Research on Pyrite Occurrence and Properties in Talc Ore with the Aim of Its Removal

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Summary

The contribution deals with pyrite occurrence in talc ore from the Gemerska Poloma deposit (Eastern Slovakia). Firstly, an applicability of talc in various industrial branches such as paper and rubber is introduced. Major producers of talc in the world e.g. China, India and USA as well as the development of talc exploitation in Slovakia are also described. According to data about reserves of talc ore the Gemerska Poloma deposit can be considered as the most significant in the Europe. Pyrite is main harmful mineral and it occurs above all in talc nearby its contact zone with magnesite bodies.

The sample of talc ore polluted by pyrite was assayed with the aim to pyrite liberation and characterization. A lumpy ore (5–20 mm) was crushed to a grain size below 5 mm and classified. The individual grain sizes were subjected to float-sink analyses in bromoforme. Obtained products were weighted and analysed. Selected products were studied using XRD.

An optical observation of lumpy ore showed, that pyrite grains attain a size of 0.5–6 mm. As to crushed ore iron and sulphur concentrate in the grain size classes of 0.5–3 mm, above all in 1–2 mm. The highest mass yield of pyrite concentrate into heavy product was attained in a class of 1–2 mm, namely 15 %. This product contains 44.62 % S and 37.06 % Fe followed by 3.14 % Mg, 2.45 % SiO2 and 0.76 % Ca. The highest grade of pyrite concentrate using float-sink analysis was achieved in the case of grain size 0.5–1 mm at a mass yield of 8.35 %. It contains 45.52 % S and 38.18 Fe. Moreover, chemical analysis of pyrite concentrate prepared by hand-picking (50.90 % S, 43.10 % Fe) proved an abundance of cobalt (1218 ppm), manganese (340 ppm), nickel (175 ppm) and arsenic (119 ppm).

Keywords: talc ore, pyrite, gravity concentration, XRD

Introduction

Talc – $Mg_3[Si_4O_{10}](OH)_2$ is an important mineral applicable in various branches of industry such as paper and pulp, foundry, glass, chemical, building, pharmaceutical, beauty, rubber, etc. (Čorej, 2001).

In 2012 the annual production of talc attained about 6.6 million ton. The biggest producers are introduced in Table 1 (Brown et al., 2014). The development of talc production in Slovakia is referred in Table 2. In the years 2007–2009 the whole Slovak production came from the Mutnik deposit and since 2010 the exploitation of talc only from the Gemerská Poloma deposit was recorded (SMA, 2014).

The talc deposit in Gemerská Poloma belongs to the most significant in the Europe. There were performed several calculations of reserves there. According to talc content in ore total reserves ranges from 23.2 million ton (talc ≥ 80%) to 180.5 million ton (talc ≥ 40%). Thus, talc content over 80% represents its clean layers, veins and/or lenses. Talc is dominant mineral in deposit. It is accompanied by magnesite, dolomite and quartz. Pyrite is considered as a main harmful mineral. It usually occurs in talc closely contact zone with magnesite (Killík, 1997; Chadwick, 2009).

So, detailed geology of talc deposit in Gemerska Poloma and data about reserves are reported by Killík (1997), Petrasová et al. (2007), Chadwick (2009) and Čorej (2010). A way of deposit opening, economic assessment and talc utilization were described by Čorej (2001, 2010), Engel and Steck (2007), Čorej and Engel (2008). The studies on the liberation of pyrite from talc ore from the Gemerska Poloma deposit and an assessment of this process were performed by Hredzak et al. (2011ab).

Material and methods

The lumpy talc ore (5–20mm) contaminated by pyrite was subjected to two-stage crushing to a grain size of –5mm using jaw crushers, namely PS D-160 and VČM-3. Subsequently, grain size analysis by dry way by means of laboratory sieves with suitable mesh size was performed. Individual classes were subjected to float-sink analyses in bromoform (pure – 2.887 g.cm^{-3} at 20ºC). Obtained prod-

Tab. 1 World Production of Talc in 2012 – Talc Producers > 0.1 Mt

Tab. 1 Światowa produkcja talku w 2012 roku − Producenci talku > 0.1 Mton

	Country	Tonnes (metric)		Country	Tonnes (metric)
1.	China	2,200,000	7.	Finland	396,332
2.	India	950,000	8.	Canada	154,000
3.	USA	623,000	9.	Russia	150,000
4.	Mexico	463,214	10.	Australia	135,000
5.	Brazil	450,000	11.	Austria	134,665
6.	France	400,000	12.	Italy	110,000
World total talc only			6,600,000		
World total including pyrophyllite			7,800,000		

