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TECTONICS AND MINERAGENY OF THE GARABAGH AND EAST ZANGAZUR (SOUTHEASTERN END OF THE LESSER CAUCASUS, AZERBAIJAN)

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Summary. The paper is devoted to tectonics, as well as formation and distribution regularities of various types of minerals within the Garabagh and East Zangazur economic regions (components of the Garabagh historical-geographical region of Azerbaijan), territorially confined to the southeastern margin of the Lesser Caucasus mountain-fold system. It is shown that tectonically the region belongs to the southeastern segment of the Artvin-Garabagh uplift (megazone), consisting of Lok-Garabagh, Goycha-Hakari and Gafan secondary structural zones and plunging northeast and southeastwards under recent continental molasses of the Middle Kur and Lower Araz superimposed depressions. It is noted that various types of metallic (ore) and non-metallic minerals are developed in the region. Minerageny of the metallic minerals characterizes geological regularities of the formation and distribution of various types of the ore minerals within the structure of metallogenic zones (corresponding to the same-named tectonic zones of the Artvin-Garabagh megazone) and ore districts of the region. Metallogenic zones were distinguished on the basis of tectonic-geodynamic zoning, geological evolution history and genetic types of the known ore deposits, and the ore bearing potential of separate geological formations within the Lesser Caucasus system. Minerageny of the non-metallic mineral deposits reflects the revealed placement and occurrence regularities of various non-metallic raw materials during the certain periods of geological evolution. The potential for increasing the list of industrially significant deposits is determined by numerous manifestations of ore and non-metallic mineral raw materials.

Introduction

The Garabagh and East Zangazur economic regions territorially related to the Garabagh historical-geographical region (Garabagh HGR) – one of the most resource-rich territories of Azerbaijan. The region covers the southeastern part of the Lesser Caucasus and the adjacent sloping plains of the Kura-Araz lowland south of the Tartar River. Territory of the region is part of the Pyrenean-Lesser Caucasus branch of the Alpine-Himalayan mobile-fold belt. Region covers the southeastern segment of the Artvin-Garabagh megazone of the Lesser Caucasus mountain-fold system, and the adjoining part of the Middle Kur depression (Геология Азербайджана. Том IV …, 2005; Azerbaycanın geologiyası. Cild I, 2015; Хаин, 1984, 2001). The border between these two systems is formed by the Pre-Lesser Caucasus deep fault which is buried under recent formations. The region is characterized by tectonic heterogeneity pronounced in complex correlation between its' structural units with different lithology-stratigraphic sections, diverse type of deformations and geological evolution background (Fig. 1).

Modern structure of the Lesser Caucasus was formed at the Alpine stage of tectogenesis within the spatial limits covering the northern edge of the South Azerbaijan segment of the Central Iranian microcontinent and the southern edge of the South Caucasus continental microplate (Геология Азербайджана. Том IV …, 2005; Azerbaycanın geologiyası. Cild I, 2015). The latter is a fragment of the Gondvana passive margin that was torn from the mainland during the Paleotethys opening and attached to Eurasia during movements of the tectogenesis of Hercynian cycle. In the tectogenesis of Alpine cycle the South Caucasus microplate looked like an island arc system (with a corresponding set of formations and mineragenic specialization), that separated the Greater Caucasus marginal sea from the Lesser Caucasus arm of the Mesotethys. In the contemporary structure, the plate central section corresponds to the Kur megadepression (intermountain

trough), where as its lateral sections, composed of volcanogenic and sedimentary complexes of the Jurassic, Cretaceous and Cenozoic rocks, participate in the generation of fold-mountain structures of the Greater (Kakheti-Vandam-Gobustan megazone) and the Lesser (Artvin-Garabagh megazone) Caucasus (Геология Азербайджана. Том IV, 2005; Azerbaycanın geologiyası. Cild I, 2015).

The main structural elements of the Artvin-Garabagh megazone are Lok-Qarabagh, Goycha-Hakari and Gafan secondary structural zones, built by the Mesozoic and partly Paleogene volcano-sedimentary and sedimentary rocks, and complicated by folding and rupture dislocations of the different shapes and genesis (Геология Азербайджана. Том IV, 2005; Azerbaycanın geologiyası. Cild I, 2015; Shikhalibeyli, 1966, 1994). On the southeastern immersion of the megazone, the Mesozoic structures plunge under the Eopleistocene-Holocene molasses of the Lower Araz superimposed depression. On the southwestern wing these structures are overlapped by the Eocene-Holocene volcanics of Kalbajar superimposed trough.

Complex and diverse geology-tectonic structure of the Earth's crust in the region preconditioned the formation of a wide range of both endogenous and exogenous mineral deposits (Геология Азербайджана. Том VI, 2005; Azerbaycanın geologiyası. Cild III, 2015; Минерально-сырьевые ресурсы Азербайджана, 2005; Мустафаев, 2002).

The study of the petrographic, mineralogical and geochemical features of the ore-bearing strata and the carried out tectonic-geodynamic reconstructions made it possible to carry out a structural-mineragenic zoning of the region with the identification of mineragenic taxa corresponding to the tectonic zones of the same name of various orders.

Tectonics

As stated above, the tectonic structure of the Garabagh HGR involves the Artvin-Garabagh and Middle Kur megazones (Геология Азербайджана. Том IV, 2005; Azerbaycanın geologiyası. Cild I, 2015).

The Artvin-Garabagh megazone represents a structural uplift on the natural eastern extension of the East Pontian (Artvin) uplift in Turkey. Within the boundaries of the region, the megazone is represented by its' southeastern termination covering the axial line, as well as the northeastern, southeastern and southwestern slopes of the Lesser Caucasus mountains. The northeastern wing of the megazone is separated from the Middle Kur megazone by the Pre-Lesser Caucasus deep fault buried under the Pliocene-Pleistocene molasses. The southwestern border is formed by the Girratagh deep fault, along which the Paleozoic complex of the Araz block within the Dinar-Zond branch of the Alpine-Himalayan belt is thrusted over the Upper Jurassic-Neocomian complex of the Artvin-Garabagh megazone.

Fig. 1. Tectonic zoning of the Garabagh HGR

The main structural elements of the megazone are the Lok-Garabagh, Goycha-Hakari and Gafan secondary structural zones, built by the Mesozoic and partly Paleogene volcano-sedimentary and sedimentary rocks, and complicated by folding and rupture dislocations of the different shapes and genesis. On the southeastern immersion of the megazone, the Mesozoic structures plunge under the Eopleistocene-Holocene molasses of the Lower Araz superimposed depression. On the southeastern wing these structures are overlapped by the Eocene-Holocene volcanics of the Kalbajar superimposed trough (Геология Азербайджана. Том IV, 2005; Azerbaycanın geologiyası. Cild I, 2015; Шихалибейли, 1966, 1994).

