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**Co, Ni, As AND Au DISTRIBUTION WITHIN PYRITE FROM THE
RADOMICE AND KLECZA ABANDONED GOLD DEPOSITS (KACZAWA
MTS.)**

Abstract: Co/Ni ratios as well as arsenic and gold contents in various generations of pyrite from the Klecza and Radomice have been subject of microprobe investigation. Co/Ni ratios in the considered pyrites reflect their different origins from the late diagenetic and metamorphic to hydrothermal. Pyrites reveal also diversified habits, from framboidal micro-grains to euhedral and anhedral crystals up to several mm in size. “Invisible Au” enrichments in pyrite (up to 450 ppm Au) are closely correlated with increasing admixture of As (up to 3.1 wt %) in the Radomice deposit.

Keywords: trace elements in pyrite, Co/Ni ratio in pyrite, As-pyrite, auriferous pyrite, Klecza, Radomice, Kaczawa Mountains, Western Sudetes.

INTRODUCTION

The behaviour and distribution of Ni and Co contents and Co/Ni ratios in pyrites of various origins has been subject of many studies published elsewhere (*e.g.* Hawley, Nichol 1961). Previous studies recognised that Co/Ni<1 ratio with Ni>20 ppm contents in pyrites characterised FeS₂ of magmatic or sedimentary origin (Bajwah *et al.* 1987 and references therein). Marques *et al.* (2003) indicates that massive sulphides of hydrothermal sub-sea floor setting contain pyrites of Co/Ni>>10, and Co contents from >50 ppm to 1.0 wt %. In schists-hosted gold deposits such as in the Klecza-Radomice abandoned Au ore district in the Kaczawa Mts., a substantial fraction of gold is present as “invisible gold” within grains of pyrite and arsenopyrite (*e.g.* Mikulski 2004). A “visible gold” was recently also documented by Paulo, Salomon 1973, Olszyński, Mikulski 1997, Mikulski 2000 and 2005. Several studies have established that “invisible gold” is spatially associated with local As-enrichment in pyrite grains (*e.g.* Fleet, Mumin 1997).

METHODS OF INVESTIGATION

Microprobe analyses have been carried out in selected thin sections containing pyrite crystals of various generations. The considered samples were analyzed by use of the Cameca SX-100 electron probe microanalyzer equipped with 3 wavelength-dispersive spectrometers. The operating conditions were typical for trace elements measurements: acceleration voltage - 20 kV, beam current - 100 nA and beam diameter - 2µm. Natural and artificial materials have been used as standards. Trace elements determination was performed assuming stoichiometric composition pyrite (Fe - 46.5 wt%, and S - 53.5 wt %).

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SHORT DESCRIPTION OF SAMPLES

The chosen samples used for the further investigations come from two localities in Klecza (R65) and Radomice (R39 and R44):

Sample R 65 is graphite schist composed of graphite (more than 70% of the rock volume) and minor quartz, sericite, muscovite and few apatite crystals. The rock has a distinct oriented texture underlined by elongated quartz boudines. Thin, latter quartz veinlets (up to 1 cm thick) cut the rock. Pyrite is not abundant, crystals are small (up to 2-3 mm), both idio- and xenomorphic, usually situated in graphite. Early paragenesis of pyrite is suggested by framboidal clusters from 1 up to 20 μm in size associated with graphite. Pyrite framboids are subject of recrystallization by next generation pyrite (Fig. 1A-B). Sample R39 represents phyllites and/or sericite schist breccia. The rock is very non-homogenous and strongly deformed. There are angular quartz crystals, concentrations of small-deformed quartz and pieces of sericite phyllites/schists surrounded by very fine-grained chalcedony and carbonate minerals (siderite, ankerite) forming mylonitic texture. At least two types of pyrite occur. The first one consists of euhedral crystals up to 3 mm and the second one of anhedral crystals with poikilitic texture (Fig. 1C). The pyrite crystals are very often associated with carbonates and grouped. Sample R44 is cataclased sericite/muscovite schist composed of quartz and sericite schist fragments surrounded by fine-grained quartz, sericite, carbonates, muscovite and minor feldspars. Pyrite crystals are big up to 1-2 cm and idiomorphic with square, triangular and hexagonal sections and sometimes fractured with arsenopyrite and electrum inclusions (Fig. 1D). Pyrites are often surrounded by skin-deep carbonate or minor chalcedony fine-grained mass. Latter, thin carbonate veins cut the rock.

