METALLOGENY AND GOLD LODE DEPOSITS OF NORTHEASTERN RUSSIA

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ABSTRACT

Gold and gold-bearing deposits are hosted in major magmatic, fluid-hydrothermal (porphyry), sedimentary-hydrothermal and hydrothermal mineral assemblages. Most of lode deposits occur in genetically different mineral assemblages, which is due to the same physicochemical conditions under which mineralization proceeded. The composition of mineral assemblages and the intensive and extensive properties of lode gold deposits are influenced by the composition and genesis of principal assemblages, including the massive sulphides, porphyries, disseminated sulphides and magmatic assemblages. These principal assemblages developed simultaneously with lode gold deposits and were often the sources of ore material for the lode deposits.

INTRODUCTION

In northeastern Russia, there are seven major mineral assemblages hosted in terranes there (Table 1 and Fig. 1). Each mineral assemblage consists of mineral deposits pertinent to different developmental stages of terranes, i. e. from pre-accretionary to post-accretionary ones. At present, the deposits belonging to the second, third and fourth mineral assemblages are developed. The most important placer-forming occurrences are quartz-sulphide disseminations of the second mineral assemblage. The deposits of the first mineral assemblage are the source for small gold-platinum placers. In our opinion, the commercial tungsten-mercury deposit in Koryakia is as well related to the first mineral assemblage. The fifth mineral assemblage includes the major proven copper (molybdenum)-porphyry deposits, which are not being developed at present. There is a lack of data on the sixth stratiform lead-zinc assemblage and the seventh mineral assemblage, that is the iron formation, to which, as we think, gold-silver deposits of Paleozoic and late Mesozoic are related. The latter are younger than the iron formation of Proterozoic and occur within the Omolon craton. The presence of gold is different in each mineral assemblage. Mineral assemblages of sulphide disseminations are much abundant with lode deposits and are interpreted to have the greatest importance. Nevertheless, other mineral assemblages, as well, contain gold-bearing deposits. This paper presents a description of the most important gold lode deposit types with reference to mineral assemblages.

