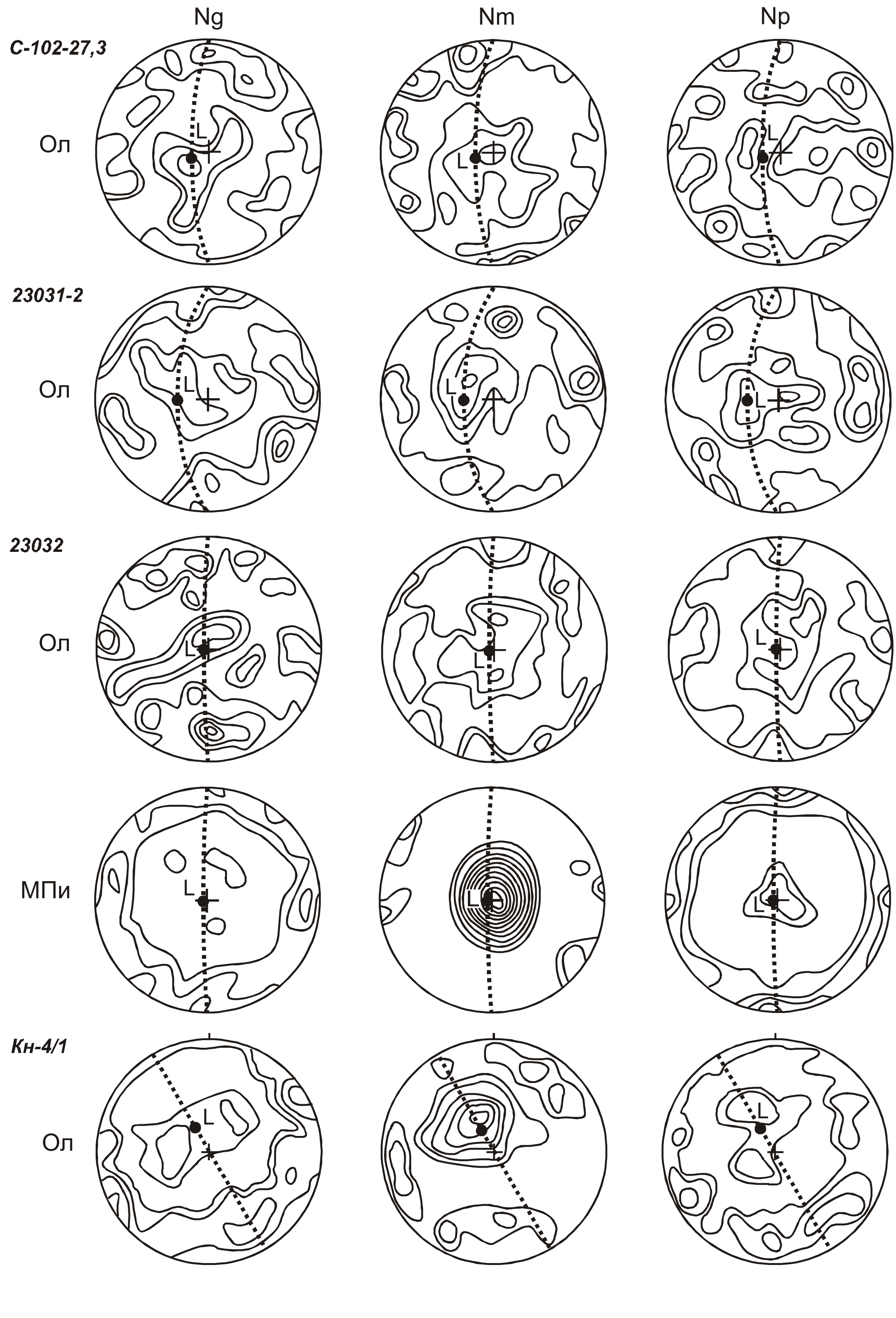
Clinopyroxene. Optical orientation of clinopyroxene, established in wehrlites of the nvestigated territory, is very close by character of the pattern to clinopyroxene in wehrlites from the lower part of the cut of the Kingashskiy massif (Fig. 1, sample 23032, C-38-218,3).

