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Geology

Svaneti Gold Occurence (Kirar-Abakuri Ore Knot) and its Genesis

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(Presented by Academy Member David Shengelia)

ABSTRACT. There is a potential opportunity of gold deposits discovery on the territory of Georgia, and first of all, along Svaneti ridge, at its western part within the Kirar-Abakuri ore knot. Here are known ore occurrences, which by geological, mineralogical and geochemical features belong to gold-quartz-low sulfide deposits.

The article includes 1:50 000 scale geological maps of lukhra potential gold deposit and Kirar-Abakuri ore knot, and geological and mineralogical features of the deposit structure are taken into consideration. Here, at endocontact zone of the Middle Jurassic montsodiorite gold-bearing quartz veins are located. Montsodiorite crosses sedimentary rock of so-called "Dizi series" that experienced regional metamorphism of the greenschist facies. Sedimentary rocks are characterized by strong disturbance, milonitization and folding. The quartz-sericite-chlorite metasomatites and sulfide disseminations in sedimentary rocks are also observed. Directly in the contact zone of the Lukhra intrusion and the Dizi series quartz-biotite and quartz-biotite-andalusite association metasomatites are defined. In the apical part of the Lukhra intrusion three gold-bearing zones are revealed, gold content in one of them (the main zone with thickness of 14 m) varies within 8.89 - 7.48 g/t. The genetic conditions of Lukhra potential deposit formation are discussed in the paper. According to the authors, gold distribution, and concentration in pore waters and sulfide minerals took place at metagenesis stage. Further, under the influence of the mantle plumes (apparently montsodiorites are derivates of plumes), gold-bearing environment was developed as magmatic system. Magmatic melt saturated by fluid moves to the upper levels of the Earth's crust, where as a result of the pressure and temperature drop the vapor-gaseous mobilizate emissions. As a result of interaction of the mobilizate and metamorphogenic waters hydrosystem evolve. Over the time, it seems, in the Midlle-Upper Jurassic, flint-containing gel and sulfides discharged from the hydro system.

Key words: Svaneti, monzodiorite, gold, genesis, hydrosystem

In the southern slope of the Greater Caucasus, within Georgia, two goldbearing ore districts Mestia-Racha – in the north, and Svaneti – in the south-west are allocated [1]. In the north-westernmost part of the last Kirar-Abakuri ore knot is delineated. Potential gold deposit – Lukhra from above noted area is described in the paper. Gold-bearing quartz veins of the Svaneti region (Lukhra, Arshira, Kirari etc.) are attributed to gold-quartz-low-sulfide type [2]. There are numerous examples of deposits like Svanetian in other regions of the world. They are related to thick, weakly- and moderately metamorphosed sandstone and volcanogenic rocks stratas. Typically, the metal reserves at deposits do not exceed 30-50 tons. But the largest are: Homestake and Mother-Lode (USA), Ashanti (Ghana); also large deposits with total reserves of gold 100-300 tons: Prestea (Ghana), Salsin (France). According to E. Nekrasov (1988), deposits are characterized by a few stages of mineralization: in the early stage releases white quartz, at a temperature exceeding 300°C. Then, from a relatively small volume of solution sulfides and gold crystallize at temperature of 150-300°C. It should also be noted that the prime concentrator of gold appears later deformed quartz, and the main ore mineral is arsenopyrite.

Within the ore knot goldbearing quartz veins are idenfied in endo- and exocontact zones of small intrusions (Fig.1). At Lukhra they are distributed in Middle Jurassic small intrusion near the village Dizi (Svaneti); they were discovered in 1998 by the Georgian Center of Geological Survey during exploration, with participation of one of the authors of the present paper.

Geological Settings of the Lukhra Deposit Area

Paleozoic volcanic-sedimentary complex hosting small gold-bearing intrusions: gold-bearing small intrusions complicate Paleozoic volcanic-sedimentary complexes (known in scientific literature under the name “Dizi series”). In the middle reaches of the river Enguri, Paleozoic rocks compose uplifted tectonic block, on the peripheries of which outcrop Lower Jurassic shales. Uplifted Paleosoic block expresses tensed tectonic environment (Fig. 1): abundance of small intrusions and dikes; composing rocks are metamorphosed under greenschist facies; numerous narrow fault zones are characterized by intense retrograde alteration of rocks and gold elevated content. For example, even in the 60s of the last century, in the western part of the ore knot, in silicified and sericite-biotite-muscovite slates, at some distance from their contact with Kirar granitoid intrusion, the gold content of about 30g/t was observed.

