GOLD MINERALIZATION IN THE TATRIC TECTONIC UNIT (WESTERN CARPATHIANS)

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Abstract: Gold-bearing quartz veins and veinlets are hosted by tectonic zones in variscan crystaline basement. We can distinguish 5 genetic type of gold in the Tatric tectonic unit. The first type – „invisible“ gold is bounded to arsenopyrite and pyrite. Visible gold of high finenes was precipitated as the latest mineral of pyrite-arsenopyrite mineral assemblage. Origin of younger Sb-Pb-Cu sulphidic mineralizations was accompanied by remobilized gold of 2 generations. The fifth genetic type is supergene gold. Gold-bearing quartz was originated from low to moderately saline CO_2-rich mesothermal (300-400 ^oC) fluids. Origin of mineralization is connected with variscan metamorfism and/or granitoid plutonism.

Key words: *gold deposits, Sb-Au-(W) mineralization, ore mineralogy and geochemistry*

Introduction

Gold mineralization is one of the most important hydrothermal mineralization in the Tatric tectonic unit. It represents the oldest stage of development of Sb-As-Au-W (Pb-Cu-Ag) mineralization, which was significant source of Sb and Au exploited from Middle age to the end of 20th century. First references about gold panning from alluvial sediments have been recorded from 13th century. Stibnite exploitation start in the first half of the 17th century and continued, with some intermissions till end of the 20th century. Gold mineralization without/or with sulphidic mineralization is developed on former important deposits - Pezinok-Kolársky vrch, Dúbrava, Magurka, Lom, Medzibrod, Nižná Boca and on small deposits - Pezinok-Staré Mesto, Kriváň, Dve Vody, Mlynná dolina, Chvojnica, Harmanec, etc. The annual recovery in the past centuries of individual deposits attained up to 20 kg. In the latest decade of 20th century was calculated reserves of Au in ores: 3 t of Au at the Pezinok-Kolársky vrch deposit and cca 1 t Au at the Dúbrava deposit.

Deposit geology

Vein and veinlet mineralization is bounded to mylonite and tectonic zones in crystalline complexes of Tatric tectonic unit. The Tatric basement is composed of fragments with variscan nappe structure (variscan granitoid plutons emplaced within medium to high grade metamorphic rocks). Deposits are hosted by variscan granitoids and metamorphic rocks (migmatites, gneisses, amphibolites). The mineralization forms ore bodies from few metres up to 4 km long and from cm scale to several metres thick. Vertical extent of well-known deposits is up to 350 m. Rare strata-bound type deposit (Pezinok-Kolársky vrch) is hosted by black shales embedded in actinolite schists and amphibolites or forms nests and bedded veins in metamorphic rocks with graphitic substance (Medzibrod).

Variscan mylonite zones were reactivated during younger tectonometamorphic events. The well documented subhorizontal mylonites in variscan granitoides are described from the Kriváň deposit. Au-mineralization is hosted by hydrothermal quartz formed synkinematicaly in inicial late variscan stages. The late deformation stages of mylonite formation are characterised by recrystalization of quartz and origin of younger vein generations without gold in shear zones.

The gold mineralization forms 3 different types of deposits. 1/ Veins, veinlets and impregnation in hydrothermaly altered zones with ”invisible gold” in pyrite and arsenopyrite (Pezinok-Kolársky vrch and Dúbrava deposits). 2/ Quartz sulphide poor veins with native gold ± pyrite and arsenopyrite (rare occurence of Ag-rich tetrahedrite and absence of younger stibnite-mineralization), (Pezinok-Staré Mesto, Kriváň and Harmanec deposits) and 3/ complex Sb-Au-(W) quartz-carbonate vein deposits – native gold with pyrite and arsenopyrite and younger stibnite and tetrahedrite, or scheelite mineralization (Magurka, Dve Vody, Nižná Boca, Mlynná dolina, Medzibrod, Chvojnica , Dúbrava, Jasenie deposits).

High Au/Ag ratio is typical at the all deposits. Higher Ag content correspond with later sulphidic mineral assemblage. Dominate quartz, carbonates and feldspars have been recognized as gangue minerals. The content of carbonates increase with accompanying sulphide mineralization.

