1. Introduction

The Central Aldan ore region is located in the Central part of the Aldan-Stanovoy shield and spatially coincides with the same-named superterrain (figure 1). In the west, in the Amga tectonic mélange zone, it borders with the West Aldan composite terrain, and in the east – on the Tyrganda tectonic mélange zone, it borders with the East Aldan superterrain. It contains the Nimnyr and Sutam terrains which differ in geological structure, divided by the Seimsky thrust (figure 1A). Orthogneisses of
granitoid composition are widely distributed in the rocks composing terrains, primary sedimentary rocks also occur in various quantities [1].

Figure 1. A – Schematic geological map of the Central Aldan superterrain [1]. B – Diagram of ore regions of the Chara-Aldan metallogenic zone of the Aldan-Stanovoy shield [2]:

1A: Terrains: ANM – Nimnyr, AST-Sutam; SM – Seimsky. 1 – Siberian platform cover; 2 – Amphibole, biotite-amphibole, diopside-amphibole, dipyroxene-amphibole plagiogneisses, rarely shales with interlayers and lenses of diopside, phlogopite-diopside rocks and calciphyres (Fedorov strata); 3 – Quartzites and high-alumina gneisses, with lenses of calciphyres, clay and diopside quartzites (Kurumkan strata), granite-gneisses; 4 – Garnet-biotite gneisses and plagiogneisses, hypersthene-biotite dipyroxene and diopside-amphibole plagiogneisses (Seimskaya strata); 5 – Granite-gneiss, charnockite-gneisses, enderbite-gneisses with lenses of dipyroxene crystalline schists; 6 – Tectonic mélange zones; 7 - rivers; 8 - Medvedev massif.

1B: 1 – ore-magmatic (gold-bearing) regions of the Aldan shield (1 – Murun-Soktokut, 2 – Usinsky, 3 – Upper-Amga, 4 – Centyr-al-Aldan, 5 – Nimnyr-Evotin, 6 – Tyrkanda, 7 – Lomamsky, 8 – Guvilgrinsky, 9 – Altan-Chaidakh; 2 – areas with supposed "blind" Mesozoic magmatism and mineralization (10 – Yarogin, 11 – Tolbachan); 3 – gold-bearing regions of the North-Stanovoy marginal suture (12 – Kabaktan, 13 – Sutamsky); 4 – Mesozoic upwarps; 5 – inter-arch zone of the Mesozoic depressions; 6 – areas of the Jurassic terrigenous deposits of the South-Yakutian basin; 7 – zone of step-flexural dislocations, bounding the Aldan shield from the platform; 8 – monoclinal structure of the platform (northern slope of the Aldan anteclise); 9 – rigid massifs, blocks (I – Chara-Kalar, II – Aldan, III – Timptonsky IV – Gonamo-Idyumsky, V – Khaikansky VI — Melemkinsky, VII— Sutamsky, VIII— Tokinsky); 10 — magma-controlling faults: ancient inter-block sutures, activated in the Mesozoic; 11 – magma-controlling faults, conjugated with the archs; magmatic belts: ST – Stanovoy, CA – Central-Aldan, NA – North-Aldan; 12 – supposed boundaries between geological structures; 13 - Medvedev massif; 14 - rivers.
Mesozoic magmatism of the Aldan-Stanovoy shield is characterized by the specificity and exceptional diversity of composition of igneous rocks (figure 1b), which dissection it can a basis for more fruitful research in the field of petrology, regional tectonics, and especially metallogeny, since deposits of gold and a number of other mineral resources are related to the Mesozoic magmatic rocks here [3].

The Medvedev massif is located in the central part of the Nimnyr block of the Aldan shield to the north of the Medvedevka creek, right tributary of M. Nimnyr river within the Leglier ore cluster - (figure 2). The massif intrudes the Precambrian crystalline rocks, they are a set of alternating, conformable, subparallel, and linear bed-like bodies contrasting in composition, composed of hypersthene and alumina gneisses of the Nimnyrskaya formation, rocks of the Medvedev massif and biotite granites of subalkaline and normal composition.