In the Paleosoic complex of the middle reaches of the river Enguri M. Somin [3] allocated 5 stratas, successively following each other in stratigraphic section: 1) quartz-amphibolite, quartz-biotite and carbonaceous silicified slates with volcanics of basic composition and marble lenses (the oldest - Devonian); 2) mica slates and marbles (Upper Devonian- Lower Carbonian); 3) black and dark green phyllitic slates with interlayers and lenses of quartzite and marbled limestone (Upper Carbonian-Lower Permian); 4) phyllitic black slates with sandstones, gravelite and conglomerate; 5) black shales with sandstone and limestone. The last two stratas are dated by Somin [3] as Upper Permian. Later V. Kazmin and E. Sborchikov [4] identified two big complexes within the Dizi series.

The lower complex, represented by sandy-aleurolitic turbidites, includes conglomerate horizons, interlayers of chert and limestone olistoliths. In olistoliths and chert interlayers there were found Devonian and Carbonian faunas. The upper complex is composed of more fine-grained sediments, including tufogenic material. At some sections olistolith inclusions were found in pelitic shales. At the upper parts of the complex, the Triassic fauna was found. Rocks of the Dizi series have steep dip (often almost vertical) - SE 70-85°. At large fault zones rocks are mylonitized, boudinaged and often form near-fault (or intra-fault) small folds; they experienced metasomatism - transformed into quartz-sericite-chlorite metasomatites with sulfide disseminations. It should be noted that the intensity of greenschist metamorphism in the Dizi series rocks weakens both to the north and south. There in the upward section biotitic- (with epidote and andaluzite), biotite-

