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Andrzej PAULO, Witold SALAMON *

NATIVE GOLD IN ORE VEINS OF THE WESTERN PART OF GÓRY KACZAWSKIE MTS. (WEST SUDETEN)

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Abstract. For the first time in the hypogenic deposits of Lower Silesia native gold was ascertained. The presence of this element had been so far detected only by chemical methods. The fineness of gold was determined by electron microprobe. Basing on microscopic examinations in reflected light, paragenetic assemblages of native gold were described and the successive stages of mineralization process were traced back.

INTRODUCTION

Traces of gold in quartz-sulphide veins of Góry Kaczawskie Mts. in Lower Silesia have been detected for a long time by chemical methods. At various periods from the Middle Ages up to the third decade of the twentieth century, attempts were made at extracting gold from arsenic and copper ores at Stara Góra, Wielisław, Pilchowice, Klecza, Radomice, Wojciechów, Mielęcice, Lubomierz, and in the vicinity of Zgorzelec (Quiring 1949; Domaszewska 1964). Ores won in 1918 from the deposit Stara Góra contained 19.5 kg of gold (Zimmermann 1941). Although chemical analyses of certain samples showed Au content to be 25—65 grams per ton or, in some cases, over 100 grams per ton, no gold mineral was observed even under the microscope. Submicroscopic grains of native gold were supposed to be disseminated in arsenopyrite, pyrite and/or quartz, or else gold was thought to form solid solutions with the above sulphides.

The present authors performed microscopic examinations on ore samples collected from dumps at the old adit mouths between Radomice and Klecza and north of Pilchowice. Among other minerals, native gold was found in the specimens. The identification of some minerals was then confirmed by X-ray powder method, whereas the chemical composition of native gold and pyrites was determined using electron microprobe.

* Institute of Mineralogy and Mineral Deposits, Academy of Mining and Metallurgy in Cracow (Kraków, al. Mickiewicza 30).

QUARTZ-SULPHIDE VEINS OF RADOMICE, KLECZA AND PILCHOWICE

Ore occurrences in these localities were relatively little known though prospecting and small-scale exploatation were still carried on there in the years 1893—1908 and 1916—1921. The data from unpublished papers of Krusch (1907 *fide* Domaszewska 1964) and Grimming (1933 *fide* Domaszewska 1964) concerning this area were briefly discussed by Domaszewska (1964).

In the adits situated between Radomice and Klecza and near Pilchowice, eight main and several smaller quartz-sulphide veins were encountered together with locally accompanying concordant pyrite-arsenopyrite lenses. The veins ran in weakly metamorphosed old-Palaeozoic argillaceous, graphitic, greywacke and quartz schists, which had been folded and faulted. Silicification and sericitization of the host rocks was observed. The veins appeared parallel to the stratification as saddle reefs or, more frequently, as lodes in the fractured zones discordant to the bedding. Post--ore transverse faults were common.

The veins were examined on a length of about 200 m, showing thickness of 0.1 to 1.5 m. Their principal components were quartz and arsenopyrite. The arsenopyrite content widely ranged from 5 to 35% As in individual veins. The accompanying minerals were: chalcopyrite, galena, sphalerite, pyrite and antimonite. The present analyses have additionally revealed the presence of small quantities of haematite, siderite, marcasite, pyrrhotite, tetrahedrite, tennantite, native gold, chalcocite, covellite, tenorite and hydrated iron oxides. The examinations failed, on the other hand, to confirm the presence of antimonite, maybe because of the small amount of the analysed material.

The occurrence of gold in the veins under study had been already recorded. Au content in samples from different parts of the veins was as a rule below 6 g/t, though in some cases, most likely in the oxidation zone, it amounted to 29, 41, 64 and even 192 g/t. Only 2 grams per ton of gold was found at a depth of 40 m, at the bottom of mediaeval mine workings (Quiring 1949).

NATIVE GOLD

Native gold occurs in isometric grains, up to 0.5 mm in size, irregularly distributed in arsenopyrite, rarely in pyrite I or galena II (Phots. 1, 2). In the latter gold was found only where galena veinlets cross arsenopyrite. Large (0.1—0.5 mm) grains of native gold were sporadically encountered at the boundary of arsenopyrite with haematite or quartz (Phot. 3). Scarcer than isometric forms are thin (0.01 mm) veinlets of native gold in arsenopyrite. Since the majority of grains of native gold are of a size below 0.005 mm, there is also a possibility of submicroscopic inclusions being present, especially in pyrite and arsenopyrite.