![Figure 2. Geological map of Medvedev massif.](image)

1, 2, 3 - Archaean complexes of crystalline basement; 4 - gabbro undivided; 5 - olivine-pyroxene hornblendes; 6 - olivine-pyroxene hornblende dykes; 7 - late-Archaean granites and granite-gneisses undivided; 8 - Proterozoic diabases; 9 - first phase of Medvedev massif; 10 - second phase Medvedev massif; 11 - third phase of Medvedev massif; 12 - borders of phases of Medvedev massif; 13 - augite-hornblende syenites; 14 - Quaternary deposits; 15 - faults; 16 - river "Medvedevka"; 17 - Federal highway A-360 “Lena”;

The rocks of the massif belong to the monzonite-syenite rock association of the syenite series of the moderate-alkaline rocks of the Upper Seligdar hypabyssal complex. According to numerous materials of predecessors, in particular [4], the rocks of the massif are represented by augite-hornblende and hornblende syenite-porphry. At the same time, during field work, we found that the massif has a three-phase structure. Within the Central Aldan ore region, numerous gold ore occurrences are associated with similar multiphase structures formed during the Mesozoic tectonomagmatic activation [2, 3, 5]. Despite a long period of study of the Mesozoic alkaline magmatism of the Aldano-Stanovoy shield, questions related to such multiphase structures concerning evolution and especially...
metallogeny remain debatable. In this regard, it is important to study single massifs that allow to get an objective picture of solving these problems.

2. Petrographic studies of rocks
In order to determine the quantitative composition of the Mesozoic magmatic rocks of the studied objects, 40 petrographic thin sections of the least changed differences were studied using the MIN-8 polarizing microscope, photos of the thin sections were taken with an Olympus BX 50 electron polarizing microscope with Zeiss Axio Cam ICc 3 camera, at a enlargement of 25, 40, 100.

Syenites of the first phase of intrusion are characterized by the smallest distribution and are leucocratic differences, with a porphyry structure due to the presence of phenocrysts of K-feldspar and plagioclase, and with elements of the monzonite structure. The main mass is fine-micrograined, difficult to diagnose material. The rocks of the phase, as a whole, bear traces of secondary changes. Composition of the rocks records a predominance of K-feldspar 60% over plagioclase 30%, in the dark-colored group of minerals the predominance of amphibole 8% over pyroxene 1%, the content of the ore mineral up to 1%. Rocks of the first phase of intrusion bear xenoliths of host rocks (figure 3a).

Figure 3. Syenite-porphyry, first phase: a - thin section I19-19/5A, contact with host rocks, magnification - 40, nicols +; b - thin section I19-19/4, general view, phenocryst of K-feldspar, magnification - 40, nicols +; c - inclusions of crystals of plagioclase of second generation in edge part of K-feldspar crystal, magnification - 40, nicols +; d - thin section I19-19/6, early generation plagioclase phenocryst, magnification - 40, nicols +; e - thin section I19-19/4, amphibole with simple twinning, K-feldspar with small plagioclase inclusions, magnification - 40, nicols +; f - thin section I19-22, barkevikite (simple twin) and simple hornblende, magnification - 40, nicols +.

K-feldspar of two generations: the first is actually porphyry crystals of orthoclase more than 1 cm (visible part in the thin section) of tabular form (figure 3b) bearing idiomorphic plagioclase crystals of the second generation to a greater extent in the marginal parts (figure 3c), as well as single amphibole grains. The peripheral and/or core parts of the grains are partially replaced by the products of secondary changes (pelitization), and they become brownish and dark brown. The second generation of K-feldspar in the groundmass is represented by smaller grains compared to the first generation and forms grains with uneven contours, irregular elongated shape, along with small plagioclase. Plagioclase of two generations, the first represented by porphyry idiomorphic tabular crystals (figure 3d), represented by polysynthetic twins, individuals bear traces of sericitization, late generation in the
form of small idiomorphic crystals is contained in K-feldspar of the first generation (monzonite structure), the second generation plagioclases are the least changed. Pyroxene is observed as single prismatic and needle-like individuals. It is not zonal, has a slightly greenish tint, slightly pleochroism, the extinction angle is up to 47°. It undergoes secondary changes, is randomly distributed across in the rock as a whole. Maximum interference colors. According to optical properties, it corresponds to the aegirine-augite. It is replaced by an amphibole along the edge, with the development of a hornblende on it. Amphibole is represented by prismatic and irregular forms of crystals as individual particles and in the form of rare monomineral schlieren-like concentrations of hornblende, yellowish-greenish and greenish-brown, and also as melted grains, it is worth noting the presence of simple twins of barkevikite (brown hornblende) in rocks of this phase (figure 3e, f). Interference colors up to highest, the extinction angle up to 40°, along with the late plagioclase is in the form of inclusions in K-feldspar of the first generation. Groundmass of the brownish rock is represented by highly modified hard-to-diagnose microcrystals of K-feldspar and plagioclase (abundant pelitization and sericitization). The ore mineral is more often developed on dark-colored – in particular on hornblende or as independent individuals.