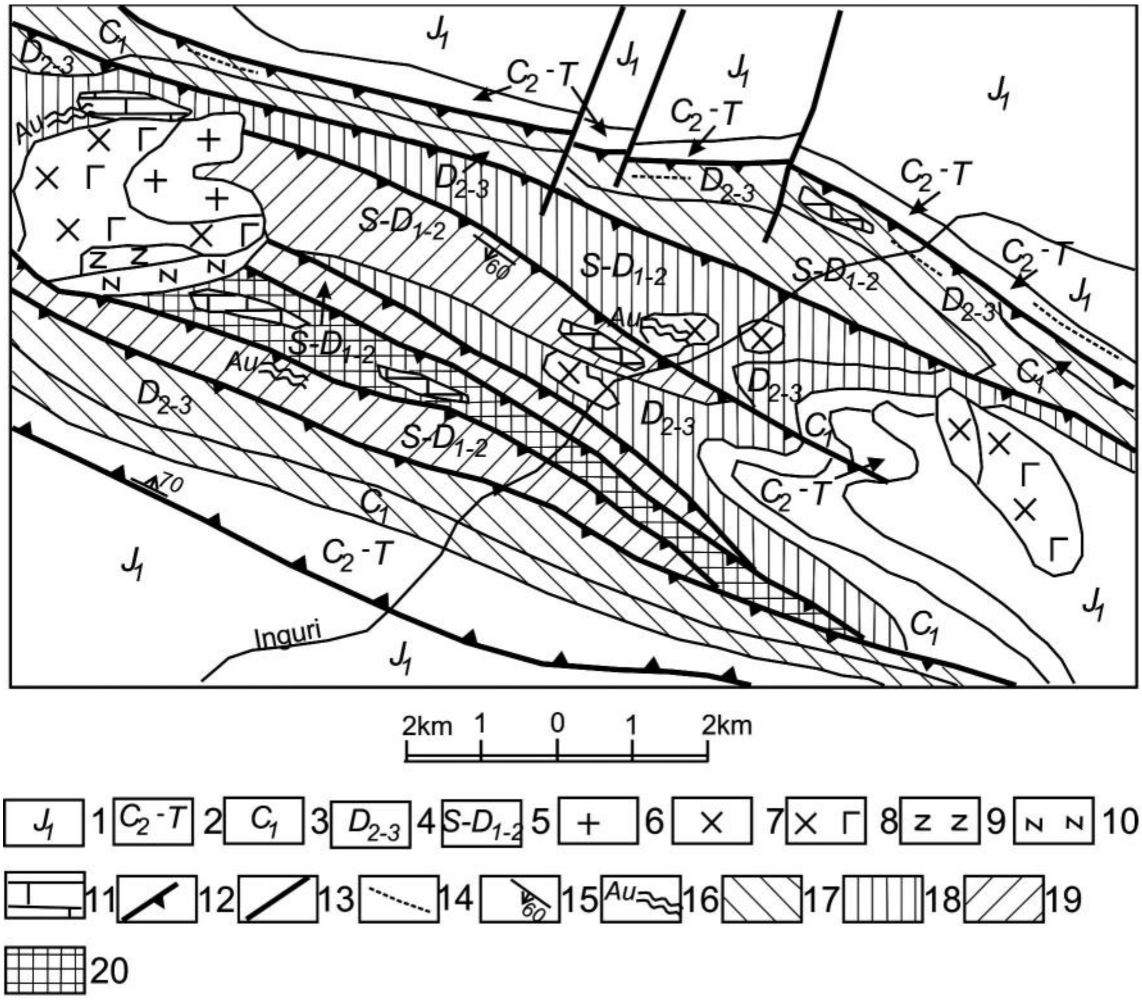

Fig. 1. Geological sketch of the Svaneti Paleozoic formations (Middle part of the Enguri basin) and distribution of Au mineralization. 1 - slates and sandstones (Lower Jurassic); 2 – slates, sandstones, volcanomictics (Upper Carboniferous-Triassic); 3 – phillitized slates, sandstones (Lower Carboniferous); 4 – phillites, silicified sandstones (Middle-Upper Devonian); 5 – phillites, silicified sandstones; marbles containing a block of volcanic-sedimentary rocks, metamorphosed under conditions of the amphibolitic facies (Silurian(?) – Lower –Middle Devonian); Middle Jurassic; 6 – granite; 7 – diorite; 8 – gabbro-diorite; 9 – pyroxenite; 10 – carbonate skarn (with superimposed copper mineralization); 11 – marble; faults: 12 – longitudinal; 13 – transversal; 14 – grafitization zones; 15 – longitudinal fault position; 16 – gold occurrences – quartz vein zones. Degree of dynamothermal alteration of Paleozoic rocks: greenschist facies, zones: 17 – chlorite-sericite, 18 – biotite-sericite, 19 – biotite (epidote, actinolite, andalusite); 20 – amphibolitic facies (mica schist, amphibolite, granodiorite-gneiss, migmatite).

muscovitic- (with actinolite) and sericite-chloritic zones of greenschist metamorphism replace each other. According to D. Shengelia et al. [5], sedimentary rocks of the Dizi series were transformed during epidiagenesis, and then experienced impact of Middle Jurassic intrusions and consequently hornfels were formed. As a result these rocks are strongly metamorphosed and also intensive graphitization is observed in zones, complicated by faults. The examples of other regions [6, 7] show that the most favorable conditions (in terms of metamamorphism) for gold localization in carbonaceous rocks created in biotite-muscovitic zone, on its border with sericite-chloritic zone. At the same time, small magmatic bodies and moderate carbonaceous of rocks are not of less importance exploration features.

Small gold-bearing Middle Jurassic intrusions: Stock form intrusions outcrop in the middle reaches of the river Enguri, gradually replacing each other quartz montsonites and quartz montsodiorites. More basic and melanocratic types of intusive rocks - montsodiorites are captured in the areas of xenolite accumulation and endocontacts of intrusions.

Petrochemical characteristics of quartz montsonite and montsodiorite indicate that they belong to igneous rocks of potassium-sodium series, high and very high aluminous, agpaitic and moderate femic [8]. The most recent differentiates of montsonite intrusions are represented by comparatively sparse and thin (up to 20 cm) aplite veins and aplite-like granites - fine-grained dense rocks, which by mineralogical and petrochemical features belong to highly aluminous leucogranites of normal alkalinity. Xenoliths in montsonite bodies are relatively rare: they are heavily processed and converted into fine-grained hornfels. Ophitic relict structure is seen in the latter that perhaps indicates the primary gabbro-diabase nature of xenolites. Hornfels of quartz-biotite mineral composition are manifested at their exocontacts around the intrusions.

