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ORE-GENERATING ROLE OF THE FOCAL STRUCTURE DURING THE FORMATION OF APOGRANITOID TUNGSTEN MINERALIZATION AT THE YAKHTON DEPOSIT

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С О Д Е Р Ж А Н И Е

ORE-GENERATING ROLE OF THE FOCAL STRUCTURE DURING THE FORMATION OF APOGRANITOID TUNGSTEN MINERALIZATION AT THE YAKHTON DEPOSIT

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Abstract*. The article analyses the ore-generating role of the focal structure during the formation of apogranitoid tungsten mineralization at the Yakhton deposit. The Yakhton ore field, within which apogranitoid tungsten mineralization has been identified, is confined to a deep focal structure, expressed by polychronic magmatism with a combination in the area of rocks of granitoid, lamprophyre and alkali-basaltoid complexes, as well as fluid-explosive breccias. The structure is confined to a tectonic node, expressed by the intersection of faults in the northwestern, meridional and northeastern directions. These faults predetermined large shear movements and flexural bending of the overall plicative structure, as a result of which a chamber space for the intrusion was created. In the Yakhton intrusion, dikes formed at the end of the formation of the entire complex.*

Recognition of the reality of this deep focal structure can explain such fundamental features of magmatism as the area of development, its high intensity, discreteness, the presence of locally manifested fluid-explosive breccias and other petrographic-geochemical features (decipher).

Key words: *structure, ore-bearing, quartz veinlets, endocontact, granodiorite, large strike-slip faults, exocontact, basaltoids.*

Аннотация: *Мақолада Яхтон конида апогранит волфрам маъданлашувининг шаклланишида очаг структурасининг маъдан ҳосил бўлишидаги роли кўриб чиқилган. Апогранитоид волфрам маъданлашуви аниқланган Яхтон кони чуқур очаг структура билан чамбарчас боғлиқлиги аниқланган бўлиб, улар гранит, лампрофир ва базалтли-ишқор комплекслари, шунингдек флюид експлозив брекчия тоғ жинслари бирикмаларининг ҳудудда полихрон магматизм жараёни билан тавсифланади. Структура шимоли-ғарбий, меридионал ва шимоли-шарқий йўналишлардаги ёриқлар кесишиши билан ифодаланган тектоник тугун билан чегараланган. Ушбу дарзликлар катта силжиш ҳаракатлари ва умумий пликатив структуранинг егилувчанлигини олдиндан намоён қилади, бунинг натижасида еса интрузивлар кириши учун камера бўшлиғи вужудга келади. Яхтон интрузивида дайкалар ҳосил бўлиши бутун мажмуа ривожланишининг сўнгида вужудга келади.*

Ушбу чуқур очаг структураси асосининг ареал магматизм жараёни билан ривожланишини, унинг юқори интенсивлиги, дискретлиги, маҳаллий даражада намоён бўлган флюид експлозив брекчияларнинг мавжудлиги ва бошқа петрографик-геокимёвий хусусиятлар (дешифр) каби асосий жихатлари орқали тушунтириш мумкин.

Таянч сўзлар: *struktura, ma'danli, kvarts tomirlari, endokontakt, granodiyorit, katta yirik suriluvchan yoriqlar, ekzokontakt, bazaltoidlar.*

Аннотация. *В статье раамотрены рудогенерирующая роль очаговой структуры при формирование апогранитоидного вольфрамового оруденения на месторождения Яхтон. Яхтонское рудное поле, в пределах которого выявлено апогранитоидное вольфрамовое оруденение, приурочено к очаговой структуре глубокого заложения, выраженной полихронным магматизмом с совмещением в ареале, пород гранитоидного, лампрофирового и щелочно-базальтоидного комплексов, а также флюидно-эксплозивных брекчий. Структура приурочена к тектоническому узлу, выраженному пересечением разломов северо-западного, меридионального и северо-восточного направления. Указанные разломы предопределили крупные сдвиговые перемещения и флексурный изгиб общей пликативной структуры, в результате которых было создано камерное пространство для интрузива. В Яхтонском интрузиве дайки сформировались в конце становления всего комплекса.*

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Признание реальности этой очаговой структуры глубокого заложения могут объяснить такие фундаментальные черты магматизма как ареальность развития, ее высокая напряженнось, дискретность, наличие локально проявленных флюидно – эксплозивных брекчий и другие петрографо-геохимические особенности (расшифровать).

