

The Khairkhan dunite-troctolite-gabbro massif (Lake Zone of the Western Mongolia) - example of syncollision Middle Cambrian mafic intrusion

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Abstract. Geological, mineralogical, petrochemical and geochronological data are considered for the Khairkhan dunite-troctolite-gabbro massif in the Lake zone of Western Mongolia. The massif intrude the Lower Cambrian molasse stratum and intruded by the Middle Cambrian diorite-plagiogranite bodies (507 Ma). Mineralogical, petrographic and geochemical data show typical suprasubduction characteristics: high An component of plagioclases with increased iron content of olivines, high whole-rock alumina content, low contents of titanium and alkalis, Ta, Nb, Zr and Hf minima. The layered series is characterized by a layers of orbicular gabbros, which can be considered as gabbro-gabbro mingling. At the same time, high-temperature viscous-plastic deformations are characteristic of the layered series, which cover the entire volume of the intrusion. These observations, together with geological and geochronological data related to the melting of the suprasubduction mantle in the Cambrian-Ordovician time, allow treating the Khairkhan massif as an example of syncollisional stratified gabbroids.

1. Introduction

The Cambrian-Ordovician stage of development of the Central Asian mobile belt is characterized by the extensive rising of granitoid batholiths, which sew terranes of various types [1]. Some researchers attribute these batholiths to marginal-continental super-subduction magmatic belts, others consider them as part of accretion-collision orogenic belts, reflecting the growth of the Siberian continent in the Early Paleozoic. The active role of mantle-driven processes in collisional settings is substantiated either in the point of the slab detachment model during the collision period, which inevitably leads to the rise of the mantle diapirs under the accretion-collisional zones [2], or in the model of the North-Asian superplume impact on the continental lithosphere. Due to the peculiarities of petrochemical and geochemical data, ultramafic-mafic and mafic intrusions are extremely diverse. In many accretion-collision-type terrains, stratified low-titanium low-alkaline high-alumina ultramafic-mafic intrusions have been established, which are indistinguishable from geological features and geochemical characteristics from island-arc high-aluminous peridotite-gabbro associations. Their attribution to the conflict stage became possible only after geological and isotope-geochronological studies. So the



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Zapevalikhinsky, Shildyrheysky and Pravotarlashkinsky intrusions in the Southern Siberia are of the same type. The formation of the Mazhalyk massif in South-Eastern Tuva corresponds to the same stage. Differentiated dunite-clinopyroxenite-gabbro bodies, which were formed as a result of fractionation of high-potassium picritic or microbasaltic melts, were established at this age [4].

The Lake Zone of Western Mongolia is a Vendian-Cambrian island-arc system related to the Precambrian Dzabkhan microcontinent in the east and the Paleozoic structures of the Mongolian Altai - in the west. Khyargasnuur peridotite-gabbro complex is unique among magmatic associations in the Lake Zone, which includes Khyargasnuur, Dzhabkhan, Bayantsagaan and Tugurik areas of peridotite, pyroxenite-anortosite-gabbro [5] considered as island-arc layered intrusions [6] (figure 1).

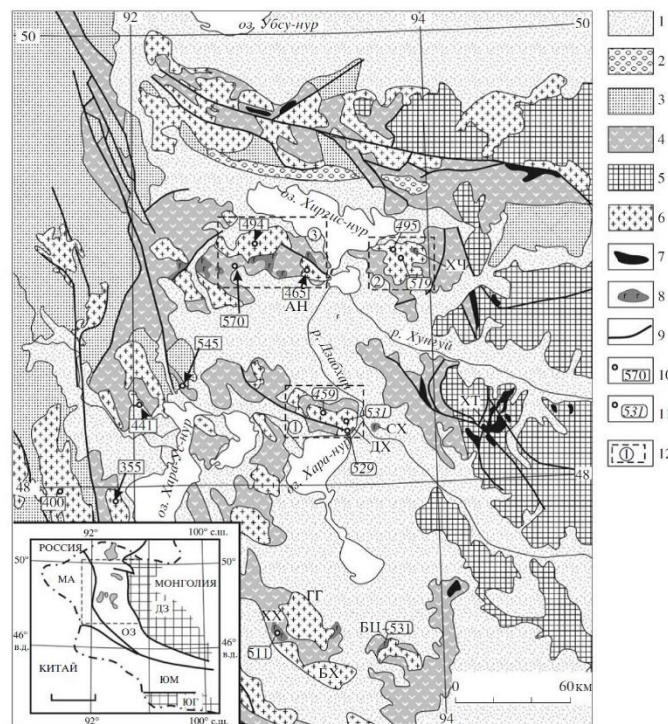


Figure 1. Geological scheme of the Lake zone of Western Mongolia [7].

1 - Late Mesozoic and Cenozoic sediments; 2 - Jurassic conglomerates; 3 - Early Middle Paleozoic formations of the Mongolian-Altai zone; 4 - Vendian-Cambrian volcanogenic-sedimentary ophiolitic and island-arc complexes of the Lake zone; 5 - Dzabkhan microcontinent. Igneous formations: 6 - early and middle Paleozoic granitoids (undifferentiated); 7 - ophiolites; 8 - Early Paleozoic peridotite-gabbro massifs; 9 - tectonic disturbances; 10 - geochronological data according to [8]; 11 - geochronological data according to [7]. Intrusions: AH - Arygnuur, BH - Bumbat-Khairkhan plagiogranite; БЦ - Bayantsagaans plagioperidotite-troctolite-gabbro; ГГ - Gundguzin; ДХ - Dzabkhan; СХ - Sarkhairkhan troctolite-gabbro; ХТ - Khutul harzburgite; ХХ - Khairkhan plagiodunite-troctolite-gabbro; ХЧ - Kharaculu high-Ti peridotite-gabbro.