Optical orientations of clinopyroxene in the studied wehrlites is well coordinated with optical orientations of the coexisting olivines, but they differ by more strict primary patterns. The strong maximum of axes Nm=[010] with high density (up to 20 %) coincides with the mineral linearity, the local maxima of axes Ng, Np with low density (less than 4 %) also gravitate to it. Axes Ng and Np are mainly concentrating into the combined belts, normal to the mineral linearity, where the local maxima of subnormally oriented to mineral flatness are marked.

The analysis of optical orientations of olivine and clinopyroxene in studied ultramafites of the Kingashskiy massif testifies to their affinity of petrostructural patterns which possibly are a reflection of similar conditions of their formation. The main structural elements defining the petrostructure of olivine, obviously, are the plane and the direction of the current of the magmatic melt. Thus, the plane of the melt, probably, is fixed by the vertical mineral flatness of grains of olivine and clinopyroxene, and its direction is a maximum of axes Nm which reflects primary crystallographic lengthening of olivine crystals. The revealed petrostructural patterns of olivine and clinopyroxene, probably, are the result of the interaction of magmatic processes at final stages of crystallization of ultramafites and metamorphic, carried out by plastic deformations when the quantity of cumulative crystals becomes too great and they begin to react to dynamic loadings [2, 5].

The obtained in dunites and wehrlites optical orientations of olivine, probably, reflect the effect of the current of magmatic melt [6]. Such orientations are defined by the form of isolated olivine crystals in melt, and crystals-cumulus with insignificant quantity of the intergranular liquid.

This maximum Nm settles down in the plane of the current and corresponds to its direction (L), and two other axes form orthogonal maxima, or belts with concentration perpendicular to the current. The strongest, in density, maximum of axes Np, possibly, is oriented normally to the plane of the current. Such type of the petrostructural pattern of olivine was formed in conditions of the melt laminar current, which was usually accompanied by turbulent rotation of crystals [2, 7]. At final stages of ultramafite formation the orientation of olivine grains became complicated by the imposed plastic deformations which were realized, mainly, by mechanisms of transmitting sliding along the system (100 [001], at participation of systems (001 [100] and (100 [010], the spatial overlapping local maxima of axes Ng and Np with a maximum of axes Nm testifies to it. At the same time, the direction of transmitting sliding in olivine and plastic current in rocks coincide and are fixed L=Nm, inherited the direction of the moving melt. Petrostructure formation of cumulative olivine in ultramafites was, possibly, carried out at temperature reduction (≈1200...800 °C), slow velocity ($<10^{-6}$ c^{-1}) and low pressure (10...20 MPa) under the structural control of the external pressure field defining the arrangement of axes maxima Ng, Nm and Np and their belts of concentration.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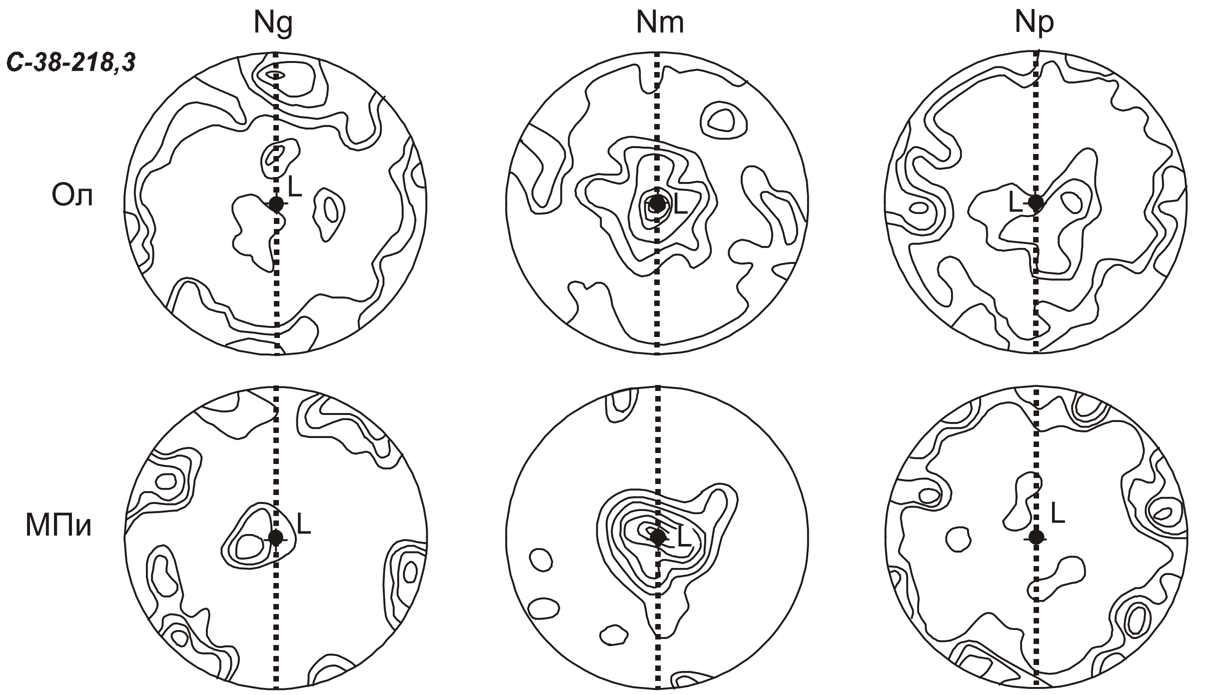