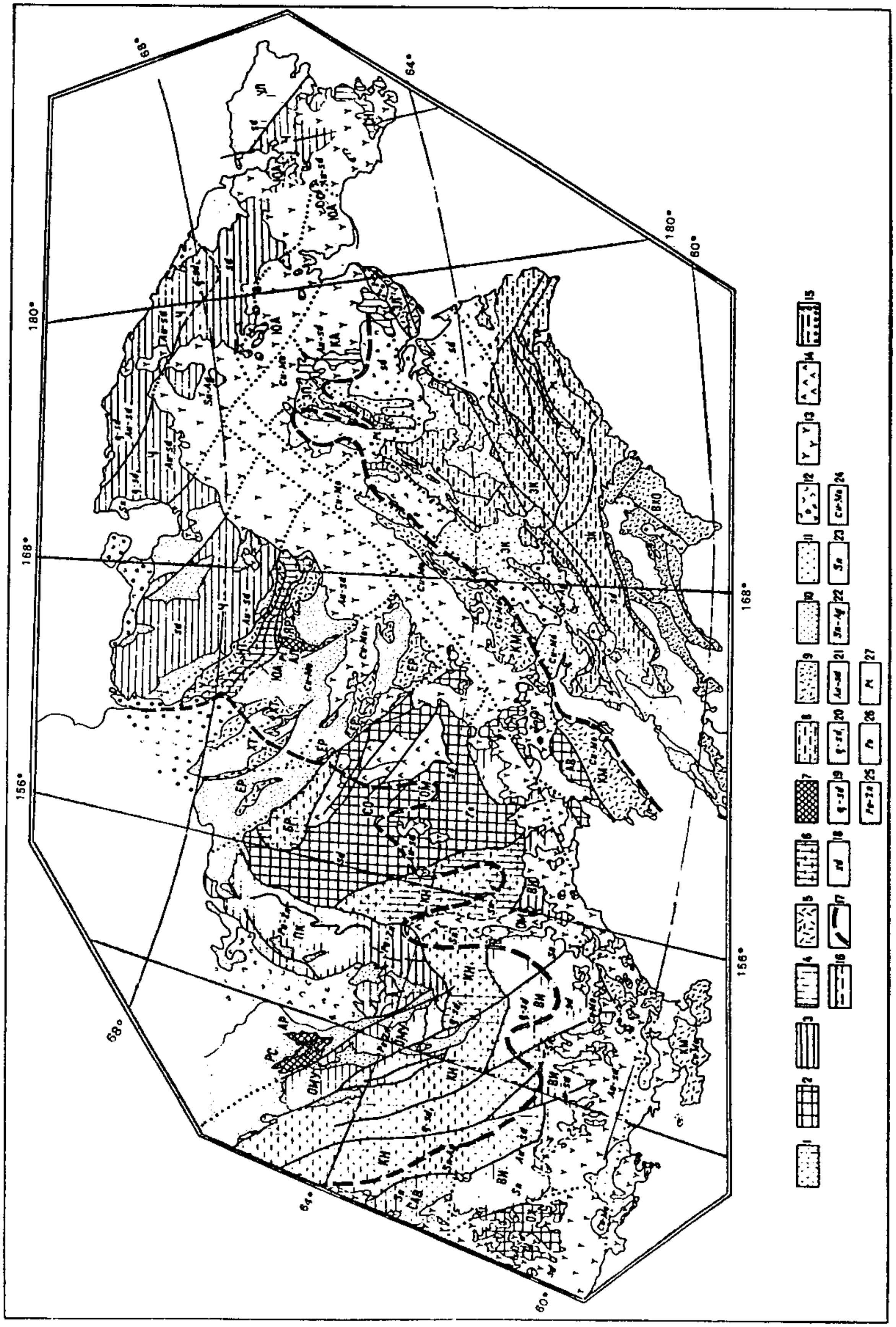
DISSEMINATED GOLD-SULPHIDE ASSEMBLAGE

Disseminated gold-sulphide assemblage, that is the principal one, includes major occurrences of fine and low-grade gold, i. e. 3-9 g/t. At present, a sufficient information is available on three deposits of this type, that is the Nezhdanin deposit in Yakutiya, the Natalka deposit in the Magadan Region and the Maiskoe deposit in Chukotka. These deposits occur in a perivolcanic zone of the Okhotsk-Chukchi volcanic belt and are mostly hosted by Permian and Lower Triassic clay rocks in terranes of passive continental margins and turbidite basins. In our opinion, the formation of these deposits was related to the origination and development of the Early Cretaceous volcanic belt, though there are the evidences of gold presence as early as the Permian and Lower Triassic sedimentation.

The Maiskoe deposit

The Maiskoe deposit occurs in Triassic terrigenous sandstones and clays of the Chukchi passive continental margin terrane. It seems to be related to the Okhotsk-Chukchi volcanic belt of Cretaceous. The Maiskoe deposit is confined to an intrusive dome made up of shales and siltstones of Middle Triassic and Carnian, and also dikes of granite-porphyry, granosyenite-porphyry and lamprophyre. The dikes intrude a contortion zone, which trends submeridionally and includes the Glavnaya mineral zone up to 300 m thick and the Zapadnaya mineral zone up to 150 m thick. These mineral zones consist of elongated ore bodies, which are placed on echelon along their strike and dip; there are steep-lying ore bodies and gentle bed-like apophyses.

Mineral occurrences there are related to zones of viscous fracturing and contortion in rocks, that underwent an intense greenschist metamorphism. The ore bodies are to 6-15 m thick. There are intensely to moderately compressed and crushed shales and siltstones, that underwent reticulated and mottled silicification and sulphidization and host scarce quartz-sulphide veins. Insignificant wall-rock metasomatites are quartz-sericite and quartz-kaolinite rocks. Mineralized rocks have their initial dark-to-black color and feature fine-to-submicroscopic dissemination of needle arsenopyrite and pyrite with the smallest gold inclusions; sulphides bear a number of trace elements as Pb, Zn, Sb, Ag and others.


68°
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168°
156°

← Fig. 1. Metallogenic Scheme for northeastern Russia (the tectonic base map compiled by S.G.Byalobzhesky, G.M.Sosunov and L.M.Parfyonov).

1 - the North Asia craton, the Verkhoyan myogeosynclinal belt (CAB); *terranes accreted to the North Asia craton prior to the formation of the Okhotsk-Chukchi volcanic belt*: 2 - cratonal terranes with a relatively uprisen granitized Archean basement and volcanic-sedimentary cover (Riphean-Lower Mesozoic): AB - Avekov, OM - Omolon, OX - Okhotsk; 3 - passive continental margin terranes with a subsided and crushed Precambrian basement and including the deposits on the shelf, continental slope and its foot: ВИ - Viligin, ОМУ - Omulyov, ПК - Prikolymsky, Ч - Chukchi; 4 - displaced continental margin terranes: KA - Kanchalan, CH - Senyavin; УЛ -Uelen; 5 - island arc and continental margin magmatic arc terranes: ЕП - Eropolvegel, ЗЛ - Zlatogorsky, ЗП - West Pekulney, KM - Koni-Murgal, NT - Nutesyn, XT - Khetachan, ЯР -Yarakovaam; 6 - turbidite basin terranes with a reduced continental crust or oceanic crust: БР -Beryozov, KH - Kulino-Nersky, ЮА - South Anyui; 7 - oceanic crust and (or) ophiolite terranes: АЛ - Aluchin, AP - Argatass, PC - Rassoshin; *terranes accreted during the formation of the Okhotsk-Chukchi belt and later (the oceanic crust basement is Paleozoic and Mesozoic in its age)*: 8 - the West Kamchatka group of terranes (ЗК), 9 - the East Kamchatka-Olyutor group of terranes (ВКО); *overlying accretionary and post-accretionary volcanics and sediments*: 10 - Upper Jurassic and Lower Cretaceous (pre-Albian), 11 - Upper Cretaceous and Paleogene, 12 - Neogene and Neogene-Quaternary; 13 - the Okhotsk-Chukchi volcanic belt (mostly Aptian-to-Albian volcanics); 14 - Late Jurassic-to-Early Cretaceous continental rifts: OMC - Omsukchan, CO - Sredne-Omolon; 15 - faults: a) - known, b) - inferred, c) - covered with overlying deposits; 16 - thrusts; 17 - the limits of the NE Asia post-accretionary metallogenic belt; *ore deposit assemblages identified according to their principal ore assemblages*: 18 - undiffe-rentiated disseminated sulphide (sd), 19 - disseminated quartz-sulphide with predominant gold mineralization (g-sd), 20 - quartz-sulphide with tin and tungsten mineral assemblages (g-sd1), 21 - gold-disseminated sulphide (Au-sd), 22 - associated silver-sulphide and tin-porphyry (Su-Ag), 23 - tin-(silver)-porphyry (Sn), 24 - copper-(molybdenum)-porphyry (Cu-Mo), 25 - stratiform lead-zinc (Pb-Zn), 26 - iron (Fe), 27 - chromite and platinum metal accessory-magmatic (Pt).

