

## Gold in Pyrite within Altai – Sayan Folded Belt Gold Deposits

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**Abstract.** This article describes the result analysis of gold in pyrite for a number of some Altai – Sayan folded belt gold deposits. The analyzed pyrite samples showed gold grade from 0.04 to 20.0 g/t., which proves the fact that the gold concentrations in pyrites is irregular. Pyrites in productive mineral associations include significant metal enrichment, while pyrites of early poor gold-bearing associations and wallrock metasomatites are less prolific.

### 1. Introduction

Pyrite is one of the most abundant sulfide minerals in gold-ore deposits of various geneses. The accurate interpretation of decoded information on crystal morphology, physical properties and mineral element impurities provides insight into the nature of pyrite genesis, as well as genesis of ore deposits [3, 4, 7, 8]. Based on the identified typomorphic pyrite properties, the following factors have been defined: mineralogical and geochemical zoning of the deposits, level of their erosion truncation, and location of perspective ore bodies to the depth and at the flanks and “blind” ore bodies. The gold grade in pyrite and high concentrations of gold in pyrite (either in ore bodies or wall rock metasomatites) are examples of potential ore bodies and deposits [1, 5, 9, 10]. This information is of scientific importance. In most deposits there exists a positive correlation between the pyrite crystals with pyritohedron habit and the gold grade both in pyrites and in ore bodies [2, 4, 6, 7].

### 2. Data Sources and Methodology

Pyrites in ore bodies and wallrock metasomatites were analyzed by neutron-activation and polarographic methods. The samples were retrieved from two areas: Kuznetsk Ala Tau which included Kommunarovsk ore field, Balakhchino ore field and Saralinsk ore field and Sayan Mountains, mainly the eastern part which included Konstantinovo deposit, Medvezhye deposit, Lysogorsk deposit, Tardansk deposit and Oktyabrsk deposit.

Mineral associations	n	Au g/t grade			V %
		from	to	x	
<b>Kommunarovsk ore field (Kuznetsk Ala Tau)</b>					
Quartz-gold –actinolite	14	0.22	10.0	5.45	80
Quartz-gold –scheelite	5	0.22	5.0	2.92	76
Quartz-gold –tellurobismuthite	9	0.10	20.0	5.56	164
Pyrite in wallrock metasomatites	10	0.04	10.0	2.42	165
<b>Balakhchino ore field (Kuznetsk Ala Tau)</b>					



Quartz-gold polymetallic sulfide	56	0.10	20.0	3.95	124
Beresite pyrite	28	0.10	5.0	0.94	126
<b>Saralinsk ore field (Kuznetsk Ala Tau)</b>					
Quartz-gold – sulfide	9	0.4	20.0	5.6	159
Pyrite in wallrock metasomatites	7	0.1	5.3	3.7	95
Metamorphogenetic pyrite	3	0.04	0.1	0.08	
<b>Olkhovsk –Chibizhek ore field (eastern Sayan Mountains) Konstantinovo ore deposit</b>					
Carbonate-pyrite-pyrrhotite	75	0.10	20.0	4.77	89
Quartz-gold - sulfide	91	0.10	20.0	4.73	102
Pyrite in wallrock metasomatites	8	1.00	9.0	4.90	60
<b>Medvezhye ore deposit</b>					
Carbonate-pyrite-pyrrhotite	18	0.10	3.0	1.05	135
Quartz-gold - sulfide	59	0.08	9.9	2.76	104
Pyrite in wallrock metasomatites	10	0.10	0.5	0.30	142
<b>Lysogorsk ore deposit</b>					
Quartz-gold –pyrite-bismutite	9	0.10	9.0	3.64	80
Pyrite in wall rock metasomatites	4	0.07	2.7	1.25	98
<b>Tardansk ore deposit (eastern Sayan Mountains)</b>					
Skarn-gold-ore-sulfide	14	0.05	5.0	1.57	147
Quartz-gold - sulfide	5	0.05	7.5	2.45	132
Pyrite in wallrock beresites	3	0.05	3.6	1.35	
<b>Oktyabrsk ore deposit (eastern Sayan Mountains)</b>					
Quartz-gold - sulfide	8	0.10	10.0	3.2	87
Pyrite of carbon-bearing shale	24	0.05	0.6	0.27	24

**Table 1.** Gold content in pyrites of gold deposits in Altai – Sayan folded belt

### 3. Results and Discussion

Gold was found in all analyzed pyrite samples from 0.04 to 20.0 g/t. In this case, the gold grade in pyrites within various ore deposits and associations was irregular. High gold grade was observed in pyrites from productive mineral associations, while low gold grade- older weak mineral associations in pyrites in wallrock metasomatites (table 1).

Pyrites of Kommunarovsk ore field are more prolific. For example, the average gold grade is approximately 5.45 and 5.56 g/t. in pyrites of quartz-gold –actinolite (Maslovsk, Yanvarsk, Kaliostrovsk) and quartz-gold–tellurobismuthite (Znamenitinsk, Kuznetsovsk, Yanvarsk) associations. The gold grade is twice lower in pyrites of quartz-gold –scheelite associations (Spasskoe), and pyrites in wall rock metasomatites from all ore field deposits.