Fig. 1. *Orientation diagrams of crystallooptic axes of olivine and clinopyroxene in ultramafites of the Kingashskiy complex. Projection onto the top hemisphere. Isolines: 1-2-4-6-8-10-12-14-16-18-20 % on 1 % of Schmidt's grid. The dotted line is a plane of mineral flatness, where «L» is the mineral linearity. Rocks: dunites, sample Кн-4/1; pyroxene dunites, sample C-102-27,3; wehrlites, sample 23031-2; 23032; C-38-218,3*

The detailed analysis of optical orientation patterns of intergranular clinopyroxene allows assuming the following sequence of their formation. At the final stage of wehrlite crystallization, the velocity of laminar current considerably slowed down and clinopyroxene individuals, crystallizing from the residual melt in interstitias of cumulative olivine, have experienced compression in the direction of the current. In conditions of the intact pressure field the direction of compression has controlled the orientation of axes Nm of clinopyroxene with formation of high density maxima spatially oriented along the direction of the current (L). A similar parity of the petrostructural pattern of clinopyroxene with the plane of the laminar current of magmatic melt is established in meimechites of the Gulinskiy pluton. [8].

Thus, petrostructural patterns of olivine and clinopyroxene orientations in cumulative ultramafites of the Kingashskiy complex were mainly generated in conditions of laminar current of the magmatic melt in the vertical direction, not in the stationary conditions where in isotropic petrostructural patterns caused by gravitational sedimentation of crystals are formed.

Ultramafites of the Idarskiy complex

The established optical orientations of olivine in dunites and harzburgites of the Idarskiy complex represent two petrostructural types (Fig. 2).

The first type of petrostructural pattern of olivine is established in dunites of granoblastic structure (Fig. 2, sample 23025-1). The presence of maximum of axes Nm (6 %) combined with mineral linearity, to which the weak local maxima of axes Ng and Np also gravitate, is characteristic for the first type. Normally linearities all three crystallooptic axes concentrate into belts with local maxima. The maxima of axes Np (6 %) and Nm (4 %) are normally located to the mineral flatness, and in its plane, perpendicularly linearity, there are maxima of axes Ng (6 %), Nm (4 %) and Np (4 %). Similar types of petrostructural patterns of olivine were established in dunites of the Western Tuva [9]. Formation of this type, obviously, occurred in conditions progressive regional metaporphism of ultramafites of the Idarskiy complex and was carried out by the mechanism of intracrystal sliding in olivine as a result of change of translation systems from low-temperature to high-temperature: (001)[010] → (110)[001] → {0kl}[100] → (010)[100], which were realized in conditions of coaxial axial deformations in the mode of temperature increase (750...1000 °C) and not high pressure (10...20 MPa) [10, 11]. Formation of combined with L maxima of axes Ng, Nm and Np occurred in the case when the subsequent activization of more high-temperature system of transmitting sliding could not destroy earlier formed petrostructures of olivine at maintained direction of plastic current. Formation of the petrostructural pattern comes to the end at high temperatures (>1000 °C) with postdeformational static recrystallization of annealing which was carried out under the structural control of the external pressure field, at the same time, the axis Np aspire to be guided along the direction of compression. The granoblastic structure of unstrained polygonal olivine individuals, often converging in three points at the angle ~120°, is formed as a result of annealing recrystalization.

