Instytut Gospodarki
Surowcami Mineralnymi
i Energią
Polskiej Akademii Nauk

2018 Report

Part II

Copper and Silver Ores Mining in Poland

Krakow 2019

Instytut Gospodarki
Surowcami Mineralnymi
i Energią
Polskiej Akademii Nauk

The presented report *Copper and Silver Ores Mining in Poland 2018* is the effect of statistical data aggregation as well as of own research carried out at the Mineral and Energy Economy Research Institute of the Polish Academy of Sciences.

The report contains data illustrating the legal situation comprising issues related to obtaining a concession to carry out mining activity, presents the resource base of copper and silver ores mines acc. to Polish classification and to the JORC Code accepted worldwide, deposits extraction systems as well as geological and mining conditions of its performance, the situation of occupational safety, and also expenditures, costs, and economic results of copper ores mining and its environmental impact. A part of presented data is referred to the mining activity in the world.

Mineral and Energy Economy Research Institute
Polish Academy of Sciences

Reservation

The report uses publicly available GUS and CIRE statistical data as well as data purchased from the Industrial Development Agency and analysed especially for the needs of this report.

Contents

Report Goals

The presented Report on the situation of copper and silver ores mining in Poland is an important part of the report on the situation of Polish underground mining. This report is aimed at:

- presentation of the sector playing an important role in the Polish economy,
- informing the society about the mining sector activities to ensure open access to the knowledge, which is a pillar of the 21st century civilisation,
- presentation of the mining sector achievements and issues in a long-term horizon,
- source of the information about the position of Polish copper ores mining against a background of global companies operating in the sector.

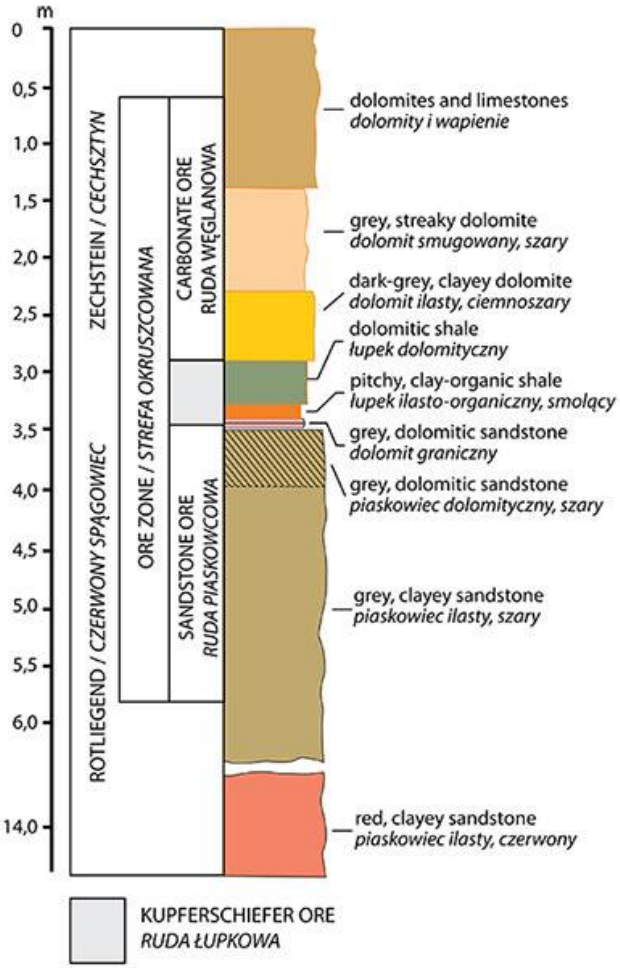
The presented report focuses on the information from the last six years, however, in certain parts it uses historical information to present the copper ores mining in a broader perspective.

Copper and Silver Ore Deposits Resources in Poland

Copper and silver ores

The copper ores deposits are situated in the Lower Silesia (in the Sudetes and in the Pre-Sudetes Monocline), in the Świętokrzyskie Mountains, and at the edges of the Upper-Silesian Coal Basin (Ney et al. 1997).

Only the deposits in the Pre-Sudetes Monocline and in the North-Sudetes Basin are currently important from economic point of view. These are stratoidal deposits, related to the Zechstein formation of copper-bearing shale. The copper minerals mineralisation with an admixture of other metals occurs in the Zechstein copper-bearing shale and in underlying sandstones and overlying dolomites and limestones.



Lithological profile of copper ores deposit in the Pre-Sudetes Monocline
Source: kghm.com/pl

Source: kghm.com/pl; Balance of Mineral Resources and Ground Waters in Poland

Copper and silver ores

Useful metals in copper ores most frequently take form of sulphides, less often oxides. The most important copper minerals existing in deposits of the Pre-Sudetes Monocline include covellite (CuS), bornite (Cu_5FeS_4), chalcopyrite ($CuFeS_2$), and chalcosine (Cu_2S).
Those copper ores deposits in fact constitute polymetallic copper-silver deposits, where apart from the basic component, being copper, occurs an equally valuable silver. They are accompanied by a big complex of metals and non-metallic components, which from practical point of view may be divided into four groups:

- recovered, co-deciding about the deposit value (Au),
- recovered as a by-product of metallurgical processes (Ni, Re, Pt, and Pd),
- recovered as non-desired due to the metallurgical processes technology or requirements of the environmental protection (Pb, Se, As),
- not recovered due to the lack of appropriate recovery technology (Co, Mo, V, and Hg) or due to a low content (Zn, Bi, Sn, Cd, and Ge), including also those accumulating in the waste of certain metallurgical processes (Co, Hg).

Bornite crystal (violet) in calcite

Chalcosine crystallisation (silver) on diabase

Ore of covellite (blue) and of chalcopyrite (brown)
Source: minerals.net

Copper and silver ores

Copper-silver ores occur in 12 deposits in the Pre-Sudetes Monocline and in the North-Sudetes Basin: 6 managed, 4 explored in details, and 2, where mining was abandoned.

Balanced reserves of non-managed copper ores deposits occur mainly in a depth zone of 1000-1250 m and even down to 1450 m (non-commercial because of the depth). Their independent management will be very difficult, but possible using openings from the existing adjacent mines or building new mines.

A deposit is considered as qualifying for mining if it meets the balance criteria . The following table provides requirements for new documentation, specified in the Regulation of the Minister of Environment of 22 December 2011 on the geological documentation of a mineral deposit and in brackets - resulting from previous regulations binding for a majority of documented deposits in Poland.

Balance criteria of copper ores deposits (stratoidal seams)

No	Parameter	Unit	Boundary values
1	Maximum depth of deposit floor	m	1500 (1250)
2	Minimum copper content in the deposit contour sample	%	0,5 (0,7)
3	Minimum weighted average of equivalent copper content (Cu)[1]	%	0,5 (0,7)
4	Minimum deposit abundance[2]	kg/m^2	35 (50)

(1) Cu equivalent is calculated based on the formula Cueq = (% Cu) + 0.01 (g/Mg Ag)
(2) This parameter refers to the copper equivalent.

Prepared based on the KGHM Polska Miedź SA data

Copper and silver ore deposits resources

Resources of copper-silver ores deposits in Poland as of 31/12/2018

Ore (million Mg)
met. copper (million Mg)
silver ('000 Mg)

Specifications	Deposit number	Geological Resources						Industrial Resources
		Balanced					Non-Balanced	
		Total	A+B	C1	C2	D		
TOTAL RESOURCES	15	1 912,68 34,23 103,15	627,52 11,16 34,38	1 199,64 21,76 65,33	74,55 1,09 4,42	3,93 0,04 0,17	802,03 13,11 41,84	1 188,51 23,74 69,71
of which – resources of managed deposits								
Deposits of operating plants	6	1 548,56 28,74 83,66	625,27 11,12 33,27	923,29 17,62 50,39	- - -	- - -	1,77 0,02 0,06	1 188,51 23,74 69,71
of which – resources of non-managed deposits								
Deposit explored in detail	5*	333,32 5,05 18,54	- - -	262,61 3,98 14,28	66,78 1,03 4,09	3,93 0,04 0,17	782,18 12,96 41,10	- - -
of which – deposits, in which mining was abandoned								
Abandoned mining	5	23,77 0,26 1,08	2,25 0,04 0,11	13,74 0,16 0,66	7,77 0,06 0,32	- - -	18,08 0,13 0,68	- - -

* - including a part of Radwanice-Gaworzyce deposit

Source: Balance of Mineral Resources and Ground Waters in Poland

List of concessions

The main deposits of economic importance are mined by the KGHM Polska Miedź SA. The company is currently carrying mining activity in the concession areas: Lubin-Małomice, Rudna, Polkowice, Sieroszowice, Głogów Głęboki-Przemysłowy, Radwanice Wschodnie, and Gaworzyce in three underground mines Lubin, Rudna, and Polkowice-Sieroszowice.

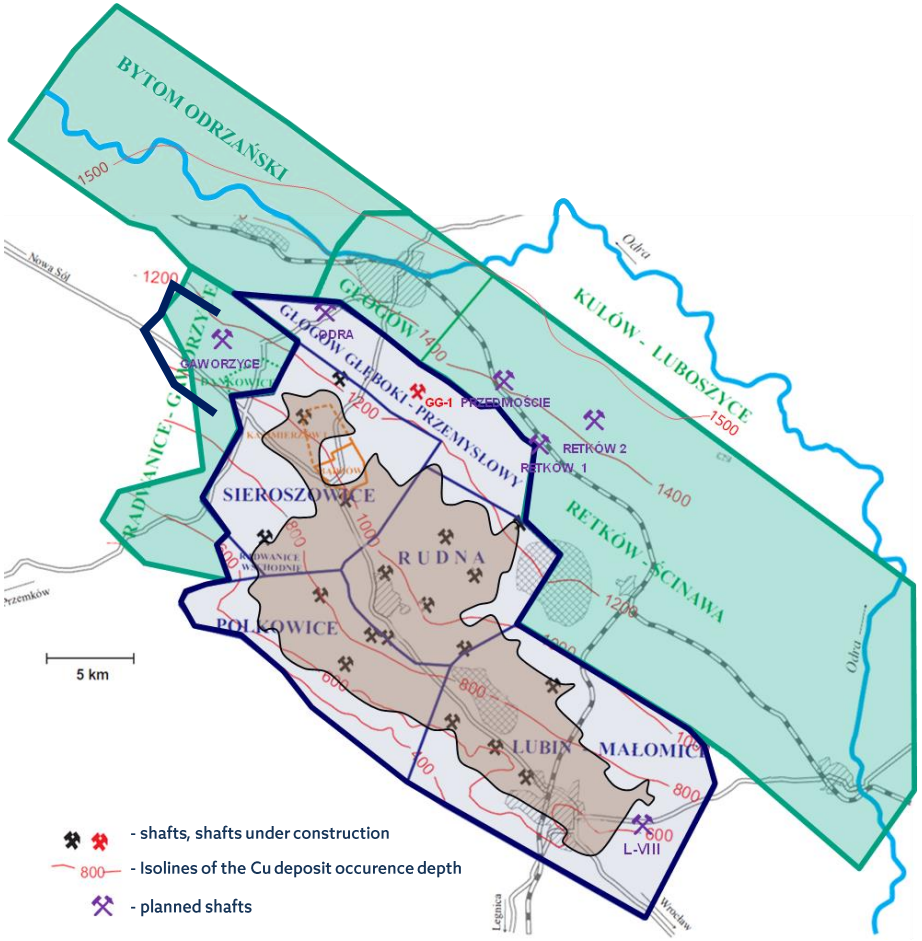
Concessions for copper and silver ore deposits mining

Mine field	Concession number	Expiry date	Mining entity
LUBIN-MAŁOMICE	Concession No 10/2013 of 12 September 2013	31 December 2063	Lubin and Rudna Mines[1]
RUDNA	Concession No 9/2013 of 14 August 2013	31 December 2063	Lubin, Polkowice-Sieroszowice[1] and Rudna Mines[1]
POLKOWICE	Concession No 7/2013 of 14 August 2013	31 December 2063	Polkowice-Sieroszowice Mine
SIEROSZOWICE [2]	Concession No 11/2013 of 12 September 2013	31 December 2063	Polkowice-Sieroszowice and Rudna Mines
RADWANICE WSCHODNIE	Concession No 8/2013 of 14 August 2013	31 December 2063	Polkowice-Sieroszowice Mine
GŁOGÓW GŁĘBOKI PRZEMYSŁOWY [3]	Concession No 16/2004 of 25 November 2004	25 December 2054	Polkowice-Sieroszowice and Rudna Mines
GAWORZYCE	Concession No 2/2017 of 23 February 2017	15 March 2065	Polkowice-Sieroszowice Mine

1) Marginal share
2) Mined at 85% by the Polkowice-Sieroszowice mine and at 15% by the Rudna mine.
3) Mined at 50% by the Polkowice-Sieroszowice mine and at 50% by the Rudna mine.

