THE ROLE OF BASIC DYKES IN THE FORMATION OF ZUN-HOLBA GOLD DEPOSIT (OKINSKY DISTRICT, SIBERIA,RUSSIA)

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Geographical settings. The Zun-Holba gold deposit is located in the S-E of Eastern Sayan Mountains in the watershed of the riverheads of Urik and Kitoy rivers. This deposit is included in the Urik-Kitoy gold-ore zone controlled by Okino-Kitoy system of northwest trending deep faults, separating Gargan high of Archean Siberian platform basement from Proterozoic and Paleozoic margins. The deposit embraces in the south- gneiss-granite Gargan basement high; in the north – Middle Paleozoic Ambartogolsk pluton of granitoids (400 – 420m.a.) of Holbinsk (Sumsunursk) complex; and host ore bodies of Riphean-Vendian volcanogenic-sedimentary formation in Ilchirsk Suite. All of which are interlaying within Holbinsk fault, found in deep faulted Okino-Kitoy system. This formation of up to 400m. includes alternating layers and bands of sandstones, siltstones, limestones, mafic and acid effusive rocks, quartzite, black shales. These rocks have been subjected to intensive folding deformation –this multi-folding process is combined with intensive hydrothermally altered rocks throughout the thickness, including granites adjacent to volcanic-sedimentary formation of Ambartogolsk pluton, hosting gold-bearing veins. Subvertical orientation of stringer-porhyry ore deposits is analogous to oriented tectonic joints in subvertical deep fault zones. In the Zun-Holba deposit, intra-ore dolerite dykes are few in number, intruded deposits of vein-impregnated ores and the altered plagiogranites of the Ambartogolsk pluton in the framing of ore-bearing fault, which is proved, it's after granitic age. But these dykes are crossed with late sulphide-quartz veins, which also follow dyke contacts for up to tens of cm. Within the Zun-Holba ore deposit, pre-ore weakly modified dykes (relative to which balance calculations were made), intra-ore dykes, and post-ore dykes are found. With an increase in the degree of changes in dykes in weakly altered metasomatites, the gold content increases from 1.3 ppm (21 samples) in slightly modified varieties to 11 ppm in highly altered varieties.

Sample description

1.1. Wallrock metasomatites. Near- veined metasomatic column in Ambartogolsk pluton plagiogranites includes the following mineral zones.

<u>The frontal zone</u> with a thickness of several tens meters embraces massive coarse-grained (grain size of up to several mm) gray plagiogranite composed of randomly oriented narrow tabular plagioclase crystals (andesite up to 60 vol. %) intertwining with gray and dark gray quartz (up to 25 vol.%) incorporated into isolated large oval grains of nested lenticular aggregates and brownish biotite grains and flakes (up to 30 vol.%) with impurities of xenomorphic orthoclase grains, single microcrystals of hypersthene, sphene, zircon, apatite. Rocks preserve a hypautomorphic structure – weakly hydrothermal alteration with new growth volume of up to 10 %. This alteration is reflected in the formation of thin albite rims on the plagioclase crystal periphery corroded by ultimate quartz. Biotite cleavage results in leucoxene-rutile accumulation and lenticular quartz segregation.