Ключевые слова: *структура, рудопродуктивным, кварцевыми прожилками, эндоконтакте, гранодиорит, крупные сдвиговые, экзоконтакта, базальтоиды.*

Introduction

The focal area includes of collisional granitoids [1] and lamprophyres and alkaline basaltoids.

The focal structure of deep origin is distinguished by two different stages of its development. During the first collision stage (C_3 – P_1), magma formation processes were localized in the upper part of the crust and culminated in the formation of autochthonous granitoid small intrusions. At this stage, there is a consistent homodromic evolution of the composition of magmatites from gabbro and diorites to leucogranites and alaskites, representing the Yakhton diorite-granodiorite complex [2].

The Yakhton intrusion is confined to an arcuate longitudinal structure, which serves as the axial part of the Khojadyk-Avgaydzhuman zone of intense folding and folding. The main volume of the diorite-granodiorite complex of the Yakhton ore field is occupied by biotite-hornblende granodiorites, which compose the Yakhton intrusion with an outcrop area of about 0.8 km^2 [4, 5]. The magma-controlling point turns out to be the intersection of this longitudinal structure with sublatitudinal (Sevak) and submeridional (central) faults [6, 3]. The faults predetermined large strike-slip movements and flexural bending of the overall plicative structure, which resulted in the creation of a chamber space for the intrusion. Its own impact on the host rocks was expressed in the stable uplift of the anticlinal fold, into the northern wing of which it penetrated, the formation of transverse and fan-shaped folds with NE-trending hinges, as well as the subsidence of the roof along more ancient sublatitudinal and NE faults that determined its frame [7, 2]. Consolidation of the massif was accompanied by further subsidence of the roof rocks with the appearance of tectonically weakened zones and detachments, subparallel to the surface of the intrusion, filled with skarn and quartz veinlets (Fig.-1).