Therefore, modern geological structure of the megazone is represented by the following secondary structural zones, from the northeast to the southeast:

1. The Lok-Garabagh zone represents a complexly structured folded block system, composed of an echelon of anticlinal and synclinal structures. The composition of the zone includes the Mesozoic and partly Paleogene volcanic, volcano-sedimentary and sedimentary material complexes, as well as differently composed intrusive formations. The northeastern flank of the zone is concealed under the Pliocene-Holocene molasses of the Middle Kur depression. The southwestern flank is bordered by the Goycha-Hakari zone along the system of large upthrusts and overthrusts.

2. The Goycha-Hakari zone is built by the Jurassic, Cretaceous and Paleocene-Eocene sedimentary-volcanic series gathered in compressed folds. The structure of the zone covers the Toraghaychay and Saribaba troughs located en echelon and conjugated along a tectonic contact. The southwestern border of the zone is determined by the Lachin-Bashlibel deep fault. The zone includes the southeastern segment of Amasya-Goycha-Hakari allochthonous ophiolite belt represented by a pack of tectonic nappes and olistostromes. The nappes had been formed between the Late Cenomanian and the Eocene. Joint structural plan of autochthonous and allochthonous complexes is leveled by a neoautochthonous cover formed by the Upper Santonian-Eocene sedimentary-volcanogenic strata (Геология Азербайджана. Том IV, 2005; Azerbaycanın geologiyası. Cild I, 2015; Hasanov, 1985).

3. The Gafan zone is built by sedimentary-volcanic and volcanic complexes of the Jurassic, Cretaceous and Paleogene. The northeastern flank of the zone is complicated by the anticlinal highs of Lachin and Kohna Taghlar, separated from each other by Chaylaggala synclinal stripe. The central place in the zone is occupied by the Hochaz trough overlapped by the Eocene-Holocene complex of the Kalbajar superimposed trough in the northwest, and plunging under the Pleistocene continental molasses of the Lower Araz trough in the southeast. The southwestern flank of the zone is represented by Gafan-Basitchay dome elevation.

4. The Kalbajar zone covers the upper course basins of Tartar and Hakari rivers. It corresponds to the eastern segment of Goycha-Ordubad rift graben built by the Paleocene-Holocene volcano-sedimentary and volcanic complexes. The zone forms an Eocene-Pliocene superimposed depression that gently levels the structural plan of the western extension of the Gafan and Goycha-Hakari structural zones.

5. The Lower Araz zone represents a transverse superimposed trough extending along the riverbed of Araz, starting from the Mighri canyon till joining with the Pre-Lesser Caucasus trough. The sedimentary rocks of the zone are represented by the Eopleistocene-Quaternary molasses. The molasses overlap the Jurassic, Cretaceous and Paleogene-Eocene stratas of the first three structural zones, all plunging under the Lower Araz zone with azimuthal unconformity from the northwest.

The Middle Kur meqazone corresponds to an intermountain depression, occupies the central place in the structure of the Kur superimposed depression, being its' largest and the most complexly structured component. The megazone consists of secondary structural zones that are buried under gentle Pliocene-Holocene molasses, built by dislocated volcanic and sedimentary series of the Meso-Cenozoic (Геология Азербайджана. Том IV, 2005; Azerbaycanın geologiyası. Cild I, 2015).

1. The Pre-Lesser Caucasus zone corresponds to the northeastern flank of the Artvin-Garabagh megazone, downcast along the Pre-Lesser Caucasus fault that is buried under recent deposits, and built by the Mesozoic volcano-sedimentary and Paleogene-Quaternary mainly molasses formations. With gentle and smooth bedding of the Pliocene-Quaternary deposits observed, the underlying Paleogene-Mesozoic stratas are gathered in a system of brachiform folds.

2. The Yevlakh-Aghjabadi zone represents a deep trough formed over the formations of the Mesozoic, Paleogene and partly Miocene rocks complicated by local uplifts and gently overlapped by the Pliocene-Quaternary molasses. The Alpine cover thickness in the most immersed part of the zone reaches and sometimes even exceeds 16 km. The trough is bordered by the Imishli-Goychay buried deep fault from the northeast, and by the Southern Kur buried deep fault from the southwest. İn the northeast (outside Garabagh) the zone along the İmishli-Göychay deep fault is separated from the Kurdamir-Saatli zone (buried Mesozoic uplift), which an eroded cover of the Cretaceous series plunges under the series of the Upper Miocene

– Holocene (depth -3.0-3.5 km) and pre-Jurassic basement (depth -9-10 km).

Minerageny of metallic minerals

Metallic minerals of the zone are represented by deposits of chrome, copper, polymetals, gold, mercury and antimony. Along with basic metals, ore bodies of these deposits contain silver, molybdenum, nickel, bismuth, tellurium, and other valuable metals (Геология Азербайджана. Том VI, 2005; Azerbaycanın geologiyası. Cild III; Ismail-Zadeh, Kangarli, 2012; Минерально-сырьевые ресурсы Азербайджана, 2005; Мустафаев, 2002; Шихалибейли, 1994). The most significant reserves of the region are the gold bearing deposits.

Minerageny of metallic minerals characterizes geological regularities of the formation and distribution of various types of the ore minerals within the structure of metallogenic zones (corresponding to the same-named tectonic zones of the Artvin-Garabagh megazone) and ore districts of the region. Metallogenic zones were distinguished on the basis of tectonic-geodynamic zoning, geological evolution history and genetic types of the known ore deposits, and the ore bearing potential of separate geological formations within the Lesser Caucasus system (Fig. 2).

The Lok-Garabagh metallogenic zone is characterized by a mineralization associated with the Middle Jurassic quartz plagioporphyres, plagiogranites and andesites, as well as with the Upper Jurassic-Lower Cretaceous granitoids. The main mineralization types are distributed as follows: 1) plagioporphyres – pyrite, copper-pyrite and gold-copper-pyrite; 2) plagiogranite massifs – copper-porphyry, complicated by tectonic faults; 3) andesites – copper-pyrite; and 4) granitoids – magnetite, cobalt, alunite, vein-polymetallic, copper-porphyry. Mineralization is represented by the deposits and occurrences spread within the ore districts of Mehmana and partly South Garabagh.

The Mehmana ore district is located on the southeastern wing of the Tartar-Injachay faulting zone. It covers the interfluve of Tartar and Khachinchay rivers, where a number of deposits and occurrences of copper-porphyry, copper-pyrite, gold-copper-pyrite and polymetallic (lead-zinc) ore formations had been developed. Derivatives of the copper-porphyry ore formation are grouped within the Demirli and Khachinchay ore fields. The Demirli ore field consists of the Demirli deposit and the occurrences of Aghdara, Yukhari Janyatag, Ashagi Gulyatag, Boyahmadli, Khatinbeyli, etc. The Khachinchay ore field includes the Khachinchay, Galaychilar, Yeddigyrkhman and several other different-size occurrences. Both ore fields are located on the western endo- and exocontact strip of the Mehmana granitoid intrusive of the Upper Jurassic-Lower Cretaceous age.