In the several meter <u>epidote-chlorite zone</u> there are no biotite and pyroxene – they are dissolved on the inner frontal zone boundary. Rock alteration intensity has increased due to increasing new crystallisation up to 25...30 vol. %, basically, epidote, chlorite, sericite. Because of abundant green minerals the rocks have a green tint. Hypidiomorphic structure groups with rounded elongated clastic grains. Short-columnar (up 1 mm) plagioclase crystals include heavy, usually not massive and, rarely, impregnated sericite and/or and / or variolated zoisite segregation (up to 30 vol.%), partially epidote substituted in micro-cracks. Although polysynthetic plagioclase twinning is veiled, it is sometimes visible. Quartz is large (up to 2…3 mm) and suboval segregations, but the number of fine-grained aggregate intergrowths, being nests, lenses and veins, increased. There is little pale green chlorite, which form as isolated rare flakes up to tenths of a millimeter or as a cluster of up to 3 mm in diameter. Sericite-substituted chlorite associated with leucoxene (rutile), quartz, rare magnetite and ilmenite grains are found along the cleavage. There is an insignificant impurity of xenomorphic calcite grains can be observed in the rocks. In the <u>chlorite zone</u> within the first meters there is no epidote-zoisite, but the rock still has a pale green color because of chlorite. There is a massive structure, the coarse crystalline texture predominately includes rounded elongated clastics with hypautomorphic relics. Plagioclase of up to 55...60 vol.% is practically substituted by sericite including impurities of xenomorphic quartz and calcite grains or without. Quartz (up to 35 vol. %.) with coarse, sometimes suboval grains, can be found in fine-grained aggregates. Coarse grains have smooth, linear or even winding contour; the aggregates develop like structure with toothed bay-like grain intergrowths. Green sericite-substituted chlorite flakes (up to 2…3 vol.%, size to tenths millimeter) are found along the cleavage, where fine-flaked muscovite incorporated with fine xenomorphic grains (hundredths of mm) of calcite (up to about 4…5 vol.%), quartz, ilmenite, leucoxene and rutile. Alternating composed sericite and quartz, including proportionally 50 * 50 vol.% with impurities of fine xenomorphic grains of calcite (up to 5 vol.%) and comparably sized (to tenths of a mm) crystals of pyrite (up to 2 vol.%) and leucoxene (rutile).

Porphyritic-like rocks (up to 3 mm) are a result of oval dark gray quartz grains comparable to those in plagiogranites immersed in fine flaked sericite, quartz-sericite mass. The grains have a smooth noncorroded contour in contrast to fine (up to tenths mm) quartz grains, having jagged, crow contours and, intergranular gradation forming clusters of subisometric, lenticular, vein-lenticular sericite mass. Substituted plagioclase crystals by pure sericite clusters preserve their shape. Sericite clusters having substituted pigment minerals – chlorite, epidote and further biotite are contaminated with impurities of leucoxene and rutile. Pyrite crystals are usually rimmed by quartz grains, including flame-shaped ones. According to the mineral composition these rocks are classified as beresite. Formation of calcite, pyrite and other sulfides, abundant potassium mica – sericite in rear (beresite) zone of near -veined metasomatic columns formed in carbonate-free, sulfide-free plagiogranites indicate the fact of potassium, carbon dioxide, sulfur, metals input (diffusion) from fractured metal-bearing fluids into porous fluids of wallrocks, that is potassium- sulfur- carbon dioxide metasomatism type [1].

1.2. Altered dykes. Intensively hydrothermally modified dolerite (table 2) is actually a metasomatite, since up to 100% of its volume is composed of the listed mineral formations of the hydrothermal stage. Intensively hydrothermally changed, as a rule, relatively large size dykes with a thikness of 0.4 ... 0.5 m and more. During and after the metasomatic transformations, they retained black color, “welded” (“welded”) contacts with host rocks, massive structure, but acquired porphyroblastic, lepidogranoblastic, granolepidoblastic medium, coarse-grained structure. Due to the partial or complete preservation of fresh porphyritic augite crystals, unlike the bulk of the rock, and the highly altered Labrador the relic porphyry structure is visible in the metasomatite. Approximately half of the porphyritic secretions of augite are replaced in varying degrees, up to skeletal forms and completely, with aggregates of newly formed minerals in various combinations and quantitative ratios. In the intergrowths of pyroxene crystals, sometimes one or two grains are replaced completely, the neighboring grains in the same aggregate remain fresh. Brown, red-brown pleochroic to pale yellow biotite of two - early and late - generations participating in the composition of epigenetic mineral tumors is not found in the “remnants” of fresh dolerite, while late biotite does not bear signs of substitution with other minerals. Fresh biotite flakes elongated scales with an aspect ratio of up to 1: 10 ... 1: 15 with a size of up to 1.0 ... 1.5 mm are randomly oriented among epigenetic minerals. Along the perimeter, partially or partially, including pseudomorphically, substituted pyroxene crystals (and olivine?) biotite flakes form "corollas", changing the orientation in accordance with the change in the orientation of the boundaries of the former crystals. Narrow flakes (“needles”) of biotite also intersect fine-grained quartz-calcite-sericite aggregates, replacing labrador crystals in the phenocryst and in the bulk. The thinnest plates of biotite, up to several thousandths of mm thick, intersect aggregates of newly formed minerals, replacing former pyroxene crystals, passing beyond them into fine-grained aggregates of sericite, calcite, rutile, formed by plagioclase. Pale yellow, pale greenish yellow slightly pleochroic serpentine (antigorite) sometimes replaces pyroxene (possibly olivine, fresh grains of which are absent in the rock) with pseudomorphically relatively large scalesAltered pyroxene grains are often bordered with a “rash” of magnetite grains with microcrystal size up to the first hundredths of a mm, which, moreover, in the form of irregular clusters is found among other replacement minerals. Magnetite fills and boundaries between serpentine scales. The smallest clusters of flakes of green pleochroic to pale yellow chlorite are formed by cracks or nests inside the antigorite plates or along their periphery. Plagioclase in the phenocrysts and leaves of the main mass of the rock is replaced predominantly by aggregates of sericite, quartz, calcite, or sericite and quartz, or sericite in the absence of zoisite – epidote minerals, but the relic polysynthetic twinning can be seen occasionally in its crystals. The absence of epidote group minerals in hydrothermal altered products of the main plagioclase is unusual. At the same time, only in aggregates of newly formed minerals there are grains of pale green magnesia-ferruginous ordinary hornblende with characteristic cleavege. [2].