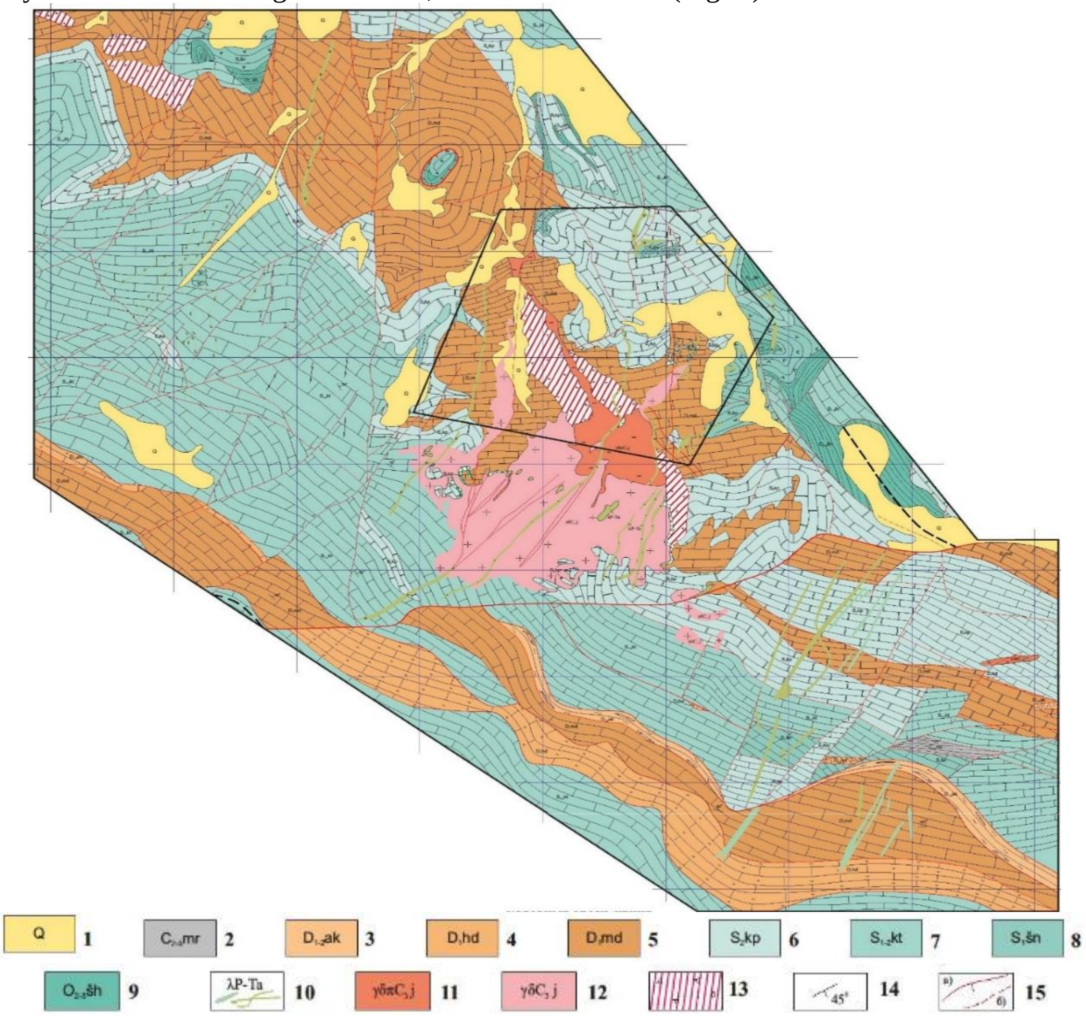

Fig.-1 Schematic geological map of the Yakhton ore field
(compiled using materials from Guzanov M.P., Ushakov V.N., Raskin V.E. and others)

The morphology of the intrusion as a whole approaches multilayer harpolyte. The root part is outlined at the NE angle of the massif along the NE zone of increased permeability and is traced by a steeply dipping wedge-shaped apophysis, dikes of basic rocks, zones of apogranites, an abundance of xenoliths of early phases and a late stock of granodiorite porphyries.

Research Methods and the Received Results

The Yakhton intrusion belongs to a single intrusive complex and was formed in 3 successive phases. Its age is determined as C_3-P_1 (280-228 million years). In the Yakhton intrusion, felsic dikes formed at the end of the formation of the entire complex (Fig.-2).