Mineralogy and geochemistry

For the time not exploited are accumulations of “invisible” gold in arsenopyrite and pyrite ores. “Invisible” gold in solid solution and colloidal size was found in sectorially and oscillatorially zoned arsenopyrite (average about 100 max. 1200 ppm Au) and concentrically zoned pyrite (average about 10 ppm Au). Oscillate zoning caused by variations in contents of As and Cu, bounded in arsenopyrite and pyrite crystals shows changes of physical and chemical conditions during crystallisation. Mössbauer spectroscopy data indicate the presence of chemically bound gold in arsenopyrite (Andráš et al., 1995).

Ores with native gold are economically most important. Gold is the youngest mineral of pyrite-arsenopyrite mineral assemblage and forms isometric grains, flakes, nests of small grains filling microfractures in quartz. Locally it is enclosed by arsenopyrite and pyrite or are found in cracks of their cataclased aggregates. Frequently is located at the margin of the quartz veins and veinlets, at the contact of vein with altered rocks. Microprobe analyses of nativ gold reveal its high fineness (800 - 980) with content of Au from 82 to 98,5 wt.%, Ag from 15 to 0,5 wt.% (Hg < 2,5; Bi < 2; Cu, Sb, Te, Fe < 0,3 wt.%). Fig.1. The content of Au in ores from Magurka, Dve Vody and Kriváň deposits is from 1 to 10 ppm, max. 150 ppm.

Younger remobilised gold is characterised by lower fineness (<800) and associated with tetrahedrite, chalcopyrite, galena, stibnite and Pb-Sb sulphosalts. Lower fineness caused by content of Ag, higher concetration of Hg, Bi, Cu and other trace elements were not observed. This generation of gold associate with Ag-tetrahedrite (6–10 at. % of Ag), chalcopyrite, galena, Pb-Sb sulphosalts and rare Ag-sulphosalts on the deposits without stibnite mineralization. Genetic type of deposits with later stibnite mineralization are characterised by tetrahedrites with low content of Ag (up to 2 at. %).

A presence of “mustard” gold was observed at the Kriváň deposit. It forms spongy and zoned grains in association with gold of low fineness or thin borders in the margins of high fineness gold grains. A high content of Sb and O were proved in aggregates of ”mustard” gold. Stibnite and gold intergrowth was described at the Magurka deposit, aurostibite was not described. ”Mustard gold” could originated by hydrothermal alteration of high fineness gold by Sb containing fluids and increasing fugacity of O_2. This appearance is also proved by main presence of small inclusions of antimony in intergrain spaces of stibnite and presence of Sb-oxides in primary ores.

Rare, the third generation of native gold penetrating older gold grains of second generation and associate with tetrahedrite and chalcopyrite (Pezinok-Staré Mesto, Chvojnica), or enveloping grains of "mustard" gold on the locality Krivaň. Gold with low fineness (Fig.1) is regarded as the youngest generation of primary gold in Tatric tectonic unit.

Supergene gold conected with tectonic zones in variscan granitoides was investigated in theTribeč Mts. (Bakos and Žitňan, 2001). It forms most commonly inhomogenous crystals, typical for secondary gold and porous aggregates in goethite. Various chemical composition represented by inhomogenous phases coincide with variable contents of Ag (1,01 to 24,34 wt. %) and Hg (up to 1,66 wt.%). Both, primary gold together with supergene gold are possible sources of gold placers (Zlatno), exploated in the Middle age. Unidentified primary ore mineralizations which could be source of gold placers in Zlatníky (Považský Inovec Mts.) and Zlatno were eroded.

Arsenopyrite, pyrite and gold-bearing quartz originated from low to moderately saline CO_2-rich hydrothermal fluids with content of NaCl and KCl. The margin of origin temperature of gold-bearing sulphidic mineralizations in Tatric tectonic unit is between 300 and 450 ^{o}C and estimated trapping pressures of 1 – 2 kbar. The $\delta^{18}O$ values indicate predominantly metamorphic and/or magmatic origin of water. (Chovan et al., 1995, Majzlan et al., 2001). According to the arsenopyrite geothermometry arsenopyrite should have crystallized in all studied occurrences at temperatures 320 - 445 ^{o}C. According to mineral assemblage of gold with pyrite and K-feldspar, mineralization was formed approximately from neutral fluids where gold is transported as thiocomplexes (Majzlan and Chovan, 1997). The precipitation of Au-bearing arsenopyrite and pyrite could happened probably by pressure decreasing or reaction of hydrothermal fluids with surrounding rocks. Invisible gold probably precipitated during crystallisation on the deformations of crystal structure of sulphides or by substitution mechanism. Important mechanism of precipitation of Au is probably fluid phase separation observed at the Pezinok-Staré Mesto (Bakos et al., 2002, Mikucki, 1998). Later lower temperatures and moderately saline hydrothermal fluids with content of Sb, Pb, Cu, and Ag caused local remobilisation of part of gold into mineralised bodies.