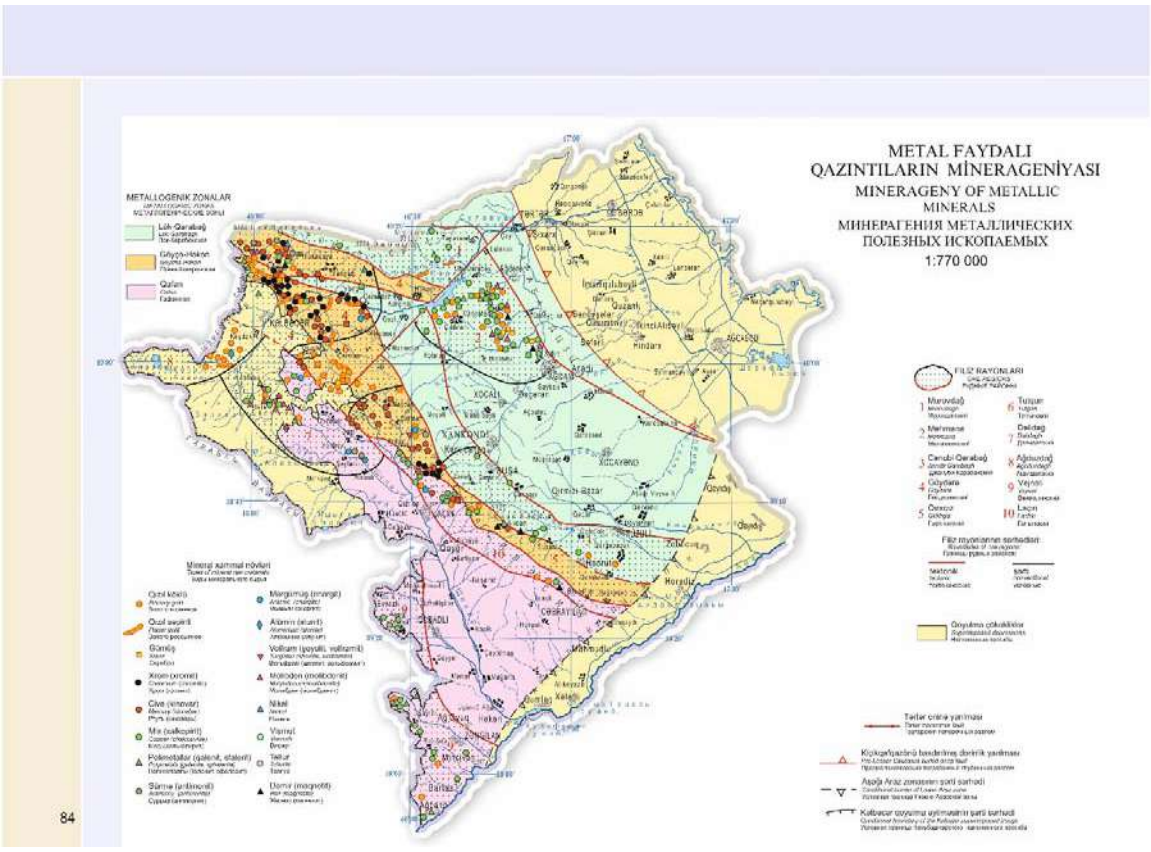

Fig. 2. Minerageny of metallic minerals of the Garabagh HGR

Additionally, there are several bodies of copper-pyrite ore formation observed at the same endo- and exocontact and at some distance from the intrusive among the Bathonian volcanics. Pyrite-chalcopyrite mineralization of the impregnated-veinlet type is represented by several occurrences, including Yukhari Gulyatag, Khazinadagh, Chullu, Demirli, Ashaghi Janyatag, Gazanchi and Vankli. The gold-copper-pyrite ore formation is represented by the Gizilbulag ore field corresponding to an ancient volcanic center located on the right shore of the Sarsang water reservoir. The ore field consists of Gizilbulag copper-gold deposit and a number of occurrences, including Heyvali, Almali, Anbarchay, Girmizitepe, Garbi Gizilbulag, etc. The polymetallic (lead-zinc) ore formation consists of Mehmana deposit and Chiragli occurrence localized within the structure of the Mehmana ore field in the interfluve of Tartar and Gabartichay.

The South Garabagh ore district is confined to the southeastern termination of the Lok-Garabagh metallogenic zone. Structurally it corresponds to the Garabagh uplift. In the district, there are several minor copper-pyrite deposits (Boyuk Taghlar, Argunesh, Bina, etc.) having no commercial value but important as ore prospecting criteria. The ore mineralization is usually confined to the zone of tectonic dislocations and dyke complexes and represented by native copper, chalcopyrite, chalcosine, cuprite, pyrite, sphalerite and galenite.

Mineralization of the **Goycha-Hakari metallogenic zone** is associated with ophiolite association, Upper Cretaceous limestones, Eocene granitoid intrusives and Miocene-Pliocene acidic volcanics. The ophiolite association is represented by chromite and scheelite mineralization, while the other complexes – by the occurrences of mercury, antimony, gold and arsenic. The part of the province that covers the territory of the Garabagh nature zone, is divided into Goydara, Girkhgiz and Tutgun ore districts.

The Goydara ore district is located in the middle course of Tartar, covering an area between Shargi Goycha range and the river valley of Tutgunchay. The district is represented by the deposits and occurrences of chromite, mercury (arsenic-antimony-mercury), gold (gold-polysulphide-quartz) and molybdenum-tungsten) ore formations. Genetically related to widely developed ultrabasites, the chromite ore formation forms Goydara and Kazimbina group of chromite deposits and occurrences. The mercury (arsenic-antimony-mercury) formation is represented by more than 40 mercury and sometimes complex mercury-antimony deposits, occurrences and mineralization fields. The ore manifestations are either grouped within the structure of Levchay, Guneypaya, Gamishli, Soyudlu, Gilinjli, Agyatag ore fields, or represented as separate objects. Commercially valuable manifestations identified by geological exploration reconnaissance activities are Agyatag, Eyvan, Levchay, Shorbulag, Aggaya, Arkhajdere, Gamishli and Zulfugarli mercury deposits, as well as multiple occurrences, including Garbi and Yeni Lev, Garagaya, Shirran, Yelizgol, Seyidler, Atdashi, Yalkend, Garbi Gamishli, Tal, Bashkend, Milli, Saridash, Arkhajdere, Goyukguney, Sarigilinj, Abdullaushaghi, Hajidere, Duzyurd, Gayali, Gushyuvasi, Kiliseli, Otaglar, Chapar, Bashlibel, etc. Gold (gold-polysulphide-quartz) ore formation is concentrated in the Soyudlu ore cluster detected on the northwestern flank of the ore district. The formation is represented by the Zod deposit and more than 20 occurrences, including Gonur, Goydara, Damirchidam, Istibulag, Alagollar, Nariman, Garbi Palidli, Soyudlu, etc. Quartz-scheelite subformation is observed in the quartzy veinlets of the listvenite zones, where it is detected together with pyrite, stibnite, bismuthinite and cinnabar. In the ore district there are several scheelite occurrences, including Goydara, Gonur, Saridash, etc.