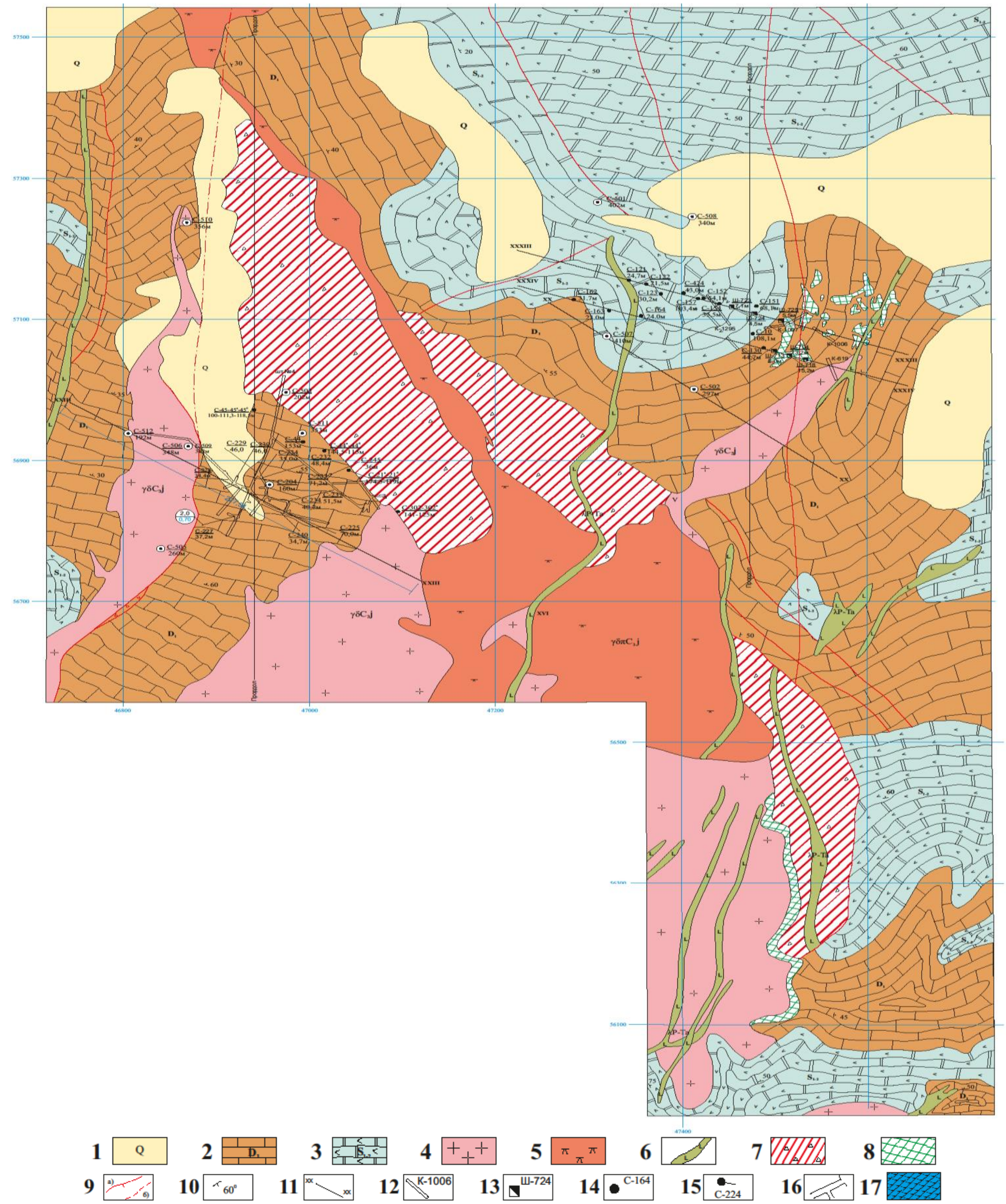

Fig.-2 Schematic geological map of the central part of Yakhtonsky ore field (compiled using materials from Guzanov M.P., Ushakov V.N., Raskin V.E. and others)

The formation of the Yakhton complex occurred in the following chronological sequence: fine-grained weakly porphyritic pyroxene-amphibole-biotite and biotite-amphibole quartz diorites and quartz syenite-diorites; fine-medium-grained porphyritic biotite-amphibole (mesocratic) granodiorites (main intrusive phase); fine- and medium-grained porphyritic amphibole-biotite (leucocratic) granodiorites; biotite granites; vein rocks of the first stage: granites, aplites, pegmatites; vein rocks of the second stage: diorite porphyrites; granodiorite porphyry; granite-porphyry.

Facies varieties of granodiorites are adamellites and porphyritic quartz diorites [8, 9]. The former can be traced in the marginal parts of the massif in an intermittent strip up to 100-150 m wide and wider in the southern contact with the dolomites. In the northern endocontact, adamellites are practically absent. Contacts with granodiorites are gradual over the first tens of meters.

1-Quaternary deposits are undivided. Loams, sandy loams with inclusions of crushed stone; 2-Coal system. The middle-upper sections are the whole. Marguzor Formation. Mudstones, silty mudstones, sandstones, gravelites, shales with blocks, olistoliths and olistoplaks of carbonate and siliceous rocks; 3-Lower-middle sections. Akbasai Formation. Cryptocrystalline cherts, siliceous mudstones, lenses, interlayers, interlayers of slurry-silty, clayey, pelitomorphic, fine-clastic limestones; 4-Lower section. Khodzhakurgan Formation. Limestones are crinoid-detrital, sludge-silty, clayey, nodules, nodules, lenses, chert interlayers; 5-Lower section. Madmon Formation. The limestones are massive and coarsely layered, aphanitic in the base - nodules, clots, and in the roof - layers and lenses of flints; 6-Upper section. Kupruk Formation. Limestones with dolomite inclusions, dolomitic and dolomitic limestones, calcareous dolomites; 7-Lower-upper sections. Kuturak Formation. The dolomites are massive and coarsely layered, in the middle of the section there are ribbon dolomites, below there are lenses and layers of dolomite conglomerate-breccia; 8-Lower section. Shingskaya suite. Thin-layered and lenticular-layered dolomite limestones with lenses of calcareous shales, tuffites, quartz sandstones and gravelites, volcanics and tuffs of dacite-liparite composition; 9-Ordovician system. Middle-upper sections. Shakhriomon formation. Mica-quartz-feldspathic sandstones and siltstones, silty mudstones, lenses of gravelites, andesitic porphyrites and their tuffs; 10-Almalysay gabbro-monzonite-syenite complex; 11-Kersantites, spessartites, pyroxene vogesites; 12-Yakhtonsky quartz-diorite-granodiorite complex; 13-Fluid-explosive breccias; 14-Elements of rock occurrence; 15-Disruptive violations: traced (a); expected (b).