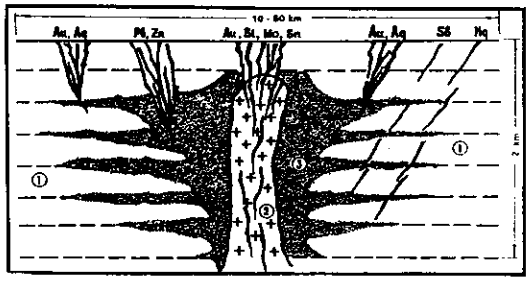


Fig. 2. Scheme of related gold-sulphide deposits in the Maisky ore district.

In addition, there are about 70 minerals dominated by fine disseminated arsenopyrite and pyrite; stibnite occurs in veins and stringers, and there is also scarce galena and sphalerite, electrum, jamesonite, chalcostibnite, chalcopyrite, silver and bismuth sulphosalts, molybdenite and cinnabar. Gold is mostly present in pyrite and arsenopyrite (100 up to 1000 g/t).

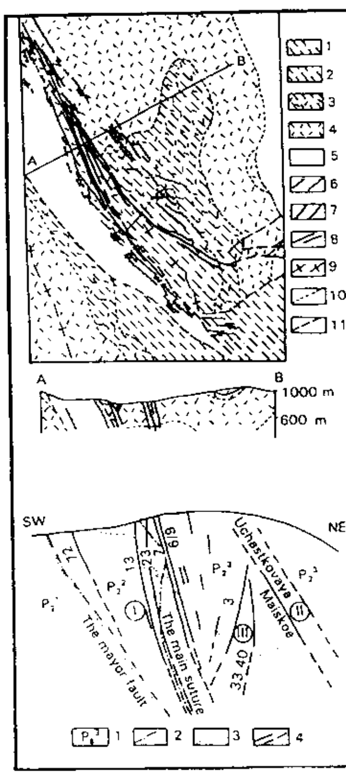


Fig. 3. Schematic geologic structure of the Natalka deposit (Ivanyuk, Khrebtov, 1976; Sidorov, Goryachev, 1994).

1-3 - the Neryuchin suite horizons (P_2); 4 - the Atkan suite (P_2); 5 - the Tasskaya suite; 6 - quartz-albite porphyry dikes; 7 - lamprophyre dikes; 8 - ore veins and zones; 9 - fold axes; 10 - geologic boundaries; 11 - faults.

Schematic sections for the middle portion: 1 - the Neryuchin (P_2^1), the Atkan (P_2^2), the Tasskaya (P_2^3); 2 - faults, 3 - lithologic boundaries; 4 - ore bodies and their suites: I - 6/9, II - the Uchastkovaya, Maiskaya, III - 3/33, 49.

Relatively large gold particles are found in late stibnite-quartz vein pockets. This is the principal deposit type, which supposition is supported by the incipient gold and rare metal, gold-silver, antimony and mercury mineralizations within the Maisky mineral district (Fig. 2).

The Nezhdanin and Natalka deposits (Fig. 3) differ from the Maiskoe deposit for important gold-quartz veins and epigenetic mineralization evidently inherited from the primary metamorphogenic and hydrothermal-sedimentary mineralization types.

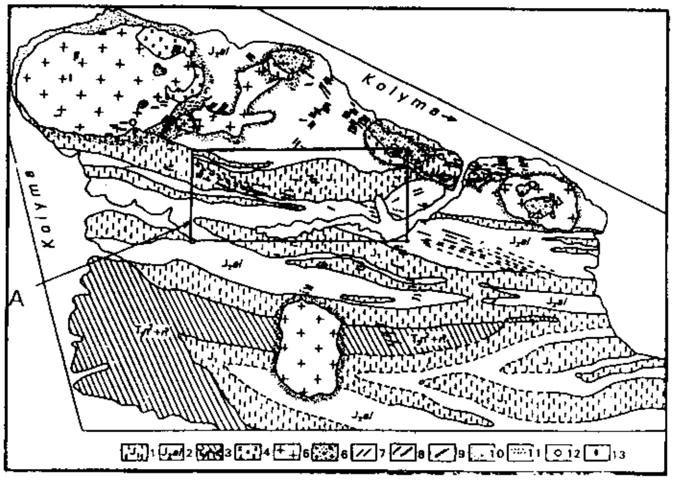
Au-QURTZ DEPOSITS

Au-quartz deposits occur in different ore assemblages. The commercial character of these deposits is mostly due to quartz-sulphide, and, to a lesser extent, gold-sulphide ore assemblages. Au quartz veins and stringers are wide-spread in the Verkhoyan gold deposits of Permian to Upper Jurassic (Figs. 4 and 4a). The most of Au quartz veins originated and developed as hydrothermal-metamorphogenic quartz veins of Alpian type, with their auriferous properties genetically related to gold-bearing zones of sulphidization. Outside these zones, hydrothermal-metamorphogenic veins do not contain gold. The gold-bearing zones of the Verkhoyan black shales are of a different nature. Zones of fault-related stratiform pyritization are the most wide-spread, and most of Au quartz veins are related to them. Morphologically, the veins are classified as sub-bedded folded and saddle to steep-crossing and fault-preceding ones. Veins and stringers are often confined to oligomictic quartz sandstones, zones of contortion, cleavage and fracturing, diorite-porphyrite dikes, and sometimes to small gabbro-diabase intrusions as it is in Chukotka (Fig. 5).