Each area of the Khyargasnuur complex unites a group of contiguous gabbroid bodies with a similar structure, rocks texture and their composition, but differing in size and erosion level. These areas are at a distance noticeably exceeding the distance between the intrusions. Similar areal placement of volcanic activity centers is also characteristic of modern island arc systems. At the same time, detailed studies of the granitoid and basic magmatism of this zone allowed to distinguish island-

arc and collisional stages [7, 9]. Based on geochronological studies, the Khairkhan massif was formed at the collisional stage.

2. Geological setting

The Khairkhan massif is the largest gabbroid intrusion in Western Mongolia. It is located in the central part of the Lake Zone to the south-west of Durgun-Nuur Lake. The rocks of the massif are exposed on an area of about 70 km² in the central part of the Bumbat-Khairkhan range. The Early Cambrian sedimentary rocks of the Burgasutai unit composed of mainly coarse-clastic terrigenous sediments with rare intercalations of carbonates serve as country rocks for the massif. In the northern part of the massif in the outcrops on the river Urtuin-Gol gabbronorites intrude the shales, sandstones and gravelites of the Burgasutai unit with the formation of hornfelses (figure 2). Two main complexes are distinguished in the the massif: the layered series and the marginal facies. Rocks of the layered series form the central part of the massif, exposing mainly on the eastern slope of the ridge. Stratification has a northwest strike, consistent with the long axis of the massif. The layered series is composed of plagiodunites, troctolites, olivine gabbros and gabbronorites with a small volume of anorthosites. In the lower half of the layerd series prevail mesotroctolites (to melanotroctolites), in the upper half prevail olivine gabbronorites, meso- and leukotroctolites with small zones of olivine gabbronorites enriched with titanomagnetite.

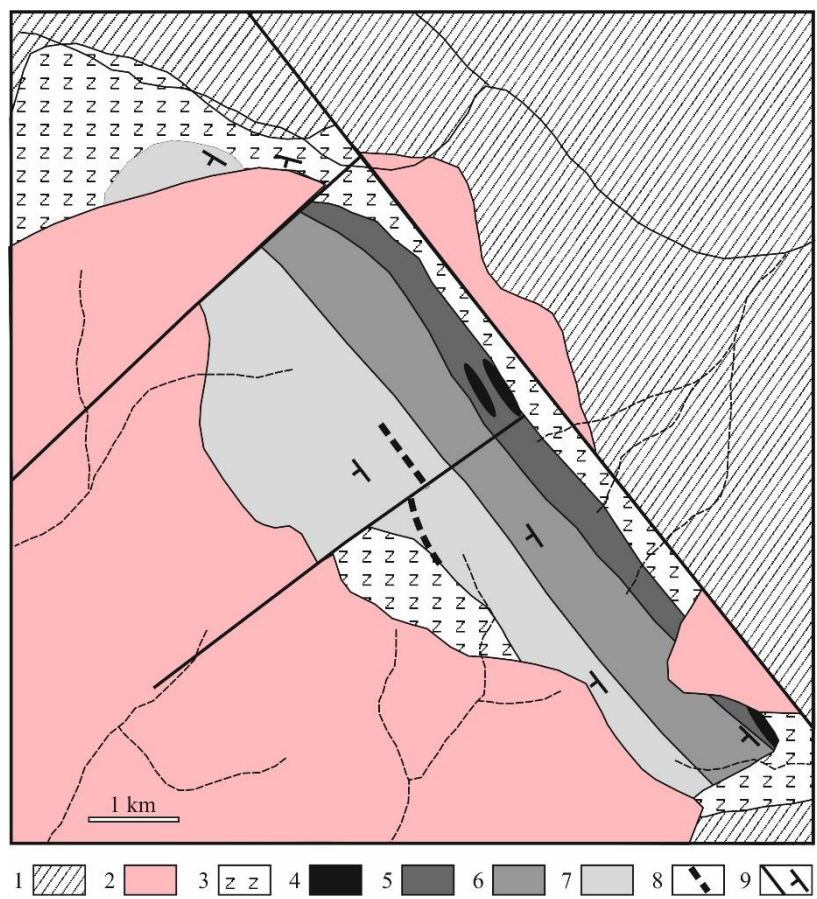


Figure 2. Geological scheme of the Khairkhan massif.

1 – Early Cambrian host rocks of the Bargasutai unit; 2 — Early Paleozoic Bumbat – Khairkhan diorite – plagiogranite massif (507 Ma [9]); 3 - marginal facies gabbronorites; 4 - plagiodunites and melanotroctolites; 5 - troctolites; 6 - taxitic olivine gabbro; 7 - olivine gabbronorite; 8 - layer of the orbicular gabbro; 9 - tectonic faults and the bedding of layering.

Of particular interest in the structure of the layered series is the layer of taxitic gabbroids and the associated layer of orbicular rocks. Outcrops of taxitic rocks can be traced almost through the entire massif along the eastern slope of the ridge, in accordance with stratification. The apparent thickness of the taxitic layer is variable, and usually ranges from 30-100 meters. Taxitic gabbroids are characterized by chaotically located leucocratic and melanocratic portions of various sizes (from 1–2 to 10–20 cm), breaks, bends, and folds of thin layering, i.e. structures that apparently have arisen as a result of visco - plastic deformations.