Tab. 2 Development of Talc Production in Slovakia

Tab. 2 Rozwój produkcji talku na Słowacji

Year	2007	2008	2009	2010	2011	2012	2013
Tonnes (metric)	200	200	200	700	300	2,700	9,900

Tab. 3 Quality of Pyrite Concentrates

Tab. 3 Jakość koncentratu pirytu

grain size [mm]		mass yield of heavy product [%]	SiO_2 [%]	S [%]	Fe [%]	Mg [%]	Ca [%]	Al [%]	Mn [%]
3	– 5	4.26	24.50	19.79	18.25	11.71	2.090	0.040	0.031
2	– 3	5.80	8.70	38.57	33.44	4.72	0.710	0.050	0.015
1	– 2	14.86	2.45	44.62	37.06	3.14	0.760	0.030	0.015
0.5	– 1	8.35	1.20	45.52	38.18	2.37	0.570	0.020	0.012
0.071	– 0.5	3.38	1.50	36.28	31.92	5.73	2.300	0.100	0.040
	– 0.071	0.23	2.95	40.89	35.34	4.22	1.350	0.050	0.034

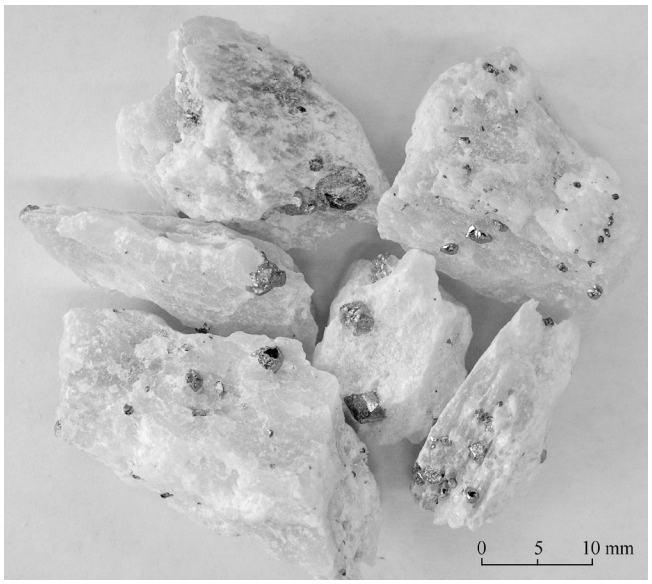

Fig. 1 Talc and pyrite intergrowth

Rys. 1 Zależność ilości talku i pirytu

Fig. 2 Pyrite grains

Rys. 2 Ziarna pirytu

Tab. 4 Composition of Pyrite Concentrate Prepared by Hand-Picking

Tab. 4 Skład koncentratu pirytu wydzielonego ręcznie

element	S [%]	Fe [%]	Mn [ppm]	Co [ppm]	Ni [ppm]	As [ppm]
content	50.90	43.10	340	1218	175	119