The Girkhgiz ore district covers part of the Garabagh range between watershed peaks of Chilgaz and Saribaba. The district is characterized by chromite, mercury and partly arsenic mineralization. The chromite ore formation is represented by Ipak group of occurrences (Ashaghi Ipak, Orta Ipak I and II, Khalifali, Gozlu, etc.) confined to serpentized peridotites that are exposed in the southeastern part of the district in the upper courses of Khalifalichay and Ipakchay rivers. The mercury (arsenic-antimony-mercury) ore formation is represented by Chilgazchay and Narzanli deposits, as well as several occurrences (Nagdalichay, Shamkend, Erikli, Garaboylu, Garibli, Dumanli, Ipak, Bozguney, Shimshak, Elyeri, Gorchu, etc.) and mineralization fields. Forming part of the formation and confined to the rupture dislocation zones, arsenic mineralization is represented by Deveboynu and Goshasu occurrences detected in the upper course basin of Hakari River.

The Tutgun ore district is located on the southwestern wing of the Goycha-Hakari metallogenic province. Characterized by the gold-quartz mineralization, it covers the upper course basin of Tutgunchay River. Within the ore district boundaries, there are more than 100 hydrothermally altered zones with different gold content, all distributed over several gold-bearing areas in the following ratio: Giziliten – 40, Agzibir – 20, Gazikhanli – 30, Galaboynu – 11, etc.

The Gafan metallogenic zone is characterized by copper-molybdenum, copper-pyrite, gold-quartz and partly tungsten and alunite mineralization. In the territory of the Garabagh nature zone, the province is

divided into Dalidagh, Aghduzdagh and Vejnali ore districts, as well as Lachin perspective ore bearing zone.

The Dalidagh ore district covers the upper courses of the rivers of Tartar and partly Hochazsu (right-bank tributary of Hakari). The district is characterized by the development of secondary copper-molybdenum and polymetallic, and partly molybdenum-tungsten ore formations. Copper-molybdenum formation is represented by the ore containing quartz veins and hydrothermally altered rock zones located within an endocontact of the Dalidagh granitoid intrusive in the northwestern and partly southeastern parts of the district. There are Teymuruchandagh deposit and Baghirsag, Sultanheydar, Gatardash, Dalidagh-Aghchay occurrences of molybdenum-tungsten ores in this territory. The polymetallic ore formations are in most cases confined to the exocontact and apical parts of the Dalidagh interusive, where they are represented by Baghirsag, Dalidagh, Garanlig and several other occurrences localized among skarnified carbonate and volcano-sedimentary series. The molybdenum-tungsten ore formation is represented by scheelite-tungsten mineralization. In total within the ore district boundaries, there are 81 tungsten containing quartz veins, 37 of which have been thoroughly studied and assessed.

The Aghduzdagh ore district is situated in the northwestern limb of the Kalbajar superimposed trough, covering the slopes of Shargi Goycha range on the left riverbank of Tartar and represented by secondary gold-quartz and alunite ore formations. The gold-quartz formation is developed relative to Keytidagh caldera and a controlling submeridional fault zone. The structure of the formation contains the Aghduzdagh deposit as well as Shirvan, Keytidagh, Zaylik, Vagif, Sabir, Fuzuli and several other occurrences of gold bearing ores. Alunite ore formation is represented by non-commercial Zar-Zaylik occurrence situated in the northeastern vicinity of Keytidagh caldera.

The Vejnali ore district corresponds to the southern segment of the Gafan-Basitchay uplift which covers the interfluve of Bargushad and Araz rivers. The geological structure of the district is constituted by the Middle-Upper Jurassic and Lower Cretaceous volcanic and volcano-sedimentary rocks protruded by hypabyssal intrusive of granodiorites, gabbros, diorites and quartz diorites. Presence of the latter formations had preconditioned development of the gold-polysulphide-quartz and copper-pyrite ore formations. The gold-polysulphide-quartz formation is represented by the Vejnali deposit and several occurrences located on the southwestern wing of the district. The copper-pyrite formation includes Aghkend occurrence located in the north on the right riverbank of Bargushadchay, as well as Garadere-Aghband group of copper ore occurrences detected in the district's central segment.

The Lachin perspective ore district corresponds to the same-named structural high built by the Middle-Upper Jurassic and Lower Creetaceous volcanic and volcano-sedimentary rocks and protruded by granitoid intrusives. There are several mineralization spots and minor occurrences of sulphur-copper-pyrite, arsenic, gold and mercury mineralization within the district boundaries.

Minerageny of non-metallic minerals

Non-metallic mineral deposits of the Garabagh nature zone are represented by mining, chemical and refractory raw materials, semiprecious and ornamental stones, as well as construction materials, including saw, facing and rubble stones, lime and cement, binding brick production materials, as well as fillers for concrete and the road construction materials. Total reserves of these minerals amount to tens of millions of cubic meters (Геология Азербайджана. Том VI, 2005; Azerbaycanın geologiyası. Cild III, 2015; Минерально-сырьевые ресурсы Азербайджана, 2005; Shikhalibeyli, 1994).

Minerageny of the non-metallic mineral deposits reflects the revealed placement and occurrence regularities of various non-metallic raw materials during the certain periods of geological evolution (Figs. 3, 4). Within the region boundaries, there are two minerogenic taxons corresponding to the same-named tectonic zones in the mountainous (the Artvin-Garabagh tectonic megazone) and lowland (the Middle Kur tectonic megazone and the Lower Araz tectonic zone in the southeastern subsidence of the Lesser Caucasus system) parts of the area. The first taxon is placed in the structure of Lok-Garabagh, Goycha-Hakari, Gafan and Kalbajar zones, where it is built by the Jurassic, Cretaceous and Paleogene-Eocene rocks in magmatic, terrigenous and carbonate facies, as well as the Miocene-Pliocene-Holocene volcanics of Garabagh plateau. The second taxon is represented by the Oligocene-Holocene marine and continental deposits of the Middle Kur and Lower Araz zones.