1-Quaternary sediments, undivided Loams, sandy loams with inclusions of crushed stone;| 2-Devonian system. Lower section. Limestones are massive and coarsely layered, aphanitic, with layers and lenses of chert in the roof; 3-Silurian system. Lower-upper sections. The Shingskaya, Kuturakskaya, Kuprukskaya formations are united. Dolomite massive and coarsely layered, thin-layered and lenticularly layered dolomite limestones with lenses of calcareous shales, tuffites, quartz sandstones, gravelites, tuff-dacite-liparite composition; 4-Medium-grained biotite-horn-monk granodiorites; 5- Porphyry granodiorite; 6-Kersantites; 7-Fluid-explosive breccias; 8-Skarns; 9-Razive disturbances: traced (a); expected (b); 10-Elements of rock occurrence; 11-Exploration lines and their numbers; 12-Ditches; 13-Pitholes; 14-Wells (vertical); 15-Wells (horizontal); 16-Previously completed mine workings; 17-Rul bodies.

Porphyritic quartz diorites are rarely found in direct endocontact, more often in small apophyses.

Gabbro is present in diorites and granodiorites in the form of xenoliths measuring a few tens of cm, diorites in the form of larger blocks up to 25 m in granodiorites. Dioritic porphyrites - vein derivatives of early phases - are noted in granodiorites in the form of a pulled out bead-shaped dike of meridional strike. Granites are present in dikes of basic rocks in the form of xenoliths, which gave the basis to A.I. Dautov (1974) to distinguish the granite phase at depth. Leucogranites and aplites are developed mainly in the endocontact parts of the intrusion in the form of dikes and veins with a thickness of 0.1-0.3 m and a length of up to 30-50 m and predominantly of NE strike. Pegmatites are rare, found in endocontacts in the form of veins up to 0.5 m thick and up to 10 m long. Granodiorite porphyries form a stock in the north-eastern corner of the granodiorite massif measuring 300 x 400 m, as well as dikes in the NE and sub-latitudinal directions with a thickness of 15-40 m. The dip of the stock contacts is steep towards the host rocks, dikes - predominantly northern at angles of 60-80° [10]. In most cases, these rocks are replete with angular and melted xenoliths of earlier rocks, mainly granodiorites, but also leucogranites, aplites, contact hornfels, magnesian and mineralized calcareous skarns. Sometimes granodiorite porphyries serve as cement for explosive breccias, the volume of fragments in which exceeds 70-80 %.

Quartz diorites and syenite-diorites are found in the form of xenoliths, less often small independent bodies. Mesocratic and leucocratic granodiorites have a similar mineral composition.

The material composition of the complex is characterized by a general increased alkalinity due to the increased potassium content, which naturally increases from melanocratic to leucocratic phases. Petrographic type for intrusive members is biotite-amphibole, plagioclase is microcline; petrochemical type – sodium-potassium.

Plagioclase is sharply zoned (nos. 25-45), iron content of amphibole 55, biotite 59 (Dautov, 1974). Accessory specialization – scheelite-zircon-sphene-apatite. In the composition of the early phases, in addition to typical diorites, varieties with increased alkalinity (monzodiorites) are noted. The main phase is characterized by strong compositional heterogeneity with widely varying contents of K-feldspar, quartz and mafic minerals. Adamellites are characterized by a high content of K-feldspar and quartz, and porphyritic quartz diorites are characterized by increased melanocraticity and basicity. The textures of the rocks are massive, rarely slightly porphyritic, the structures are fine- and medium-grained.