Table. Ore associations of terranes in the northeastern Russia

N	The name of ore associations complexes	Types of terranes	Ore associations of a complexes (base ore associations are shown)	Deposits
1	*a) Platinum metal accessory* *b) Chromite*	Oceanic crust, ophiolites	**Platinum metal, chromite**, tungsten-mercury, gold-rare metal (telluride)	Pekulney, Tamvatney (W, Hg)
2	*Disseminated quartz-sulphide (undifferentiated)*	Flysch basins of marginal continental blocks and marginal seas (collision and accretion stages)	**Disseminated gold-quartz-sulphide**, gold-quartz. Cassiterite-quartz, cassiterite-silica, cassiterite-sulphide, wolframite-cassiterite-quartz, uranium, antimony	Degdekan, Tokichan, Shturm, Utin (Au), Pyrkakai (Sn), Iultin (W, Sn), Butygtchag (U, Sn)
3	*Disseminated gold-sulphide*	Flysch basins of marginal continental blocks, continental shelf (accretion and post-accretion stages)	**Dissiminated gold-sulphide**, gold-quartz, gold-rare metal, gold-silver, gold-polymetallic, antimony-mercury	Maiskoe, Natalka, Nezhdanin, Shkolnoe (Au), Sopka Rudnaya (Au, Ag), Palyan Plamennoe (Hg, Sb)
4	*a) Silver-sulphide (pre-porphyry* *b) tin-silver-porphyry*	Flysch basins of marginal seas and marginal continental blocks (accretion and post-accretion stages)	**Silver-sulphide, tin-porphyry**, cassiterite-silica-sulphide, gold-silver (high-silver), gold-rare metal	Omsukchan, Dukat (Ag), Podgornor (Au, Co), Kheta (Sn, Ag), Valkumei (Sn)
5	*Cooper-porphyry (cooper-molybdenum-porphyry)*	Island arcs, continental rifts, ophiolitic	**Cooper-(molybdenum)-porphyry**, gold-rare metal polymetallic, gold-silver, gold-telluride, mercury	8Bain, Peschanka (Cu, Mo), Vesennee (Au, Ag), Chimchememel (Hg), Koni-Murgal
6	*Lead-zinc (stratiform)*	Continental shelf	**Lead-zinc**, scheelite-sulphide-quartz, gold-silver, gold-sulphide-quartz	Omulev, Bitum-Sdvig (Pb, Zn, F)
7	*Iron formation*	Cratonal	**Iron formation**, quartz-magnetite, quartz-hematite, gold-sulphide-quartz, gold-silver	South Omolon, Upper Omolon (Fe), Kubaka (Au, Ag)

Au quartz deposits are less typical of the gold-sulphide assemblage related to epigenetic fine sulphide disseminated mineralization, that occurred during a post-accretionary development of volcanic belts and active tectonomagmatic areas. Such Au quartz deposits, or, at least, their upper horizons feature a near-surface ore type and are characterized by fahlore parageneses, i. e. gold-freibergite and gold-sulfostibnite, a relatively low gold fineness, i. e. 800-750, and an increased silver content of ore. According to data obtained for the upper part of these deposits, these are sometimes interpreted as belonging to the gold-silver epithermal type, but the evidences obtained for their lower horizons prove such a viewpoint quite invalid. Au quartz veins together with gold-sulphide disseminations make up the major and unique deposits, which we classify as belonging to a principal assemblage of the gold-sulphide complex.



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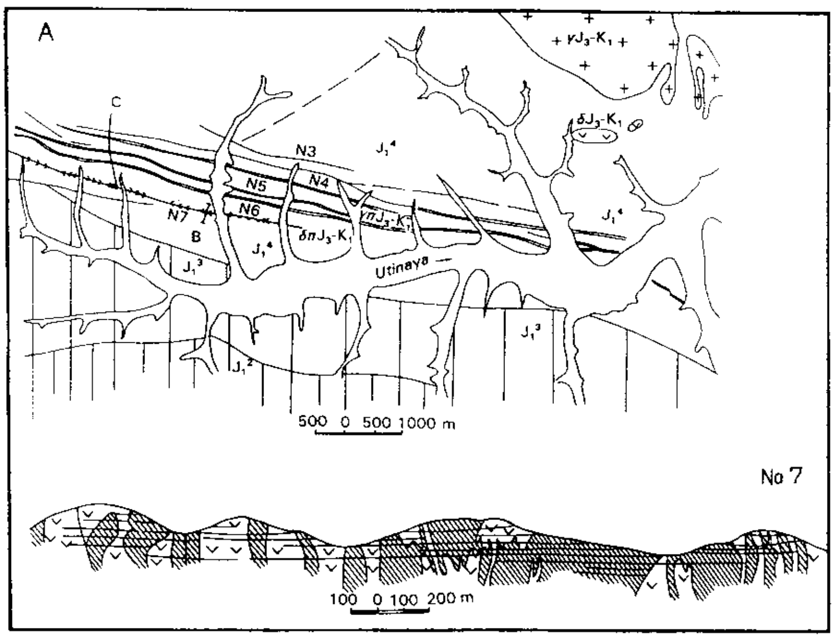