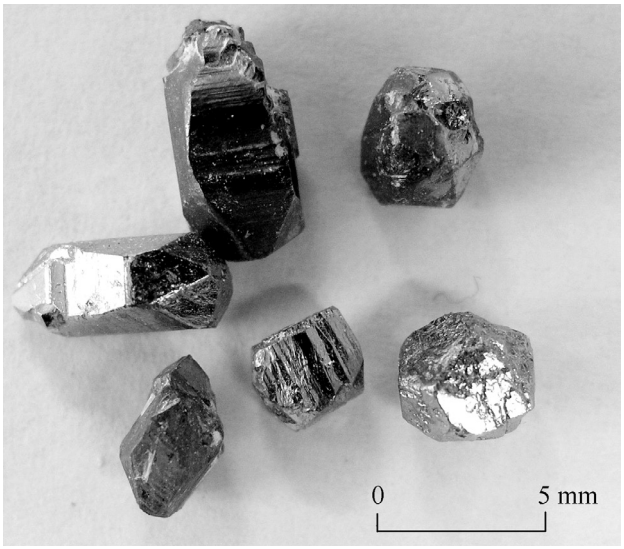

Fig. 3 Shapes of pyrite grains in detail

Rys. 3 Szczegóły kształtu kryształów pirytu

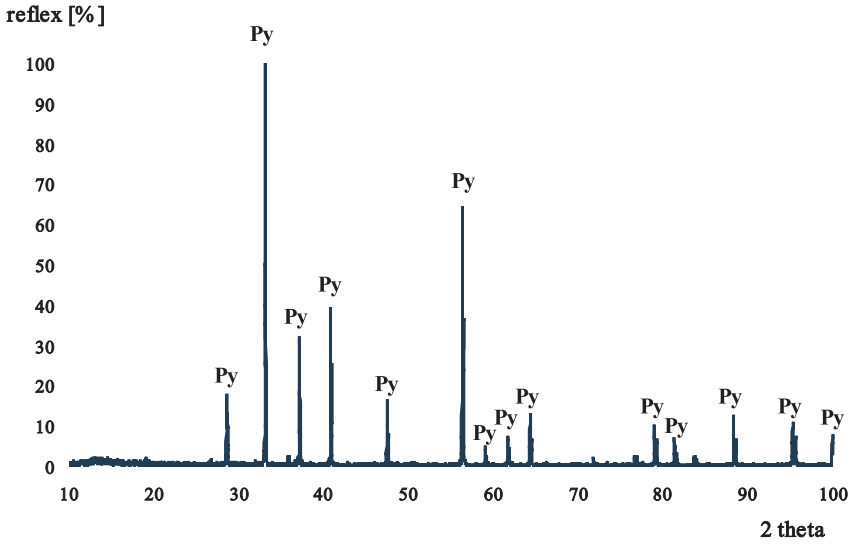

Fig. 4 XRD pattern of pyrite concentrate (1–2mm)

Rys. 4 Wyniki analizy XRD koncentratu pirytu (1-2mm)

ucts have been filtered, washed by methanol and water.

SiO_2 content was assayed gravimetrically. Other elements have been determined by atomic absorption spectroscopy using the device VARIAN with accessories: Fast Sequential AAS AA240FS, Zeeman AAS AA240Z with Programmable Sample Dispenser PSD120, Graphite Tube Atomizer GTA120 and Vapor Generation Accessory VGA-77.

The XRD study of selected samples was performed using the diffractometer D8 Advance, Bruker AXS (Germany) at following conditions: radiation CuKα, Cu-filter, voltage 40 kV, current 40 mA, step of goniometer 2°/min.

Results

The quality of obtained pyrite concentrates as the heavy products of float-sink analysis is described in Table 3. The content of sulphur and iron in grain size classes – 3 mm attains more than 36 % and 31%, respectively. Talc

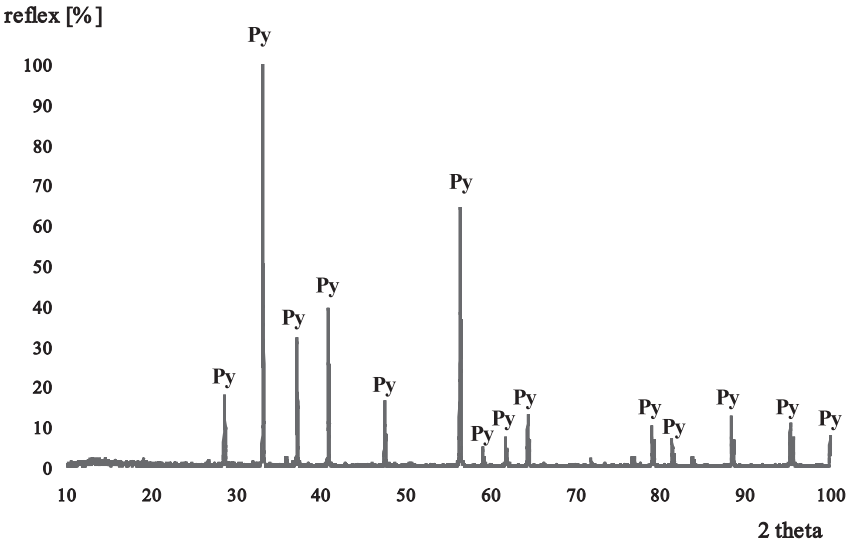

Fig. 5 XRD pattern of selected pyrite grain

Rys. 5 Wyniki analizy XRD wybranych ziaren pirytu

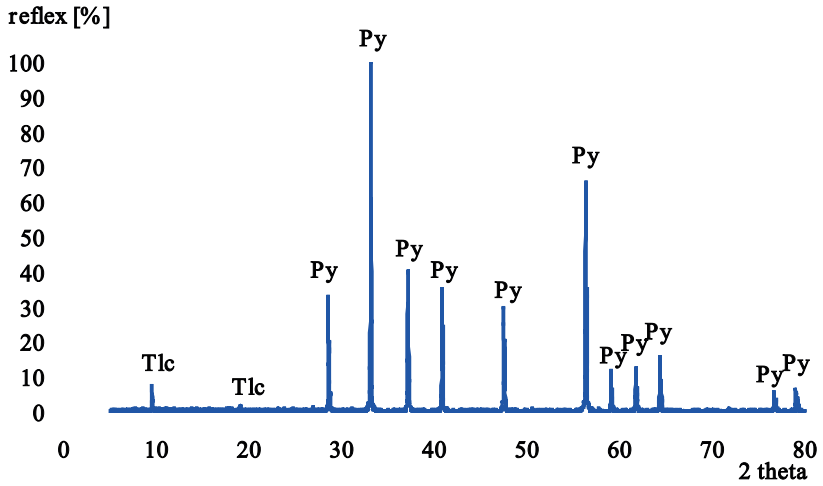

Fig. 6 XRD pattern of pyrite concentrate prepared by hand-picking

Rys. 6 Wyniki analizy XRD ziaren pirytu wybranych ręcznie

and pyrite intergrowth is illustrated in Figure 1. Thus, Figures 2 and 3 show liberated pyrite grains. The size of pyrite grains attain 0.5–6 mm. Light products are created from almost clean talc.