The range of structures and composition of granodiorite porphyries is diverse - from coarse porphyritic with micrograined groundmass (at absolute heights of 2000-2300 m) to well-crystallized porphyry-like varieties (1400-1600 m) with varying basicity and melanocratic content depending on the degree of contamination with alien inclusions [12]. The dike series of rocks inherits the increased alkalinity of the complex as a whole. Age groups of dikes are characterized by a consistent increase in melanocratic content with rejuvenation, up to the appearance of olivine in the youngest dikes.

The Upper Paleozoic Yakhton collisional diorite-granodiorite complex is accompanied by a substantially “crustal” set of xenoliths [13, 14]. Inclusions in the granodiorites of the main phase of the Yakhton complex are represented mainly by melanocratic autoliths (gabbro, diorites), which indicate the composition of the early phases of the formation of the intrusion, and the presence of xenoliths of quartzites, sandstones, siltstones, and marbles indicates the autochthonous nature of the granodiorites of the Yakhton intrusion.

Yakhton medium-grained and porphyritic rocks crystallized in hypabyssal conditions at a relatively high temperature (600-700°C), which is due to:

- medium- and fine-grained structure of rocks even in the main phase of the intrusion (the rate of crystallization at relatively high temperatures and hypabyssal depths determined the fine-grained and even porphyritic structure of rocks);

- relatively high basicity of plagioclases with pronounced zoning;

- weakly and locally expressed recrystallization and potassium feldspar porphyroblastosis in diorites and quartz diorites of phase I.

The entire set of petrographic features indicates that the rocks of the Yakhton intrusion belong to a single igneous complex, the formation of which took place in hypabyssal conditions.

Porphyritic quartz diorites are rarely found in direct endocontact, more often in small apophyses.

The Upper Paleozoic Yakhton collisional diorite-granodiorite complex is accompanied by a substantially “crustal” set of xenoliths. Inclusions in the granodiorites of the main phase of the Yakhton complex are represented mainly by melanocratic autoliths (gabbro, diorites), which indicate the composition of the early phases of the formation of the intrusion, and the presence of xenoliths of quartzites, sandstones, siltstones, and marbles indicates the autochthonous nature of the granodiorites of the Yakhton intrusion.

Post-collision (intraplate) igneous formations are characterized by a mantle set of inclusions and xenoliths.

South Tien Shan basanite complex (camptonite-monchikite association). Khojagaspinsky alkali-basalt-(basanite)-trachypho-nolite complex.

Breccias are represented by angular and isometric fragments of dark gray dolomites, gray and white marbles, hornfels and granodiorites. The size of the fragments ranges from fractions of a cm to 5-10 m in diameter. The volume of debris varies from 10-15% to 70-80%. Breccia cement is sometimes served by granodiorite porphyries. The formation of breccia is probably associated with a powerful gas release after the formation of a granodiorite intrusion, caused by the entry of deep-seated magmas into conditions at shallow depths, at which the magma acquires the properties of a superheated liquid supersaturated with volatile components.

The development of explosive bodies, the formation of which is caused by explosive-hydrothermal activity, is associated with the explosive impact of gas-liquid fluids separating from the magma chamber. Explosive phenomena develop due to volatile components accumulating in the apical parts of the magma chamber, due to which high internal fluid pressure is created.

FES could have been formed during the crystallization of intrusive rocks during the spontaneous passage of volatiles through weakened zones and their caisson-explosive rupture while part of the magma had not yet undergone consolidation. In such a case, the fluid-explosive breccia is the frontal part of the magma column. Fluid-explosive breccias are developed in three areas: central, northern and northwestern, generally tracing a longitudinal tectonically weakened zone. The breccias are most fully manifested in the central part of the deposit, where they form two separate lens-shaped bodies with a length of 650 m and a width of 100 m to 250 m (Fig.-3). The eastern body of fluid-explosive breccias has a length of 400 m with a width of 30 m to 80 m and clearly marks the submeridional tectonic zone.

In the northern and northwestern areas, fluid-explosive breccias form a group of isometric bodies with a diameter of 100 m to 200 m, apparently confined to focal structures.