Directly above taxitic gabbroids, there is a layer of orbicular rocks, with a capacity of up to 15 meters. Orbicules are spherical zonal formations up to 30-40 centimeters in diameter (most up to 10-15 centimeters). The structure of most of them is allocated two zones: external with radially oriented crystals olivine and (or) clinopyroxene, the space between them is filled with fine grains of plagioclase and inner zone of anorthosite composition, often with large (up to 5-6 mm) crystals. Less commonly, multilayer orbicules with a variable number (up to 8–10) of layers of different thickness and composition are found. However, petrographically, orbicular rocks are represented by the same troctolites and olivine gabbros as in the “normal” layered series. The composition of minerals in orbicules, host gabbro and troctolites varies slightly. Orbicules usually occupy up to 40–50% of the volume; however, in certain areas, where they are in close contact and mutually deformed, their volume fraction reaches about 80%.

The marginal facies is fragmentary distributed along the periphery of the intrusion, while its apparent thickness reaches in some areas more than 1 km. The marginal facies are composed mainly of non-olivine gabbronorites, which are altered to quartz-bearing amphibole gabbronorites to contact (figure 3).

Synmagmatic plastic deformations and breakdowns are widely developed in the rocks of the massif, both at the macro and at the micro level. They are expressed in crushing of the layering into small folds of various amplitudes (usually up to the first tens of centimeters), often turning into taxitic sites. The greatest number of such deformations is characteristic of the upper part of the layered series, including the layers of orbicular and taxitic gabbroids. At the same time, such structures are observed in the entire massif and are not confined to the edge areas. These features indicate fairly intense tectonic processes that accompanied not only the intruding, but also the further solidification of the intrusion.

3. Mineralogy and petrography

Two petrographic series of rocks are distinguished in the structure of this object: dunite-troctolitegabbro and websterite-gabbronorite. The first is usually considered as a banded or layered series, and the second is allocated to the marginal facies. The layered series forms most of the pluton, mainly its central part, exposing predominantly on the eastern slope of the ridge. Petrographic varieties such as troctoliths, olivine gabbros with an insignificant role of plagioclases prevail in its composition. For the composing rocks of the layered series, banded and trachytoid textures are characteristic, fixing the elements of the primary igneous stratification. The marginal facies is characterized by a relatively homogeneous structure with gradual transitions between species. However, especially in mesotypic and leucocratic varieties, elements of trachytoidity are fixed. The main petrographic varieties here are olivine-free gabbronorites with the local development of plagiowebsterites and pyroxene-anorthosites, which are gradually replaced by quartz and amphibole-containing gabbronorites towards the host rock. The transition between the rocks of the marginal facies and the layered series is rather gradual and, as a rule, is traced by the development of the vein bodies of pegmatoid gabbronorites and leuco-gabbronorites.

The main rock-forming minerals of the Khairkhan massif are plagioclase, olivine, clinopyroxene and orthopyroxene, and amphibole is present in smaller quantities. Auxiliary accessories include magnetite, chalcopyrite, pyrite and other ore minerals. The composition of olivine in the rocks of the massif varies slightly - from Fo74 to Fo77. Within the individual crystals, there are no differences

between the compositions of the inner and outer zones. The amount of MnO in olivines varies from 0.38 to 0.46 wt. %. There is an inverse relationship between the concentrations of MnO and MgO.