RESULT OF MICROSCOPIC AND MICROPROBE INVESTIGATIONS

Three generations of pyrite have been recognised within samples from Radomice and Klecza (Fig. 1). According to microprobe investigation framboidal pyrite from Klecza contains admixture of Ni from 0.005 to 0.43 wt % and As from 0.06 to 0.44 wt % (Table 1). In framboidal pyrite Co/Ni ratio is much below 1:5 (often <1:10 to 1:500), (Fig. 2).

Table 1. Trace elements content and correlation matrix in pyrites from Klecza and Radomice

	FRAMBOIDAL PYRITE (Py1a)		PYRITE 2		As-RICH PYRITE (Py 3b)	
	Aver. Cont..	Range	Aver. Cont	Range	Aver. Cont	Range
Co	0.022	0.005-0.043	0.012	0.000-0.060	0.01	0.001-0.02
Ni	0.299	0.178-0.044	0.131	0.000-0.302	0.016	0.0-0.058
Co/Ni	~1:15	-	~1:10	-	~1:2	-
As	0.181	0.063-0.444	0.174	0.030-0.431	1.46	0.822-3.09
Au	-	b.d.l.	-	b.d.l.	-	b.d.l.- 0.045

b.d.l.- below detection limit

Correlation matrix

	FRAMBOIDAL PYRITE			PYRITE 2			As-RICH PYRITE (Py 3b)		
	Co	Ni	As	Co	Ni	As	Co	Ni	As
Co	1	0.33	0.56	1	0.14	-0.02	1	0.08	0.36
Ni	0.33	1	0.12	0.14	1	0.78	0.08	1	-0.17