Near the Lukhra deposit, on the left slope of the r. Enguri, Abakuri intrusion outcrops at about 2.5 sq. km, which has active contacts with both the Paleozoic and Early Jurassic sediments. Intrusion is built up by pyroxenite, anorthosite, gabbro and gabbro-diorite. Radiological age of small intrusions was defined at the isotopic geochronology laboratory of the Institute of Geology of Georgian National Academy of Sciences by K-Ar- method. Age of intrusive rocks Kirar-Abakuri ore knot is 162 ± 2 - 172 ± 4 Ma [8].

Characteristics of the Lukhra Deposit

The Lukhra deposit is located on the right slope of the river Enguri, near the village Dizi, 500-600 m from the marble quarry. Gold-bearing intrusive rocks are exposed along the main road Zugdidi-Mestia, and quartz vein zone outcrops 100 m above the road. The intrusion is hosted by the Devonian Dizi series, which (near the contact with the intrusion) consists of quartz-biotite and quartz-biotite-andalusite slates. Intrusion has stock form, on the plane with ellipsoidal shape, elongated in sub-latitudinal direction at 650-700 m, exposed area of which amounts 175,000 square meters (Fig. 2). The rocks are relatively fresh, with the exception of quartz vein zones, where they experienced nonequal silicification. Gold-bearing quartz veins are fragmented and intensely colored rusty along cracks by iron oxides. The main zone (Fig. 2 №1) is located in the south part of the outcropped intrusion and most of it appear to be covered by dumped debris of montsodiorites. The apparent thickness of the zone is about 12 m. A 6-meter interval of solid milky white medium-grained quartz, fragmented and healed by more coarse-grained quartz, is distinguished within the zone. Inside the latter the thin chalcedony-like veinlets are visible under the microscope. In the earliest quartz, the two-phase primary inclusions with homogenization temperature of 220-250°C are visible.

Ten samples were analyzed on gold (in quartz) on microprobe “CAMEBAX”; at six points there were identified the following gold contents (in%) - 0.169; 0.035; 0.105; 0.213; 0.100 and 0.343. Oxygen isotopic composition of quartz was $\delta^{18}O_2$ - 20,3 or 10,2 ‰ (analyses were carried out at the US Geological Survey laboratory in Denver). These figures are likely to show metamorphic nature of water, which is in equilibrium with ore quartz [9].

From the central part to north, the mono-quartz zone is replaced by intensely silicified quartz diorites, which are replaced by unmodified varieties of diorite. Thickness of altered quartz diorite in the north part of the main zone reaches 4-6 m. Sericite in small quantities and sulfide impregnations are present in silicified zones.

Sampling of the main zone (data of the Georgian Center of Geological Survey; INAA analysis; the zone was sampled transversely to the strike) revealed the following metal content (10 samples, length of each channel sample was 1 m): Gold (g/t) - 7.3; 5.7; 9.8; 7.4; 19.09; 6.2; 8.1; 8.1; 2.4; 0.9; bismuth (%) - 0.7; 0.4; 0.8; 0.9; 0.14; 0.08, 0.0002, 0.009, 0.09, 0.03; Tellurium (%)

