Дубровский В.Н., Малиновский Е.П., Родионов СМ. Структура и зональность оловорудных месторождений Комсомольского района. М., "Наука", 1979. 136с.

Излагаются результаты исследования структуры и минеральной зональности некоторых высокотемпературных близповерхностных оловорудных месторождений Комсомольского района (Хабаровский край), образовавшихся вследствие позднемеловой тектоно-магматической активизации мезозойской геосинклинальной области. На примере месторождений Фестивального и Придорожного расшифрована история развития структуры вмещающих пород, установлены соотношения пространственной ориентировки осей деформации разных этапов с условиями залегания минерализованных зон и рудных тел в их пределах. На основании систематических изучений в горных выработках составов и количественных соотношений продуктов разновозрастной минерализации выявлено наличие рудной зональности. Предложены методические приемы, позволяющие проводить сопоставление элементов минеральной зональности с деформационной историей рудовмещающего блока. Определены закономерности поведения рудных столбов в плоскости минерализованных зон.

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Копылов М.И., Плотницкий Ю.Е., Родионов СМ., Романовский Н.П. **Хингано-Олонойский оловорудный район: геолого-геофизические характеристики, рудоносность, проблемы развития сырьевой базы.** Владивосток; Хабаровск: ДВО РАН, 2004.252 с: 53 ил., 5 табл., библиогр. 164 назв. ISBN 5-7442-1361-9.

Исследованы частные и разработаны комплексные критерии прогноза и оценки промышленного оруденения в оловорудных районах Дальневосточного федерального округа. Определены возможности обеспечения минерально-сырьевой базы оловодобывающих предприятий. На основе анализа результатов 50-летних геолого-геофизических исследований в Хингано-Олонойском районе выделены промышленно перспективные объекты в пределах Хинганской, Березовской, Центральной и Карадубской групп месторождений, приведены данные о количестве и качестве балансовых запасов и прогнозных ресурсов олова и сопутствующей минерализации. Рекомендованы участки первоочередных работ. Существенно по-новому оценено влияние глубинных рудоносных структур, генерирующих оруденение на коро-мантийных уровнях.

Ключевые слова: олово, месторождения, прогнозные запасы, Дальний Восток, Хингано-Олонойский район.

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Для специалистов в области наук о Земле, горнорудной промышленности, аспирантов и студентов геологических специальностей вузов.

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The Kuranakh epithermal gold deposit, East Russia

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Abstract. The Kuranakh mine is one of the largest lode gold mines in Russia and has produced 220 tonnes of gold. From 1957 until 1997 the mine has extracted 74.1 million tonnes of ore grading 3.57 g/t gold (Benevolskiy, 1985). The Kuranakh gold deposit is of the epithermal, quartz-adularia-sericite (illite)-type. Several sub-horizontal, blanket- or ribbon-like ore bodies up to 50 m thick occur mainly along and/or above, and in some places, under the contact between Cambrian calcareous footwall rocks and overlying Jurassic clastic rocks within a narrow zone, about 30 km long, bounded by several south-north trending faults. Originally, gold mineralization was associated with pyrite, arsenopyrite, sphalerite, and galena; however, total sulfides were only a few percent of the total rock mass. The deposit has been thoroughly oxidized and only traces of arsenopyrite and pyrite are found. Gold occurs primarily as mineral grains less than 5 microns in size and is usually contained within friable grains of porous goethite. Studies of fluid inclusions show homogenization temperatures from 80oC to 220oC but generally averaging from 110 °C to 160°C.

Keywords. Kuranakh mine, epythermal, gold, Aldan Shield, Russia

1 Geologic setting

The Kuranakh gold deposit is located within the Central Aldan Ore District (CAD) that is situated within Aldan shield on the southern flank of Siberian Platform (Fig. 1). The Aldan shield consists predominantly of Archean rock complexes that are metamorphosed to granulite and amphibolite facies. Mesozoic collision of the Siberian Platform and Bureya superterrane resulted in formation of sub-latitudinal systems of sedimentary basins of back-arc type that are filled with Jurassic and, partly, Lower Cretaceous coal-bearing terrigenous deposits. The continuing collision resulted in intensive folding of Mesozoic sedimentary rocks with development of complex systems of gentle folds, isoclinal folds, and overturned folds (Mokrinskiy 1961), as well as numerous north-verging thrusts. Widespread Mesozoic magmatic activity is also related to the collision processes.