Source: Balance of Mineral Resources and Ground Waters in Poland

Location



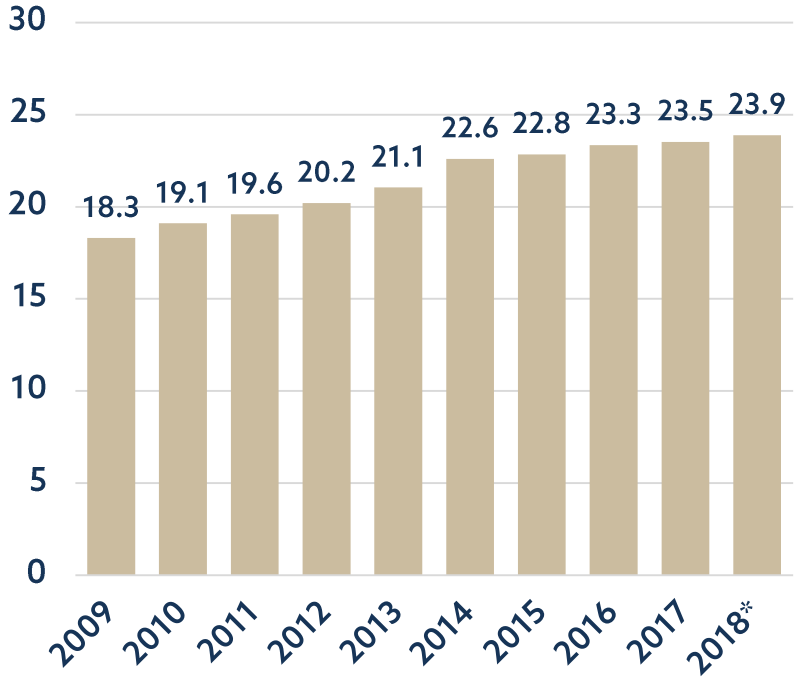
Location of areas covered by the mining concessions of KGHM Polska Miedź SA

Source: Stach R., Raport o stanie górnictwa rud miedzi 2018 (2018 Report on the Copper Ores Mining Situation), XXVIII SEP

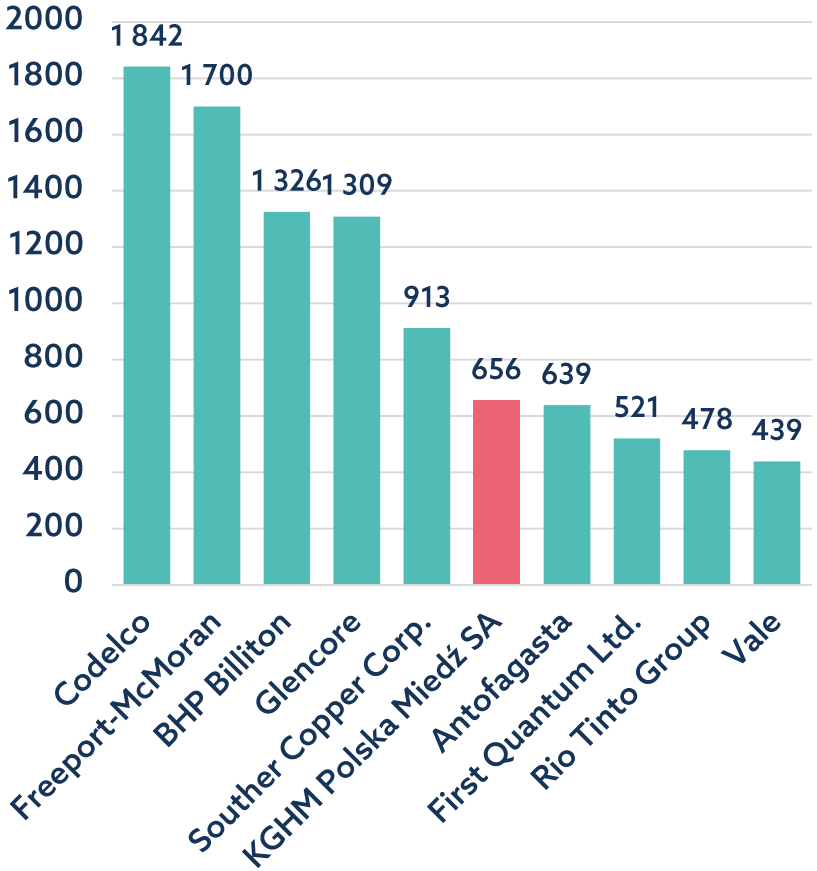
Extraction and Production of Copper and Silver Worldwide

Copper production worldwide

Copper production worldwide in the years 2008-2018 [million Mg]



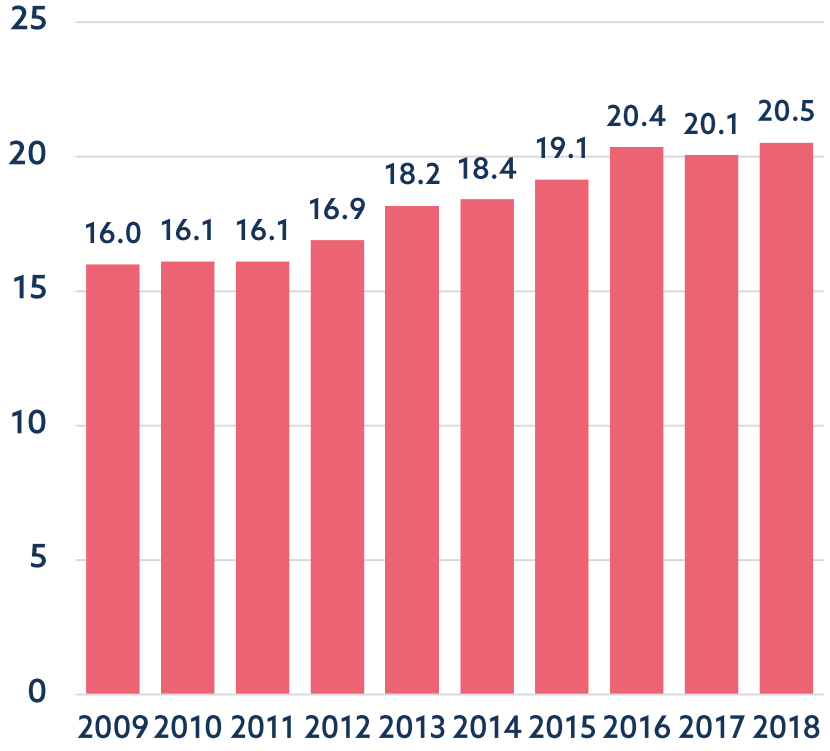
Biggest world copper producers in 2017 r. ['000 Mg]



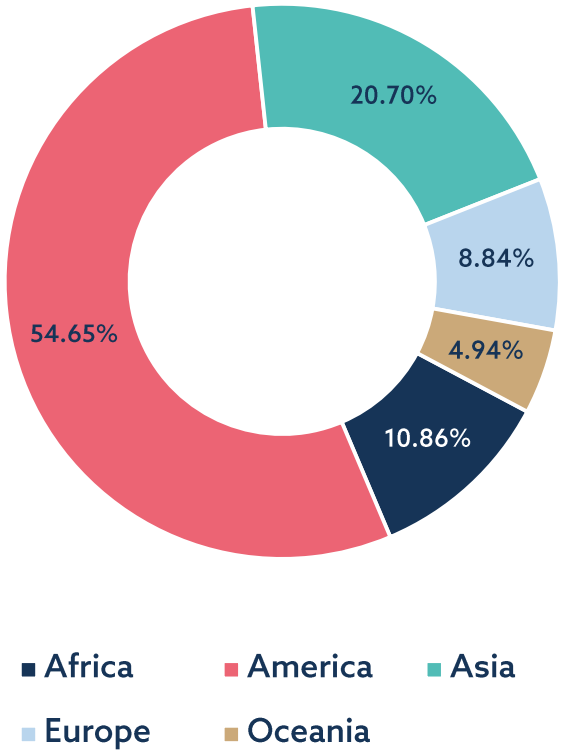
Source: The World Copper Factbook 2018, ICSG; Minerals Yearbook 2012-2015; USGS

Mining copper production worldwide

Mining copper production worldwide in the years 2008-2018 [mln Mg]

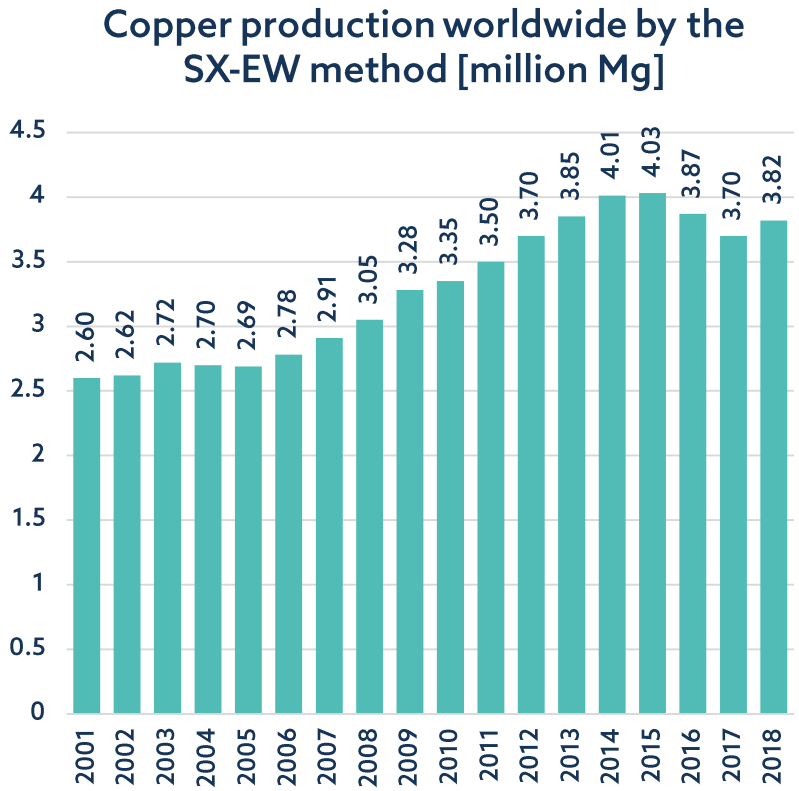


Mining copper production worldwide in 2018 [%]



Source: Copper mine, smelter, refinery production, and refined copper usage by geographical area, ICSG;

Copper production by means of SX-EW method



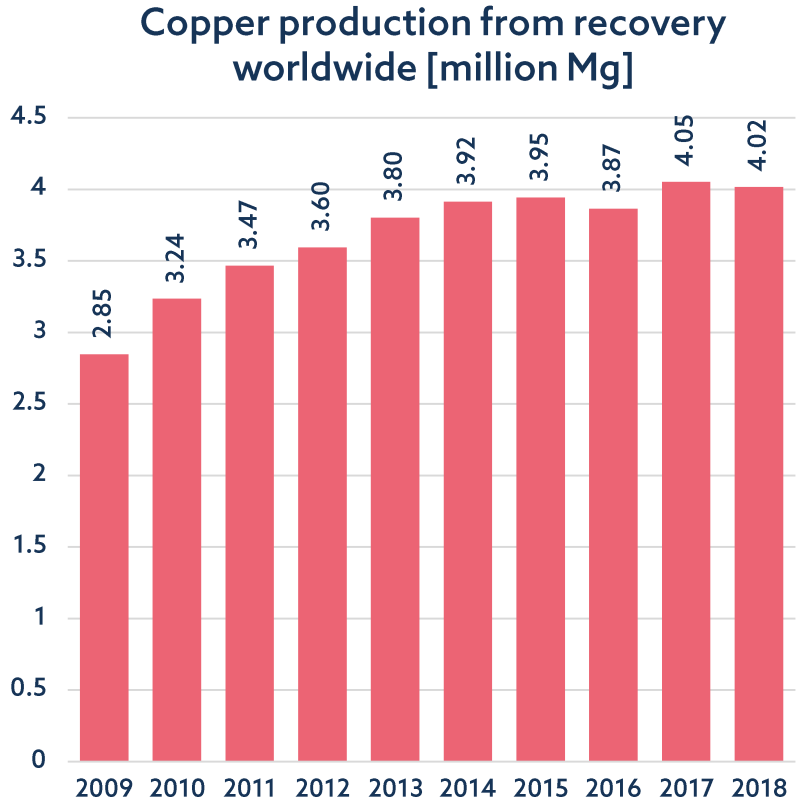
The SX-EW method, in other words the leaching method, consists in dissolving copper-bearing minerals by means of a sulphuric acid solution. Such solution is drained and directed to the SX-EW reactor, where it is cleaned and concentrated. Then the solution is subject to electrolysis.

This method allows to recover copper from oxide ores and from very lean sulphide ores. The SX-EW methods accounted in 2018 for approx. 16 % of the global copper production.

In Poland this method is not used, but the KGHM Polska Miedź SA uses it in Sierra Gorde and Franke mines in Chile and Carlota mine in the USA

Source: The World Copper Factbook 2018, ICSG; Minerals Yearbook 2012-2015; USGS

Copper production from waste



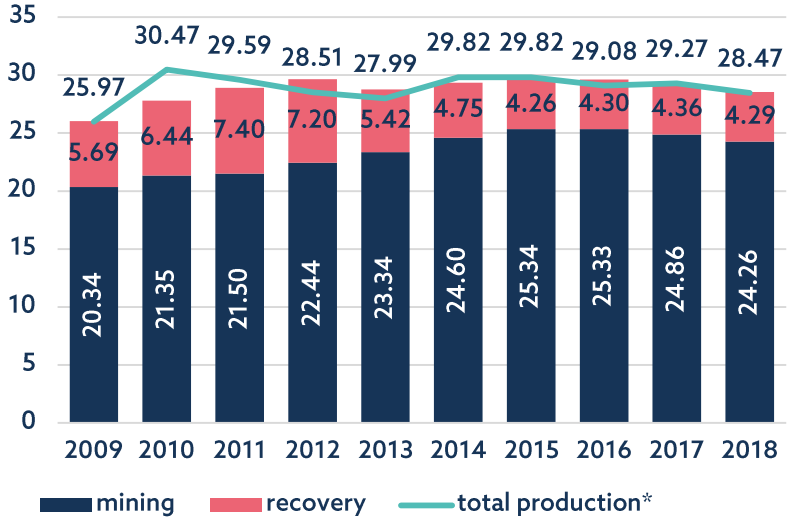
The copper recovery from waste is another method of copper production. This could be the production waste of copper elements or used products containing copper. Methods for copper waste processing are similar to those used in smelters for copper concentrates.