4a

Figs. 4 and 4a. The geologic environment and structure of the Utin deposit. The Basugunyin ore-magmatic district (according to G.N.Gamyanin et al., 1991; Konyshev, 1953)
Sediments: 1 - Lower Jurassic, 2 - Middle Jurassic, 3 - Upper Triassic; magmatic complexes: diorite-granodiorite: 4 - quartz diorites, 5 - porphyry granodiorites, 6 - small-grained granites, 7 - dikes and stocks of intermediate and felsic composition; granodiorite-granite: 8 - granodiorites, 9 - adamellites, 10 - granites; 11 - quartz veins; 12 - gold and rare metal quartz veins; 13 - gold quartz veins.
A - the deposit locality; B - a transverse section, and No 7 is a longitudinal section after dike No 7.

Au quartz (gold-sulphide-quartz) deposits are as well peculiarized for how they are related to porphyry assemblages, i.e. copper-(molybdenum) and tin-porphyry ones. There are the major commercial porphyry deposits belonging to these assemblages, whereas the associated gold-quartz veins are not usually classified as independent occurrences. But if the concentrations of such main metals as copper, molybdenum and tin are low, these deposits are defined as gold-porphyry, and, in northeastern Russia, gold and rare metal ones, based on the presence of relatively high-temperature mineral parageneses of molybdenum, tin, tungsten and bismuth.

GOLD-SILVER DEPOSITS

Gold-silver deposits belong to the epithermal type. They are classified into different mineral assemblages and have different sources of ore matter. This deposit type mostly belongs to the described gold-sulphide and porphyry assemblages occurring within the post-accretionary metallogenic belt related to the Okhotsk-Chukchi volcanic belt of the Aptian-Albian ages in northeastern Asia. Within this belt, gold-silver deposits of the massive sulphide assemblage may be present in the island arc terranes; in our opinion, the Kubaka gold-sulphide deposit of Late Paleozoic occurring in the Omolon cratonal terrane is related to the iron formation (or massive sulphide?) assemblage of Proterozoic. These deposits have the ore composition and structure as follows.

The Karamken deposit

The Karamken deposit is related to the Arman volcanic structure (Fig. 6) of the Okhotsk portion of the Okhotsk-Chukchi volcanic belt. Here, the ore bodies are related to a semi-circular subsidence structure of the caldera type, the inner portion of which is infilled with Upper Cretaceous rhyolites and dacites, and the outer uprisen one - with andesites and andesite-dacites of volcanic-sedimentary and volcanic origin.

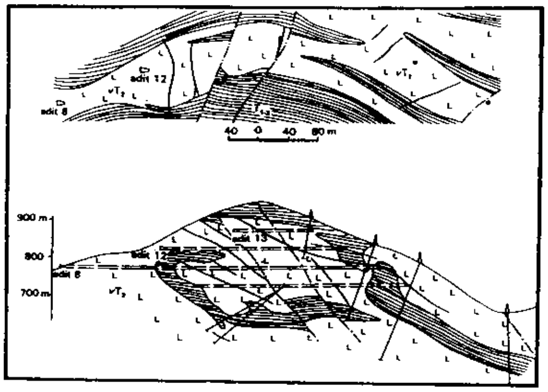

Fig. 5. Schematic geologic structure of the Karaveem deposit (the Bezymyanny area is shown after F.B.Raevsky, 1979; Sidorov, Goryachev, 1994).

Andesite, andesite-dacite and rhyolite subvolcanic intrusions are confined to the arc faults and form a complex semi-circular sheet body. It has the dip angle 30-40° toward the center of the volcanic structure, and, to the north of it, there are outcrops of plagiogranite porphyry and granodiorite porphyry rocks. Ore bodies are related to subvolcanic dacites and their automagmatic breccias (Fig. 7). Ore veins and stringers are grouped into zones, which trend northeast and sublatitudinally. Veins have the dip angle 45-85° northwest and southeast. Veins have thickness 0.6 to 3 m and length to 500-600 m. Gangue minerals include adularia-quartz, carbonate-quartz and quartz, the amount of ore minerals, which are more than 60 in their number, is not more than 0.5-1%. Mineral inclusions are usually not more than several tenths of millimeter and are dispersed in the matrix or form linear accumulations after the vein salbands.