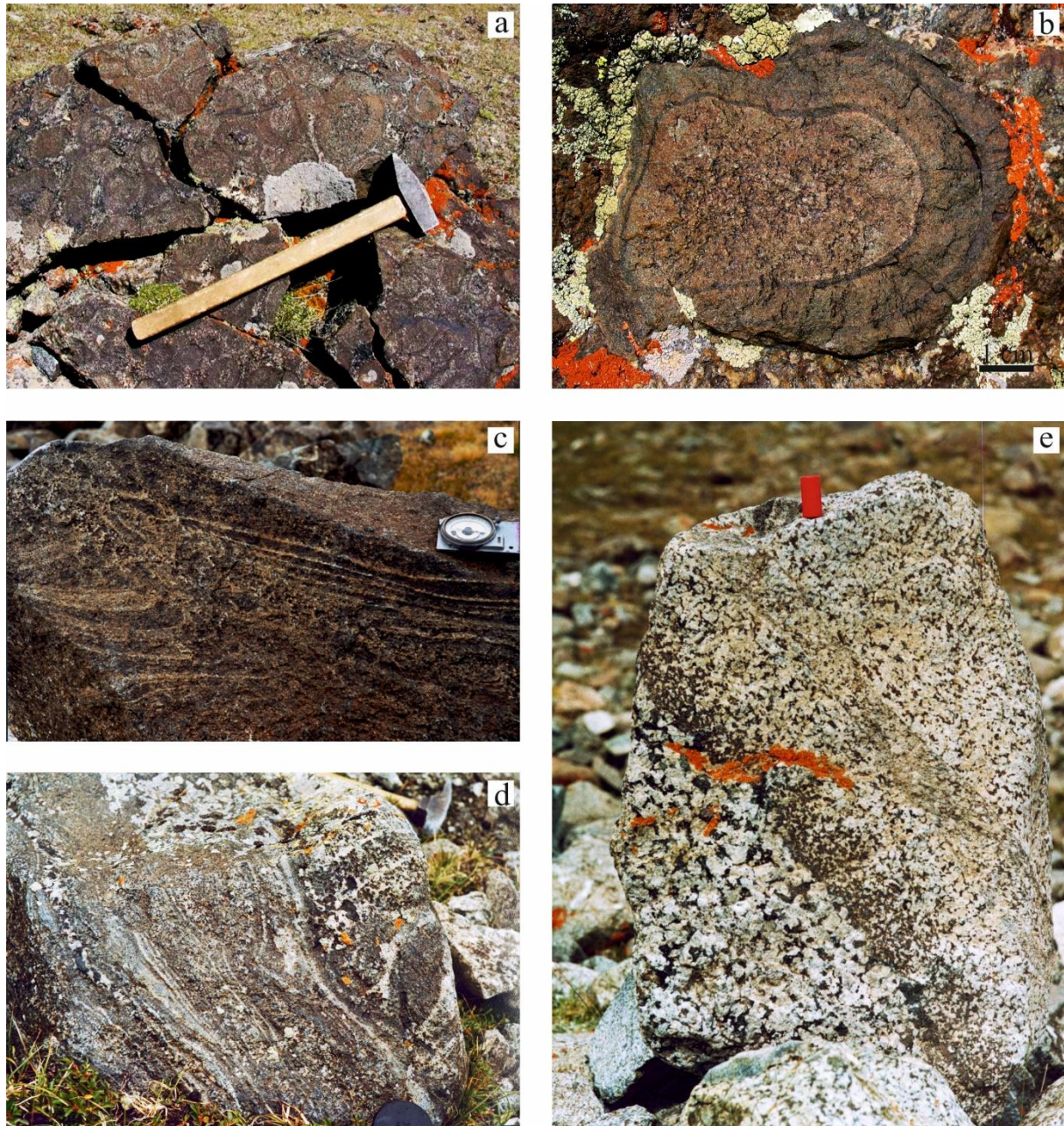


Figure 3. Orbicules and deformations in the layered series of the Khaikhan massif
 (a) outcrop of orbicular rocks in the central part of the massif; (b) deformed orbicule with a three-zone shell and coarse-grained central part; (c) plastic deformations of fine rhythmic layering in olivine gabbro; (d) visco-plastic deformation of rocks of the stratified series; (e) large-scale rhythmic stratification and a zone of breakdown, sealed with amphibole.

Olivine occurs predominantly in rocks of the layered series (troctolites, olivine-gabbros, and gabbro-norites). In crystals, generally, fissures are observed, on which secondary serpentine and magnetite develop. In some varieties of troctolites around olivine, rims up to 2-3 mm wide, consisting

of amphibole and orthopyroxene, are observed. Olivine forms crystals, ranging in size from second decimal places of the millimeter to 1 cm in pegmatoid differences.

Plagioclase is present in all rocks of the massif. For the layered series, it is bitovnite and anortite (An87-93), and for gabbronorites of the marginal series - labrador (An50-60) or bitovnite (An82-89). Plagioclase crystals vary in size from the smallest (about 0.01 mm) to large (up to 1-1.5 cm) in pegmatoid species. Inclusions of plagioclase in olivine and pyroxenes are quite frequent, and vice versa, which indicates their co-crystallization. For all investigated grains of the plagioclases of the layered series characteristic weakly expressed reverse zonation. The content of anortite mineral in the marginal zones of all analyzed crystals is 2-3 mole percent higher than in the center. The content of K_2O in plagioclase of the layered series reaches 0.07 wt. %, whereas in some plagioclases of the marginal facies, it is up to 0.37 wt. %. The marginal facies plagioclases also have reverse zonation, best expressed for labrador (from An50 to An58).

Orthopyroxene is represented by two morphological types. First type is characteristic for the rocks of the marginal facies and forms idiomorphic grains of various sizes. Orthopyroxene of the second type together with amphibole forms rims around olivine crystals in troctolites and olivine-gabbros. The composition of the mineral corresponds to bronzite. Orthopyroxenes of the marginal facies are characterized by increased iron content (En 64-73), compared to orthopyroxenes of the layered series (En 72-78). In addition, elevated Al_2O_3 contents for orthopyroxenes of the layered series, (on average, 1.46 versus 1.21 wt.% for the marginal facies) and lower CaO (0.6 and 0.87 wt.%, respectively) are noted. It should also be noted the presence of TiO_2 impurity (up to 0.2 wt.%), which is typical mainly for the idiomorphous orthopyroxene crystals from the gabbronorite of the marginal facies.

Clinopyroxene is distributed among the rocks of the marginal facies and the layered series. It forms grains of various sizes, often xenomorphic, less often poikilocrystals with inclusions of plagioclase and magnetite. In composition, it corresponds to augite with an iron index from 14 to 20, and, as for orthopyroxenes, a higher iron index is characteristic of clinopyroxenes of the marginal facies. The content of Na_2O in clinopyroxenes of the layered series and marginal facies ranges from 0.16 to 0.85 wt. %, and Al_2O_3 - from 0.7 to 2.85 wt. %. However, according to the Mn content, augites of layered series are depleted by this component. The average content of MnO in pyroxenes of the layered series is 0.22 wt. %, whereas in the marginal facies - 0.33 wt. %.

Hornblende forms xenomorphic grains between rock-forming minerals and rims around olivines and orthopyroxenes. The investigation of thin sections showed that two types of amphibole are distinguished by color: brown-green and light green. Among the ore minerals, magnetite is most common, less common is chalcopyrite, pyrite. Magnetite is represented by several morphological types. In the first type, small idiomorphic magnetite crystals, enclosed in grains of rock-forming minerals (mainly in orthopyroxene), are distinguished. The second type is represented by large xenomorphic segregations in the interstitium. The third type includes fine precipitates of secondary magnetite in the cracks of olivine crystals, in conjunction with serpentine.