According to the ISCG even 50% of copper used now in Europe originates from recycling. It is estimated that the copper production from waste uses by 85% energy less than its acquisition from an original deposit and the world saves in this way approx. 100 million MWh of electricity and emits 40 million tonnes of CO_2 less per year.

Source: The World Copper Factbook 2018, ICSG; Statista.com; Copperalliance.eu

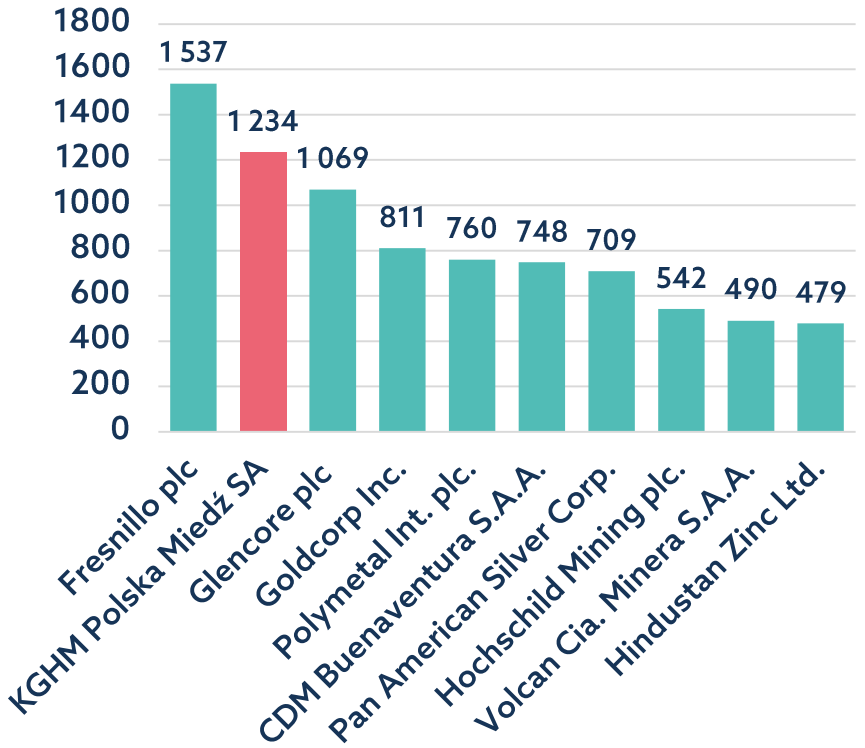
Silver production worldwide

Silver production from the mined ore and from the recovery in the years 2009-2018 ['000 Mg]*



* takes into account also silver reserves building and releasing by state banks and by hedging contracts

Biggest silver producers in 2017 [Mg]



Source: World Silver Survey 2018, The Silver Institute

Copper and silver prices on world stock exchanges

Copper prices in the years 2009-2018[1] [USD/Mg]

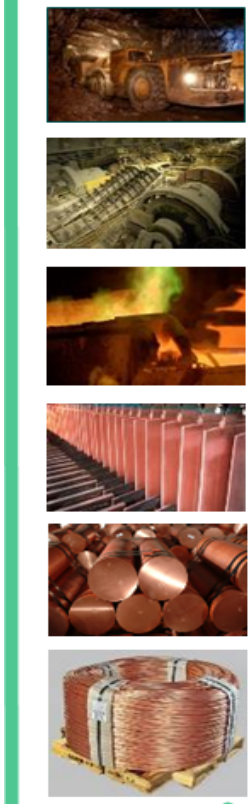
Silver prices in the years 2009-2018[1] [USD/kg]

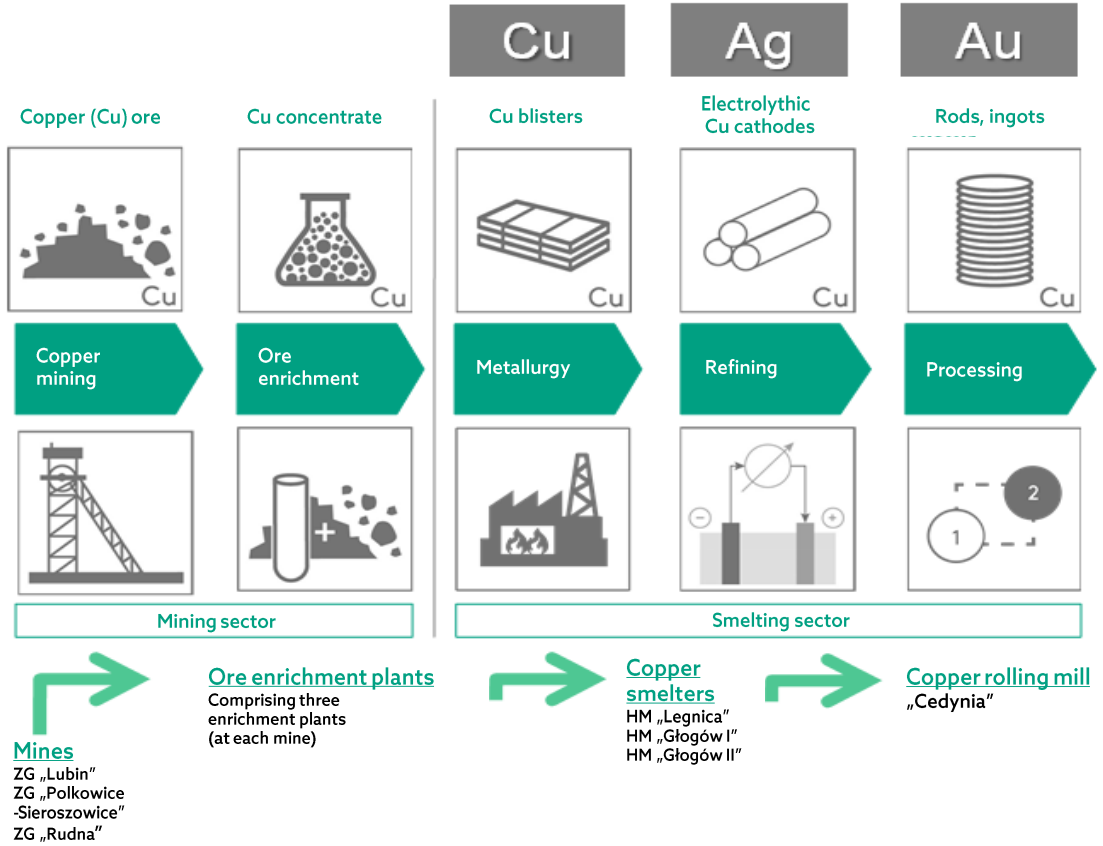
[1]Settlement prices of futures

Source: indexmundi.com

Technology and Engineering of Copper and Silver Ores Mining

KGHM Polska Miedź SA production process





Source: Świderski D., Strategiczne wyzwania sfery wydobywczej KGHM PM S.A. do roku 2030 (Strategic Challenges of KGHM PM S.A. Mining Area by 2030), XXVII SEP

Technological conditions of mining at KHGM Polska Miedź SA

Increase in the mining depth

- The Company is mining at depths from 600 to 1250 m

High variability of the deposit

- Stone or barren rock zones, tectonic disturbance zones

Expansion of the ventilation network structure

- Required for cooling purposes – the primary rock mass temperature is 25-46°

Significant scope of access and development works

- 46.5 km of workings were driven to open the Głogów G-P deposit

Expansion of the underground infrastructure

- Belt conveyors, utilities, power network etc.

Shorter effective time of work

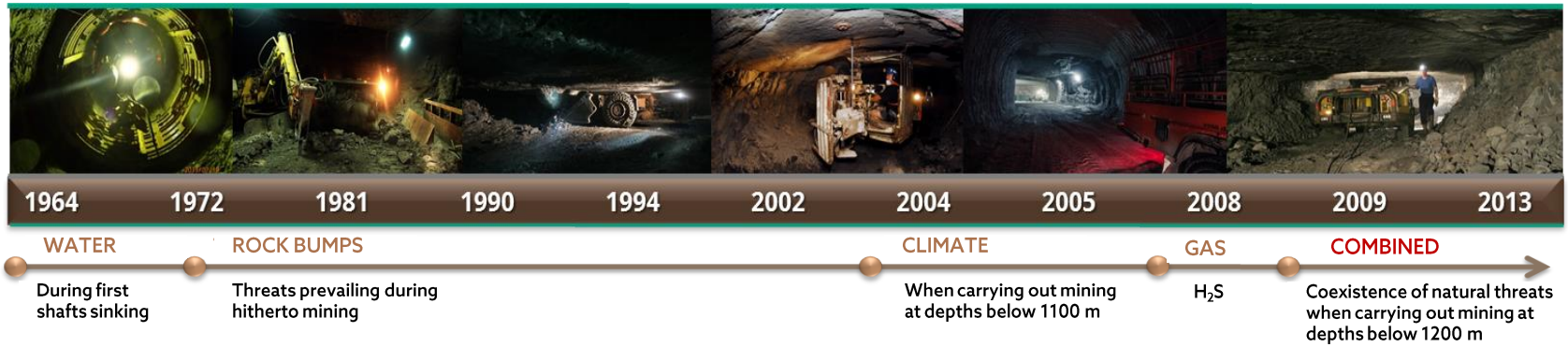
- Results from the increasing distance from the shafts

Activation of the natural hazards

- At great depths climate, gas and rock-bumps hazards co-exist

Source: Stach R., Raport o stanie górnictwa rud miedzi 2019 (2018 Report on the Copper Ores Mining Situation), XXVIII SEP

Natural hazards accompanying mining at the KGHM



Many types of natural hazards occur at the KGHM: gas (hydrogen sulphide), water, rock-bumps, climate and gas-goedynamic, to a lesser extent - methane.

The hydrogen sulphide hazard means an outflow of hydrogen sulphide to the mine atmosphere, which is toxic to people - at high concentrations it causes respiratory system paralysis. To protect against this gas persons present in the threatened area are obliged to use gas masks and instruments measuring the hydrogen sulphide concentration.

Gas half-mask with absorber
Source: shopbhp.pl

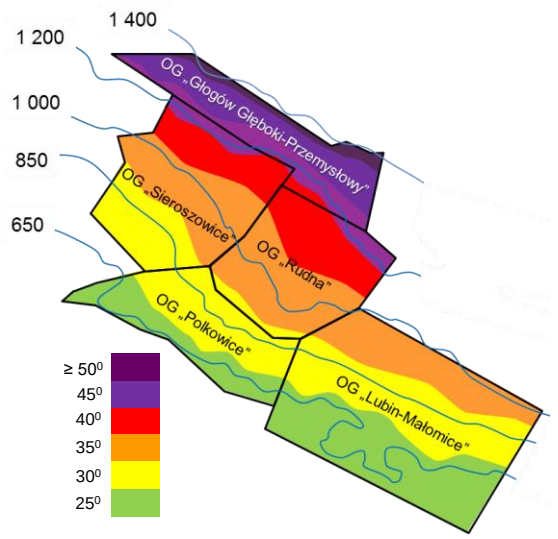
Source: Świderski D., Strategiczne wyzwania sfery wydobywczej KGHM PM S.A. do roku 2030 (Strategic Challenges of KGHM PM S.A. Mining Area by 2030), XXVII SEP, 2018
Gola S., Soroko K., Turkiewicz W. Profilaktyka zagrożenia siarkowodorem na przykładzie oddziału G-63 w kopalni Polkowice-Sieroszowice (Hydrogen Sulphide Hazard Prevention Using Example of G-63 District in the Polkowice-Sieroszowice Mine)

Natural hazards accompanying mining at the KGHM

Rock-bumps mean damage or destruction of mine workings due to seismic shocks. The rock-bumps hazard is one of most dangerous hazards found in the mining sector, therefore to protect against it a wide range of preventive actions is carried out at the KGHM. It comprises seismological observations, selection of dimensions and shapes of chambers and inter-chamber and protective pillars, the choice of mining direction and sequence. Also so-called active methods are used, i.e. provoking controlled bumps by means of explosives.

Climate hazard is a growing challenge for the KGHM. It results from the increasing depth of mining and from a high temperature of the rock mass. It is fought by the application of central cooling systems, and also of air conditioners and slow-flow fans in workings. To reduce the temperature and decrease the amount of exhaust gas in the mine atmosphere the KGHM studies also a possibility of electric loaders operation in underground conditions - those used so far are equipped with Diesel engines.