Several different types of gold deposits occur within the Central Aldan Ore District (Vetluzhskikh, Kim 1997). Disseminated Au-U mineralization occurs within the Archean basement in the southeastern flank of the district. The deposit is related to feldspar-pyrite-carbonate and fluospar-carbonate-quartz altered rocks within breccia zones. Gold-bearing lens-shaped ore bodies are of hundreds meters long and of 10-30 meters thick. Gold content varies from 0.1 to 100.0 g/t.

Cambrian calcareous rocks on the southwest flank of the district host flat-laying gold-sulfide veins of very complex morphology; they also host zones of disseminated gold-sulfide mineralization at depths from 0-20 to 135-140 m. The ore contains pyrite, pyrrhotite, galena, hematite, mag-

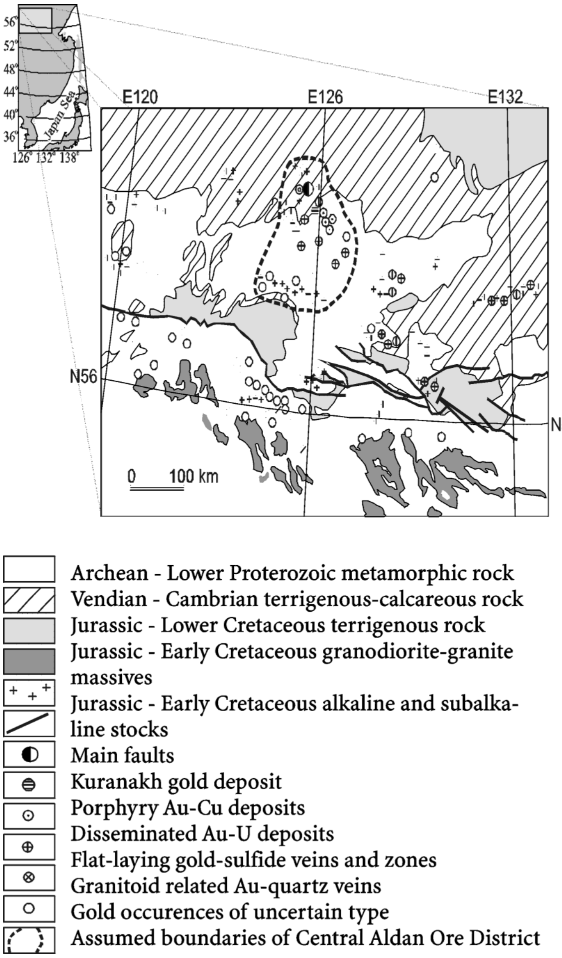

Figure 1: Geologic setting of Central Aldan Ore District (adapted from Vetluzhskikh and Kim 1997)

netite, sphalerite, native gold, rare cinnabar, native bismuth, silver, and tetrahedrite. Au/Ag ratios vary from 10/1 to 5/1. Gold content varies from 0.9 to 100.0 g/t and more.

Porphyry Au-Cu deposit occurs in the central part of the district. Stockwork gold-sulfide mineralization is related to alkaline syenite stock. Altered rocks consist of sericite, microcline, pyrite, ankerite. Disseminated and veinlet-controlled ore contains pyrite, chalcopyrite, bornite, and native gold.

Stratabound low-sulfide gold mineralization occurs at the contact of Jurassic sedimentary and Cambrian calcareous rocks in the northern part of CAD. This type of gold deposit is now the most economically important in the district. The Kuranakh deposit belongs to this type.

2 Geology of the Kuranakh deposit

The Kuranakh deposit (Fig. 2) is situated topographically lower and stratigraphically higher than most gold occurrences of the CAD. Jurassic clastic rocks, which are the predominant host rocks of the Kuranakh-type, are preserved in the uplift within a shallow synclinal basin which trends north-south and extends north onto the edge of the platform sedimentary rocks.

The stratigraphy of the Kuranakh deposit is composed of approximately 1,000 meters of Cambrian dolomite and limestone unconformably overlain by 40 to 70 meters of Jurassic sandstone.

The upper contact of the Cambrian sequence is marked by the presence of a terra rossa of variable thickness. The unit generally varies from zero to 15 thicker at some localities, and consists of clay and weathered limestone. It is mapped and logged by the mine geologists as “limestone weathering crust” and contains some gold.