Native gold in the latter sulphides differs in tinge from that co-occurring with galena. As expected, these differences are reflected in the fineness of gold. An analysis of native gold * in arsenopyrite has demonstrated Au content to be 69.7%, Ag — 28.9% and As — 0.X%, whereas three analyses of gold grains in galena yielded the values 82—86% Au, 14—17% Ag and revealed a lack of detectable admixtures of Cu, As, Sb, Bi.

The discussed differences in the composition, texture and paragensis of native gold point to the existence of two generations: the older electrum and younger native gold of higher fineness, the latter being connected with the secondary processes in the deposit.

ACCOMPANYING ORE MINERALS

A r s e n o p y r i t e forms coarse-crystalline aggregates or automorphic specimens, cataclased in both cases. The cataclastic fissures are filled with chalcopyrite I, pyrite III, galena, quartz, siderite and, in rare instances, with native gold II. Indications of metasomatosis along these fissures are also visible (Phots. 2, 4).

P y r i t e appears in three generations. Pyrite I, cataclastic as rule, forms large metacrysts and coarse-crystalline aggregates. It is assembled with arsenopyrite and pyrite II and locally replaced by chalcopyrite and galena. Pyrite II was observed only in the form of rims on pyrite I euhedral grains, differing in weaker reflectance (R ∾ 50%), pink tinge and slightly lower polishing hardness. An electron-probe microanalysis has revealed a lowered Fe content in pyrite II, which is only partly compensated by Ni and Co admixtures (Tab. 1). Microcrystalline pyrite III forms together with marcasite streaks among other sulphides as well as monomineral veinlets in cataclastic arsenopyrite.

Table 1

Chemical composition of pyrites from Klecza (weight %)

Element	Pyrite I	Pyrite II	Theoret. FeS_2
Fe	45,8	40,7	46,55
Ni	—	1,3	—
Co	—	0,6	—
S	53,1	54,7	53.45
Total	98,9	97,3	100,00

M a r c a s i t e is fine-crystalline, usually allotriomorphic and hipidiomorphic. It forms intergrowths with pyrite III, in which concentric and nearly parallel fissures, characteristic of metacolloids, are often present.

P y r r h o t i t e was found as small inclusions in arsenopyrite, pyrite I and sphalerite I.

C h a l c o p y r i t e appears in two generations. Chalcopyrite I is in

* The analyses were performed on CAMECA electron microprobe X-ray analyser. The detectability of elements was 0.1—0.01%.

general coarse- and medium-crystalline, euhedral, with polysynthetic twinnings. It coexists with pyrite I, sphalerite I, tennantite, galena I and fills cataclastic fissures in arsenopyrite. Chalcopyrite II is fine-crystalline and anhedral. It is found together with siderite II, goethite, marcasite, pyrite III, and Zn and Pb sulphides of the second generation. Moreover, its pseudomorphs of pyrite I and arsenopyrite could be observed.

S p h a l e r i t e shows different typomorphic features as well. Polygonal sphalerite aggregates with numerous inclusions of tetrahedrite, pyrite, chalcopyrite and pyrrhotite associating with chalcopyrite I and pyrite I were recognized as the older generation. Younger sphalerite occurs together with siderite II and goethite, and contains only few inclusions of galena and tetrahedrite. It locally replaces siderite-goethite aggregates, pyrite I and arsenopyrite.

G a l e n a was found in two assemblages, having distinct features in each. Galena I, which associates with chalcopyrite I and sphalerite I, is coarse-crystalline, partly fissured, and replaced by weathering products along grain boundaries. Galena II is fine-crystalline and, together with sphalerite II and chalcopyrite II, forms a system of metasomatic veinlets in pyrite I, arsenopyrite and chalcopyrite I. Galena veinlets in arsenopyrite frequently contain native gold.

T e n n a n t i t e and t e t r a h e d r i t e appear in the form of irregular or roundish grains in chalcopyrite and sphalerite.