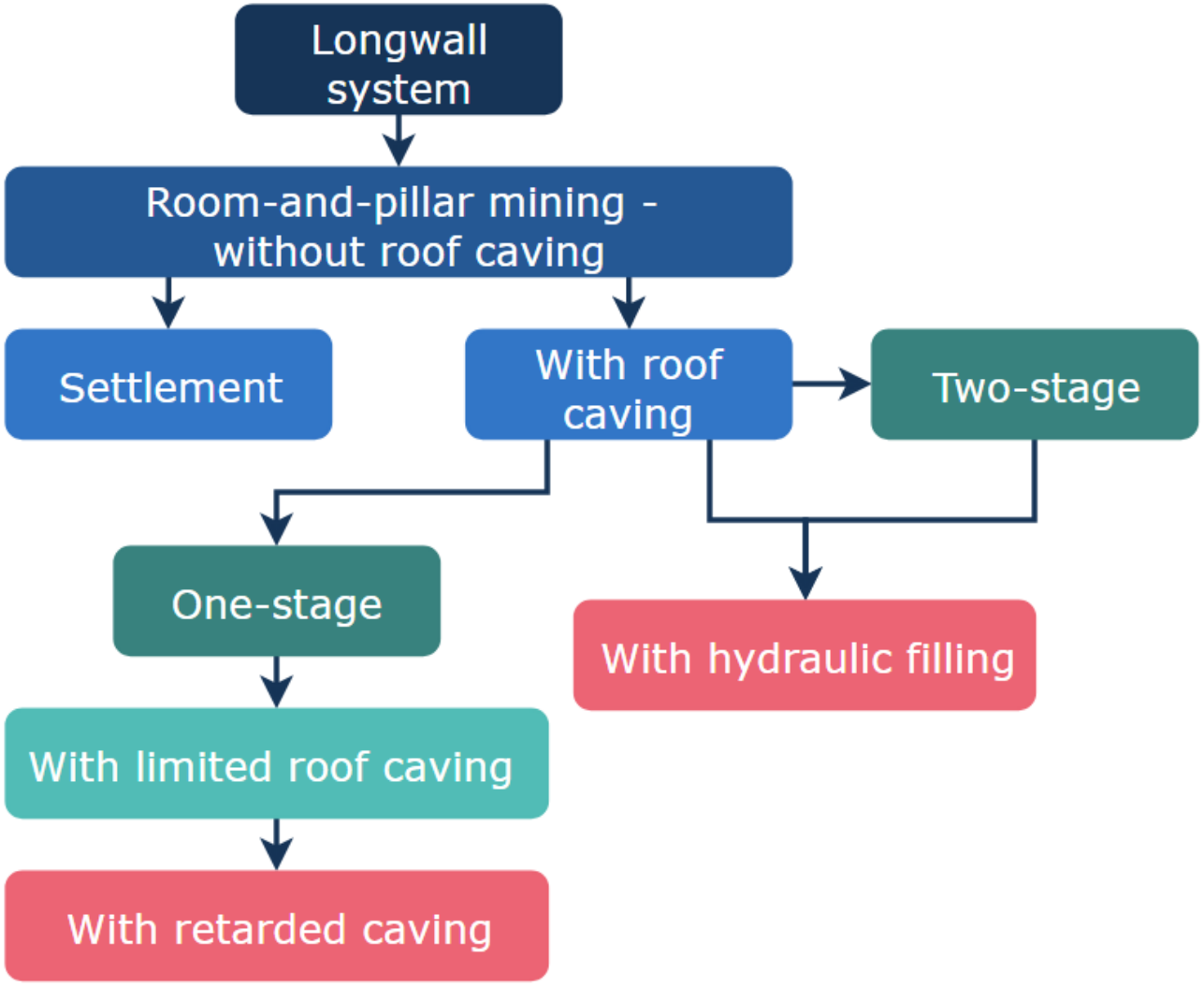
Water hazard is now under control and constitutes primarily a component of costs resulting from the necessity to pump mine waters. Such waters are drained to the surface by the central pumping station and then used in flotation.



The primary temperature of the rock mass in mining areas of KGHM Polska Miedź SA

Source: Stach R., 2019, Raport o stanie górnictwa rud miedzi 2019 (2018 Report on the Copper Ores Mining Situation), KGHM Polska Miedź SA data

Evolution of copper and silver ores deposits mining systems at KGHM Polska Miedź SA



Source: Monografia KGHM Polska Miedź SA (Monograph), 1996

Copper and silver ores deposits mining systems used at the O/ZG Lubin

System name	Symbol	Deposit thickness	Deposit slope	Goaf liquidation method
Room-and-pillar mining with hydrauilng filling	D-P	to 7 m	to 8°	Hydrauling filling
Room-and-pillar mining with retarded caving	J-UG	to 7 m	to 8°	Retarded caving
Room-and-pillar mining with retarded caving for a deposit with the slope incrased to 16°	J-UGN-1	to 7 m	to 16°	Retarded caving
Room-and-pillar mining with retarded caving for a deposit with the slope incrased to 35°	J-UGN-2	to 7 m	to 35°	Retarded caving
Room-and-pillar mining with retarded caving for closing panels	J-UGZ	to 7 m	to 8°	Retarded caving
Room-and-pillar mining with retarded caving under conditions of weak roof and reduced thickness of dolomitic-anhydritic rocks	J-UGS	to 5 m	to 30°	Retarded caving
Room-and-pillar mining with retarded caving	J-UG-PS	to 6 m	to 25°	Retarded caving

Prepared based on the KGHM Polska Miedź SA data

Copper and silver ores deposits mining systems used at the O/ZG Rudna

System name	Symbol	Deposit thickness	Deposit slope	Goaf liquidation method
Room-and-pillar mining with retarded caving	J-UG-PS	to 6 m	to 25°	retarded caving
Room-and-pillar mining with retarded caving and fenced ventilation-haulage roadways in goafs	J-UGW-PS	to 7 m	to 8°	retarded caving
Room-and-pillar mining with retarded caving with yielding the deposit and additional roof protection	R-UO	to 7 m	to 8°	retarded caving
Room-and-pillar mining with retarded caving for areas with unusually difficult geological and mining condition	R-UO/H	to 7 m	to 8°	retarded caving
Room-and-pillar mining with retarded caving and/or hydraulic filling for conditions od suport pillars yielding and liquidation	R-UO/FO	to 15 m	to 8°	retarded caving or hydraulic filling
Room-and-pillar mining with hydraulic filling for medium and thick deposits	J-3S-PH	to 15 m	to 8°	hydraulic filling, solid
Room-and-pillar mining with bottom layer liquidation by means of dry backfilling	RG-6	to 15 m	to 8°	dry backfilling, partial
Room-and-pillar mining with hydraulic filling for conditions of variable roof stability existence	RG-8	to 15 m	to 8°	hydraulic filling
Room-and-pillar mining with barren rock placing and liquidation by means of hydraulic filling	RG-9	to 15 m	to 8°	dry and hydraulic filling

Prepared based on the KGHM Polska Miedź SA data

Copper and silver ores deposits mining systems used at the O/ZG Polkowice-Sieroszowice

System name	Symbol	Deposit thickness	Deposit slope	Goaf liquidation method
Room-and-pillar mining with retarded caving	J-UG-PS	to 6 m	to 25°	retarded caving
Room-and-pillar mining with retarded caving, with participation of non-mineralised zones	J-UGK-PS	to 6 m	to 8°	retarded caving
Room-and-pillar mining with retarded caving for suport pillars	J-UGO-PS	to 6 m	to 8°	retarded caving
Room-and-pillar mining with retarded caving and operational closing pillar	J-UGR-PS	to 6 m	to 25°	retarded caving

Prepared based on the KGHM Polska Miedź SA data

Copper and silver ores deposits mining systems used at KGHM Polska Miedź SA

The share of goafs liquidation methods in the mining systems used at KGHM Polska Miedź SA (as of 31/12/2016)

	Number of mining panels	Mining systems		
		Retarded caving	Backfilling	
			Hydraulic	Dry
ZG Lubin	10	7	3	-
ZG Polkowice-Sieroszowice	17	17	-	-
ZG Rudna	24	19	5*	
Total	51	43	8*	
Total (%)	100%	84%	16%	

The KGHM is currently using many variations of the basic room-and-pillar system. Each of those variations features a defined range of allowed pillar dimensions. The actual pillar dimension within a specific range are determined after considering additional criteria, such as depth of deposit occurrence, the degree of deposit folding or faulting, closeness to other mining panels, stress conditions, and potential rock-bumps threat.

Prepared based on the KGHM Polska Miedź SA data

Mechanisation of copper ores mining

At the KGHM self-propelled underground machines are the key element of mining.
1260 self-propelled mining machines were used in 2018 in the Company mines, that is 29 more than in the previous year.
The face loaders used have capacity of up to 16 Mg, and the haulers up to 50 Mg. 100% of drilling cars are driven with electro-hydraulic systems, and 78.5 % of them are vehicles operated by one person. 632 vehicles are equipped with life-saving cabs (86 more than in the previous year), and 537 (43 more than in 2017) with air-conditioning. Apart from that 165 km of belt conveyors are used.

Examples of self-propelled machines used at the KGHM Polska Miedź SA:
Roofmaster bolter 1.4, wheel loader KOT 170
Source: kghmzanam.com; minemaster.com

Prepared based on Stach R., Raport o stanie górnictwa rud miedzi 2018 (2018 Report on the Copper Ores Mining Situation), XXVIII SEP

Copper and silver ores enrichment

The ore extracted from a mine before processing in a smelter should be subject to enrichment. This process is aimed at increasing the amount of copper content in the material delivered to smelters. Three phases are distinguished in the ore enrichment:

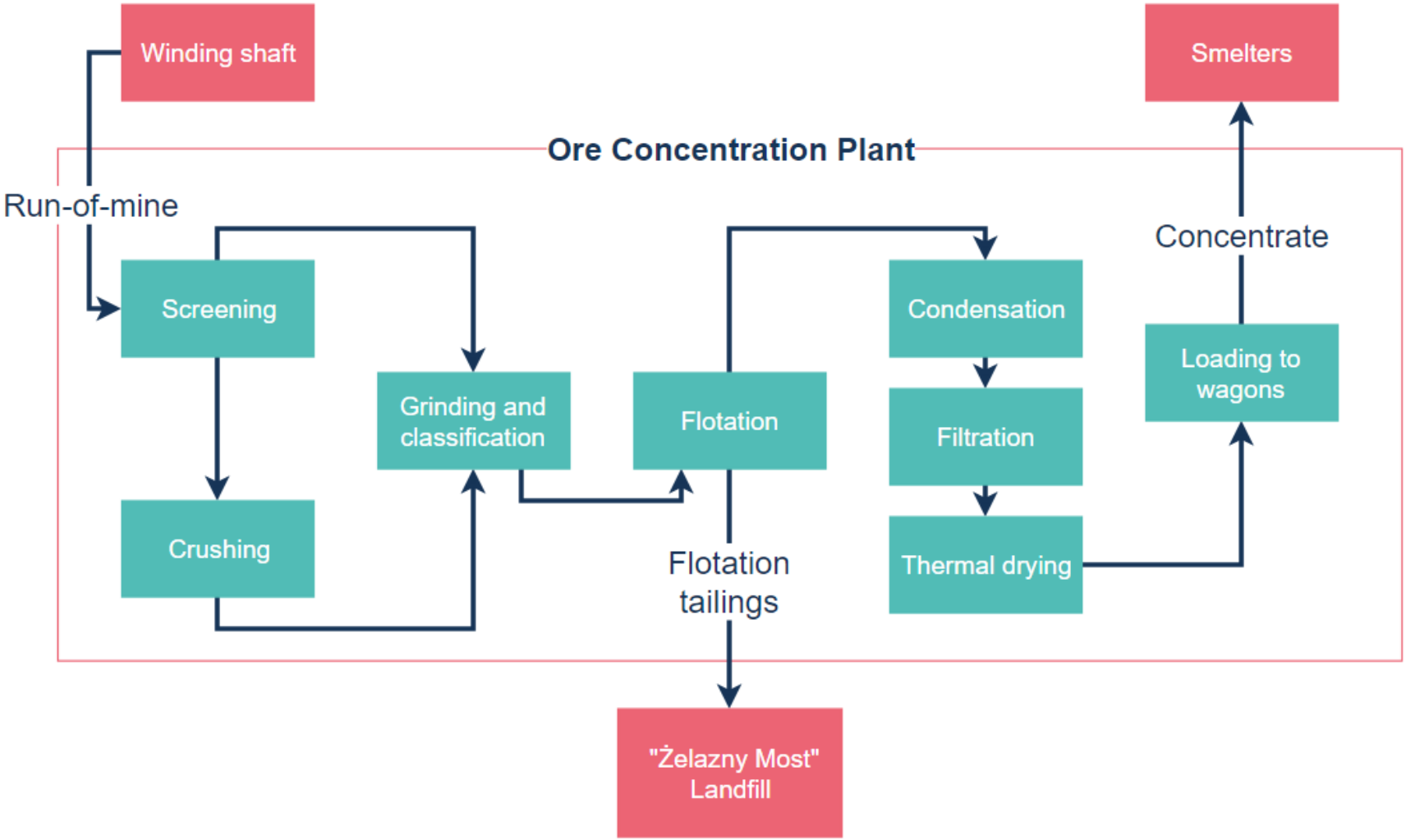
- Preparatory - run-of-mine crushing, grinding and classifying. They are aimed at obtaining fine grains of the ROM required in the next stage,
- Main - flotation carried out in three stages. This process separates the ROM into concentrate with approx. 24% Cu content and waste containing approx. 0.2% Cu. It is carried out by passing air bubbles through a tank with water and ROM. Under appropriate conditions those bubbles raise copper minerals grains, forming a foam on the tank surface, which is collected to the next stage,
- Supplementary - concentrate drainage and flotation tailings storage. Flotation tailings are directed to the OUOW Żelazny Most (waste management facility). Concentrate goes to the Legnica Smelter and to the Głogów Smelter.