The study of the morphology and composition of minerals in rocks of the Khairkhan dunite-troctolite-anorthosite-gabbro massif led to the following conclusions. First, the change in the composition of the main rock-forming minerals along the section of the layered series is insignificant and amounts to An 87-93 for plagioclase, and Fo 72-77 for olivine. Secondly, the minerals of the layered series do not have zonation, or this heterogeneity is expressed extremely weakly with the reverse sequence. Thirdly, the minerals of the marginal facies have a wider range of compositions as compared with the minerals of the layered series.

4. Geochemistry

On the TAS diagram, the points of the rock compositions of the layered series and the marginal facies lie in the field of the ultramafic and mafic rocks of the normal alkalinity. The SiO_2 content of for the rocks of the layered series ranges from 42.1 to 52.6 wt. %, and the alkali content ($Na_2O + K_2O$) is 0.15 - 2.41 wt.%. The rocks of the marginal facies in terms of the silica content correspond to gabbro and diorites (48-58% SiO_2) with higher alkalinity (up to 3.1 wt.%) (figure 4). However, it should be

noted that the observed variations in alkali content are due to changes in the amount of Na₂O, the content of K₂O is almost constant and averages 0.2 wt.%, both for layered series rocks and for the marginal facies.

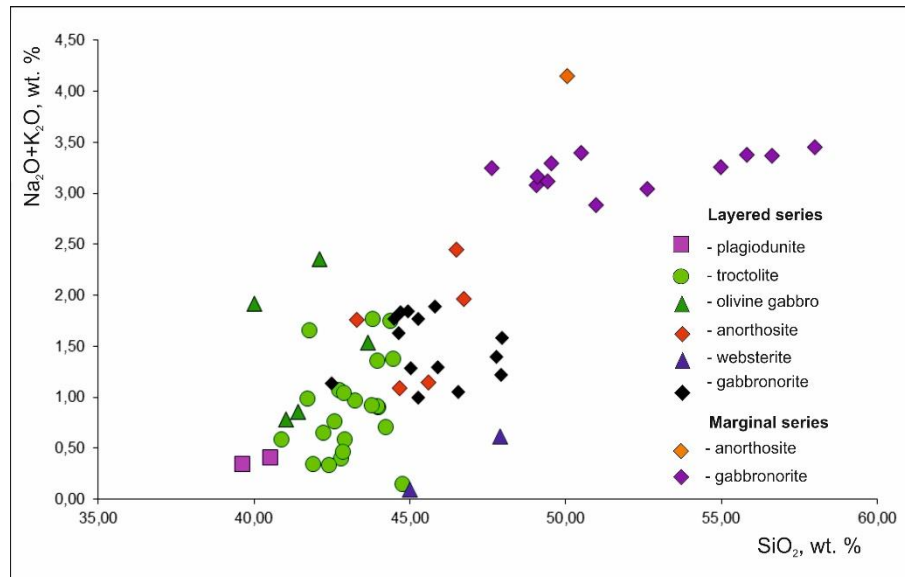


Figure 4. TAS diagram for rocks of the Khairkhan massif.

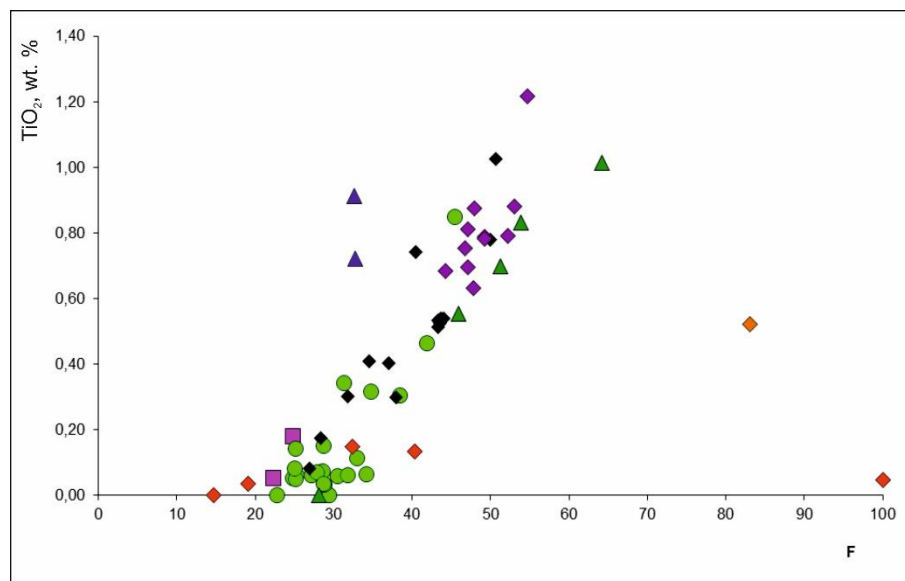


Figure 5. The dependence of the F (F=FeO/(FeO+MgO), wt.%) and the TiO₂ content in the rocks of the layered series and in the marginal facies of the Khairkhan massif.

The rocks of the marginal facies and layered series are well distinguished by the content of titanium and iron index (F=FeO/(FeO+MgO), wt.%). For rocks of the layered series, the iron index increases from troctolites (F = 20–40) to olivine gabbros and olivine gabbronorites (F = 30–60). At the same time, there is a positive correlation with the content of titanium. Nevertheless, even for the most ferrous rocks, TiO₂ does not exceed 1% (Fig. 5). For gabbroids and diorites of the marginal facies, the iron index varies within narrow limits (F = 45-60), and the TiO₂ content reaches 1.2% (figure 5).