C o v e l l i t e is present in small quantities as a product of recent weathering of chalcopyrite.

C h a l c o c i t e was recorded in fine-grained pseudomorphic aggregates beside arsenopyrite and chalcopyrite relics. The X-ray strongest lines 2.393 (8), 1.963 (9), 1.873 (10), 1.696 (4), and others have confirmed this identification.

T e n o r i t e forms small, elongated, locally twinned grains. It occurs together with haematite in arsenopyrite-chalcopyrite aggregates.

H a e m a t i t e appears in fine-crystalline micaceous aggregates. It forms metasomatic rims and interlacing veinlets in arsenopyrite as well as pseudomorphs of this mineral (Phot. 5). The phenomenon of arsenopyrite replacement by haematite, which has so far not been noted in Góry Kaczawskie Mts., may account for a relatively high As content in the haematites from the veins at Lipa (0.37%) and Stanisławów — Wilcza (0.15%).

S i d e r i t e forms irregular concentrations and veinlets in quartz. Locally, areas of small concentric-zonal intergrowths of siderite and goethite were observed (Phot. 6) that did not contain veinlike iron hydroxides. The two minerals seem to have been formed simultaneously. Non-oxidized sphalerite II, chalcopyrite II, pyrite III and marcasite appear among them.

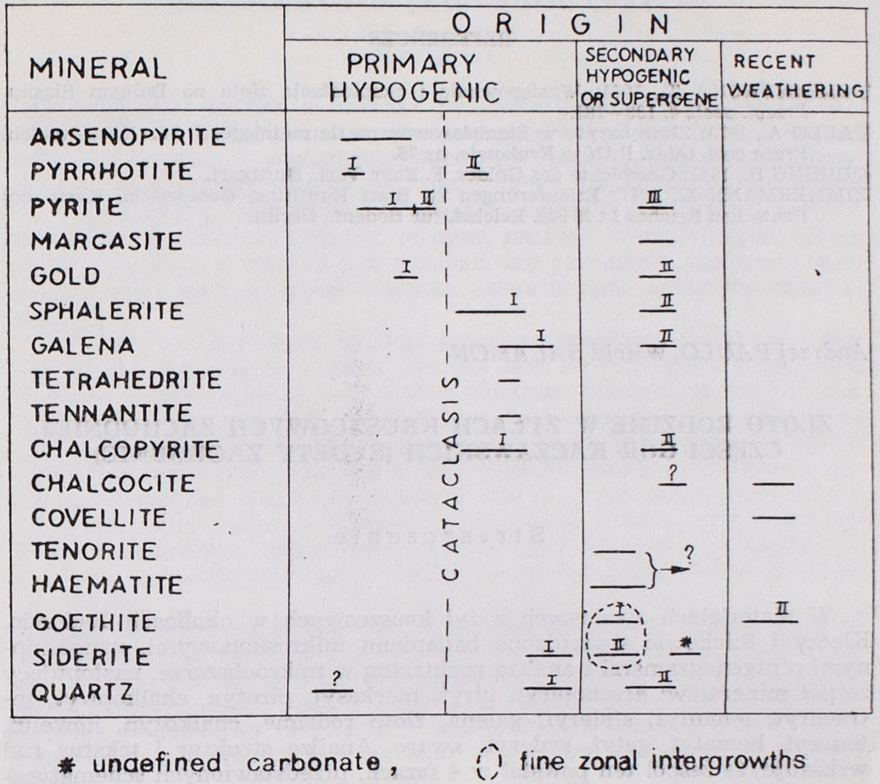
SEQUENCE OF FORMATION AND GENESIS OF THE MINERALS

Four distinguishable stages of formation of the mineral assemblage under study are presented in Table 2.

Hydrothermal (*sensu lato*) origin, considered against the background

Table 2

Sequence of minerals in ore veins from Radomice, Klecza and Pilchowice



of polymetallic veins of Góry Kaczawskie Mts. (Paulo 1973), is claimed for the primary assemblage, though the source of metals is obscure. A considerable admixture of silver in native gold I is, in fact, characteristic of low-temperature deposits, associated with vulcanites, which can be hardly accepted in the specific geological conditions. The fineness of gold II 820—860, on the other hand, is typical for both mezo-hypothermal deposits and oxidation zones.