Rocks of the second phase occupy a large part of the massif and are represented by pyroxene-amphibole syenites with hypidiomorphic-grained and porphyry-like structures (figure 4a). The composition of the phase rocks records a predominance of K-feldspar - 60%, over plagioclase - 20%, approximately equal number of the main dark-colored minerals of pyroxene - 6%, amphibole - 8%, the content of both biotite and quartz is noticeably less than 1%, the content of ore minerals is up to 4%.

![Figure 4. Pyroxene-amphibole syenites: a - thin section I19-10, porphyries of K-feldspar and plagioclase, magnification - 40, nicos +; b - thin section I19-11/2, syenite with plagioclase porphyry, magnification - 40, nicos +; c - thin section I19-10, porphyry of pyroxene and amphibole, magnification - 40, nicos +; d - thin section I19-9/7, hornblende, magnification - 40, nicos +; e - thin section I19-11/3, foreign inclusion of host rock in syenite, magnification - 40, nicos +; f - thin section I19-9, foreign inclusion of host rock in syenite, magnification - 40, nicos +.](image-url)
characterized by partial albitionization in the marginal parts. Large crystals of early generation of plagioclase have regular rectangular shapes. The second generation of the mineral, usually smaller in size, as well as K-feldspar, has irregular, elongated and rectangular crystal shapes. Individuals of both generations are characterized by polysynthetic twins and zonal structure (figure 4a, b). The phenocrysts of the latter partially undergo secondary changes (sericitization and kaolinitization), especially in the marginal parts of the crystals, and melting rims are noted in the zonal differences. Pyroxenes are represented by colorless grains of regular and prismatic shapes with a slightly greenish tinge (figure 4c). Cleavage is moderate in two directions at an angle of 87-88°. In crossed nicols, it has high interference colors. It often forms aggregates of smaller irregular grains (flakes) exposed to secondary changes (chloritization). Hornblende occurs in the form of large, regular hexagonal phenocrysts of the first generation, as well as small irregular crystals of the second generation (figure 4d). The latter has a good cleavage. Hornblende minerals are yellowish-brown, green. There are also elongated green individuals, with simple twins, sometimes with a zonal structure in the form of a barkevikite. Hornblende from samples near the fault zones, is ferruginated and partially chloritized. Biotite is represented by irregular elongated grains. In parallel nicols, its pleochroic color varies markedly from light brown to dark brown. In crossed nicols it has a direct extinction. Secondary changes in the biotite are presented in the form of chloritisation and ferruginization in varying degrees. Single grains of quartz have irregular grains and form interstices between grains of salic minerals. Accessory minerals are represented by apatite and zircon, located inside other minerals, usually in dark-colored individuals. Ore minerals are represented by single aggregates or developed on hornblende. Rocks of the second phase bear an abundant amount of xenoliths of host rocks (figure 4e, f).

Rocks of the third phase massif are close to monzonite porphyrys with a clear plagioclase idiomorphism relative to K-feldspar (figure 5a), as well as the presence of idimorphic plagioclase crystals included in K-feldspar grains (figure 5b). The porphyry structure is caused by the presence of K-feldspar phenocrysts, plagioclase and dark-colored minerals on the background of the general fine-micrograined mass.
The prevalence of plagioclase up to 55% over the content of K-feldspar up to 20% is typical for the rocks of the third phase of intrusion of the massif. The distribution of dark-colored minerals in them is not uniform, there is a significant predominance of hornblende 16% over pyroxene 2%. The fine-grained groundmass consists of hard-to-diagnose feldspar and fine biotite 2%. The rocks also contain quartz up to 2%. The amount of ore mineral is up to 3%.