The Ore Concentration Plant Division of KGHM Polska Miedź SA consists of three regions, capable of processing up to 33 million tonnes of the run-of-mine per year, of which:

- Lubin Region - approx. 8 million tonnes,
- Polkowice Region - approx. 9 million tonnes,
- Rudna Region - approx. 16 million tonnes,

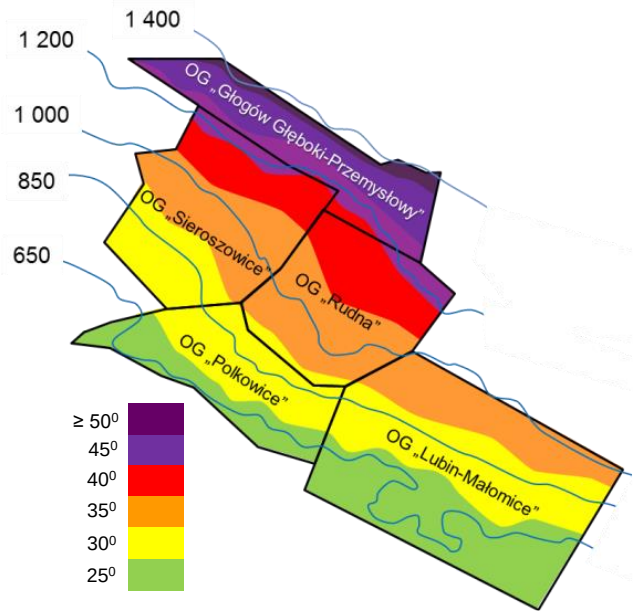
Source: Księżniak K, Wzbogacanie rudy miedzi w KGHM Polska Miedź S.A. (Copper Ore Enrichment at the KGHM Polska Miedź S.A.)

Diagram of copper and silver ores enrichment at KGHM Polska Miedź SA



Source: Księżniak K, Wzbogacanie rudy miedzi w KGHM Polska Miedź S.A. (Copper Ore Enrichment at the KGHM Polska Miedź S.A.)

Description of Głogów Głęboki – Przemysłowy project



The primary temperature of the rock mass of KGHM Polska Miedź SA deposits on the deposit level

- Approx. 300 million tonnes of ore,
- Average Cu content ~ 2.4%,
- Estimated mine life - approx. 40 years,
- Target production - 10-11 million tonnes of ore; 200-220,000 tonnes of Cu,
- Partly used infrastructure of ZG Rudna and ZG Polkowice-Sieroszowice,
- The deposit layers are situated at depths to 1385 m,
- The primary temperature of the rock mass exceeds 45°C,
- Expected lower than in other areas degree of deposit faulting, but stronger thermal and gas effects.

Source: *Świderski D.*, Strategiczne wyzwania sfery wydobywczej KGHM PM SA do roku 2030 (Strategic Challenges of KGHM PM SA Mining Area by 2030)

IT in the copper ores mining

The operation on such a large scale, as the mining at the KGHM Polska Miedź SA, generates high costs, but also can be a valuable source of data, which comprise potential to optimise the production. Therefore the company invests in the technological progress, in 2018 focusing on broadened monitoring of machinery, equipment, and personnel work.

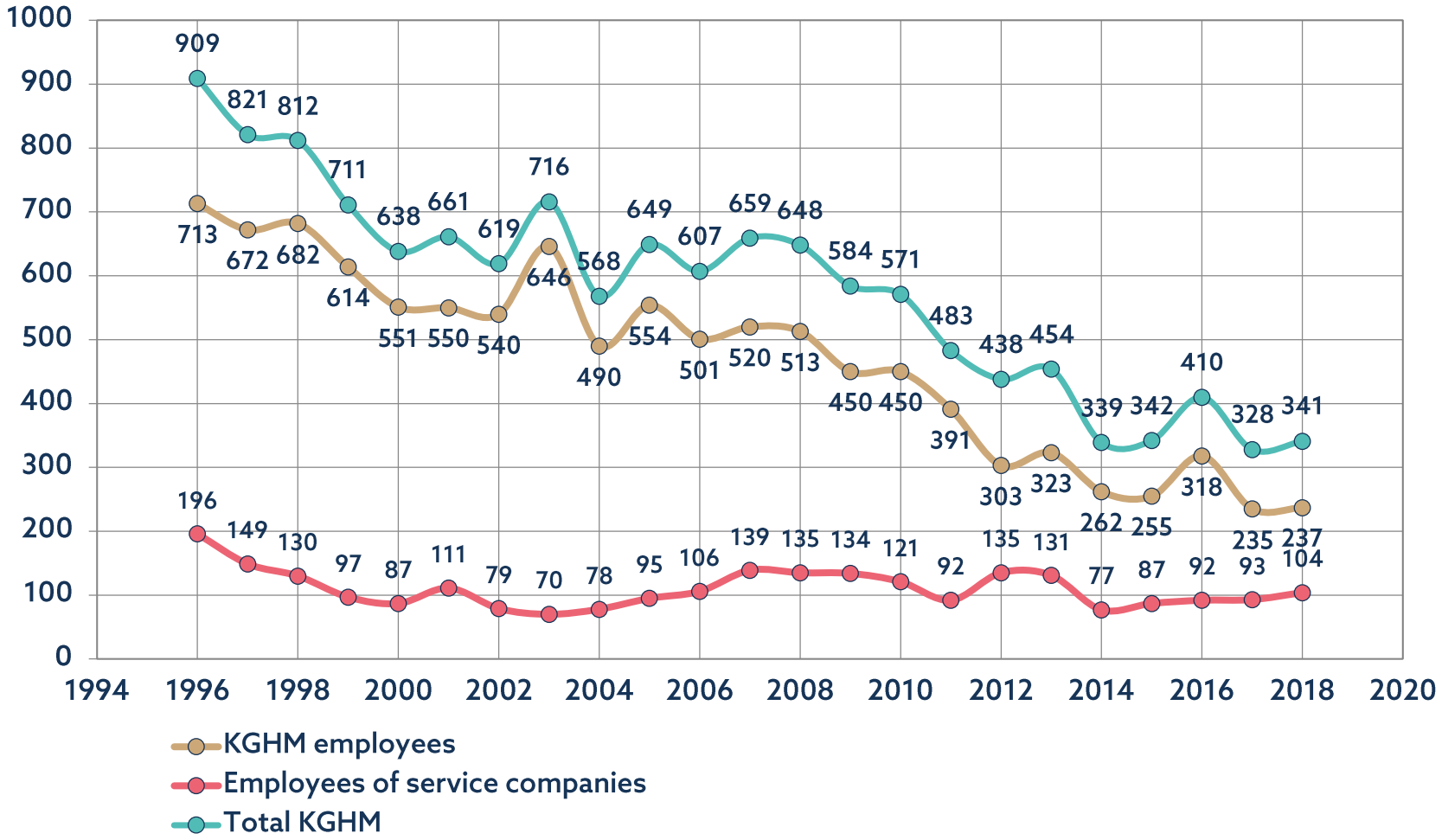
To this end it implements, among other things:

- a new control room at the ZG 'Lubin', modelled on the already operating One Control Room at the ZG 'Polkowice',
- wireless communication system on mining fronts,
- IT system for Production Infrastructure Management iZIP,
- Centre for Advanced Data Analysis - i.e. a team with a task of broad production data analysis based on Big Data systems - *a concept of this solution has been developed at the Mineral and Energy Economy Research Institute of the Polish Academy of Sciences.*

Situation of Occupational Safety in the Copper and Silver Ores Deposits Mining in Poland

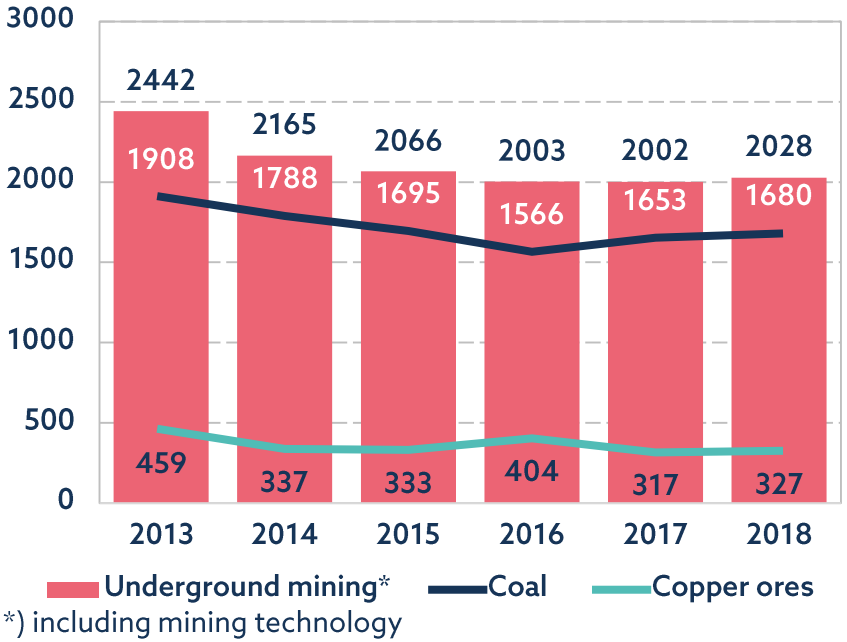
*Prepared based on the Report on the Safety State in Polish Mining Sector in 2018, presented during the XXVIII School of Underground Mining, Krakow, February 2019

The number of accidents in KGHM plants in the years 1996-2018



Source: Stach R., Raport o stanie górnictwa rud miedzi 2018 (2018 Report on the Copper Ores Mining Situation), XXVIII SEP

Accident rate in the copper and silver ores mining in Poland



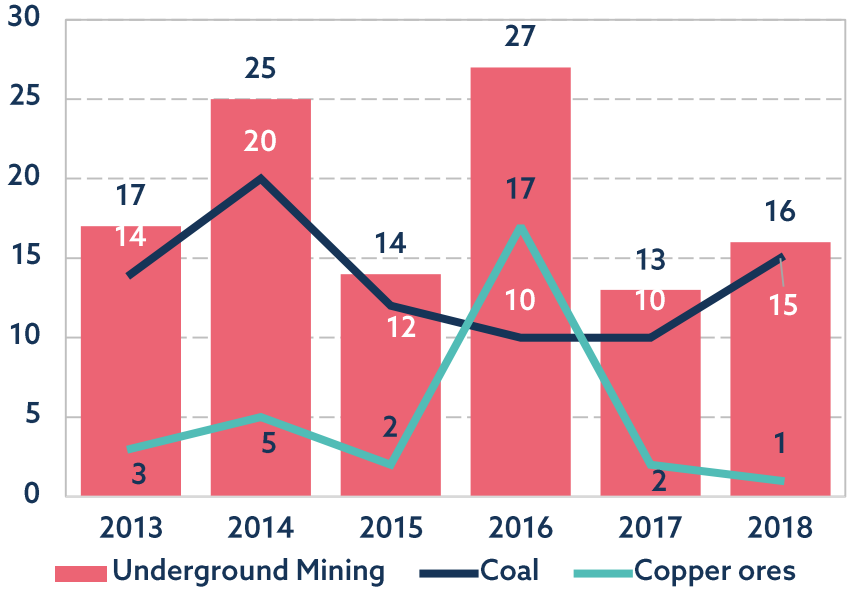
*) including mining technology

- The number of accidents in the underground mining increased in 2018, both in hard coal and copper ores mining,
- Despite that, the accident rate in 2018 decreased for the copper ores mining and leveled in hard coal mines.

Overall accident rate per 1000 employees						
	2013	2014	2015	2016	2017	2018
Mining total	11,9	11,0	11,5	11,5	11,8	11.7
Underground*	15,1	13,9	15,2	15,3	15,9	15,6
Coal mines	13,8	13,5	15,3	14,7	16,1	16,1
Copper ores mines	23,2	18,2	16,4	20,6	17,0	15,6

Source: Karkula P. Raport o stanie bezpieczeństwa w polskim górnictwie w 2018 roku, (Report on the Safety State in Polish Mining Sector) XXVIII SEP, 2019.

Fatal accidents in the copper and silver ores mining in Poland

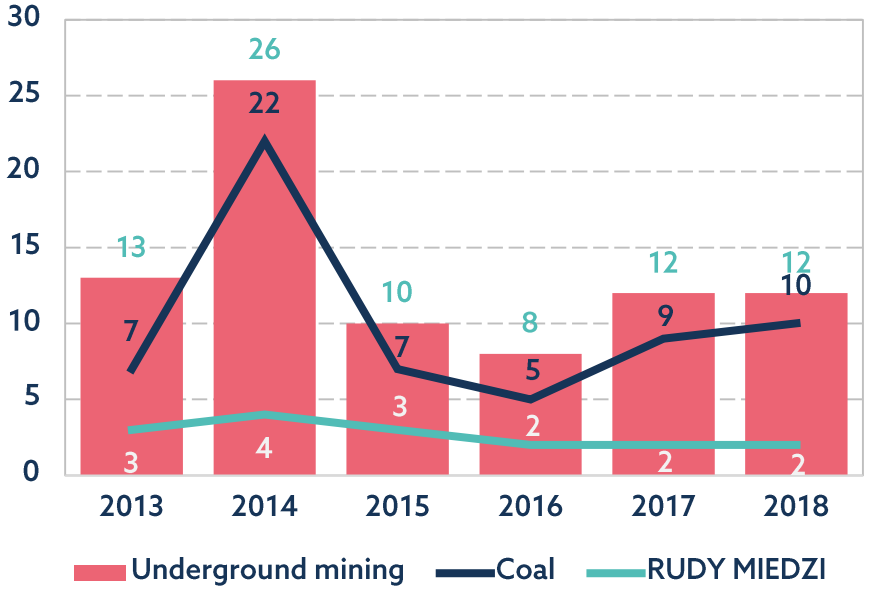


- In the copper mining only 1 fatal accident occurred, resulting in a record-low value of fatal accidents rate,
- On the contrary, in the hard coal mining the number of fatalities was the highest since 2014. The shock in Zofiówka mine was among the most tragic ones in 2018, resulting in the death of five miners.

Fatal accidents rate per 1000 employees						
	2013	2014	2015	2016	2017	2018
Coal mines	0,10	0,15	0,11	0,09	0,10	0,14
Copper ores mines	0,15	0,27	0,10	0,88	0,11	0,05

Source: Karkula P. Raport o stanie bezpieczeństwa w polskim górnictwie w 2018 roku, (Report on the Safety State in Polish Mining Sector) XXVIII SEP, 2019.