Within the immediate vicinity of the mine, the igneous rocks present are Mesozoic (Early Cretaceous?) dikes and some plugs and sills of vogezite, biotite-pyroxene porphyry, shonkinite, syenite-porphyry, trachyte, bostonite, microgabbro, and minette. The dikes have a close spatial relationship with the gold ores and may be related to the same thermal event that gave rise to the deposits.

3 Physical description of the Kuranakh ore field

In plan view, the ore bodies comprising the Kuranakh Ore Field (KOF) have a shape resembling an inverted “Y”. The KOF extends from the south end of the Kanavnoye ore body to the northern limit of the Severnoye ore body in the north - a distance of more than twenty kilometers; the field varies from one to eleven kilometers in width in an east west direction (see Fig. 2). One of the longest stretches of continuous gold mineralization are the coalescing of Porphirovoye, Tsentralnoye, and Yakokutskoye ore bodies, which combine for a length exceeding ten kilometers. Although the terrain is hilly, one of the striking features of the deposits is that the principal ore bodies tend to occur along topographic highs. This geomorphic phenomenon is perhaps due to the resistance to weathering that the Jurassic sandstones have gained through processes of metasomatic alteration and the fact that the sandstones themselves seem more resistant to weathering than the underlying carbonate rocks.

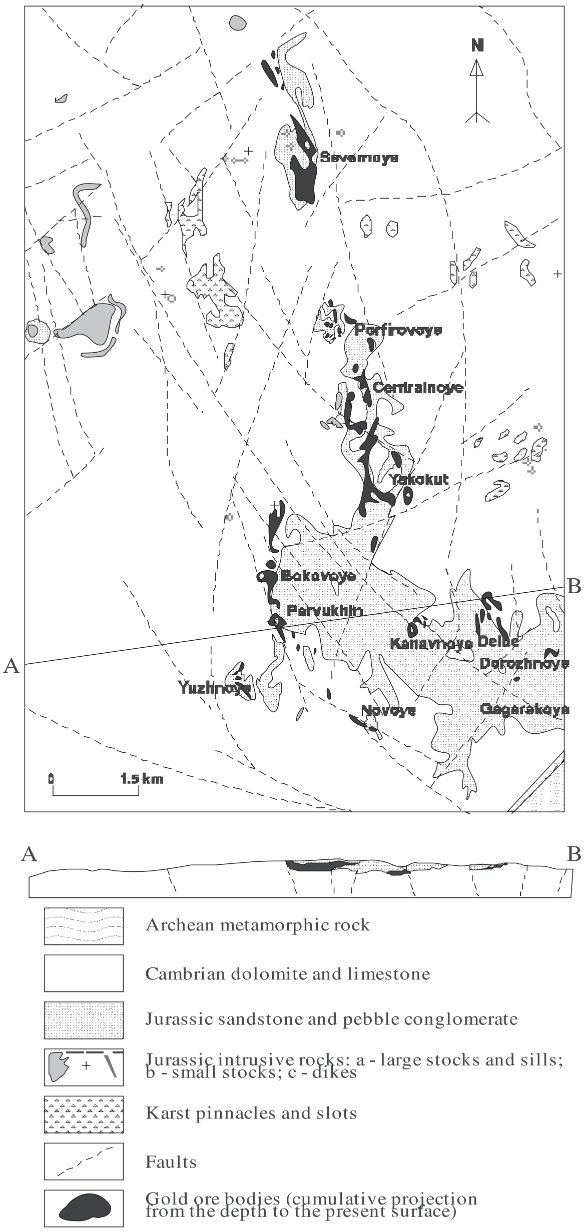

Figure 2: Geologic map of Kuranakh deposit (adapted from Kazarinov 1969)

Morphologically the ore bodies have disjointed blanket-like shapes in their shortest dimension with thicknesses that rapidly increase in the areas of the most extreme faulting of calcareous rocks and karst development. Some disruptions in continuity perpendicular to the long axis of the ore bodies are due to gentle folding of the deposit and erosion of the limbs; other disruptions are due to the faulting and the considerable relief of the Cambrian-Jurassic contact which is now incised by erosion. Individual ore bodies (>1 g/t gold) have a lenticular shape, strongly oriented NNW-SSE and commonly coalesce or diverge along strike.