The formation of breccia is probably associated with a powerful gas release after the formation of a granodiorite intrusion, which caused fragmentation of the overlying volcanic-terrigenous-carbonate sequence. In the breccia mass there are drop-shaped fragments of granodiorites, probably ejected from the viscous, weakly frozen mass of the intrusion, indicating a slight gap in time between the formation of the main phase of the intrusion and the formation of breccia.

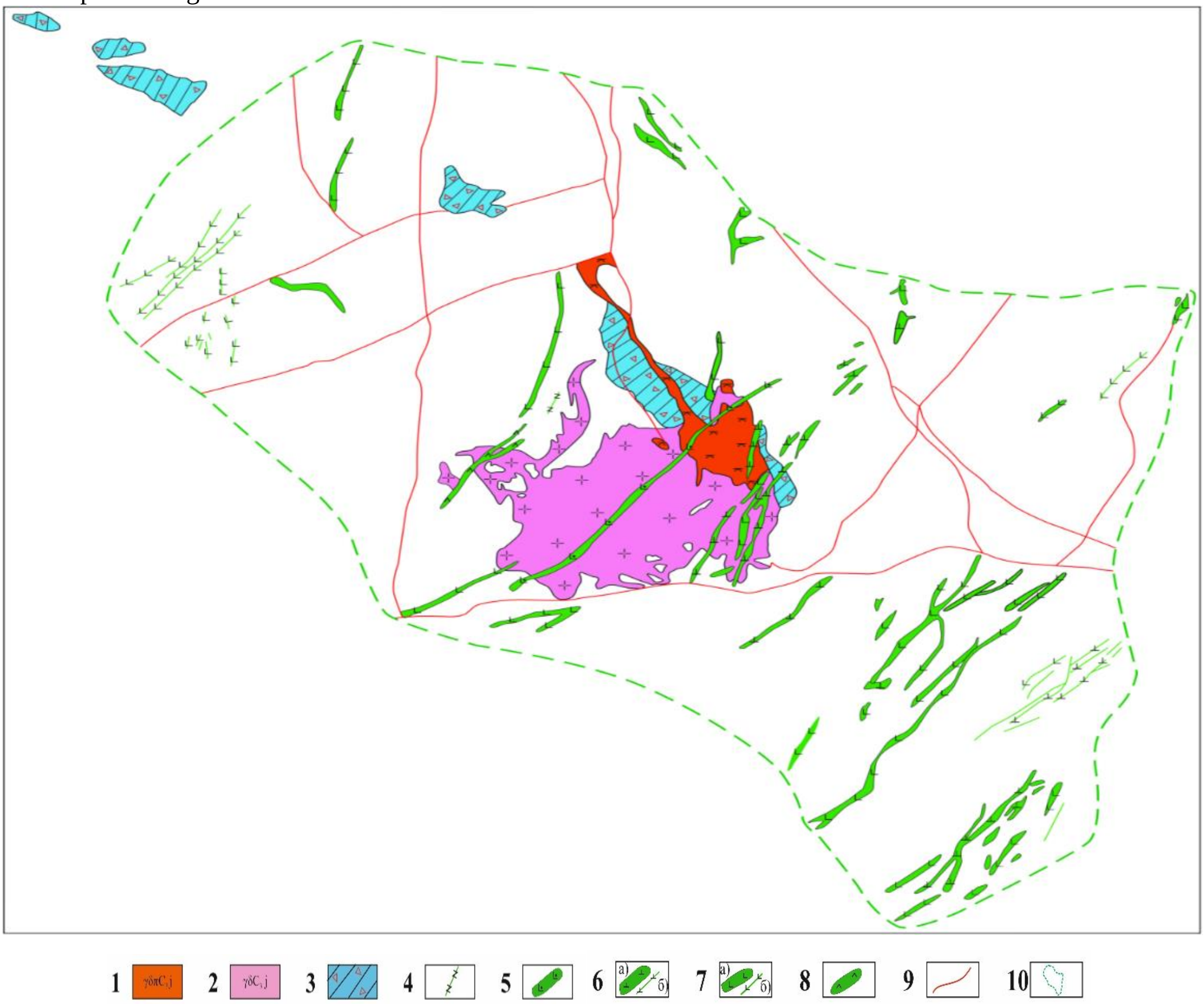

Fig.-3. Scheme of distribution of granitoids, lamprophyres, silk basaltoids and fluid explosive breccias in the Yakhton ore field *(compiled using materials from Guzanov M.P., Ushakov V.N., Raskin V.E. and others)*