Serious accidents in underground mining plants and in the copper and silver ores mining in Poland

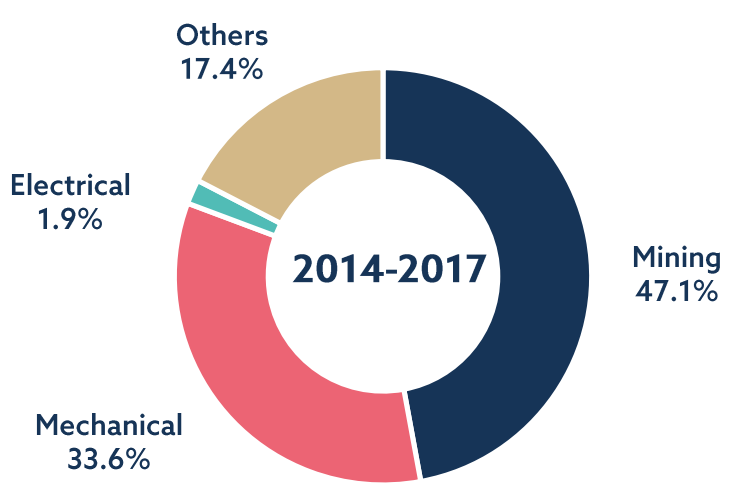


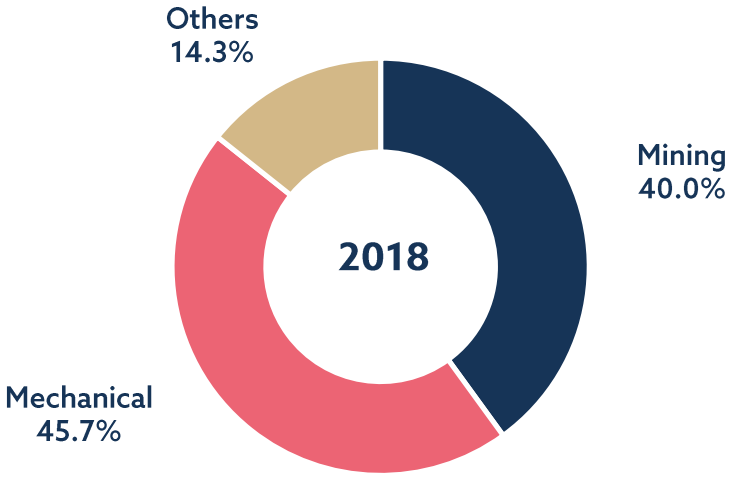
- Comparing to the previous year, on 2018 the number of serious accidents increased by 1, and serious accident rates in copper ores and hard coal mining levelled.

Serious accidents rate per 1000 employees						
	2013	2014	2015	2016	2017	2018
Coal mines	0,05	0,17	0,06	0,05	0,09	0,10
Copper ores	0,15	0,22	0,15	0,10	0,11	0,10

Source: Karkula P. Raport o stanie bezpieczeństwa w polskim górnictwie w 2018 roku, (Report on the Safety State in Polish Mining Sector) XXVIII SEP, 2019.

Main reasons for fatal and serious accidents in Polish mining in the years 2014-2018





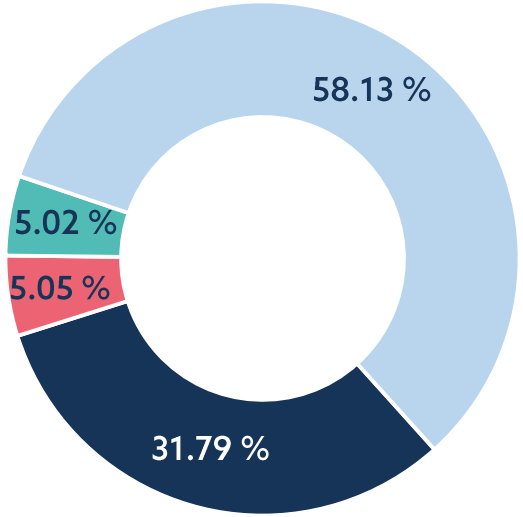
- The share of fatal and serious accidents with mining and mechanical reasons increased in 2018 comparing to the previous year,
- In this year there were no serious accidents with electrical reasons.

Source: Karkula P. Raport o stanie bezpieczeństwa w polskim górnictwie w 2018 roku, (Report on the Safety State in Polish Mining Sector) XXVIII SEP, 2019.

Economic Results of Copper and Silver Ores Mining in Poland

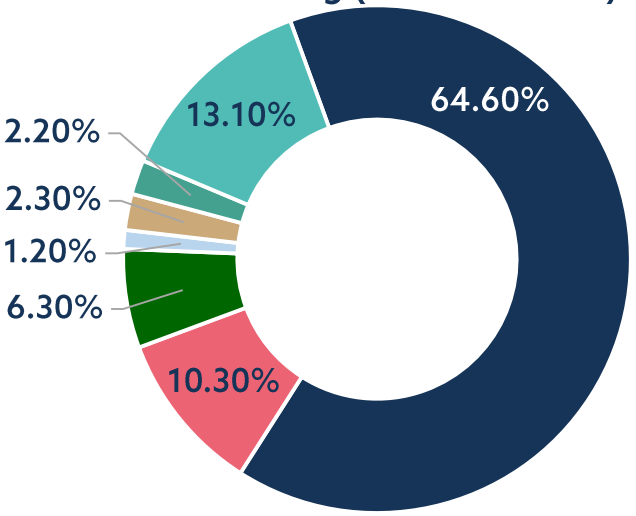
KGHM Polska Miedź SA ownership structure

KGHM Polska Miedź SA Shareholders (march 2019)



- National Treasury
- Nationale Nederlanden OFE
- Aviva Otwarty Fundusz Emerytalny Aviva BZ WBK
- Other shareholders

Geographic structure of KGHM shareholding (october 2018)



- Poland
- USA
- United Kingdom
- The Netherlands
- Europe - others
- Rest of the world
- Unidentified

The shareholding structure of KGHM Polska Miedź SA changed in 2018. During the year the share of stocks held by Aviva Otwarty Fundusz Emerytalny Aviva BZ WBK and by Otwarty Fundusz Emerytalny PZU „Złota Jesień" exceeded 5%. However, till the date of yearly report submission by the management board the share of OFE PZU „Złota Jesień" went down below 5%.

Source: Report of the KGHM Polska Miedź SA Management Board on the Activities ... in 2018

KGHM Polska Miedź SA mining activity

KGHM Polska Miedź SA has been operating incessantly in the Legnica-Głogów Copper Basin from 1961 and is one of leading producers of electrolytic copper and refined silver worldwide. The mining capacities of KGHM mines currently exceed 32 million tonnes of ore per year, where the amount of output is limited by the shafts capacity. Because of that any increase in the underground mining would require construction of a new shaft adapted to the ore mining.

KGHM Polska Miedź SA production activity

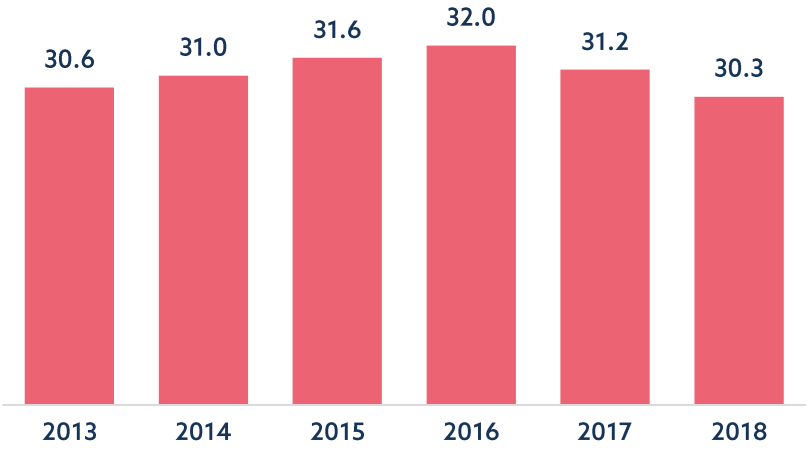
	O/ZG „LUBIN"	O/ZG „POLKOWICE-SIEROSZOWICE"	O/ZG „RUDNA"
Mine fields area [km^2]	157,33	229,50	111,40
Mining depth [m]	368 ÷ 1006	676 ÷ 1 084	844 ÷ 1 250
Number of active mining panels	14	17	27
Annual ore output [million Mg]	~ 8	~12	~ 12

KGHM output 2018 r		
Run-of-mine extraction	Million Mg (d.w.)	30,3
Cu content in the ROM	%	1,49
Cu extraction in the ROM	'000 Mg	452,0
Electrolytical copper, including:	'000 Mg	501,8
- from own charge	'000 Mg	385,3
- from external charge	'000 Mg	116,5
Metallic silver	Mg	1 189
Rod, OFE and Cu Ag wire	'000 Mg	266,4

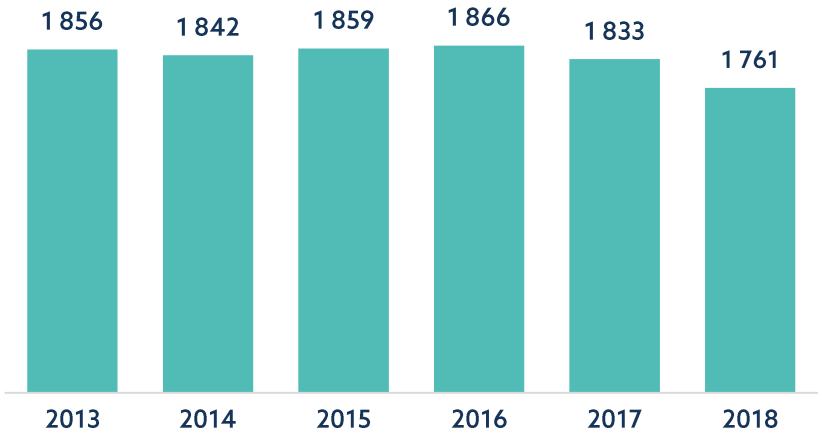
Source: Stach R., Annual Report of the KGHM Polska Miedź SA Management Board for 2018
Report of the KGHM Polska Miedź SA Management Board on the Activities ... in 2018

Output and production of copper and silver at KGHM Polska Miedź SA

Copper ore output [million Mg (d.w.)]



Concentrate output '000 Mg (d.w.)]

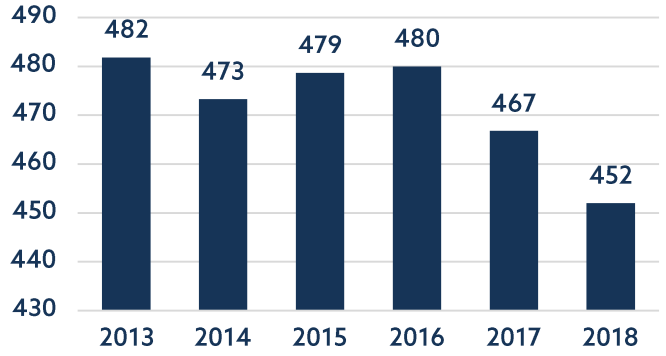


In the years 2017 and 2018 a decline in mine output of both copper ore and the copper concentrate was recorded. Also, as compared to previous years, areas with lower copper ore mineralisation were mined. The concentrate output went down by 72,000 Mg. Also the copper production decreased, despite an increase in production from own charges. A lower production results from a downtime related to the overhaul of concentrates smelting plant in "Głogów II" smelter, lasting approx. 2.5 months.
In recent years the KGHM has been recording a noticeable increase in the silver content in the mined ore, which translated into increased output of this metal.