The same average gold grade – 5.6 g/t. was identified in pyrites of quartz-gold-sulfide associations from Saralinsk ore field. The highest gold grade in pyrites in wallrock metasomatites were found in this region, i.e. - 3.7 g/t (table 1). The deeper the Kaskodniy ore deposits and Andreyevsk ore fields, the lower the gold grade. These concentrations are wave-like with the amplitude of 260-280 m where enrichment occurs in the most prolific zones of ore bodies. Diagenetic pyrite in enclosing shales contains the minimal gold grade– 0.08 g/t. According to the high gold grade in pyrites and the predominate development of pyrite crystal with pyritohedron habit in ore field quartz veins, the following potential ore areas were identified: Central, Kuznetsovsk, Vstrechni, Verkinski.

Increasing erosion truncation level was observed in Olkhovsk – Chibizhek ore field from Lysogorsk (drift-in horizons) to Medvezhye (depleted in 11 horizons), from Konstantinovo (depleted in 5 horizons) to north-east Tarchinski ore field (explored by core drilling), where there are very low metal concentrations in ores and pyrites. The highest gold grade could be observed in pyrites of all Konstantinovo ore deposit mineral associations, i.e. 4.73-4.90 g/t. in the Olkhovsk – Chibizhek ore field. The pyrites of the productive associations from Lysogorsk (3.64 g/t) and Medvezhye (2.75 g/t) ore deposits have lower gold grade. Pyrites in wallrock metasomatites have 3-9 times less gold grade than ore pyrites (except Konstantinovo ore deposit, where the average gold grade is a bit higher than that of in ore pyrites) (table 1). The deeper the Medvezhye ore deposit the lower the gold grade is in pyrite. These decreasing concentrations are wave-like with the amplitude of 200-240 m. Similar wave-like alterations are observed in most element-impurities in pyrite deposits [1, 5]. The deeper the Konstantinovo ore deposit, the higher the average gold grade in pyrites - from 3.1 g/t in the horizon of 417 m to 5.9 g/t in the horizon of 297 m. Such ore deposits could be potential.

Pyrites of quartz-gold polymetallic sulfide associations in Balakhchino quartz veins exhibit a rather high metal concentration – 3.95 g/t (ranging from 0.1 to 20.0 g/t). There are both horizontal and vertical zoning of gold distribution in pyrites of ore bodies. Horizontal zoning in pyrites shows the gold grade decrease from Maiskaya (highly temperature vein – 6.9 g/t,) to Oktyabrskaya pyrites (medium temperature vein – 3.2 g/t), then to pyrites of Chapayevskaya and Izotovskaya (low temperature veins – 3.07 g/t). This demonstrates the decrease of vein erosional truncation level towards this direction. A significant gold grade increase in all quartz veins is observed at depth. High gold grade in accessory pyrites of Balakhchino diorite – monzonite massif – 0.11 g/t. is also observed.

Pyrites of Tardansk skarn-ore deposit and Oktyabrsk quartz –vein deposit of Tyva ore field are characterized by a reduced gold grade in comparison to other deposits of this region (table 1). The gold grade in pyrites is up to 10 g/t (the average is 3,2 g/t) in Oktyabrsk deposit (Amylo-Sistighemsk region) in Stepanovsk and Grigoryevsk quartz veins. The gold grade is significantly lower in other ore deposit veins (Nikolskaya, Neizvestnaya, Poperechnaya, Baba). Metamorphogenetic pyrites in carbonic shales contain only 0.27 g/t. gold.

Medium gold grade in pyrites from Tardan skarn-ore bodies is 1.57 g/t. Fine-grained gold can be found not only in pyrite but also in ores. Downward the gold grade increases gradually in pyrites. In quartz veins of Kopto (6 km to the north-east of Tardan) ore formation the gold grade in pyrites of quartz veins and wallrock beresites is higher – 2.45 and 1.35 g/t respectively, in comparison to those in Tardan skarn-ore bodies.

Gold concentration in pyrites from various temperature mineral associations and ore deposit geneses is left- asymmetrical, sometimes 2-mode and often extremely irregular. This can be explained by the fact that there are large-sized, fine-dispersed and submicroscopic gold concentrations in pyrite. Large-size gold concentrations are typical for rather low-temperature mineral associations, while fine-dispersed – for high -temperature ones. There is often no stable relationship between the gold grade and other impurity elements in pyrites of deposits. For example, only in Lysogorsk ore deposit there is a positive bonding of gold with Zn (0.50), Bi (0.69), Ag (0.89), Cu (0.55), Co (0.88), Ni (0.70) and a negative one with As (0.75). Sometimes there is a positive bonding between Au and Cu – Konstantinovo ore deposit (0.41), Balakhchino ore deposit (0.53), Kommunarovsk ore deposit (0.51), Au and Mn – Balakhchino ore deposit (0.47), Au and Co (0.52) and Ni (0.62) – Kommunarovsk ore deposit; a negative bonding – Au and As in Balakhchino ore deposit (0.85).

#### 4. Conclusions

The research determined that pyrites in gold ore deposits of Altai – Sayan folded belt contain increased gold grade, including pyrites in wallrock metasomatites of these ore deposits, where, in some cases, the metal content is higher than in the pyrites of non –gold deposits. The findings show the possible approach in evaluating ore bodies and ore deposits, level of their erosional truncation, depth prospects and flanks.

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