The cited formations are connected to multiple deposits and occurrences of various nonmetallic minerals used in the following industry sectors: 1) mining and chemical (barite, pyrite, soda, Icelandic spar (optical calcite), piezoquartz, zeolites, lithographic stone); 2) mining and metallurgical (flux limestones, kaolinite, bentonite clays, serpentinites); 3) precious, semi-precious and ornamental stone production; and 4) construction (e.g. sawing, facing and building stones, cement raw materials (lime-

stone, loam, marl, volcanic ash, pumice), binders (gypsum, drywall), mineral paints, raw materials for brick production (clay and loam), fillers for concrete and road-building materials (sand-gravel and sand-boulder-gravel mixture, construction sand, perlite, vermiculite).

According to formation conditions, industrial mineral deposits may be of the endogenous (actually magmatic, hydrothermal and skarn deposits, pegmatites), exogenous (weathering (clastic, residual, infiltration and hypergene) and sedimentary (mechanical and chemogenic) deposits) or metamorphogenic (metasomatic) origin. In terms of tectonic and formational confinement, industrial mineral deposits of the Garabagh nature zone are distinguished within the structure of the following formations:

The Lok-Garabagh zone is represented by the Bajocian-Bathonian volcanic-terrigenous, Late Jurassic terrigenous-volcanic-carbonate, Early, Middle and Late Cretaceous volcanic-terrigenous-carbonate formations, as well as Paleogene terrigenous formation exposed in the zone's northeastern periphery. The first two formations of the zone are rich in various types of industrial mineral deposits.

The Middle Jurassic volcanic-terrigenous formation is represented by effusive and partly sedimentary rocks, and characterized by widely developed zones of hydrothermally altered series scattered along differently oriented fault dislocations. The structure of the formation is broken by multiple different-size Middle and Upper Jurassic acidic intrusives. The formation contains resources of hydrothermal barite, pyrite, mineral paints, secondary quartzites, pegmatite jewelry (agate, chalcedony) and ornamental (jasper) stones, magmatogenic ornamental (felsitic tuff) and facing (basalt, porphyrites) stones, metamorphogenic andalusite and hypergene malachite (a product of copper ores weathering), as well as fossilized remains of trees as ornamental stone.

Being in paragenesis with predominantly acidic (gabbro-tonalite formation) intrusions, *the Late Jurassic terrigenous-volcanic-carbonate formation* contains manifestations of hydrothermal Icelandic spar, mineral paints, jewelery stones (opal), pegmatite jewelry and ornamental stones (agate, carnelian), biogenic and chemogenic limestones and corals, magmatogenic facing and building stones (volcanic tuffs, gabbros, gabbroids, gabbro-diabases, diorites, granodiorites), metamorphogenic andalusite and marbled limestones, as well as chemogenic and hydrothermal gypsum. Additionally, there are the deposits and occurrences of coal used as fuel and energy raw material.