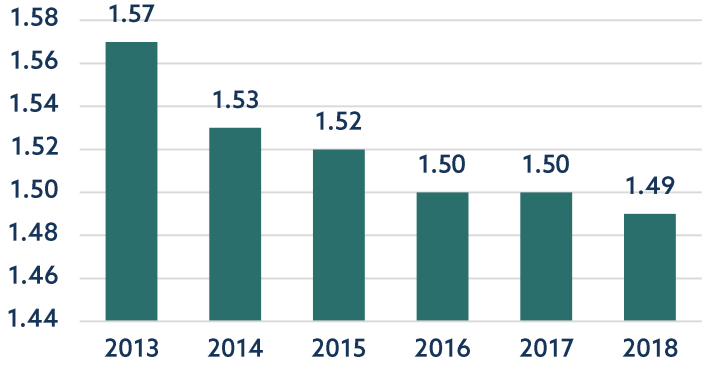
Source: Report of the KGHM Polska Miedź SA Management Board on the Activities, years 2012-2018

Output and production of copper and silver at KGHM Polska Miedź SA

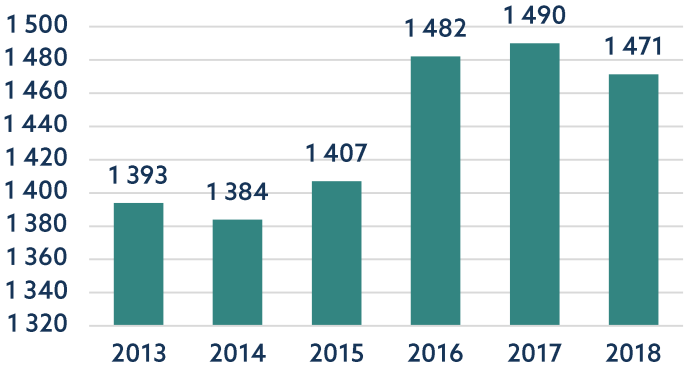
Amount of copper in the ore ['000 Mg]



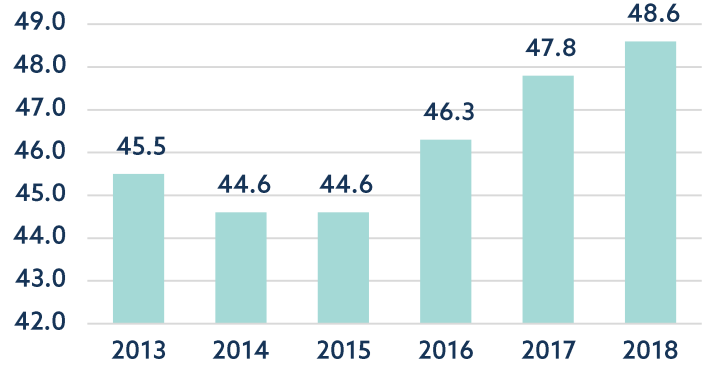
Copper content in the ore [%]



Amount of silver in the ore [Mg]

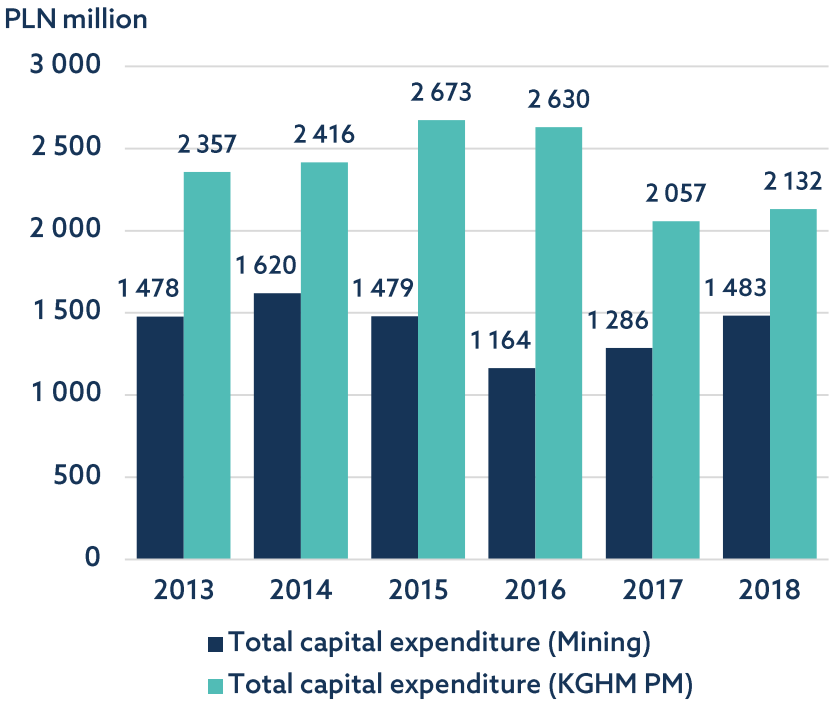


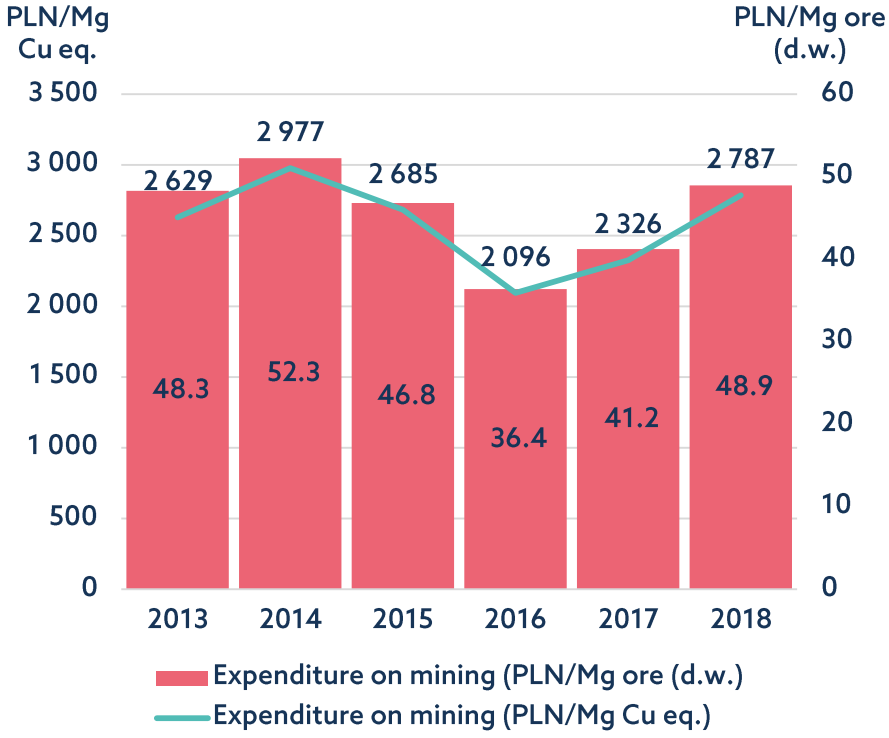
Silver content in the ore [g/Mg]



Source: Report of the KGHM Polska Miedź SA Management Board on the Activities, years 2012-2018

Capital expenditures at the KGHM Polska Miedź SA

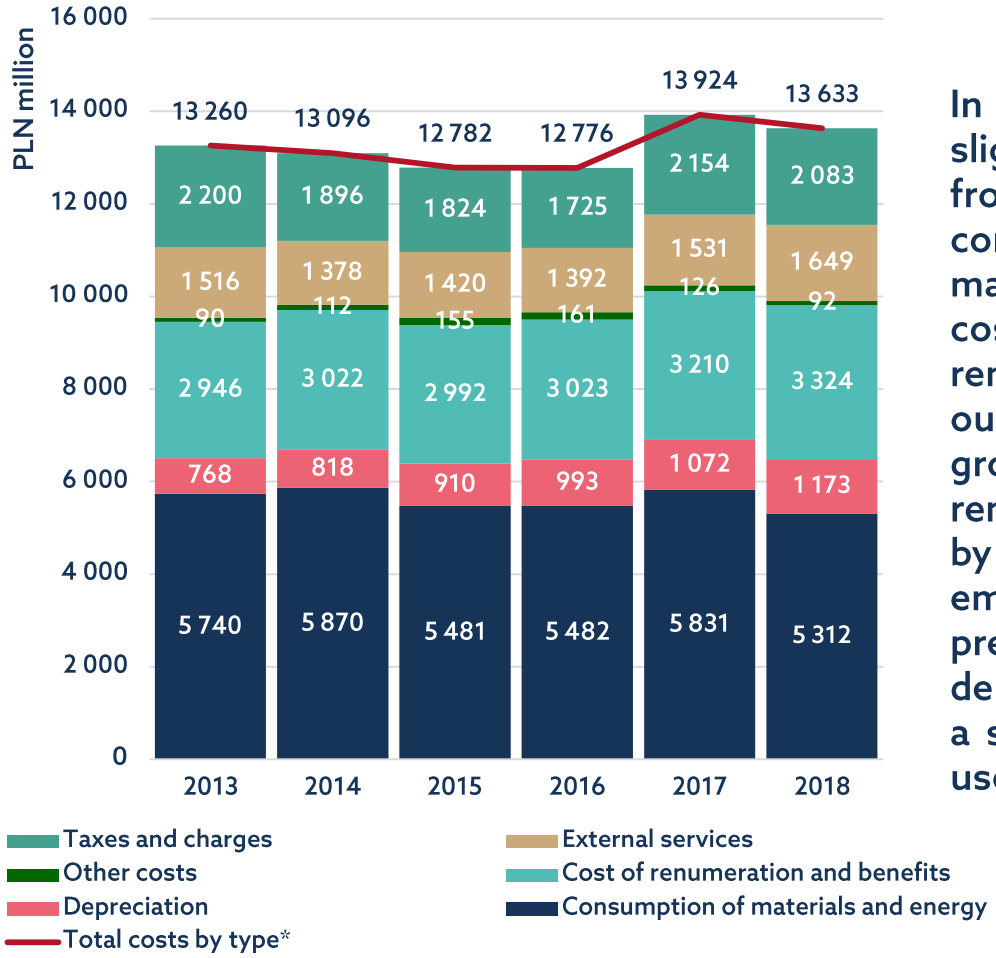




The capital expenditures at the KGHM Polska Miedź SA are slightly higher than in the previous year, but substantially lower than in the years 2015 and 2016. This is related to continuing at that time big investment into Głogów Copper Smelter modernisation.
Also the company's capital expenditures in the mining activity have been growing, however, they didn't yet reach the level of 2014.

Source: Report of the KGHM Polska Miedź SA Management Board on the Activities, years 2012-2018

Costs at the KGHM Polska Miedź SA

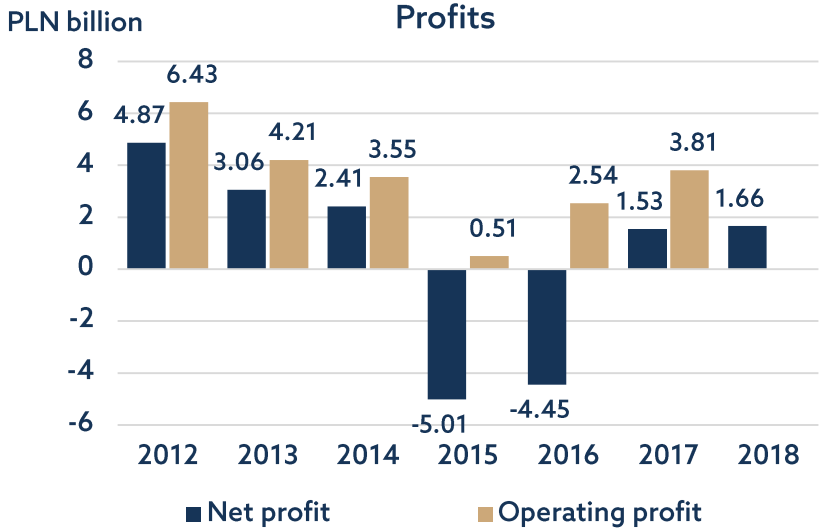


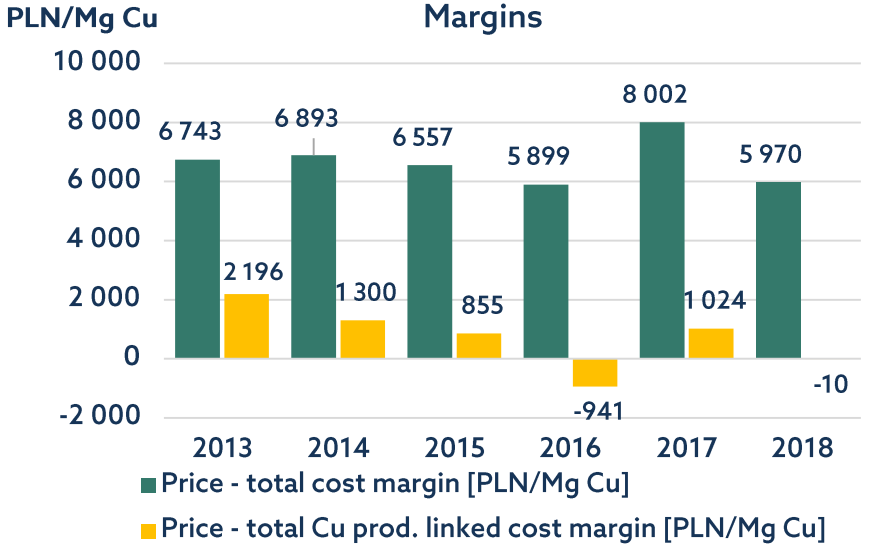
In 2018 the total costs of the company slightly decreased, which resulted mainly from a decline of external charges use - it converted into a significant fall of materials and energy consumption costs. However, the costs of remuneration, depreciation, and outsourced services are systematically growing. The increase in the remuneration costs is caused primarily by the going up payroll, the company employs marginally more people than in previous years. The growing depreciation cost results from a systematic increase in the number of used machines.

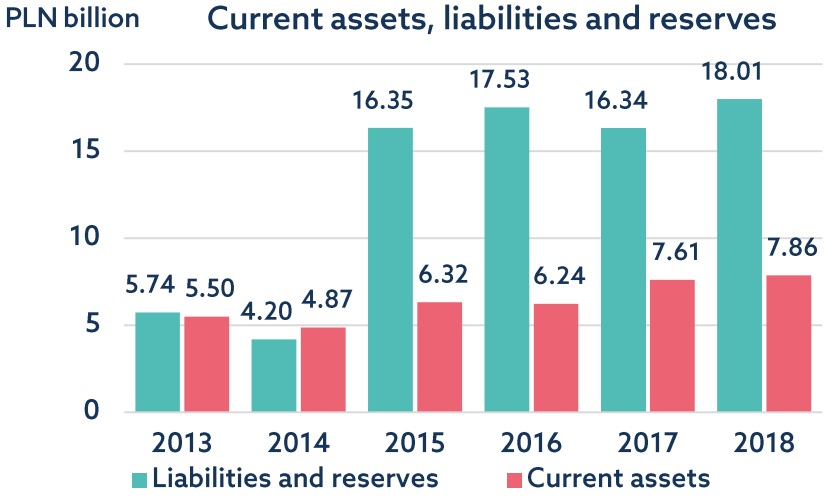
(*) - total costs may slightly differ from the aggregated figures, reported by the KGHM PM SA.

Source: Report of the KGHM Polska Miedź SA Management Board on the Activities, years 2012-2018

Selected financial results of the KGHM Polska Miedź SA







In 2018 the Company has shown a profit of PLN 1.66 billion, which is the highest value since 2014.
Also the levels of liabilities and reserves, as well as of current assets, went up.
However, the value of margin calculated based on the linked cost may worry - in 2018 it was negative.