The second assemblage is represented subordinately in the analysed samples, and the established regularities require confirmation on a greater amount of material. Both hypogene and supergene origin of this assemblage is possible. The position of haematite-tenorite association in relation to siderite and sulphides cannot be determined because of their separate occurrences.

The youngest assemblage must have been formed as a result of weathering. It is much richer in mineral kinds than specified in Table 2, but was of no interest for the authors.

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REFERENCES

DOMASZEWSKA T., 1964: Występowanie i eksploatacja złota na Dolnym Śląsku. *Przegl. geol.*, 4, 180—185.
PAULO A., 1973: Złoże barytu w Stanisławowie na tle metalogenii Gór Kaczawskich. *Prace geol. Oddz. PAN w Krakowie*, nr 76.
QUIRING H., 1949: Geschichte des Goldes. F. Enke Verl., Stuttgart.
ZIMMERMANN E., 1941: Erläuterungen zu Blatt Kauffung. Geologische Karte des Deutschen Reiches 1 : 25 000. Reichst. für Bodenf., Berlin.

Andrzej PAULO, Witold SALAMON

ZŁOTO RODZIME W ŻYŁACH KRUSZCOWYCH ZACHODNIEJ CZĘŚCI GÓR KACZAWSKICH (SUDETY ZACHODNIE)

Streszczenie

W materiałach zwałowych z żył kruszcowych w okolicach Radomic, Kleczy i Pilchowic stwierdzono badaniami mikroskopowymi, uzupełnionymi rentgenogramami i analizą spektralną w mikroobszarze, następujący zespół minerałów: arsenopiryt, piryt, markasyt, pirotyn, chalkopiryt, tetraedryt, tenantyt, sfaleryt, galena, złoto rodzime, chalkozyn, kowelin, tenoryt, hematyt, getyt, syderyt, kwarc. Analiza struktur i tekstur rud wskazuje, że zespół ten powstał w 4 fazach, przedstawionych schematycznie w tabeli 2.

Po raz pierwszy w złożach hipogenicznych polskiej części Sudetów dostrzeżono obecność minerałów złota. Dotychczas na podstawie analiz chemicznych przypuszczano ,że złoto tworzy roztwór stały z arsenopirytem i pirytem albo w postaci submikroskopowych wrostków złota rodzimego rozproszone jest w jednym z tych siarczków. Autorzy stwierdzili obecność licznych wrostków złota rodzimego w arsenopirycie, rzadziej w pirycie I i galenie II. Ziarna złota rodzimego w arsenopirycie i pirycie mają na ogół wielkość 0,005—0,1 mm, ziarna występujące wraz z galeną w szczelinach skataklazowanego arsenopirytu lub na granicy arsenopiryt — hematyt są z reguły większe i osiągają 0,1 do 0,5 mm.

Rentgenowskie analizy spektralne w mikroobszarze wykazały, że próba złota rodzimego I wynosi około 700, zaś próba złota rodzimego II 820—860. Główną domieszką jest w obydwu przypadkach srebro. Zasobna w srebro odmiana złota rodzimego (elektrum) jest typowa raczej dla złóż związanych genetycznie z wulkanizmem, geologiczne warunki występowania żył nie wskazują jednak na taką ewentualność.

Анджей ПАУЛО, Витольд САЛЯМОН

САМОРОДНОЕ ЗОЛОТО В РУДНЫХ ЖИЛАХ ЗАПАДНОЙ ЧАСТИ КАЧАВСКИХ ГОР (ЗАПАДНЫЕ СУДЕТЫ)

Резюме

В образцах, взятых в отвалах рудников района Радомице, Клеча и Пильховице, с помощью микроскопических наблюдений, дополненных рентгенограммами и микрорендгеноспектральным анализом, определен следующий комплекс минералов: арсенопирит, пирит, марказит, пирротин, халькопирит, тетраэдрит, теннантит, сфалерит, галенит, самородное золото, халькозин, ковелин, тенорит, гематит, гётит, сидерит, кварц. Анализ структур и текстур руд показал, что указанный комплекс минералов образовался в четырех фазах, схематически представленных на таблице 2.