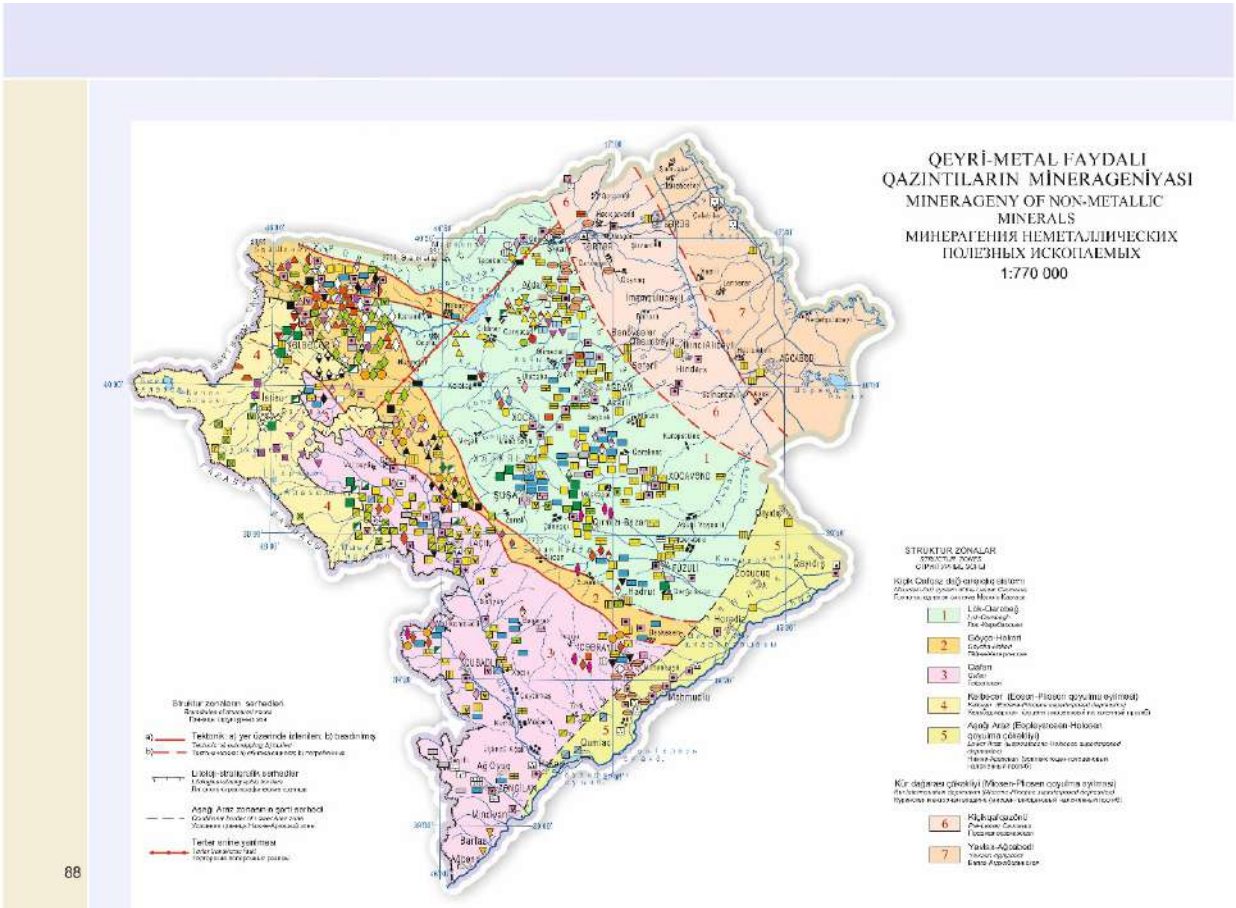

Fig. 3. Minerageny of non-metallic minerals of the Garabagh HGR

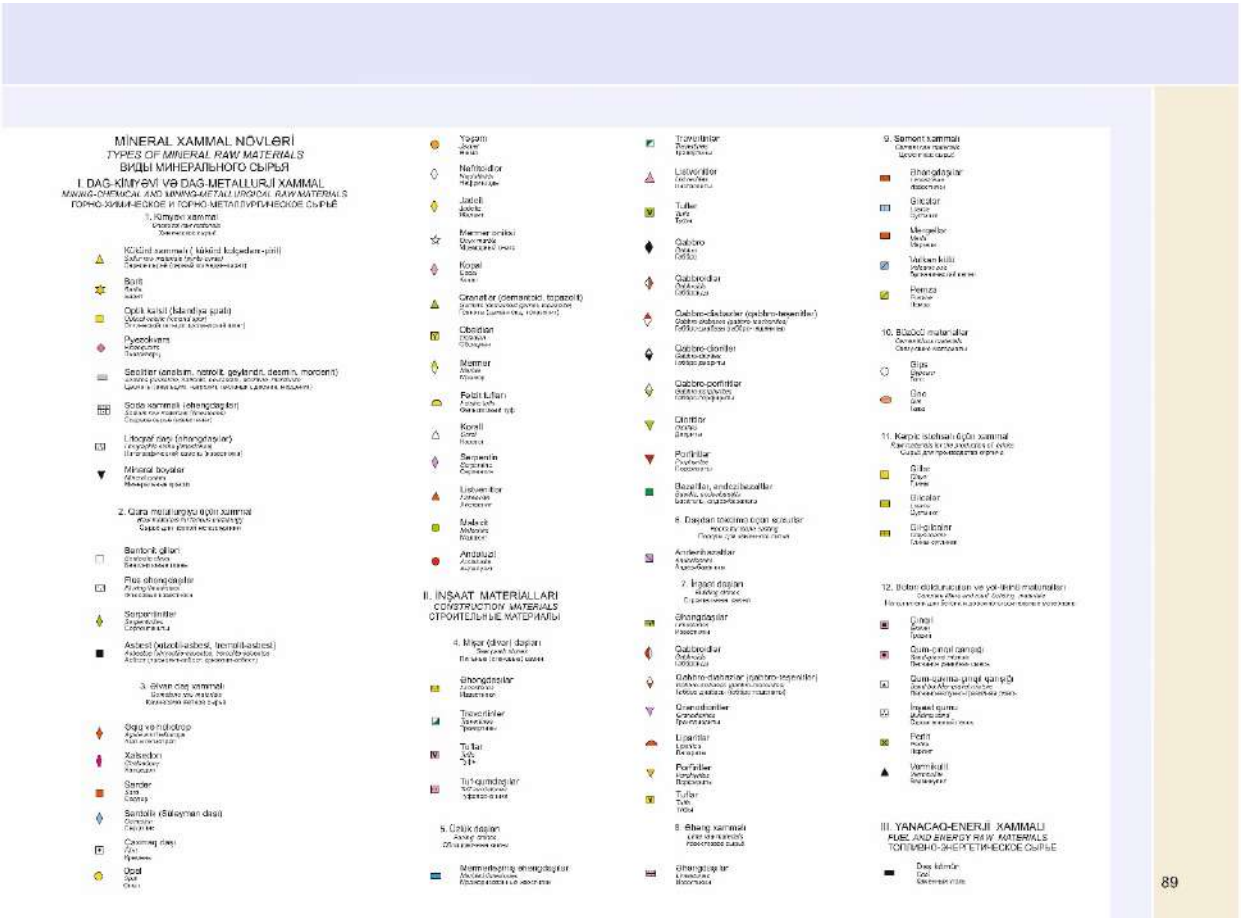

Fig. 4. Legend to the map of minerageny of non-metallic minerals

The volcanic-terrigenous-carbonate formation of the Early-Middle Cretaceous deposits is in paragenesis with mainly acidic (gabbro-tonalite formation) intrusives. There are the deposits and occurrences of such nonmetallic minerals as biogenic and chemogenic limestones (fluxing, building) and biogenic precious stones (copal), pegmatite precious (agate) and ornamental (jasper) stones, magmatogenic facing (gabbro-diabases, gabbro-porphyrites) and building (porphyrites, tuffs) stones, metamorphic marbled limestones, etc. in the formation.

Being similar to the previous complex in terms of formation, the Late Cretaceous complex is in paragenetical relation with intrusions of basic composition (formation of subalkaline gabbroids). The formation is characterized by the presence of deposits and occurrences of hydrothermal Icelandic spar, zeolites, kaolinite and mineral paints, residual bentonites, chemogene lithographic stone, pegmatite precious (agate, chalcedony) and ornamental (jasper) stones, magmatogenic building (tuff) and facing (gabbro-diabase) stones, biogenic and chemogenic saw and building limestones, chemogenic marls (cement raw material), mechanical sludge (clays), metamorphic marbled limestones and volcanic pumice (cement raw material).

In addition to the listed mineral raw material types, there are young occurrences of chemogenic travertine, as well as deposits of different building materials, including sandstone, gaja, clay, loam, mason's sand, gravel and sand-gravel deposits. These manifestations are detected in the formation of the Pleistocene-Holocene continental molasses. This formation is superposed on the more ancient complexes of the northeastern wing of the zone.

The Goycha-Hakari zone is mainly represented by the *Upper Cretaceous ophiolite formation* which overlies the Lower Cretaceous volcanic-terrigenous-carbonate series and partly underlies the terrigenous-volcanic rocks of Eocene. The formation is associated with manifestations of hydrothermal zeolites, Icelandic spar, secondary quartzites, pyrites, mineral paints, hydrothermal-metamorphic serpentinites, listvenites, asbestos, marbles, pegmatite precious (carnelian, sarder, cream) and ornamental (jasper) stones, biogenic precious stones (copal), hydrothermal precious (nephrites, jadeite, garnets) and ornamental (listvenite, serpentine) stones, magmatogenic facing (gabbros, gabbroids, gabbro-diabases, gabbro-diorites, diorites, basalts, basaltic andesites), facade (tuffs) and construction (granodiorites, gabbroids, tuffs) stones, as well as hypergene

vermiculite, volcanic pumice, residual bentonite clays, biogenic and chemogenic limestones as cement raw materials, wall stones, rubble stones, and marbled limestones.

Within the zone's boundaries, there are also ornamental (marble onyx) and facing (travertine) stone occurrences confined to *the chemogenic formation of the Late Pliocene-Holocene* – products of chemical precipitation of a calc-spar from hot mineral springs. In addition, one deposit of the Lower Pleistocene clays and several gravel and sand-gravel deposits were established in the alluvium of the mountain rivers.

The Gafan zone has its' northeastern wing built by the Bajocian-Bathonian volcanic-terrigenous formation. In its' southeastern plunge, the formation is superstructed by the Late Jurassic terrigenous-volcanic-carbonate formation. The southeastern wing of the zone is represented by volcanic-terrigenous-carbonate formation of the Early and Middle Cretaceous series, and the central segment – by the similarly composed Late Cretaceous formation, southwestern segment of which is overlapped by the Late Pliocene-Holocene formation of secondary trachybasalts and trachyandesites.