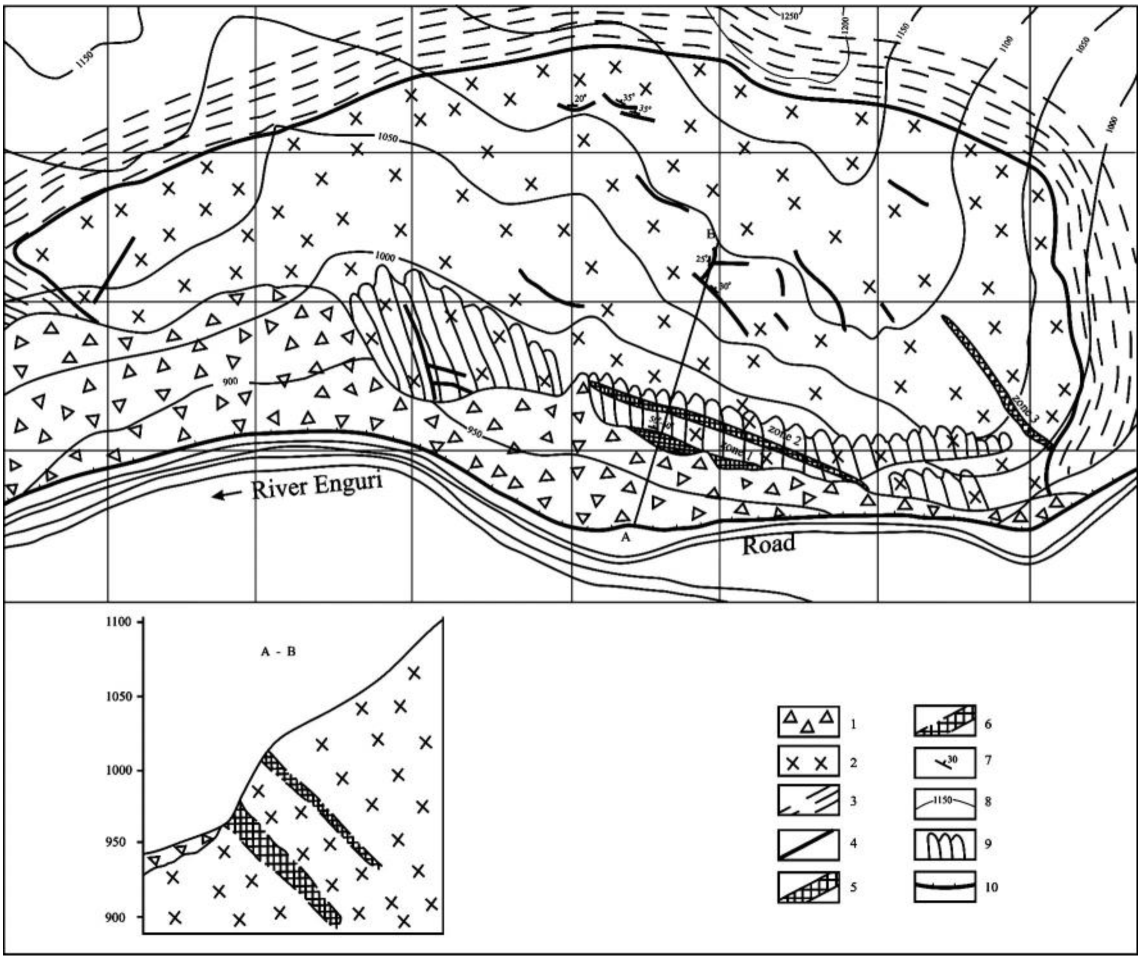

Fig. 2. Geological sketch of the Lukhra deposit (Svaneti, Georgia). 1. Deluvium: debries of large fragments of diorite and granodiorite; 2. Bathonian quartz diorite and granodiorite; 3. Devonian hornefell mica slates; 4. Quartz vein, some of them gold-bearing and include scheelite; 5. Gold-bearing zone (brecciated milky white quartz, cemented by quartz-chalcedony); zones (in numerator - gold content in g/t, in denominator - thickness of zone in m): № 1-8.9/6 visible thickness), № 2-3/5; № 3(1.0/5); 6. Probable stretching of gold-bearing zone; 7. Position of gold-bearing zone and quartz vein; 8. Contour lines of relief; 9. Benches; 10. Relief truncation projection on plane along the road.

- 0.14, 0.008, 0.16; 0.002; 0.014; 0.012; 0.014; 0.014; 0.0005.

Quartz vein zone №2, about 10 m thick, is located 50 meters above the main zone, and is exposed at cornice; sampling of which was possible only along one meter interval, where gold content amounted 3g/t. The zone №3 is revealed near the intrusion eastern contact of about 5 m thick. The gold content in 5-meter sampling interval was 1.5 g/t. In addition, throughout the intrusion massif, above the main thick quartz veins, numerous low-capacity and nonpersistent along the strike quartz veins, some of which are gold- and tungsten-bearing. In the main gold-bearing vein (phase content of mineralization on the Lukhra deposit was determined by diffractometer system XV^{TIV}, of firm SCINTAG, at the Institute of Mining Mechanics of the Georgian Academy of Sciences, Tbilisi) was defined the following mineral phase composition (samples for №№ 55, 59, 142 , 148): native metals - tetra-auricupride (Au Cu), copper-gold (Cu Au), gold copper- and zinc-containing (Au_2CuZn), gold zinc-containing (Au_3Zn_n), gold manganese-containing ($Au_{11}Mn_4$); sulfides - bornite copper iron sulfide (Cu_5FeS_4), zharleit copper sulfide

($Cu_{1,96}S$), barium iron sulfide ($Ba_{16}Fe_8S_{29}$), manganese sulfide (MnS), tellurides - tsumoite (BiTe), pilsenite (Bi_4Te_3), hedleyite (Bi_4Te_6), copper-zinc telluride ($Cu_{50}Zn_{30}Te$); oxides - manganese oxide (MnO_2), manganese bismuth oxide ($Bi_{1369}Mn_{31}O_6$), smirnite (Bi_2TeO_5); silicides - copper silicide ($Cu_{83}Si_{17}$); non-metallic minerals - quartz (SiO_2), tridymite-M (SiO_2), gismondine ($CaAl_2Si_2O_{18}$ $4H_2O$).