Впервые в эндогенных рудопроявлениях польских Судет выявлено присутствие минералов золота. До сих пор на основании химических анализов предполагалось, что золото образует твердый раствор с арсенопиритом и пиритом или же в виде субмикроскопических включений рассеяно в одном из этих сульфидов. Авторы наблюдали многочисленные включения самородного золота в арсенопирите, реже в пирите I и галените II. Величина зерен самородного золота в арсенопирите и пирите составляет, как правило, 0,005—0,1 мм, зерна золота, выполняющего вместе с галенитом трещинки в катаклазированном арсенопирите или контакты арсенопирит-гематит обычно большие и достигают величины 0,1—0,5 мм.

Рентгоновские микроанализы показали, что проба самородного золота I составляет около 700, а самородного золота II — 820—860. Основную примесь в обоих случаях образует серебро. Богатая серебром разновидность самородного золота (электрум) характеризует чаще рудопроявления, генетически связанные с вулканизмом, однако геологические условия исследованных рудных жил не подтверждают такой возможности.

PLATE I (PLANSZA I, ТАБЛИЦА I)

Phot. 1. Inclusions of native gold I (*g*) in arsenopyrite (*a*). Dark grey — quartz and pits on the polished surface. Reflected light, enlarged 400 ×

Wrostki złota rodzimego I (*g*) w arsenopirycie (*a*). Ciemnoszare — kwarc i wykruszenia. Światło odbite, pow. 400 ×

Включения самородного золота I (*g*) в арсенопирите (*a*). Темносерое — кварц и пустоты. Отраженный свет, увел. 400 ×

Phot. 2. Native gold II (*g*) with galena (*ga*) and sphalerite (*s*) as well as chalcopyrite (*cp*) and quartz (*q*) fill cataclastic fissures in arsenopyrite (*a*). Replacement along the fissures is visible. Reflected light, enlarged 500 ×, oil immersion

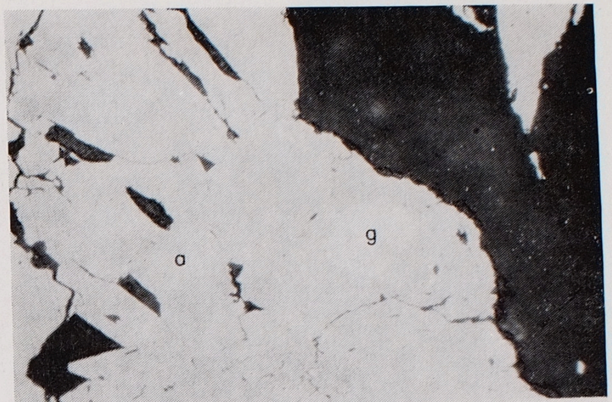
Złoto rodzime II (*g*) z galeną (*ga*) i sfalerytem (*s*) oraz chalkopiryt (*cp*) i kwarc (*q*) wypełniają szczeliny kataklastyczne w arsenopirycie (*a*). Oznaki metasomatozy wzdłuż tych szczelin są także widoczne. Światło odbite, pow. 500 ×, imersja

Самородное золото II (*g*) с галенитом (*ga*) и сфалеритом (*s*), а также хальконирит (*cp*) и кварц (*q*) выполняют катакластические трещинки в арсенопирите (*a*). Видны признаки метасоматоза вдоль этих трещинок. Отраженный свет, увел. 500 ×, иммерсия в масле

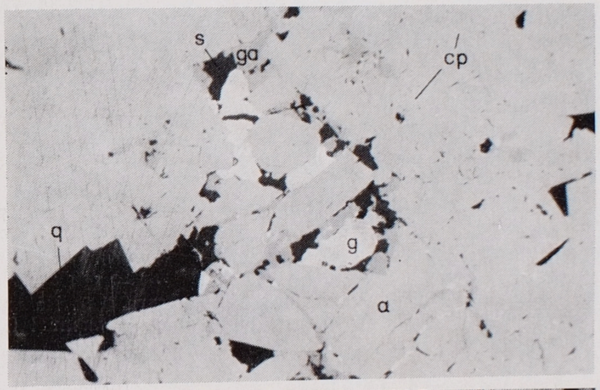
Phot. 3. Native gold II (*g*) and haematite (*h*) replace arsenopyrite (*a*). Black — quartz. Reflected light, enlarged 400 ×