Origin of gold mineralization is connected with variscan metamorfism and/or granitoid plutonism at the coarse margin of nothern variscan plate before formation of triasic sedimentary basins. Mineralization is considered as neovariscan and was not found in mesosoic cover of crystaline basement or younger nappes. Detritic gold flakes in Triasic quartz sandstones of Tríbeč Mts. (Jánošov, 2002) also induce the late variscan age of gold mineralization in Tatric tectonic unit.

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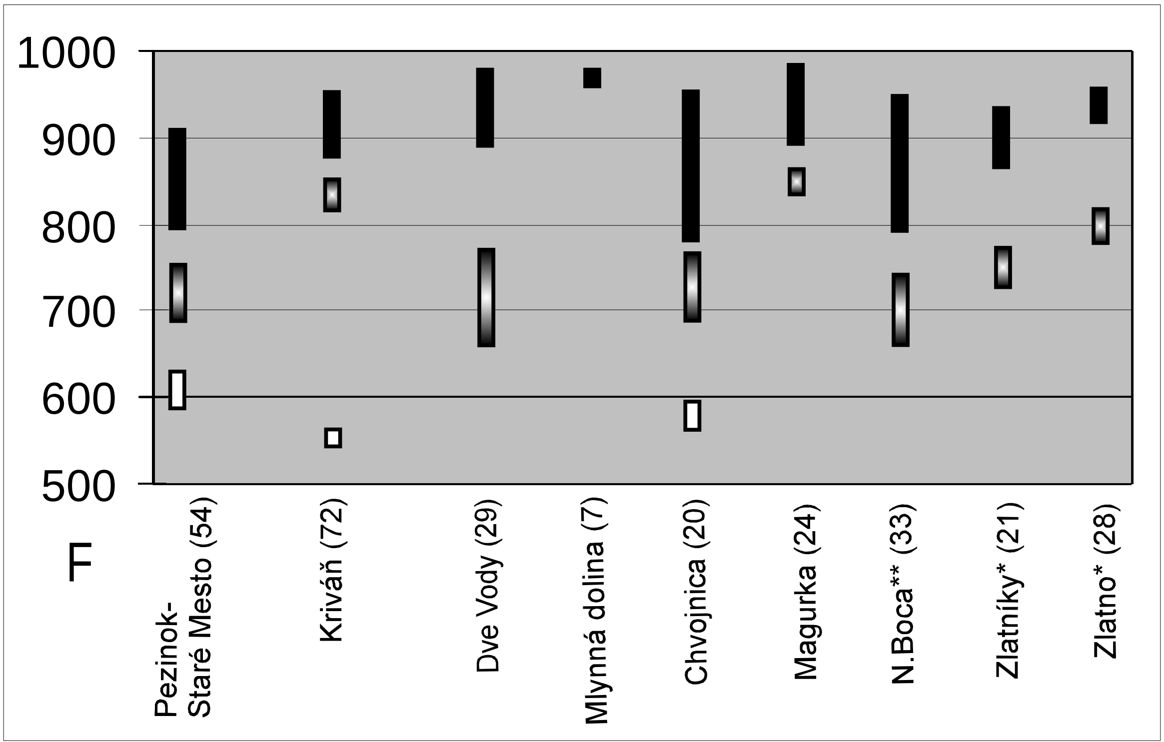
Fig.1. Fineness (F) of primary native gold (3 generations) in comparision of Au and Sb deposits at the Tatric unit. Zlatníky*, Zlatno* - alluvial gold, N. Boca** – alluvial and primary gold. (29) amount of analyses.



1000
900
800
700
600
500
F
Pezinok-
Staré Mesto (54)
Kriváň (72)
Dve Vody (29)
Mlynná dolina (7)
Chvojnica (20)
Magurka (24)
N.Boca** (33)
Zlatníky* (21)
Zlatno* (28)