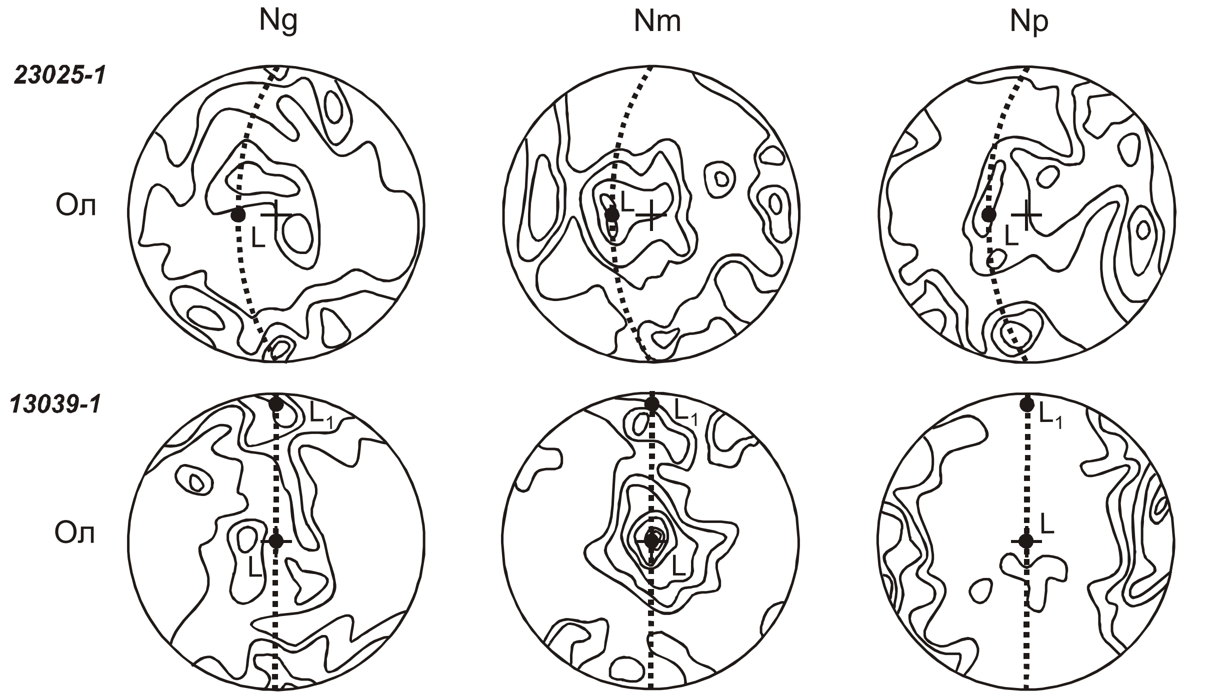

Fig. 2. *Orientation diagrams of crystallooptic axes of olivine in ultramafites of the Idarskiy complex. Projection onto the top hemisphere. Isolines: 1-2-4-6-8-10-12 % on 1 % of Schmidt's grid. The dotted line is a plane of the mineral flatness, where «L» is the mineral linearity. Dunites: sample 23025-1; harzburgites: sample 13039-1*

The second type of the petrostructural pattern of olivine is established in harzburgites with porphyroclastic structure (Fig. 2, sample 13039-1). It has a strict preferable orientation and is characterized by the belt arrangement of axes Ng and Nm in the plane of mineral flatness, where two mineral linearities (L и L_1) are located. From the early L the strongest maxima of axes Nm (12 %) and local maximum Ng (4 %) are spatially combined. The local and the strongest maxima of axes are probably a reflection of the first type of petrostructural patterns of olivine. For this type of orientation the presence of maximum Np with high density (10 %) and which is located to the mineral flatness under the angle ~70° is characteristic. Reorientation of mineral linearity in L_1 and formation of gravitating maxima of axes Ng (6 %) and Nm (4 %) is connected with the advent of this maximum.