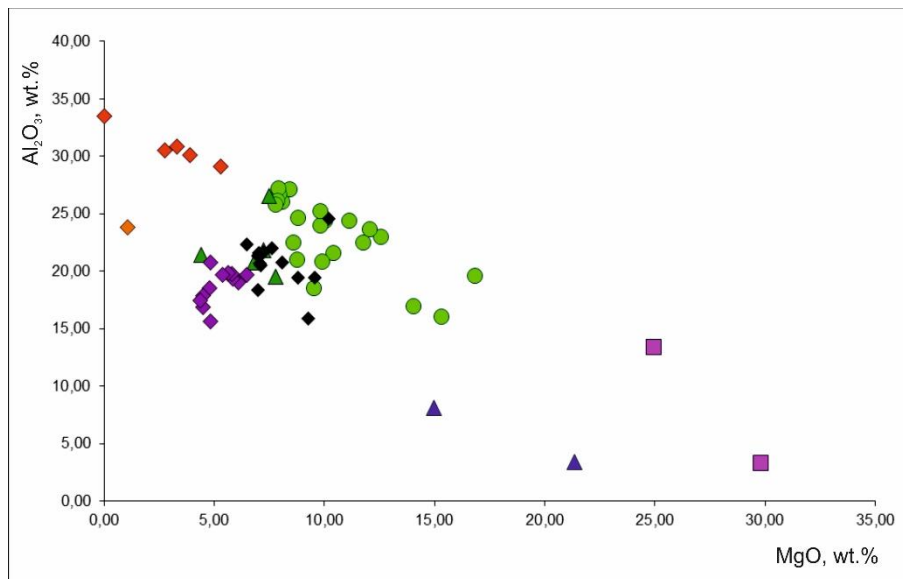


Figure 6. MgO-Al₂O₃ diagram for rocks of the layered series and the marginal facies of the Khairkhan massif.

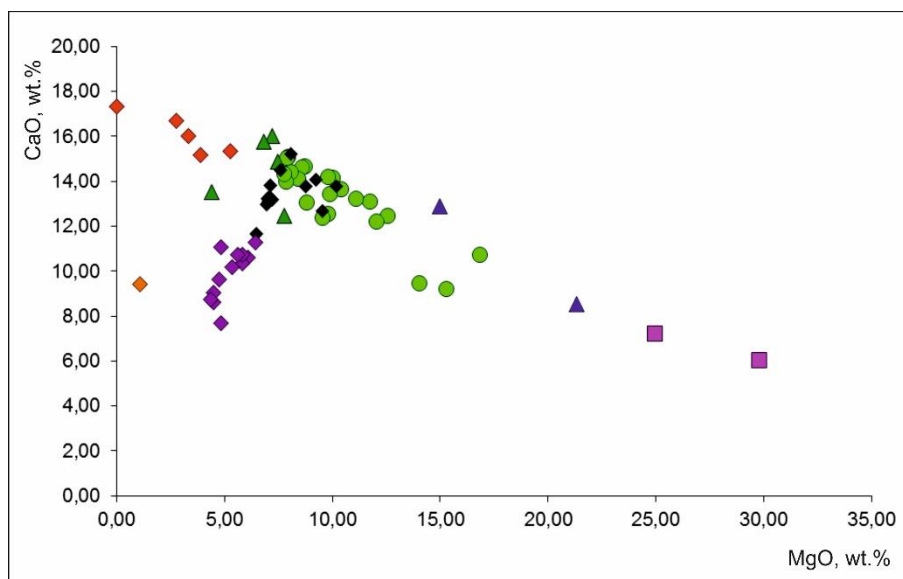


Figure 7. MgO-CaO diagram for rocks of the layered series and the marginal facies of the Khairkhan massif.

A clear trend is observed in the MgO-CaO and MgO-Al₂O₃ diagrams for layered series rocks due to the fractionation of the plagioclase and olivine. Olivine gabbros and olivine gabbro-norites of the upper part of the layered series deviate from this trend, which is due to the more siliceous composition of plagioclase. A completely different character of the trend is characteristic of the rocks of the marginal facies, for which there is a sharp decrease in the contents of CaO and Al₂O₃ with decreasing magnesia (figure 7).

REE spectra, normalized by chondrite CI, for rocks of the layered series have a weak negative slope ((La / Yb)_n from 1.21 to 5.9), more significant for leucocratic species - samples of anorthosite and leucotroktolite. Marginal facies rocks shows practically flat REE spectra with (La / Yb) _n from 1.05 to 1.52 with concentrations from 5 to 10 chondritic units (figure 8). The Eu maximum is more pronounced in the rocks of the layered series (Eu / Eu * 1.86-4.8) than in the marginal facies (Eu / Eu * 1.27-2.12), which indicates the significant role of fractionation of plagioclase in layered series. For gabbronorite from the upper part of the layered series, intermediate contents are characteristic, which can be clearly seen on the REE plot.

On multielement primitive mantle - normalized spectra, seen that the distribution of elements in the rocks of the layered series and the marginal facies is very similar. The differences consist mainly in a higher level of concentrations of the corresponding components in the rocks of the marginal facies. Plots have a weak negative slope, and in the HREE are practically flattening out. The most significant and interesting features of the distribution of trace elements are a sharp positive Sr anomaly and a distinct relative depletion of Th, Nb and Zr with a lower degree depletion of U, Ta and Hf, which gives Th-U, Zr-Hf and Ta-Nb minima.