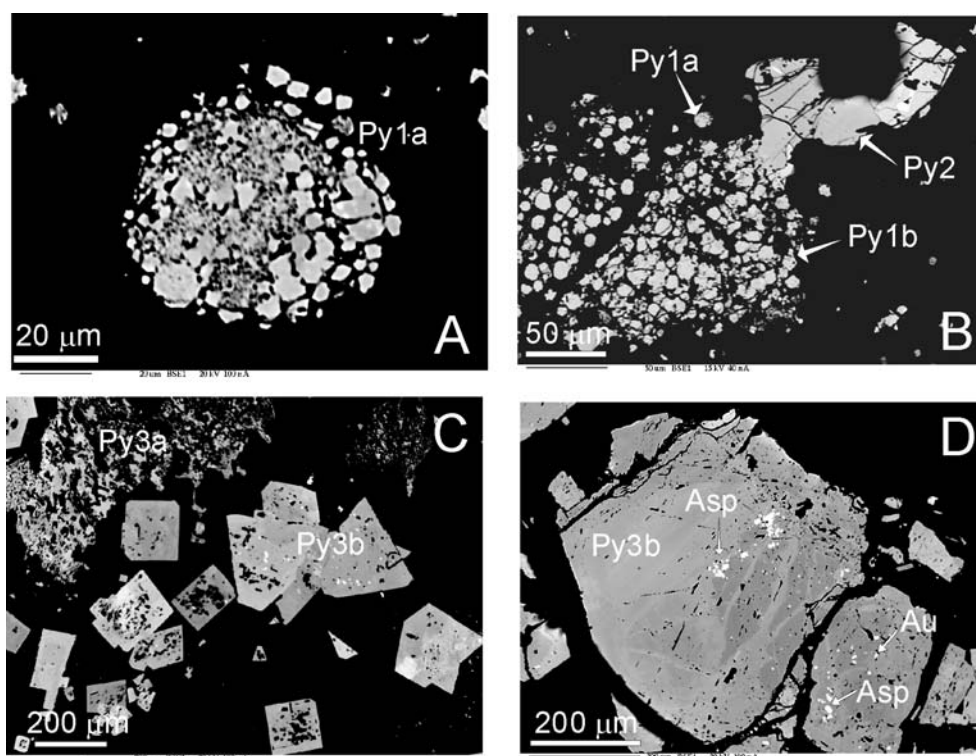


Fig. 1. BSE images of various generations of pyrite from the abandoned Klecza-Radomice gold ore district. **A.** Framboidal (spheroidal) pyrite (Py1a) in graphite schist from Klecza, sample R65. **B.** Framboidal pyrite (Py1a) as a subject of recrystallization into a new generation anhedral pyrite (Py1b, 2), sample R65. **C.** Skeletal (anhedral) pyrite (Py3a) in intergrowth with gangue (carbonate) and euhedral (*metacrystal*) pyrite (Py3b) as the last phase of development of skeletal pyrite to fully idiomorphic forms. Breccia of sericite schists from Radomice, sample R39. **D.** Numerous inserts of arsenopyrite (Asp) and rare electrum (Au) in pyrite of 3rd generation (Py3b). Radomice, sample (R44) - cataclased sericite/muscovite schist. Note that darker and lighter areas within pyrite crystal reflect also different Ni-, Co-, and As-admixtures.

Later pyrite occurs as anhedral crystals recrystallized from framboidal pyrite (Py1b) and as euhedral fractured crystals up to 200 µm in size in graphite schists (Py2). Framboidal pyrite was already described from the *Radzimowice schists* by (Sawłowicz 1987). Anhedral pyrite that recrystallized after framboidal pyrite is characterized by loss of Ni and As admixtures. In Radomice dominates the 3rd generation of pyrites (Py3a, b), characterized by inhomogeneous chemical composition that is visible under the ore microscope by light (As-rich) or dark sectors within pyrite. These pyrites are associated with muscovite, carbonates (mainly ankerite), and minor quartz. Microprobe analyses revealed also different admixtures of Ni, Co and As within pyrite of the both types. The Co/Ni ratio in anhedral pyrite varies from 1:10 to 1:1 and in euhedral pyrites from 1:10 to 10:1. Arsenic-rich pyrite may contain up to ca. 3.1 wt % As (Fig. 1D). Arsenic-rich euhedral pyrite may also contains arsenopyrite, galena or chalcopyrite inclusions. Base metal sulphides are subordinate comparing to pyrite Py3 type. As-rich pyrite may also contain up to 450 ppm of gold admixture. Cobalt displays a positive correlation with As

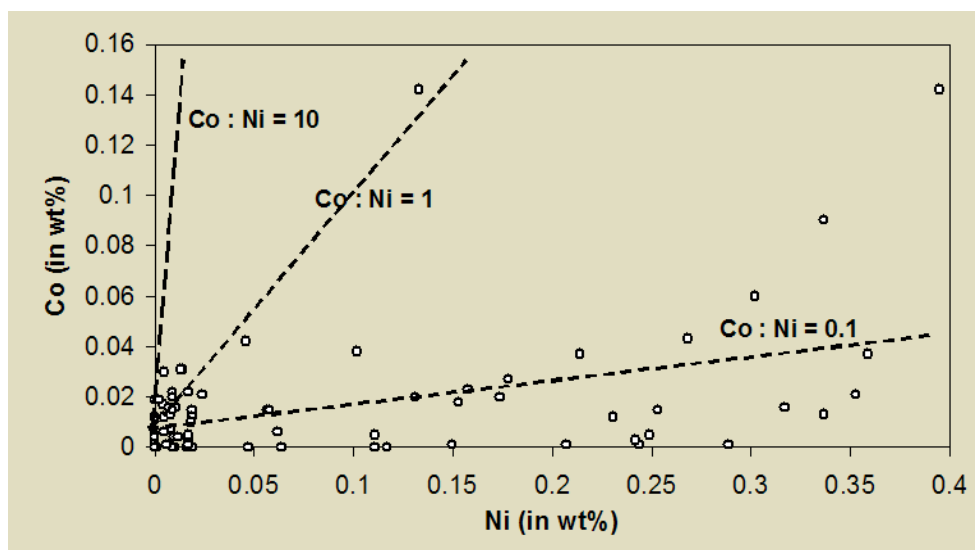


Fig. 2. Plot of cobalt contents vs. nickel in various generation of pyrite from Klecza and Radomice

and Ni in framboidal pyrite and positive correlation with As in As-rich pyrite (Table 1). The euhedral pyrites from Klecza represent mostly As-poor pyrite (<0.2 wt % As). Arsenic distribution within Py₂ pyrite has a strong correlation with Ni admixture ($r = 0.78$).

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