K-feldspar of two generations, the first one is represented by porphyry grains of orthoclase bearing idiomorphic partially sericitized plagioclase grains of the second generation. The crystals of early generation are affected by pelitization, in rare grains with changes of peripheral parts. K-feldspar of second generation are represented by irregular small grains of the groundmass. They are subject to secondary processes and have a dark brown color in places of change. The first generation of plagioclase is represented by idiomorphic porphyry crystals of rectangular and prismatic shapes, as a rule, as simple and polysynthetic twins (figure 5c), as well as polygonal phenocrysts of zonal plagioclase. Plagioclase crystals of early generation are characterized by the presence of plagioclase inclusions and K-feldspar of late generation. The second generation - rectangular, prismatic, irregular-shaped crystals with polysynthetic twinning, is present both as the main basis along with K-feldspar of second generation, and as inclusions in the marginal parts of individuals of early generation. Rare pyroxene occurs in the form of porphyry inclusions of short-prismatic crystal habit (figure 5d), as well as in the form of needle-like individuals with blunt ends, pyroxene crystals are transparent with a light green tint, the interference colors are the brightest (the highest order), it is affected by secondary changes and is unevenly distributed in rocks as a whole. Extinction angle up to 45°. Hornblende is represented by prismatic, long-prismatic crystals and irregular grains, often in the form of simple twins and zonal individuals (figure 5e, f), greenish or greenish-brown colors. The mineral has an uneven distribution in the rock between the porphyry grains of K-feldspar and plagioclase. It is identified as aggregates and/or as schlieren. It is partially developed on pyroxene, often bears inclusions of accessory minerals. Extinction angle up to 30°. Quartz is represented by small round-shaped grains (in amphibole), in interstices between plagioclase, K-feldspar, and dark-colored minerals. The ore mineral of irregular, rounded shape is developed both on dark-colored minerals, in particular on hornblende as rare rims, and is represented by single aggregates.

3. Results and discussions
During the crystal-optical study of the magmatic formations of the Medvedev massif, we identified three phases of intrusion with clear contacts between the latter (figure 6), which differ in their material composition and structural features.

![Figure 6. The phases of intrusion of the Medvedev massif: I-Syenite-porphyry; II-pyroxene-amphibole syenites; III-monzonite-porphyry](image)

The rocks of the first phase of the massif are composed essentially of leucocrate (the content of dark-colored minerals is up to 9%) syenite porphyry with elements of the monzonite structure. The composition of rocks records a quantitative predominance of K-feldspar over plagioclase, in the dark-colored group of minerals, there is a predominance of amphibole over pyroxene. Phase rocks bear abundant xenoliths of host rocks, and are also intensively modified by secondary processes.
Rocks of the second phase of the massif differ from those of the first phase primarily in structural features and are represented by hypidiomorphic-grained differences with an increased content of dark-colored minerals in the rocks up to 15%. In general, the rocks have undergone secondary changes (pelitization, sericitisation).

Rocks of the third phase have a noticeable difference from the first two phases and are represented by mesocratic monzonite porphyry (the content of dark-colored minerals is up to 20%). The rocks are characterized by a distinct monzonite structure (with a clear plagioclase idiomorphism relative to the K-feldspar). The predominance of plagioclase over K-feldspar, as well as a significant content of hornblende are some of the features of the composition.

It is worth noting that within the Central-Aldan ore region, a large gold deposit Samolazovskoye is associated with such multiphase arrays, in particular with the Yukhtin massif; the formation of this deposit is associated with intensively manifested hydrothermal-metasomatic transformations of the host rocks, which products are the result of multi-stage silica alkaline metasomatism, related to the second and especially the third phases of the intrusion of the massif, as well as to further weathering processes, involving karst formation, disintegration of gold metasomatites and the formation of a thick oxidation zone [6, 7].

Taking into account the crystal-optical studies and the results of field work, it can be assumed that the rocks of the second and first phases of the Medvedev massif intusion is associated with gold-ore mineralization, which formation is related to an intense contact-metasomatic effect on both the rocks of the first phase of intusion and the host rocks. Based on this, it can be assumed that the main part of the gold of metasomatites, as a result of their weathering, was probably released and moved to the environment of products of the weathering crust.

4. Conclusions
Thus, petrographic studies of Mesozoic alkaline igneous rocks revealed that, the Medvedev massif has a zonal structure and is represented by three phases, which rocks differ in composition and structural features. The late phases of the massif rocks, most likely, were formed during fractional crystallization of mostly only dark-colored rock-forming minerals, that is reflected in their petrographic composition, where the content of dark-colored reaches 20%. This fact suggests that the formation of the Medvedev massif began with the intusion of leucocratic syenite porphyry, followed by the pyroxene-amphibole syenite phase, and at the final stage – monzonite porphyry. That is, the magmatism of the Medvedev massif displays features of the antidromic sequence of development (reduction of the light colors of magmatism, from early to later formations). In general, based on the petrographic study of the material composition of the rocks of the massif, it can be concluded that gold ore occurrences can be associated with such massifs of multi-phase intusion.

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