Złoto rodzime II (*g*) i hematyt (*h*) zastępują metasomatycznie arsenopiryt (*a*). Czarne — kwarc. Światło odbite, pow. 400 ×

Самородное золото II (*g*) и гематит (*h*) метасоматически замещают арсенопирит (*a*). Черное — кварц. Отраженный свет, увел. 400 ×



Phot. 4



Phot. 5

Phot. 6

Andrzej PAULO, Witold SALAMON — Native gold in ore veins of the Western part of Góry Kaczawskie Mts. (West Sudeten)

PLATE II (PLANSZA II, ТАБЛИЦА II)

Phot. 4. Fissured arsenopyrite (*a*) partly replaced by chalcopyrite (*cp*), galena (*ga*) and sphalerite (*s*). Reflected light, enlarged 500 ×, oil immersion

Spękany arsenopiryt (*a*) zastąpiony częściowo przez chalkopiryt (*cp*), galenę (*ga*) i sfaleryt (*s*). Światło odbite, pow. 500 ×, imersja

Трещиноватый арсенопирит (*a*), частично замещенный халькопиритом (*cp*), галенитом (*ga*) и сфалеритом (*s*). Отраженный свет, увел. 500 ×, иммерсия в масле

Phot. 5. Haematite (*h*) pseudomorphs of arsenopyrite (*a*) metacrysts; *q* — quartz. Reflected light, enlarged 150 ×

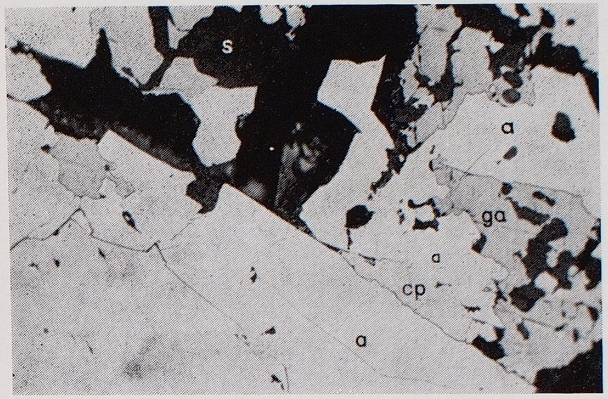
Pseudomorfozy hematytu (*h*) po metakryształach arsenopirytu (*a*); *q* — kwarc. Światło odbite, pow. 150 ×

Псевдоморфозы гематита (*h*) по метакристаллам арсенопирита (*a*). *q* — кварц. Отраженный свет, увел. 150 ×

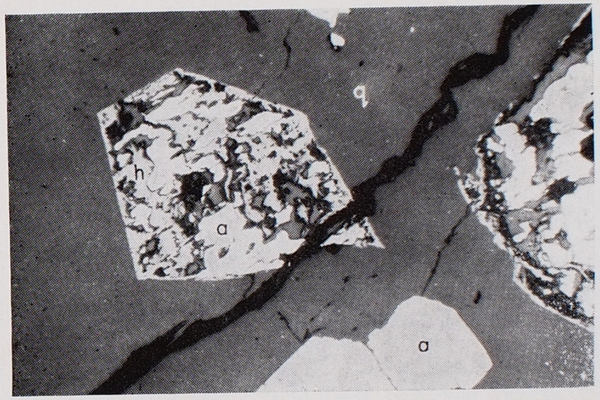
Phot. 6. Zonal intergrowths of siderite (*fc*) and goethite (*gt*). Among them non--weathered pyrite III (*p*) grains are visible. Reflected light, enlarged 400 ×

Zonalna budowa agregatów syderytu (*fc*) i getytu (*gt*). Na ich tle występują siarczki bez oznak wietrzenia. *p* — piryt III. Światło odbite, pow. 400 ×

Зональное строение агрегатов сидерита (*fc*) и гётита (*gt*). На их фоне наблюдаются сульфиды без признаков выветривания. *p* — пирит III. Отраженный свет, увел. 400 ×



Phot. 4



Phot. 5

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