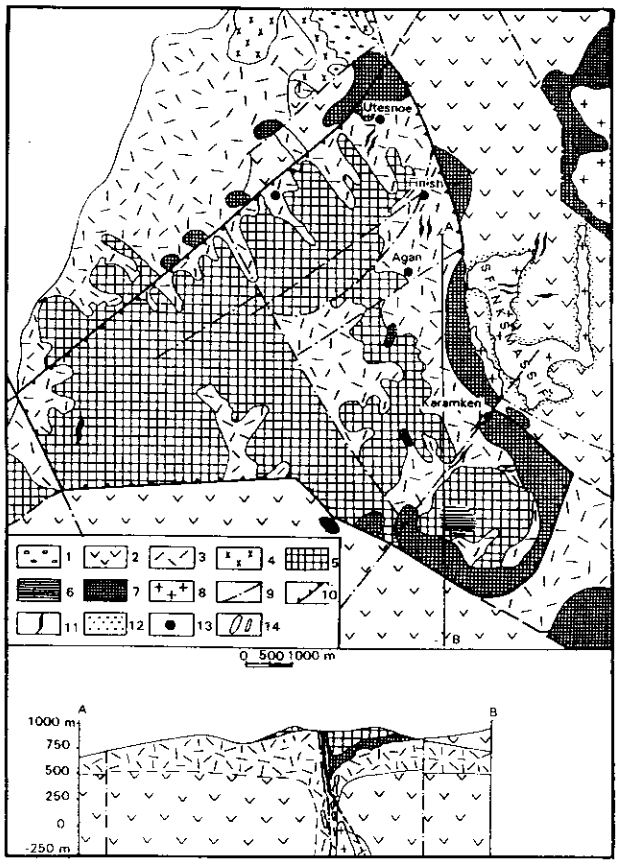

Fig. 6. Schematic geologic structure of the Arman volcanic structure (compiled by N.A.Shilyaeva and with the use of materials of R.B.Umitbaev, R.A.Eryomin, G.P.Demin and A.A.Krasilnikov; Sidorov, Goryachev, 1994).
Albian-Cenomanian rocks: 1 - terrigenous sandstones and conglomerates, 2 - andesite basalts, 3 - rhyolite dacites and rhyolites, 4 - granodiorites; Turonian (?) rocks: 5 - flow rhyolites, 6 - rhyolites of the volcano neck facies, 7 - subvolcanic rhyolite intrusions and extrusions, 8 - granites of the Sfinks massif; 9 - faults; 10 - the tectonic boundaries of the volcanic structure; 11 - adularia quartz veins; 12 - hornfels alteration; 13 - gold mineralization occurrences; 14 - felsic volcanic xenoliths.

The most wide-spread minerals include quartz, adularia, pyrite, sphalerite, chalcopyrite, electrum, sometimes canfieldite, freibergite, tennantite, naumannite, pseudopolybasite and native silver. Canfieldite and, at a larger depth, stannite and cassiterite represent the later parageneses. Electrum is often present as intergrowths with pyrite and has fineness 650-570 per mille. Gold-to-silver ratio of ore is 1:3. Ore bodies occur in association with adularia-quartz, monoquartz and kaolinite-hydromicaceous metasomatites with cinnabar-stibnite-pyrite mineralization. Carbonate-chlorite metasomatites occur in the outer portions of zones of hydrothermal alterations.

We classify the Karamken deposit as belonging to the gold-sulphide assemblage (complex), which includes the following deposit types: disseminated gold-sulphide, gold and rare metal (gold-porphyry), gold-silver, antimony and mercury deposits. These mineral assemblages are usually pre-sent in "frontier" ore districts, which separate between the occurrences of copper (molybde-num)-porphyry and tin (silver)-porphyry minerals.

The Baim group of deposits

The Baim group of gold-silver deposits belongs to the copper-(molybdenum)-porphyry assemblage and occurs in the island arc terrane adjacent to the Aluchin oceanic crust terrane. These deposits are confined to an area of northwestern and submeridional faults and thrusts. There are intricately intercalated terrigenous and effusive rocks of Late Jurassic.

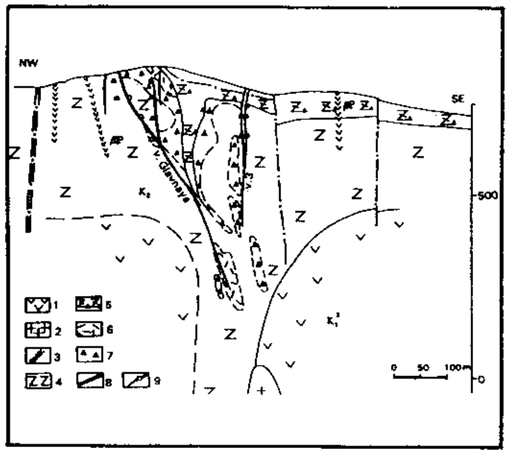

Fig. 7. Vertical schematic section of the Karamken deposit (Sidorov, Goryachev, 1994).
1 - andesites; 2 - plagiogranite porphyries; 3 - basalt dikes; 4 - dacites; 5 - automagmatic andesite breccias; 6 - rhyolites; 7 - breccias with quartz sulphide cement; 8 - faults; 9 - ore veins and mine workings after them.

Intrusive rocks are distinguished here into three groups as follows: gabbro and gabbro-syenite stocks and dikes, diorite porphyrite, granite-porphyry, granodiorite-porphyry and quartz albitophyre dikes, trachyandesite dikes, diorite porphyrite stocks and large rock masses, and rare spessartite dikes. Rocks have an increase in their general alkalinity; the amount of sodium is usually twice as much as potassium. The infilling and replacement veins are concordant to subvolcanic dikes and sometimes are confined to their contacts or cut them; there are also brecciated zones and stockworks. The main ore zone is confined to a contact between the rhyolite and andesite sequences. Within it, there are quartz veins and lenticular occurrences established for several tens and hundreds meters, the thickness is 1 to 10 m. This deposit type is characterized by different mineral assemblages. The electrum-sphalerite-galena assemblage is usually a productive one. Gold grade is to several tens g/t. There are just preliminary data obtained on this deposit type. Some ore-bearing veins occur within the Peschanka copper (molybdenum)-porphyry deposit and can be interpreted as a non-porphyry component of this deposit.