XRD pattern of pyrite concentrate (1–2 mm) obtained at the highest mass yield is illustrated in Fig. 4. Pyrite is a dominant mineral and small peaks of talc can be observed on the background (Hredzák, 2011ab). XRD pattern of selected pyrite grain and its photo are in Fig. 5. Finally, XRD pattern of pyrite concentrate prepared by hand-picking is in Fig. 6 (Py – pyrite, Tlc – talc).

Chemical analysis of pyrite concentrate prepared by hand-picking is introduced in Table 4. It was focused on trace elements, which can occur in pyrite. Thus, a presence of manganese, cobalt, nickel and arsenic was detected. The rest to 100% represents the elements of talc as it can be seen above in Fig. 4 and 6, respectively.

A comparison of pyrite concentrate (1–2 mm) XRD pattern (Fig. 4) with the XRD patterns of pyrites in Figs. 5 and 6 on the other side results in a detection of roentgenographically two modification of pyrite. They are different in position of the strongest peaks (I = 100%):

1) $2theta_1 = 56{,}30^{o}$; $d_1 = 1{,}634$ Å;

2) $2theta_2 = 33{,}08^{o}$; $d_2 = 2{,}708$ Å.

Conclusion

The properties of pyrite as a harmful mineral in talc ore from the Gemerska Poloma deposit (East Slovakia) were studied. It forms variable shapes and its grain size can attain 0.5¬–6 mm.

The results of float-sink analyses showed that pyrite can be eliminated from talc ore by means of gravity con-

centration with high efficiency. Thus, besides obtaining of clean talc, a relatively high-grade pyrite concentrate can be also obtained.

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Badania występowania i właściwości pirytu w rudzie talku w celu jego usunięcia

Praca ta opisuje występowanie pirytu w rudzie talku ze złoża GemerskaPoloma (wschodnia Słowacja). Po pierwsze, przedstawiono stosowanie talku w różnych gałęziach przemysłu, takich jak przemysł papierniczy i gumowy. Opisane zostały również: główni producenci talku na świecie tj. Chiny, Indie i USA, jak również rozwój eksploatacji talku na Słowacji. Według danych dotyczących zasobów rudy talku złoże GemerskaPoloma można uznać za najbardziej znaczące w Europie. Piryt jest głównym szkodliwym minerałem i występuje przede wszystkim w pobliżu talku w jego strefie kontaktu z organami magnezytowymi.

Próbki rudy talku zanieczyszczonej pirytem badano w celu wyzwolenia i charakteryzacji pirytu. Grudkowata ruda (5-20mm) została zgnieciona do wielkości ziarna poniżej 5mm i sklasyfikowana. Poszczególne rozmiary ziarna poddano analizie unoszenia-tonięcia w bromoforme. Otrzymane produkty zważono i poddano analizie. Wybrane produkty badano stosując metodę XRD.

Optyczna obserwacja grudkowatej rudy wykazała, że ziarna pirytu osiągają wielkość 0,5-6mm. W przypadku pokruszonej rudy żelazo i siarka koncentruje się w ziarnach o klasach wielkości 0,5-3mm, przede wszystkim w 1-2mm. Najwyższa wydajność masy koncentratu pirytu w ciężkim produkcie uzyskana została w klasie 1-2mm, to znaczy 15%. Produkt zawiera 44.62% 37.06% S i Fe, następnie 3,14% Mg, 2,45% SiO_2 i 0,76% Ca. Najwyższy stopień czystości koncentratu pirytu, stosując analizę typu unoszenia-tonięcia został osiągnięty w przypadku wielkości ziarna 0,5-1mm, przy masowej wydajnością 8,35%. Zawiera 45,52% S i 38,18% Fe. Co więcej, analiza chemiczna koncentratu pirytu przygotowany przez zbiór ręczny (50,90% S, 43,10% Fe) wykazała obfitość kobaltu (1218ppm), manganu (340ppm), niklu (175ppm) i arsenu (119ppm).

Słowa kluczowe: ruda talku, piryt, wzbogacanie grawitacyjne, XRD