The main zone is traced on the surface for 140 meters, but it seems that the major part of it is hidden under the slide-rocks of intrusive rocks. In the exposed part, the maximum apparent thickness of the zone is 14 m. Six meter capacity ore interval is allocated on the surface within the zone, where average gold content amounts: at one section – 8.89 g/t, and at the second -7.48g/t. According to our data, probable gold resources at the Lukhra area amount about 30 tons of metal.

Conclusion (Some Considerations on the Genesis of the Deposits)

Numerous examples of the world show that Phanerozoic gold deposits in terrigenous clastic strata (stratas differ by high thicknesses and are accumulated mainly in different geomorphological zones of marginal seas) occupy a clearly expressed temporary position. They are formed at subduction stage of development of the mountain fold systems. Hosted within the latter are mainly of gold-quartz - and rare - gold-quartz-sulfide ore deposits, which are often paragenetically connected to small bodies of gabbro-plagiogranite complexes; and are accompanied by quartz-feldspar metasomatites. Clastic rocks experience amphibolization [10] in the limits of the ore fileds and beresite-listvenitic alteration. It is known that the processes prevail in the Earth’s history, which mainly contribute ore material scattering, and only as exception, form an essential concentrations in the Earth’s crust. In the case of gold, most likely the following sequence of events meet these conditions: 1) the exogenous decay of “gold-bearing” basite-ultrabasites; 2) release of metals (leaching of minerals) and their transport, mainly in soluble form at flyschoids’ sedimentation areas and trapping by organic and clay minerals (in some cases, such as trenches of marginal basins or mid-ocean ridges). On the enrichment with gold of carbonaceous clastic rocks influenced hydrothermal-volcanogenic processes: long before the gold ore accumulation in trenches under reducing conditions precipitated “black” muds, which periodically were enriched by chalcophiles and precious metals brought by hydrotherms. Thus, layers enriched by sulfides were formed (with high contents of copper, zinc, chromium, nickel, gold and other metals); 3) redistribution of metals within sediments under the influence of epigenetic and katagenesis processes (part of metals is concentrated in diagenetic sulfides, other - dissolved in pore waters); 4) the ongoing process of sulfide and pore water enrichment by gold while metamorphism intensification (greenschist and amphibolite facies of metamorphism); 5) at the later stages of the Earth’s crust development - during the Phanerozoic partial meltdown of “goldbearing” meta-terrigenous and meta-volcanic rocks took place, most likely under the influence of thermal energy of mantle diapirs; 6) floating of local magma centers and the subsequent migma meltdown under decompression. According to Letnikov [11] granitoid magma at the level of its origin (PT conditions of amphibolite facies) is quasiequilibrium, as in isobaric conditions melt temperature is close to ambient one. Under slow decompression (isothermal conditions) is involved melt structuring mechanism and isolation of liquation spherulites, and also - of schlieren pegmatites and miaorolites. With the “shock” decompression, when the system rapidly rises to a high level (T - 850°S, P - 1-2 kb) dramatically increases the melt volume and separation of homogeneous material into silicate and fluid-gas phase takes place. At the level of “shock” decompression (hypabyssal level) “fluid phase” - gold-bearing mobilizate separates, part of which silicon is fixed in the form of quartz and quartz-feldspar veins in nature, and the gas-water part, reacting with carbonaceous terrigenous rocks, isolates in the form of hydrothermal metasomatite (beresite) and disseminated sulfide mineralization.