Formation of this petrostructural pattern of olivine, probably, occurred in conditions of simple shift and high velocity of deformation, mechanism of cataclastic current accompanied by transmitting sliding with formation of fracture strips and syntectonic recrystallization. Presence of numerous fracture strips in olivine and enstatite testifies to the non-uniform plastic deformation which, possibly, was carried out in a wide interval of temperatures (500...850 °C) and high pressure (100...200 MPa) [12] in the upper parts of the earth's crust during subhorizontal moving of ultramafites along abyssal overlaps.

Conclusion

Ultramafites of the Kingashskiy complex, according to the results of the petrostructural analysis of olivine and clinopyroxene, were crystallized in conditions of laminar current of magmatic melt in the mode of slow velocity ($<10^{-6}$ c^{-1}) and temperature reduction (≈1200...800 °C) under the structural control of the external pressure field.

Ultramafites of the Idarskiy complex, according to the petrostructural analysis of olivine, have undergone metamorphic transformations in conditions of progressive regional metamorphism in the mode of temperature increase (750...1000 °C) and a low pressure (10...20 MPa) with formation of granoblastic structures. In active dynamic zones they were exposed to intensive plastic current in the mode of a wide interval of temperatures (500...850 °C) and high pressure (100...200 MPa) at increasing deformation speed and increase in a role of syntectonic recrystallization, which promoted formation of porphyroclastic structures.

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PETROLOGIC-GEOCHEMICAL EVIDENCE OF GEOLOGIC-GENETIC UNIFORMITY OF GOLD HYDROTHERMAL DEPOSITS FORMED IN BLACK-SHALE AND NON-SHALE SUBSTRATUM

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The problem of gold deposits origin lying in crystal and black-shale substratum is discussed. The expediency of comparative research of all geologic-real-genetic factors of their formation, among which a significant value is retained by the geochemical, is emphasized.
The technique of geochemical researches, based on use of substratum petrologic studying results of golden-ore fields and their frame, providing formation of multilevel system of geochemical selection representing stage-by-stage history of rock formation and their geochemical shape at each stage, is offered.
The results of the offered approach realization in golden-ore deposits of the North Transbaikalia lying in the crystal substratum and Proterozoic black-shale strata in the frame of the Muiskiy ledge of the Archean base of the Siberian craton are presented. The resulted materials prove in geochemical aspect the geologic-genetic uniformity of formed in non-shale and black-shale substratum of gold hydrothermal deposits, proved by the totality of empirical data. The offered technique provides formation of regional, and in the long term global banks, of correct geochemical data.

Introduction

The opposition between magmatogene-hydrothermal and metamorphogene-hydrothermal concepts of gold deposit formation in their different variants with an accent on geological situations of shale type areas continues more than forty years and there is no end to it. The uncertainty of problems, naturally, does not promote the theory of ore-formation and the decision of the major applied problem – the development of scientifically proved «working» criteries of forecasting of new ore-bearing areas.

It is known, and it is an axiom, that the discussion solitarily influences the development of any science, but its semicentenial, in this case, duration without achievement of positive results demands analysis of the situation and search for possible reasons of obviously tightened debates, no less than ways of elimination of key contradictions. Some reasons of the existing unsatisfactory state of affairs were analyzed and offered to discussion earlier [1]. The attention was paid to the two main ones.

The first one presumes that the metamorphogene-hydrothermal concept of ore-formation in shale type areas, assuming the local pedigree source of gold with rare exception [2], is based on position according to which the obligatory precondition is a superclark, with increased or high pre-ore golden-bearing ability of ore-containing rocks formed at stages of sedimentation or regional metamorphism, or at any of these stages. However, the continuing till now accumulation of numerous new excluding one another variants of the solution with an estimation in the same rocks and strata of pre-ore contents of gold (as a rule, with no attraction of other metal-satellites) from mg/t up to g/t [3–5, et al.] serves as an objective prove that often applied methods of such estimation are not correct.

The second reason explains the first. It is obvious, to prove pre-ore and sin-ore accumulation of the raised against clark or abnormal concentrations of metals in ore-containing rocks, meaning in the interore space of ore fields and/or behind their limits, it is necessary to use such methodical methods that would provide finding-out of geological history of chemical elements