4 Mineralization and alteration

At Kuranakh the mineralization is essentially restricted to the basal portion of the Jurassic sandstone, and the breccias or karst cavity fillings; the thicknesses of material grading better than one gram per tonne gold may be up to 100 meters or more. The basal section of the sandstones has been altered (metasomatized) by hydrothermal fluids, and where intense enough, is distinguished by mine geologists as a separate rock unit – "metasomatite". The metasomatite (a clay-potassic feldspar-quartz-bearing rock) is often reddish in color and usually displays myriad druzy quartz veinlets and open space fillings. In some places, this metasomatite resembles jasperoids. Sandstone peripheral to metasomatites also displays quartz veinlets, and contains low-grade gold mineralization, differing from the metasomatite principally in the intensity of silica and adulalria flooding. The progressive transition of the arkosic host rocks to a massive, quartz-adularia metasomatite is well displayed on the west side of the Severnoye pit, for example.

The ores display a variable clay content, from a few percent to twenty percent, and it is difficult to determine how much of this clay is the result of original hydrothermal alteration of potassium feldspars in the arkosic sandstones and how much is a result of the high degree of weathering and oxidation which the rocks have been subjected to since the Quaternary. Mineralization was likely manifested by a low sulfide content (up to a few percent) but almost no sulfides have survived the thorough oxidation of the ores. Reportedly, the original surface, prior to mining, was littered with resistant boulders of highly silicified metasomatite and blocks of ore that contained some sulfides.

The primary gold ore contains two generations of pyrite (3 to 20%), minor marcasite, chalcopyrite, pyrrhotite, sphalerite, arsenopyrite, and tellurides (Kazarinov 1969; Nesterov 1985). Gold is strongly associated with iron oxides and is represented by fine-grained native gold particles measuring from less than 50 to 250 µm, and rarely 4 mm, and by dispersed gold in the pyrite of first generagion. Usually no visible gold is observed in the field. Gold fineness in pyrite is 900-970, native gold 700-885.

5 Fluid inclusion studies

Thermometry and cryometry of individual inclusions in samples of Kuranakh mineralization have been studied to determine some physical and chemical factors of ore formation. The equipment used allowed analysis of phases and their changes in inclusions greater than 3-5 mcm in diameter. The inclusions less than this diameter have been used as accessory material. The accuracy of temperature measurements was ±0.5°C for the cryocamera and 3-5°C for the thermocamera.

P-correction volumes were added to the homogenization temperatures (Th) in order to determine the forming temperatures (Tf) and calculated using data of Potter (1977). According to the petrological and geological data, a depth of formation of ore-bearing rocks in Kuranakh Ore Field was probably no more than 500 m. Because of the open character of the ore-forming hydrothermal fluid system, P-corrections were calculated in accordance with the hydrostatic model of fluid pressure. Estimations of the pressures were derived from fluid inclusions on the base of data from Potter and Brown (1977). In this case, the composition of inclusions is approximated by the system H_2O-NaCl.

We have studied quartz and calcite from Au-bearing ores of Severnoye, Porfirovoye, Tsentralnoye and Yuzhnoye ore bodies and found out that they contain two groups of inclusions of different origin. Gas-liquid and liquid inclusions of water solutions predominate. Based on the obtained data, the temperatures increase southward from the Severnoye ore body towards the Yuznoye one. Apparently, the source of the ore-forming solutions was located nearer to the southern edge of the Kuranakh Ore Field.

Solution concentrations in inclusions for all deposits are nearly equal; the maximum values do not exceed 10% NaCl eq. There is no correlation between homogenization temperatures and solution concentrations, though, possibly, a tendency can be envisioned for a decrease in concentrations with increasing temperatures, especially in the "hottest" inclusions. At the same time, a drop in solution concentrations is distinct from primary to secondary inclusions in one same sample.

Fluid composition in inclusions from metasomatic quartz in all ore bodies are similar. They are essentially water solutions of chlorides of sodium and potassium, and rare calcium, magnesium and iron. Very low (-65, -78 and -79°C) eutectic temperatures hint at the presence of Li in one-phase liquid inclusions in quartz from the Severnoye and Yuznoye ore bodies.

Pressures of formation of Kuranakh ores did not exceed 100 bars, corresponding to a depth of no more than 1000 m according to the hydrostatic model and less than 500 m in terms of the lithostatic pressure.

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