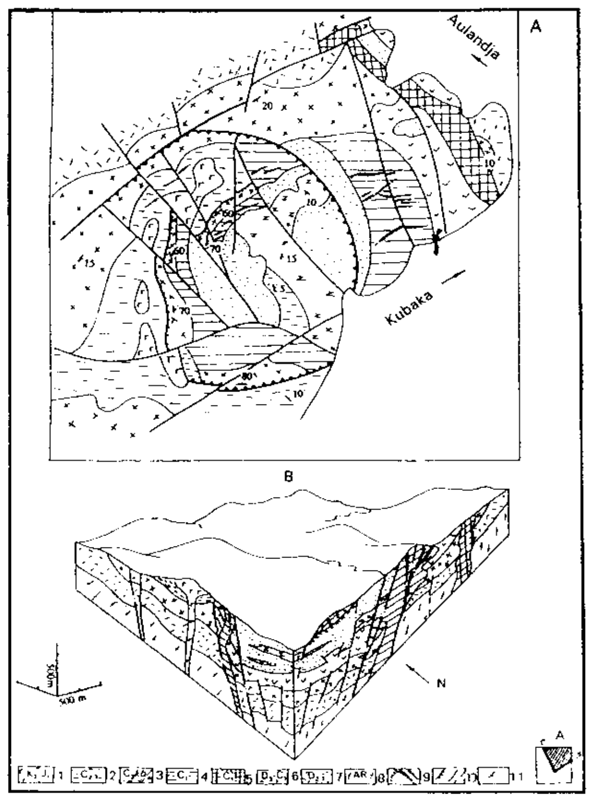

Fig. 8. Schematic geologic structure of the Kubaka caldera, according to I.N.Kotlyar and N.E.Savva (Sidorov, Goryachev, 1994).
1 - alkalic gabbroids; 2 - coaly shales of the Korbin suite; 3 - trachybasalt tuffs and trachyandesites of the Kubaka sequence; 4 - trachydacites; 5 - rhyolites; 6 - tuff sandstones; 7 - ignimbrites and rhyolite tuffs; 8 - biotite-amphibole gneiss; 9 - ore bodies; 10 - tectonic displacements; 11 - rock bedding elements.

The Kubaka deposit

The Kubaka deposit is located within the Omolon craton and related to the andesite volcanic event of Devonian-Carboniferous evidencing the rejuvenated mineralization in Late Mesozoic. The Kubaka deposit is confined to a caldera-form structure (Fig. 8), which underwent a resurgent dome formation during the intrusion of ore-hosting subvolcanic trachydacites (Kotlyar et al., 1988). The ore bodies here are dominated by infilling veins and small stockworks. Veins have a sublatitudinal strike and their length is up to 500 m, the thickness is impersistent with swells up to 20 m and pinches to 10 cm. The structure of veins is typical of epithermal deposits. About forty hypogenic minerals are established, but, nevertheless, quartz (chalcedony), adularia, electrum and carbonates make up 99% of the total. There are also other minerals as pyrite, sphalerite, arsenopyrite, freibergite, acanthite, aguilarite, naumannite, native silver and others. Some ore bodies contain fluorite and barite. The average gold fineness is 780 per mille. Gold-to-silver ratio is about 1:1, the average gold grade is up to 20-40 g/t for some veins.

We tentatively classify this mineral deposit as belonging to the iron formation complex, to which barite-massive sulphide occurrences may be probably related.

GOLD-PORPHYRY GROUP

Gold and rare metal (gold-porphyry) group of deposits is also classified into the most various mineral assemblages, though the commercial character of these deposits seems to be related only to gold-sulphide and copper (molybdenum)-porphyry assemblages. Porphyry deposits, which are not commercial by their main components as Cu, Mo or Sn and Ag, are often defined as gold-porphyry ones. With reference to different ore assemblages, these mineral deposits are classified as follows.

Gold and rare metal deposits of the gold-sulphide assemblage

Gold and rare metal deposits of the gold-sulphide assemblage are related to small rock masses of diorite, granodiorite, biotite granite and adamellite rocks. Later differentiated occurrences include granite-porphyry and lamprophyre dikes. In the Shkolnoe deposit, that is the Viligin passive continental margin terrane, quartz veins are known at depth within a granitoid rock mass, and also occur in the Verkhoyan hornfelsic sandstones and clays (Fig. 9).

There are two gold-bearing mineral assemblages distinguished by their composition, as follows: gold-arsenopyrite-quartz (arsenopyrite, pyrite, scheelite, gold and other minerals), and gold-sulphide (gold, freibergite, jamesonite and other minerals). There is also a high-temperature (pre-productive) molybdenite-quartz assemblage (arsenopyrite, scheelite, molybdenite and other minerals) and the late quartz-carbonate one (pyrite, marcasite and stibnite). The size of gold inclusions in ore is from microscopic to 3-5 mm and larger. The gold particle fineness is from 500 to 800.