Based on our scarce geochemical data indicating mantle source paragenetic with small intrusions ores (Abakuri intrusion appeared mantle according to $^{87}Sr/^{86}Sr$) [8], and metamorphogenetic nature of hydrotherms, we tend to present conceptual geological genetic model as follows. At metagenesis stage (green schist facies), gold and accompanying elements, forming together the primary anomaly in carbonaceous clastic strata, experienced redistribution - concentrated in sulfides and pore waters. With increasing metamorphism degree of, possibly causally related to the thermal effects of mantle plumes, gold-bearing environment (carbonaceous phyllites, sulfide phenocrysts and mineralized waters) was transformed into the gold-bearing magmatic system. The rocks saturated by fluid and partly molten (migmas), at collision stage of development of the mountain-fold structures, moved to the higher hypsometric levels of the Earth's crust, where they transformed into fluid-magmatic systems. The last, due to the pressure and temperature drop, evolved with the release of silicon vapor-gas mobilizate. In the area of ore localization mobilizate, displaced from zone, bounded by high temperature isogrades, reacted with metamorphogenic waters, resulting in creation of peripheral supra-intrusion systems. Where, under the presence of hydrogen sulfide and carbon oxide at relatively low temperatures and high pH, tiochloroaurates (main carriers of gold in high-temperature magmatic fluids) disintegrated and "were replaced" by tioaurates. In the issue of dehumidification of these peripheral hydraulic systems silicone gel was singled out, and around these systems " as a result of saline water interaction with shales' components, auriferous sulfides, and primarily arsenopyrite precipitated.

We can state with a certain degree of confidence that fluid system - H_2O-CO_2-N_2-CH_4-H_2S operated at the level of ore deposition, where the salts were represented by bicarbonate-sodium-calcium-magnesium. Solutions including gold, arsenic, tungsten, zinc and nickel in complex forms, were weak-acidic and relatively low-salinity.

From the above considerations, is clear we tend to share the ideas according to which the ore-hosting environment (carbonaceous slates) is perceived as physical and chemical barrier for ore deposition, and underlying meta-sedimentary and meta-volcanic rocks - as a source of metals. It is appropriate to note that according to Korobeynikov [12] amphiboliization is accompanied by the formation of similar to lamprophyre rocks often with high gold content.

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გეოლოგია

სვანეთის (კირარ-აბაკურის მადნიანი კვანძის) ოქროს საბადოები და მათი გენეზისი

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(წარმოდგენილია აკადემიის წევრის დ. შენგელიას მიერ)

საქართველოს ტერიტორია ინარჩუნებს ოქროს საბადოების აღმოჩენის პოტენციურ შესაძლებლობას და, პირველ რიგში, სვანეთის ქედზე, მის დასავლეთ ნაწილში, კერძოდ, კირარ-აბაკურის მადნიანი კვანძის ფარგლებში. აქ ცნობილია მადანგამოვლინებები, რომლებიც თავისი გეოლოგიური, მინერალოგიური და გეოქიმიური თავისებურებებით მიეკუთვნება ოქრო-კვარც-მცირესულფიდურ საბადოთა საწარმოო ტიპს.

სტატიაში მოყვანილია ლუხრას პოტენციური ოქროს საბადოს და კირარ-აბაკურის მადნიანი კვანძის 1:50000 მასშტაბის გეოლოგიური რუკები; გათვალისწინებულია საბადოს გეოლოგიურ-მინერალოგიური აგებულების თავისებურებანი. აქ შუაიურული ასაკის მონცოდიორიტების სხეულის ენდოკონტაქტში განლაგებულია ოქროსმატარებელი კვარცის ძარღვები. მონცოდიორიტები კვეთს ე.წ. "დიზის სერიის" დანალექ ქანებს, რომელმაც განიცადა რეგიონული მეტამორფიზმი, ძირითადად მწვანე ფიქლების ფაციესის პირობებში. დანალექი ქანებისათვის დამახასიათებელია ძლიერი აშლილობა, მილონიტიზირებული და დანაოჭებული ზონების არსებობა. სწორედ მათშია დაფიქსირებული კვარც-სერიციტ-ქლორიტიანი მეტასომატიტები და სულფიდების ჩანაწინწკლები. უშუალოდ ლუხრას ინტრუზივის და დიზის სერიის კონტაქტურ ზონაში დაფიქსირებულია კვარც-ბიოტიტიანი და კვარც-ბიოტიტიან-ანდალუზიტიანი ასოციაციის მეტასომატიტები. ლუხრას ინტრუზივის აპიკალურ ნაწილში აღმოჩენილია სამი ოქროსშემცველი ზონა, მათგან ერთ-ერთში (მთავარ ზონაში რომლის სიმძლავრე 14 მ-ია), ოქროს შემცველობა აღწევს 8,89გ/ტ და 7,48 გ/ტ-ს.