The Middle Jurassic formation is composed similarly to the same-age complex of the Lok-Garabagh zone. The formation is breached by different-age acidic intrusives, and characterized by the occurrences of hydrothermal mineral paints, pyrite and listvenite, magmatic building (tuff) and facing (gabbro) stones, pegmatite ornamental stones (jasper) and residual bentonite clays.

Composition of the *Upper Jurassic terrigenous-volcanic-carbonate formation* includes marbled limestones and limestones that are used as the wall stones.

The Early-Middle Jurassic formation is in paragenetic relations with acidic (gabbro-tonalite formation) intrusives. The composition of the formation includes biogenic and chemogenic limestones (fluxing, wall and soda raw materials), metamorphic marbled limestones, hydrothermal zeolites, biogenic precious stones (copal), pegmatite precious (agate) and ornamental (jasper) stones, magmatogenic facing (gabbro-diabase), walling (tuff) and building (porphyrites, tuff) stones.

The Late Cretaceous volcanic-terrigenous formation contains deposits and occurrences of hydrothermal Icelandic spar, piezoquartz, zeolites, mineral paints, sulfur pyrite, pegmatite precious (agate, chalcedony, sardius, flintstone) and ornamental (jasper) stones, biogenic, chemogenic (walling stones and raw materials for the production lime) and marbled limestones, magmatic facing (basalts, gabbro), walling (tuffs) and building (granodiorites, tuffs) stones, volcanic ash and pumice, as well as volcano-sedimentary tuffaceous sandstones.

The Late Pliocene-Holocene chemogenic formation is represented by travertines, suitable for walling and facing works. In the section of the same-aged trachybasalt-trachyandesite formation, there are deposits of magmatic volcanic ashes and pumice (raw materials for the production of cement). The deluvial deposits of the same age include manifestations of clays and loams, and the river alluvium contains occurrences of sand-gravel and sand-boulder-gravel mixtures. Finally, there are deposits of chemogenic gypsum and drywall detected in the section of continental molasses, confined to the southeastern immersion of the Gafan zone.

The Kalbajar zone (Garabagh plateau). The surface structure of the zone is constituted by magmatic formations of the Eocene-Holocene. The Eocene terrigenous-volcanic formation is in paragenesis with mainly acidic intrusives (granosyenite-granite formation). Within the formation structure, there are deposits of magmatic facing (basalts, porphyrites, andesibasalts, gabbro-diorites) and construction (liparites) stones. Also being in paragenesis with mainly acidic intrusives (granosyenite-granite formation), the Miocene andesite-dacite-rhyolite formation is represented by the building stone deposits of hydrothermal-vein piezoquarts and granodiorites. The Late Pliocene rhyolite formation contains deposits of iridescent obsidian. In the trachybasalt-trachyandesite formation of the Late Pliocene-Holocene, there are the deposits of cast stone materials (basaltic andesites), volcanic tuffs and ash, as well as pumice and perlite used for the production of cement and other building materials. In turn, the same-aged chemogenic formation is represented by the deposits of ornamental (marble onyx) and facing (travertine) stones, both products of chemical precipitation of calc-spar from the thermal mineral springs.

The Middle Kur zone. On the erosional truncation, the zone is built by Late Pliocene marine terrigenous formation containing sedimentary sandstones, and Pleistocene-Holocene continental molasse formation, containing chemogenic gaja and mechanical sediments (clay, loam, sandy loam, masonry sand, gravel, sand-gravel and sand-boulder-gravel mixtures) used as construction materials.

The **Lower Araz zone** is represented by two continental formations. Late Pliocene-Early Pleistocene terrigenous-volcanic formation contains the horizons of volcanic ash, vitric tuff and pumice (raw material for the production of cement and other construction materials) enclosed in the alluvial-proluvial continental molasses. Pleistocene-Holocene continental molasse formation has a nonmetallic mineral content similar to its' analogue within the structure of the Middle Kur zone.

Conclusions

The minerageny of the southeastern end of the Lesser Caucasus is determined by the geodynamic setting of the formation of structural zones, the geochemical characteristics of structural-material complexes, and their age evolution. The established geological patterns of the formation and spatial distribution of various types of mineral raw materials make it possible to predict the discovery of new industrially significant deposits, both due to the known numerous manifestations, and new promising areas. Provision with mineral resources is a factor of economic security and a guarantor of the social stability of the region in the medium and long term.

REFERENCES

Geology of Azerbaijan (chief ed. Ak.A.Ali-zadeh). Volume VI. Economic minerals. Nafta-Press. Baku, 2005, 578 p. (in Russian).

Geology of Azerbaijan (chief ed. Ak.A.Ali-zadeh). Volume IV. Tectonics. Nafta-Press. Baku, 2005, 506 p. (in Russian).

Geology of Azerbaijan (chief ed. Ak.A.Ali-zadeh). Volume I. Stratigraphy, lithology, tectonics. Nafta-Press. Baku, 2015, 532 p. (in Azerbaijani).

Geology of Azerbaijan (chief ed. Ak.A.Ali-zadeh). Volume III. Magmatism, solid minerals, hydrogeology, geological engineering. Nafta-Press. Baku, 2015, 382 p. (in Azerbaijani).

Hasanov T.Ab. Ophiolites of Lesser Caucasus. Nedra. Moscow, 1985, 240 p. (in Russian).

Ismail-Zadeh A.J., Kangarli T.N. Geodynamic environment of the formation of ore complexes and metallogenic epochs of the Eastern Caucasus. In the book: The modern problems of geology and geophysics of Eastern Caucasus and the South Caspian depression. Nafta-Press. Baku, 2012, pp. 132-145.

Khain V.Ye. Regional geology. Alpine-Himalayan belt. Nedra. Moscow, 1984, 344 p. (in Russian).

Khain V.Ye. Tectonics of continent and oceans. Nauchni Mir. Moscow, 2001, 606 p. (in Russian).

Mineral-products resources of Azerbaijan (chief ed. V.M.Baba-zadeh). Ozan. Baku, 2005, 808 p. (in Russian).

Mustafayev G.V. Main features of Azerbaijan's metallogeny. Nafta-Press. Baku, 2002, 231p. (in Russian).

Shikhalibeyli E.Sh. Geological structure and history of tectonic development of the eastern part of the Lesser Caucasus (tectonic structure and magmatism). Publishing house of the Academy of Sciences of the Azerbaijan SSR. Baku, 1966, 263 p. (in Russian).

Shikhalibeyli E.Sh. Geology and mineral resources of Nagorno-Karabakh of Azerbaijan. Elm. Baku, 1994, 284 p. (in Russian).

ЛИТЕРАТУРА

Ismail-Zadeh A.J., Kangarli T.N. Geodynamic environment of the formation of ore complexes and metallogenic epochs of the Eastern Caucasus. In the book: The modern problems of geology and geophysics of Eastern Caucasus and the South Caspian depression. Nafta-Press. Baku, 2012, pp. 132-145.