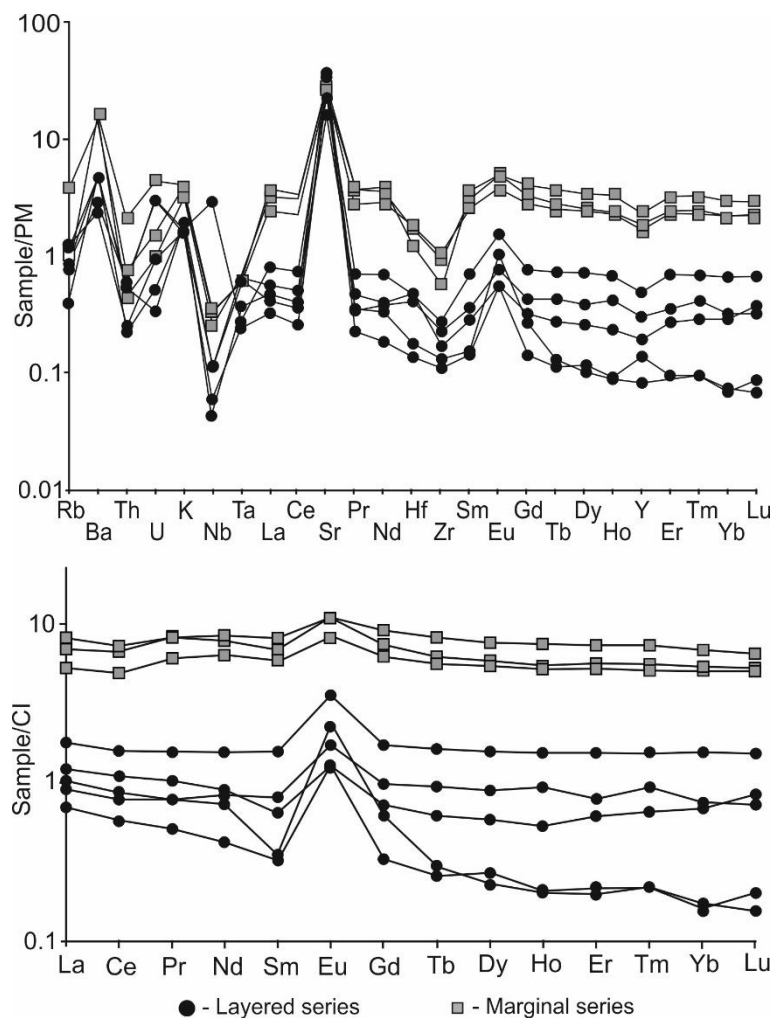


Figure 8. Distribution of trace elements in the rocks of the Khairkhan massif. REE spectra are normalized to chondrite CI, multielement spectra are normalized to PM

5. Ore features in structure of massif

Noble metal explorations in Khayrkhan gabbroid massif were conducted by employees of Tomsk State University with the financial support of the Australian mining company «Elayne Nominee P TY.LTD» in 2000. The work was based on the development of scattered chalcopyrite-pyrrhotite mineralization within the massif, which reveals elevated concentrations of platinum-group metals (up to 0.3 g/t), as well as detects mineable gold grades (up to 0.5 g/t) among blocks of gabbroids outside the main body in local zones of copper sulfide accumulation. In the process of field and laboratory studies, it was found that despite the significant scattering of chalcopyrite-pyrrhotite mineralization for tens and hundreds of meters, high concentrations of noble metals are observed only in local horizons (reefs) up to 3-5 meters thick and 10-15 meters long. Four reefs were allocated within the Khayrkhan massif with a total grade of gold, palladium and platinum from 0.03 to 1.6 g/t. Geochemical characteristics/specifics of each horizon indicate an obvious zoning of noble metal accumulation suggesting a different mobility of gold and platinum-group metals [17].

The first horizon is limited to the contact of the layered series and the marginal facies. It occupies the highest North-Eastern position in the structure of the complex. The thickness of this horizon is 3-5 m. It stretches for up to 4 km in the south-eastern part of the pluton and fragmentarily (up to 500 m) in its north-western part. The maximum concentrations of noble metals (140-430 mg / t) are concentrated in vein bodies of pegmatoid leucocratic gabbroids averaging a total value of (Pd + Pt) / Au about 0.2.

The second and third horizons are located within the layered series of mafic rocks and are concentrated in melanocratic varieties such as gabbro-peridotites, plagioclites and olivine plagiowebsterites. High concentrations of both gold and platinum-group metals are found in these horizons. For the second horizon, a very moderate accumulation of noble metals is recorded (on average 90 mg / t) with the ratio Au / (Pt + Pd) = 0.75. Whereas, the third horizon has much higher concentrations of these elements (on average 320 mg / t with Au/(Pt+Pd) = 0.80). Some samples from the third horizon yielded concentration levels close to industrial scale ones (about 1600 mg/t). Both horizons stretch for almost entire length of the array/complex, which is more than 10 km, with a thickness of 2 to 10 m. The fourth ore horizon is located in the axial part of the massif among olivine gabbroids considerably far from the previous ones (about 1000 m apart). Fragments of it stretch for up to 8 km, and the thickness does not exceed couple meters (the thickness of the reef does not exceed the first meters). Its geochemistry is characterized by predominance of platinum-group metals over gold (Au/(Pt+Pd) = 3.00) and the overall low level of noble metal concentrations (about 60 mg / t on average).