სტატიაში განხილულია ლუხრას პოტენციური საბადოს ჩამოყალიბების გენეტური პირობები. ავტორთა წარმოდგენით, ოქროს გადანაწილება, მისი კონცენტრირება ფოროვან წყლებსა და სულფიდურ მინერალებში მოხდა მეტაგენეზისის სტადიაზე. შემდგომ, მანტიური პლუმების ზეგავლენის შედეგად (როგორც ჩანს, მონცოდიორიტები პლუმების დერივატებია), ოქროსშემცველი გარემო მაგმურ სისტემად ჩამოყალიბდა. ფლუიდებით გაჯერებული მაგმური მდნარი გადანაცვლდებოდა დედამიწის ქერქის ზედა დონეებზე, სადაც წნევის და ტემპერატურის ვარდნის შედეგად ხდებოდა კაჟმიწიანი ორთქლ-გაზოვანი მობილიზატის გამოყოფა. აღნიშნული მობილიზატის და მეტამორფოგენული წყლების ურთიერთქმედების შედეგად ყალიბდებოდა ჰიდროსისტემა. დროთა განმავლობაში, როგორც ჩანს, შუა-ზედაიურულში, ჰიდროსისტემიდან გამოიყოფოდა კაჟიანი გელი და ოქროსშემცველი სულფიდები.

REFERENCES

1. Kekelia S., Kekelia M., Gagnidze N., Popkhadze N., Lobzhanidze K., Khazishvili G. (2016) Gold potential of Georgia. *Bull. Georg. Natl. Acad Sci*. **10**, 4: 41-49.
2. Nekrasov E.M. (1988) Zarubezhnye endogennye mestorozhdeniya zolota. M. 286 p. (in Russian).
3. Somin M. L. (1971) Prediurskii fundament glavnogo khrebta i iuzhnogo sklona Bolshogo Kavkaza. M. 246 p. (in Russian).
4. Kazmin V.G., Sborshikov I.M. (1989) Paleozoiskie i rannekimeriiskie deformatsii na Kavkazei mesto v razvitii Tetisa. A. Belov and M. Satian (reds). In: Geodinamika Kavkaza. M. 46-54 p. (in Russian).
5. Shengelia D., Tsutsunava T., Chichinadze G., Beridze G. (2015) Novye dannye o metamorfizme Dizskoi serii. *Trudy GIN, TGU, nov. seria*. Tbilisi. **127:** 117-123 (in Russian).
6. Buryak V. A. (1987) Formirovanie zolotogo orudeneniia v uglerodosoderzhashchikh tolshchakh. *Izvestiia Akademii Nauk SSSR, ser. geologicheskaya*, 12: 19-105 (in Russian).
7. Buryak V. A. (1986) Istochniki zolota i soputstvuiushchikh komponentov zolotorudnykh mestorozhdenii v uglerodistykh tolshchakh. *Geologia rudnykh mestorozhdenii*, 6: 1-43 (in Russian).
8. Dudauri O.Z., Togonidze M.G. (2016) Petrologiia i izotopnaia geokhronologiia mezozoiskikh intruzivnykh kompleksov Gruzii. *Trudy GIN, TGU*, nov. seria. Tbilisi. **128**: 338 (in Russian).
9. Hugh P., Taylor Jr. (1982) Izotopy kisloroda i vodoroda v gidrotermalnykh rudnykh mestorozhdeniiakh. In: Geokhimia gidrotermalnykh rudnykh mestorozhdenii. Kh. L. Barnce (edit.) M. 200-237(in Russian).
10. Marakushev A. A., Khokhlov V. A. (1992) Petrologicheskaiia model formirovaniia zolotorudnogo mestorozhdeniia Muruntau. *Geologia rudnykh mestorozhdenii*. 1: 38-57 (in Russian).
11. Letnikov F. A (1997) Protsesy samoorganizatsii pri formirovanii magmaticheskikh i gidrotermalnykh mestorozhdenii. *Geologia rudnykh mestorozhdenii*, **38,** 4: 307-322 (in Russian).
12. Korobeinikov A. F. (1997) Geokhimiia zolota v gabbro-plagiogranitnykh kompleksakh skladchatykh struktur. *Geokhimiia*, 5: 519-520 (in Russian).

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