The described transformations of the mineral composition of rocks took place under conditions of potassium-sulfur-carbon-dioxide metasomatism (table 2). In altered dolerites the content of potassium is doubled, up to 50% of magnesium, by 500% of carbon dioxide, to 160% of reduced sulfur recorded respectively in biotite, carbonates, pyrite, and minerals not characteristic of standard dolerite. The content of titanium is reduced to 47.1% of the initial content, to about 20% - of iron, phosphorus, to 60% of water. No significant redistribution of other petrogenic elements occurred.

Conclusion. There is continuity between the early altered dolerite dykes and the later near-ore metasomatites, respectively, by propylites and beresites. This is inherited, which is expressed in the following. Those and other metasomatites are formed under the conditions of potassium-sulphide-carbon-dioxide metasomatism with the entry and fixation of potassium in biotite of altered dolerite dykes and in lower-temperature sericite of near-oreolus beresites, sulfur in pyrite and carbon dioxide in carbonates (Table 2).

Table 2

Value of gain and setting out (–) of the elements atoms in standard geometric volume 10000 A˚3 (%) to a number of their atoms in standard geometric measurement of the original rock

Mineral zones	Chemical elements											
	Si	Ti	Al	Fe_3+	Fe_2+	Ca	Mg	Mn	P	K	Na	CO_2	S
Metasomatic wallrock of Zun-Holba deposit (apogranitic column)													
Ep-Ch	-2,00	-2,14	16,90	-4,60	-22,73	-10,77	-16,70	-0,68	-0,39	-23,19	21,84	-3,22	0,00
Ch	58,45	-4,44	-36,05	-12,34	-39,20	-50,04	-31,17	-1,14	-1,03	-1,48	2,12	6,12	0,00
Beresite	46,56	-2,21	-12,96	6,34	-50,51	-55,92	-26,00	-1,23	-0,41	64,90	-67,81	3,27	28,02
Beresite	55,85	-4,12	-19,81	-13,61	-44,20	-25,83	-25,01	-1,11	-0,99	60,85	-68,37	13,97	6,55
Metasomatic doleritic intra-ore dykes of Zun-Holba deposit													
Altered Dyke	1,2	-45,2	-14,3	-21,7	-15,7	-6,28	53,0	-5,9	-17,9	178	13,2	486	72,5
Altered Dyke	2,1	-47,1	-3,5	-24,1	-19,7	-14,5	39,4	-8,4	-23,9	214	13,8	508	167
Altered Dyke	-1,7	-45,5	-12,3	-28,3	-19,3	-13,3	23,8	-16,8	-24,7	186	38,3	486	164

References

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