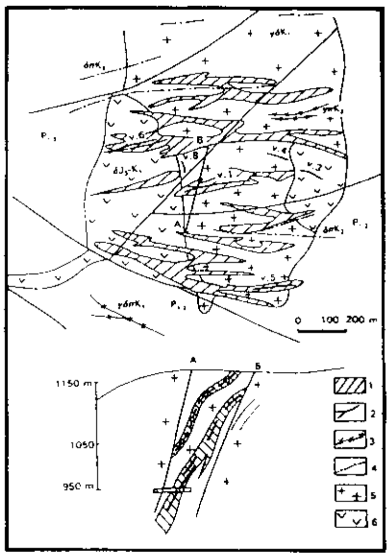

Fig. 9. Geologic scheme of the Shkolnoe deposit (Sidorov, Goryachev, 1994).
1 - metasomatites; 2 - quartz bodies; 3 - felsic dikes; 4 - mafic dikes; 5 - granites; 6 - quartz diorites.

Gold and rare metal deposits of the quartz-sulphide assemblage

Gold and rare metal deposits of the quartz-sulphide assemblage occur in terranes of passive continental margins and turbidite basins in Kolyma and Chukotka. These deposits are associated with well-known gold-quartz deposits and form a single complex with them. Gold-bearing intrusions are of a "pre-batholith" origin and include potassium-sodium granite and granodiorite-porphyry rocks. Quartz veins, which are confined to these intrusions, are often very similar to gold-quartz veins in dikes, that is the dike type of gold-quartz deposits. The presence of high-temperature rare metal assemblages (Sn, Mo, W, Bi) is the difference from gold-quartz deposits.

Gold and rare metal deposits of the copper-porphyry assemblage

Gold and rare metal deposits of the copper-porphyry assemblage are related to monzonitoid sodium intrusions and occur within the post-accretionary metallogenic belt in northeastern Asia. They are close to the similar deposits of the gold-sulphide assemblage by their ore type, but differ for an obvious chalcopyrite mineralization and increased silver properties of ore.

Gold and rare metal deposits of the tin (silver)-porphyry assemblage

Gold and rare metal deposits of the tin (silver)-porphyry assemblage are present in the outer zone of the mentioned metallogenic belt. These deposits are related to different intrusions ranging from biotite granites and gabbro-diorite-granodiorite rocks to leucocratic granites. Ore bodies occur in association with major zones of tourmaline and chlorite rock alterations. This is a high-sulphide ore type (up to 5-10%) abundant with rare metal assemblages including bismuth-telluride, cassiterite-wolframite, lollingite-stannite with cobaltite and others. These mineral deposits have small gold reserves, but may be of a commercial interest for a combined production of other metals.

GOLD-PLATINUM MINERALIZATION

The discovery of gold-platinum and gold-osmium-platinum placer deposits of the Alaska type is possible in Chukotka in the Aluchin massif, the Pekulney Range and in the Bering District area. A combined mining of gold, platinum and osmiridium is conducted in the Bering and Anadyr District areas. Here, the platinum metal contents in placers range from several tens mg/m up to several g/m. The amount of platinum metal minerals is sometimes 10-15% in gold heavy concentrate. According to L.V.Razin, there are osmiridium crystals 1 cm in size in the Khatyrka placer deposit. In 1977, at the Otrozhny mine, the production of osmiridium from the Listvenitovy Creek placer was several hundreds grams.

The estimates of platinum metal and gold-platinum metal placer reserves in Chukotka, Koryakiya and Kamchatka are just fragmentary and insufficient due to the lack of data on these areas and that the estimate standards have not yet been developed for these deposits.

In the last few years, the researchers from the Northeast Interdisciplinary Research Institute in Magadan have substantially studied the bedrock sources for gold-platinum metal placer deposits, and, by now, the information is obtained on four rock masses of alpinotype ultramafites measuring from 4 to 40 sq. km. The alpinotype ultramafite rock masses are generally grouped into several belts, the length of which is about several hundreds km. An accessory gold-platinum metal mineralization occurs in all known rock masses of this kind, which are, thus, the potential sources for placer deposits. It will be probably true also for other rock masses featuring the similar composition. Accessory minerals of gold-platinum elements are related to the incipient disseminations of chrome spinellids and their mineral segregations of chromites. Gold-platinum metal mineralization in ultramafites, that is lherzolite-harzburgite and dunite-harzburgite series, has ruthenium, iridium and osmium as the main mineral-forming elements and platinum, rhodium and palladium are secondary. The reverse is characteristic of another taxite rock assemblage and neighboring magnesian dunites, which have platinum, rhodium and palladium as the main mineral-forming elements, with the proper osmium, ruthenium and iridium minerals being scarce. The bedrock sources for gold-platinum metals related to alpinotype ultramafites hardly have any commercial importance except for major expected chromitite occurrences, which may be possibly found. Nevertheless, the placer deposits related to ultramafite rock masses are the payable targets and their mining technology seems to be quite simple.

Thus, it becomes a fact now, that gold and gold-bearing deposits occur within the most important magmatic, fluid-hydrothermal (porphyry), sedimentary-hydrothermal and hydrothermal mineral assemblages. Most of lode deposits are typical of mineral assemblages, which are genetically different, and this is due to the identical physicochemical conditions of mineralization. The composition of mineral assemblages, the intensity and extensity properties of gold lode deposits are influenced by the composition and genesis of the principal deposits of mineral assemblages, i. e. massive sulphide, porphyry, disseminated sulphide and magmatic ones. These principal deposits develop simultaneously with lode deposits and often serve as the sources of ore matter for lode deposits.

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