1-Granodiorite-porphyry; 2-Granodiorites are biotite-amphibole, porphyritic, fine-medium-grained; 3-Fluid-explosive breccias; 4-Camptonites; 5-Pyroxene vogesites; 6-Spessartites: a) on scale, b) out of scale; 7-Kersantites: a) on scale, b) out of scale; 8-Dioritic porphyrites; 9-Rupture violations; 10-Conditional boundary of the distribution area of dike formations.

The breccia matrix (cement) is represented by magnesian skarns, which include forsterite, chondrodite, spinel and diopside. Magnesian skarns inside individual blocks of dolomite rocks also form thin veinlets that fill differently oriented cracks, characterizing the injection nature of the crack filling. Magnesian skarns are overlain by later mineralization, represented by ludwigite, fluorite, magnetite, and later ore mineralization (pyrrhotite, pyrite, chalcopyrite).

The different stages of formation of the focal structure are emphasized both by the igneous formations themselves, reflecting different levels of processes occurring in connection with the transformation of the continental crust, and by two groups of xenoliths and inclusions accompanying the formation of magmatites of the collisional and intraplate stages.

The shallow depth of the intrusion and small size determined an insignificant degree of thermal processing and a fairly clear zoning, expressed in the brightening and recrystallization of carbonate rocks and a change in associations in terrigenous rocks. The intense mechanical impact of the intrusion during the creation of the chamber space caused intense deformation of the exocontact and the subsequent diversity of morphotypes of skarn ore bodies: near-contact skarn zones, vein and stockwork bodies, interstratal deposits.

Closed explosions often accompany rapidly ongoing processes of differentiation of ore-bearing magmas and are typical for shallow magmatic bodies. Features of the morphology and internal composition of fluid-explosive structures (FES) show that they arise not as a result of powerful single-act gas explosions, but in the process of relatively long-acting fluidization.

The intrusive frame was created by latitudinal faults that define the northern dip of the southern and northern contacts at angles of 40-70°, and a system of NE and submeridional faults healed by mafic dikes in the east and the Western apophysis in the west, defining steep to reverse eastern and western contacts. The roof and walls are complicated by numerous interstratal and interformational gently sloping and cutting steeply dipping apophyses, common in the host rocks at a distance of the former up to 50 m, the latter up to 200 m from the massif. The structure of the roof is wavy with log-like depressions and wave-like uplifts, oriented both along the dip and along the strike of the intrusive surface. The facies varieties of granodiorites are adamellites and porphyritic quartz diorites. The first can be traced in the marginal parts of the massif in an intermittent strip up to 100-150 m wide and wider in the southern contact with the dolomites. In the northern endocontact, adamellites are practically absent. Contacts with granodiorites are gradual over the first tens of meters.

Conclusion

The area of the Yakhton ore field is determined by the spatial combination of products of granitoid, lamprophyre and alkali-basaltic magmatism.

The values of the magnesium coefficients Mg/(Mg+Fe) and Ni/Co ratios in the least differentiated rocks of the complexes suggest that the original magma is directly mantle melts.

Considering the identified complexes in a more general form, it can be supposed that the formation of camptonites of the South Tien Shan complex is associated with the iron-titanium type of magmas characteristic of "hot spots" and rift zones [15].

In contrast, the camptonites and basaltoids of the Kyzylalma and Khojagaspin complexes are formed from primary magmas with low titanium and total iron contents, but significantly enriched in chromium. The formation of such magmatic series is usually associated with the supply of melts along deep fault zones from the lower levels of the mantle during the period of tectonic-magmatic activation [16].

The genetic nature of fluid-explosive breccias can be interpreted as a hidden part explosion of fluid-saturated magma of acidic composition. The formation of a significant amount of fragments and the gigantic size of some of them (several m^3) is probably defined by the significant separation of fluid components from the acidic magma, the accumulation of which leads to an explosive effect with catastrophic explosions and the release of large amounts of fragmentary material and magma particles.

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