We have performed analysis of the matter composition of ore minerals for the most promising horizons (first and third ones). Pyrite, chalcopyrite and bornite were found among sulfides. Sulfides from the first horizon (gold-bearing) are characterized by high concentrations of sulfur, whereas sulfides from the third horizon (gold-platinum-bearing) have a small deficiency in sulfur comparing to increased concentrations of mercury and tellurium. This indicates mineralization of noble metals. Thus, native gold and electrum (Au, Ag) were found in the rocks from the first horizon, and palladium telluride temagamite (Pd₃HgTe₃) was found in the rocks from the third horizon. The ore paragenesis of 4 selected horizons indicates a significant role of volatile components in the formation of noble metals at relatively low temperatures. A similar zoning in gold and PGE deposits reflects their mobility in magmatic and hydrothermal stages of the gabbro series in general [17].

6. Discussion

The Khayrkhan troctolite-gabbro massif is located in the Lake Zone of western Mongolia, which is regarded as a Vendian-Cambrian island-arc system [8]. The Early Paleozoic peridotite-gabbro massifs that were considered as part of the Tochtogenshil Complex were combined into a separate Khyargasnuur Complex [10, 11]. However, according to recent geochronological data, it was shown that Early Paleozoic granitoid and peridotite-gabbro complexes of the Lake Zone were formed in a wide age range of 540 - 450 Ma. This indicates a longer than expected earlier duration of the Early

Paleozoic intrusive magmatism associated with the change of geodynamic settings from the island arc (540-520 Ma) through accretionary (510–485 Ma) to post-collisional (465–450 Ma) [7]. It should be noted that the granitoid and gabbroid associations of the above-mentioned age levels, reflecting the different stages of the formation of the early Caledonides of the Central Asian fold belt, are developed not only in the Early Caledonian structures of the Lake Zone of Western Mongolia plutons and individual massifs in Eastern and South-Eastern Tuva, Eastern Sayan, Gonaya Shoria, Gorny Altai, and on the Batenevsky ridge [1, 5, 9, 12, 13, 14].

At the first stage (540–520 Ma), in the island arc geodynamic setting, some high-alumina gabbroids, previously attributed to the Khyargasnuur peridotite-pyroxenite-gabbro-norite complex, were formed. These are the Kharachulu massif and a number of small, highly altered gabbroid bodies in the Dzabkhan and Bayantsagaan areas of the Lake Zone, which are intruded by the calc-alkaline high-alumina plagiogranites of the tonalite-plagiogranite association with age 540-530 Ma [7].

On accretion-collision stage (510–485 Ma) Lake Zone and its frame formation occurred Uregnuur picrite basalt association (512 ± 6 Ma [4]), tholeiitic low-alumina diorite-tonalite-plagiogranite association of Sharatologoy pluton (494 ± 10 Ma) and calc-alkaline high-alumina plagiogranitoidov diorite-tonalite-plagiogranite association of the Khyargasnuur pluton (495 ± 2 Ma). Granitoids of this age level in the Early Caledonian structures of the Lake Zone are also described as part of small intrusions of the Daribi ridge (490 ± 4 Ma, [15]). According to the date we received, the Khairkhan troctolite-gabbro intrusion should be attributed to this stage.

The geological evidence for attributing the Khairkhan massif to the collisional stage is that it intrude the Lower Cambrian molasses of the Burgusutai Unit, the formation of which completes the island arc phase. The presence of synmagmatic visco-plastic deformations also makes it possible to attribute the time of formation of the massif to the accretion-collisional stage of development of the Central Asian fold belt. It should be noted that such deformations cover the entire volume of the massif and their confinement to the marginal zones is not observed. Similar visco-plastic deformations are observed in gabbroids of the Burlaksky massif in the East Sayan (490 Ma), in the Bayankolsky gabbro-monzodiorite massif on Sangilen (495 Ma).

At the same time, the mineralogical and petrographic features of the layered series of the Khairkhan massif are typical of characteristic layered intrusions of the island arc paleosystems. The gabbroids of the Khairkhan massif are characterized by a high proportion of the anorthite mineral in the plagioclase (up to 90% An) with a relatively high iron content of olivine ($f = 25-30$), which is typical of allivalite and eucrite xenoliths described in modern island arcs [16]. The characteristics of the petrochemical composition and the character of differentiation also do not differ from the peridotite-gabbro massifs, which are intermediate chambers of the island arc high-Mg high-alumina basalts [6]. The geochemical features of the Khairkhan massif rocks also do not differ from island arc associations. The convergence of the compositional characteristics of the Khairkhan massif and island-arc gabbroids is explained by the melting of the same suprasubduction mantle, but in different geodynamic settings.

7. Conclusions

Geological, mineralogical, petrochemical, and geochronological data for the Khairkhan dunite-troctolite-gabbro massif in the Lake Zone of western Mongolia allow us to consider it as an example of syncollision peridotite-gabbro associations. The massif breaks through the Lower Cambrian molasse stratum and intrudes by Middle Cambrian diorites and plagiogranites (507 Ma). Mineralogical, petrographic and geochemical data for gabbroids of this massif have typical suprasubduction characteristics: high An of plagioclases with increased iron content of olivines, high alumina content, low contents of titanium and alkali, Ta, Nb, Zr and Hf minima. The layered series is characterized by a wide manifestation of orbicular gabbros, which can be considered as gabbro-gabbro mingling. At the same time, the layered series of the massif is characterized by high-temperature visco-plastic deformations that cover the entire volume of the intrusion. These observations are

combined with geological and geochronological data associated with the melting of the suprasubduction mantle in the Cambrian-Ordovician time.

Potential of the Khairkhan Massif to be an ore deposit remains very high. Zoning of the noble metal scattering, which we have defined, lets us forecast spatial distribution of scattered gold and platinum deposits.

Acknowledgements

This work was carried out with the support of the grant of the RSF № 18-17-00240.

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