Геология Азербайджана (гл.ред. Ак.А.Ализаде). Том VI. Полезные ископаемые. Nafta-Press. Баку, 2005, 578 с.

Геология Азербайджана. (гл.ред. Ак.А.Ализаде). Том IV. Тектоника. Nafta-Press. Баку, 2005, 506 с.

Гасанов Т.А. Офиолиты Малого Кавказа. Недра. Москва, 1985, 240 с.

Хаин В.Е. Региональная геология. Альпийско-Гималайский пояс. Недра. Москва, 1984, 344 с.

Хаин В.Е. Тектоника континентов и океанов. Научный Мир. Москва, 2001, 606 с.

Минерально-сырьевые ресурсы Азербайджана (гл.ред. В.М.Баба-заде). Озан. Баку, 2005, 808 с.

Мустафаев Г.В. Основные черты металлогении Азербайджана. Nafta-Press. Баку, 2002, 231 с.

Шихалибейли Э.Ш. Геологическое строение и история тектонического развития восточной части Малого Кавказas (тектоническая структура и магматизм). Изд-во АН Азербайджанской ССР. Баку, 1966, 263 с.

Шихалибейли Э.Ш. Геология и минеральные ресурсы Нагорного Карабаха Азербайджана. Элм. Баку, 1994, 284 с.

Azerbaycanın geologiyası (baş red. Ak.A.Əli-zadə). Cild I. Stratigrafiya, litologiya, tektonika. Nafta-Press. Bakı, 2015, 532 s.

Azerbaycanın geologiyası (baş red. Ak.A.Əli-zadə). Cild III. Maqmatizm, bərk faydalı qazıntılar, hidrogeologiya, mühəndisi geologiya. Nafta-Press. Bakı, 2015, 382 s.

ТЕКТОНИКА И МИНЕРАГЕНИЯ ГАРАБАГА И ВОСТОЧНОГО ЗАНГЕЗУРА (ЮГО-ВОСТОЧНОЕ ОКОНЧАНИЕ МАЛОГО КАВКАЗА, АЗЕРБАЙДЖАН)

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Резюме. Статья посвящена тектонике и закономерностям формирования и распространения различных видов полезных ископаемых в пределах Гарабагского и Восточно-Зангезурского экономических районов Азербайджанской Республики, территориально связанных с юго-восточным окончанием горно-складчатой системы Малого Кавказа. В ней показано, что регион тектонически относится к юго-восточному сегменту Артвин-Гарабагского поднятия (мегазоны), состоящего из структурных зон второго порядка (Лок-Гарабагской, Гейча-Хакаринской и Гафанской) и погружающегося на северо-востоке и юго-востоке под современные континентальные молассы Средне-Куринской и Нижне-Аразской наложенных впадин. Отмечается, что в регионе распространены различные виды металлических (рудных) и неметаллических полезных ископаемых. Приведены сведения об их минерагении и промышленно значимых залежах. Минерагения металлических полезных ископаемых характеризует геологические закономерности формирования и размещения различных видов рудного минерального сырья в металлогенических зонах (отвечают одноименным тектоническим зонам Артвин-Гарабагской мегазоны) и рудных районах, которые выделяются исходя из тектоно-геодинамического районирования, истории геологического развития, генетических типов известных рудных месторождений и потенциальной рудоносности геологических формаций Малого Кавказа. Минерагения неметаллических полезных ископаемых отражает выявленные закономерности размещения объектов различного нерудного сырья в пространстве и их возникновения в определенные периоды геологи-

ческого развития. Потенциал увеличения перечня промышленно значимых месторождений определяется многочисленными проявлениями рудного и нерудного минерального сырья.

Ключевые слова: *Малый Кавказ, Гарабагский и Восточно-Зангезурский экономические районы, тектоническое районирование, минерагения, металлогеническая зона, рудный район, металлические (рудные) и неметаллические (нерудные) полезные ископаемые*

QARABAĞ VƏ ŞƏRQİ ZƏNGƏZURUN TEKTONİKASI VƏ MİNERAGENİYASI (KİÇİK QAFQAZIN CƏNUB-ŞƏRQ QURTARACAĞI, AZƏRBAYCAN)

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Xülasə: Məqalə ərazi baxımından Kiçik Qafqaz dağ-qırışıqlıq sisteminin cənub-şərq qurtaracağı ilə bağlı Azərbaycan Respublikası Qarabağ və Şərqi Zəngəzur iqtisadi rayonlarının tektonikası və müxtəlif faydalı qazıntıların formalaşma və yayılma qanunauyğunluqlarına həsr edilmişdir. Göstərilmişdir ki, region tektonik cəhətdən ikincidərəcəli struktur zonalardan (Lök-Qarabağ, Göyçə-Xəkara və Qafan) ibarət olan və şimal-şərq və cənub-şərqdə Orta Kür və Aşağı Araz qoyulma çökəkliklərinin müasir qitə molassları altına gömülən Artvin-Qarabağ qalxmasının (meqazonanın) cənub-şərq seqmentinə aiddir. Qeyd olunur ki, regionda müxtəlif növ metal (filiz) və qeyri-metal faydalı qazıntılar yayılmışdır. Onların minerageniyası və sənaye əhəmiyyətli yataqları haqqında məlumat verilmişdir. Metal faydalı qazıntıların minerageniyası Artvin-Qarabağ meqazonunun eyniadlı tektonik zonalarına uyğun gələn metallogenik zonalarda və filiz sahələrində müxtəlif növ filiz mineral xammalının əmələ gəlməsinin və yerləşdirilməsinin geoloji qanunauyğunluqlarını xarakterizə edir. Bu zona və sahələr Kiçik Qafqazın tektono-geodinamik rayonlaşdırma, geoloji inkişaf tarixi, məlum filiz yataqlarının genetik tipləri və geoloji formasiyalarının potensial filizliliyi nəzərə alınmaqla ayrılır. Qeyri-metal faydalı qazıntıların minerageniyası müxtəlif qeyri-metal xammal obyektlərinin məkan yerləşdirilməsinin və geoloji inkişafın müəyyən dövrlərində onların yaranmasının aşkar edilmiş qanunauyğunluqlarını əks etdirir. Sənaye əhəmiyyətli yataqların siyahısını artırmaq potensialı çöxsaylı filiz və qeyri-filiz mineral xammal təzahürlərinin mövcudluğu ilə müəyyən edilir.

Açar sözlər: *Kiçik Qafqaz, Qarabağ və Şərqi Zəngəzur iqtisadi rayonları, tektonik rayonlaşdırma, minerageniya, metallogenik zona, filiz rayonu, metal (filiz) və qeyri-metal (qeyri-filiz) faydalı qazıntılar*