Source: Report of the KGHM Polska Miedź SA Management Board on the Activities, years 2012-2018

Copper and Silver Ores Mining and the Environment

Environmental impact

Environmental burden of the copper ores mining:

- In the areas of mining perceptible shocks on the surface, resulting from the underground mining interference in the rock mass,
- a big amount of waste (finely ground rock) from the flotation, disposed in one location - the 'Żelazny Most' facility,
- local ground flooding, resulting from the ground subsidence (in a large area),
- occurring volatile odour compounds in the air originating from mines ventilation

Main streams of waste generated at the copper production:

- copper ores flotation tailings,
- slags from copper fire production processes: shaft slag, granulated slag, Dorschl furnace slag,
- waste from acidic sewage neutralisation,
- slurries and dusts originating at gases dedusting.

Source: Department of Ecological Policy of KGHM Polska Miedź S.A.

Environmental impact

Main plants of the KGHM Polska Miedź SA affecting the environment:

- plants of pyrometallurgical line (shaft furnaces, fluidised-bed furnaces, electric furnaces, converters, anodic furnaces, Dorschl furnaces, Kaldo furnace),
- copper ores enrichment (flotation) plants,
- 'Żelazny Most' mining waste disposal facility,
- return shafts of copper mines,
- continuous copper rod caster, 'Cedynia' rolling mill in Orsk.

KGHM Polska Miedź SA plants environmental impact:

- dust-gas emission to the air,
- waste, storage and warehousing in ground facilities,
- emission to surface waters (mainly discharge of water from above the sludge from 'Żelazny Most'),
- noise emission to the environment.

Source: Department of Ecological Policy of KGHM Polska Miedź S.A.

Flotation tailings

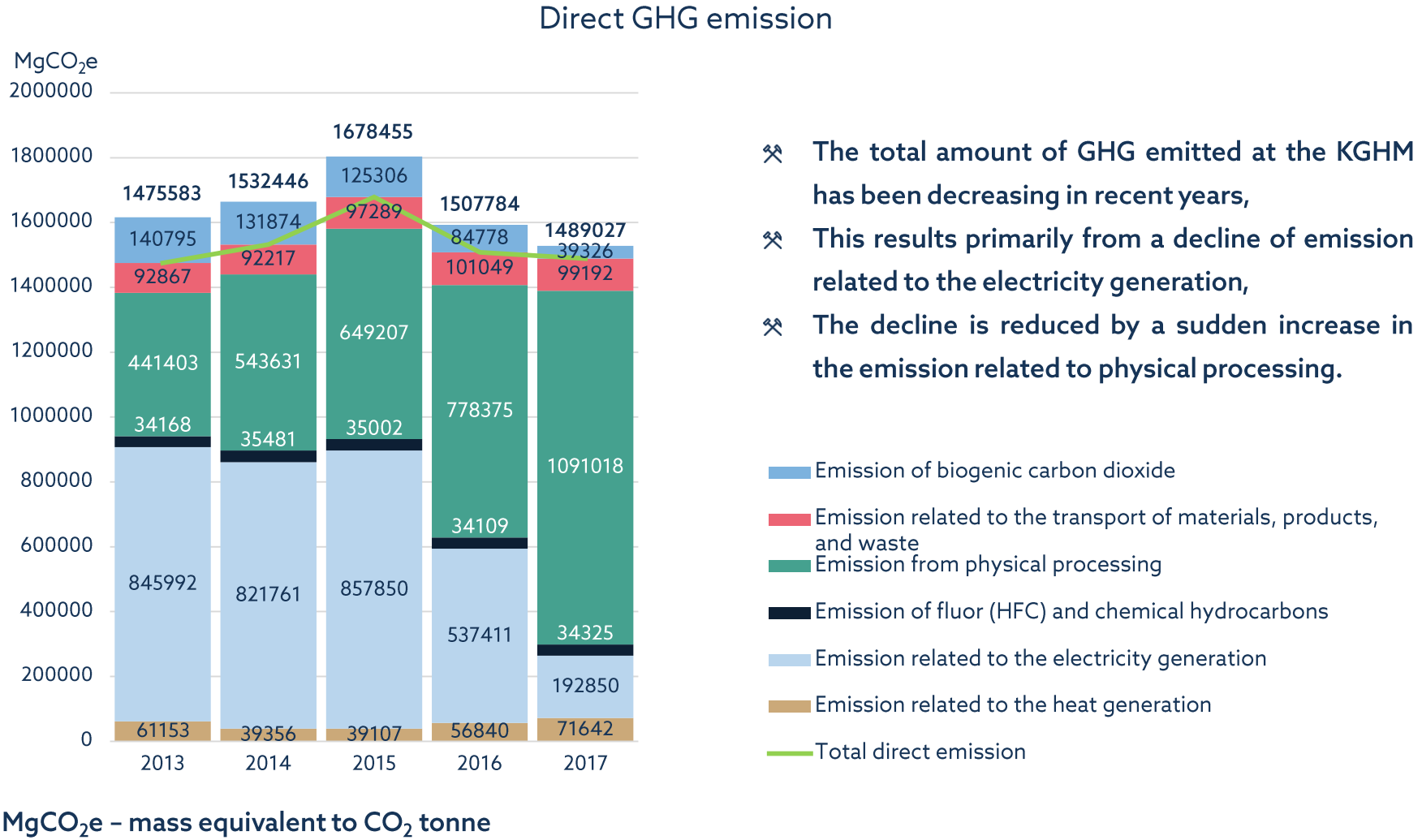
The waste originating from the copper ores enrichment is disposed at the 'Żelazny Most' Mining Waste Disposal Facility (OUOW). On this dumping ground overall approx. 496 million m^3 of waste is stored, and yearly approx. 20-26 million tonnes are added. The reservoir fulfils the role of a settling pond, solid waste settles on its bottom, while water after cleaning is partly recirculated for use (approx. 120 million m^3 a year), and partly discharged to the Oder river. The Company has recently implemented a system of chlorides and sulphates level monitoring in mine waters, due to which it stopped paying charges for chlorides and sulphates discharge to the Oder river. Because of that more than PLN 28 million were saved in 2017.

The KGHM is investing now in the facility expansion with a Southern Quarter, enabling to deposit additional 170 million m^3 of waste. The first stage of construction is to be completed in 2021.

OUOW 'Żelazny Most"

Source: Integrated 2017 Report of KGHM Polska Miedź, Polkowice.eu, google.com/maps

Direct GHG emission at the KGHM



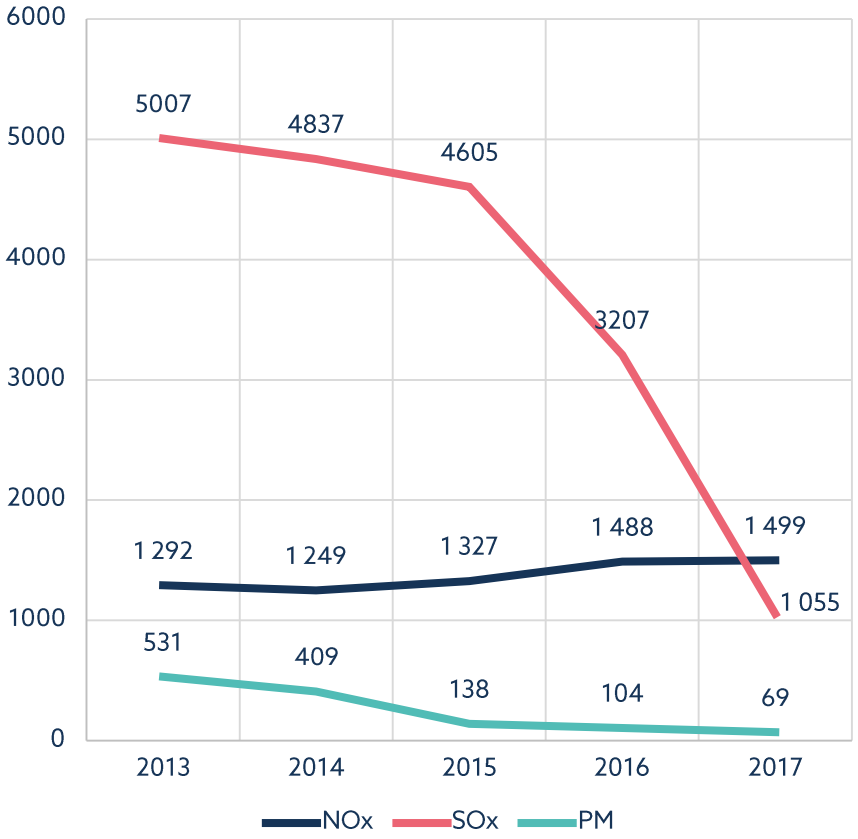
- **The total amount of GHG emitted at the KGHM has been decreasing in recent years,**
- **This results primarily from a decline of emission related to the electricity generation,**
- **The decline is reduced by a sudden increase in the emission related to physical processing.**

$MgCO_2e$ – mass equivalent to CO_2 tonne

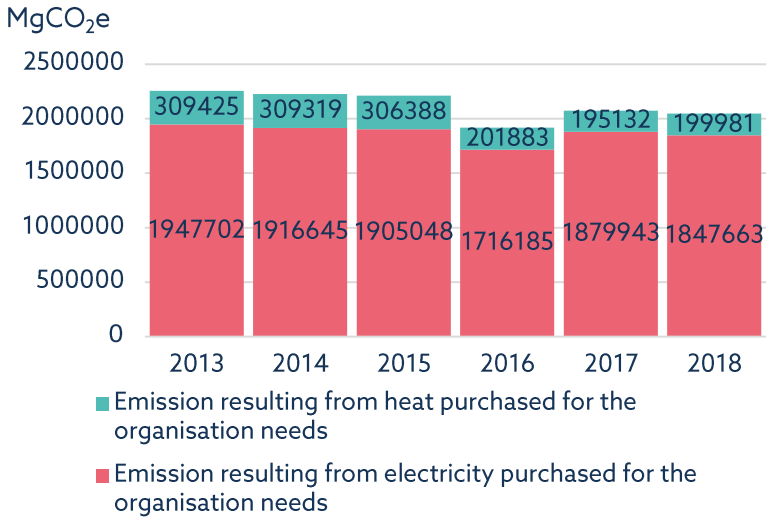
Source: Integrated Report of the KGHM Polska Miedź SA, years 2013-2017

Indirect GHG emission and emission of SOx, NOx, and of PM

Emission of harmful gases and particulate matter to the air



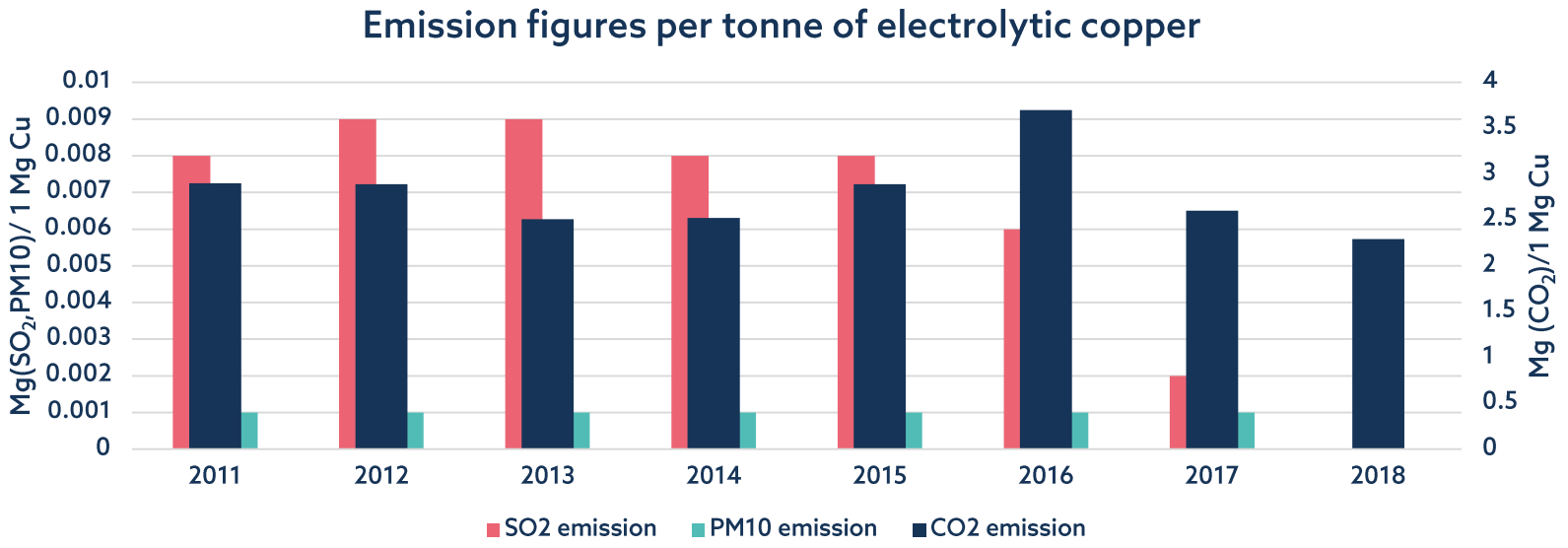
Indirect GHG emission



- In recent years indirect GHG emission related to the electricity is not subject to significant changes, however, a clear decline of emission related to heat is visible,
- In recent years the Company has registered a slump in the emitted sulphur oxides and PM. The amount of emitted nitrogen oxides has been slowly growing.

Source: Integrated Report of the KGHM Polska Miedź SA, years 2013-2018

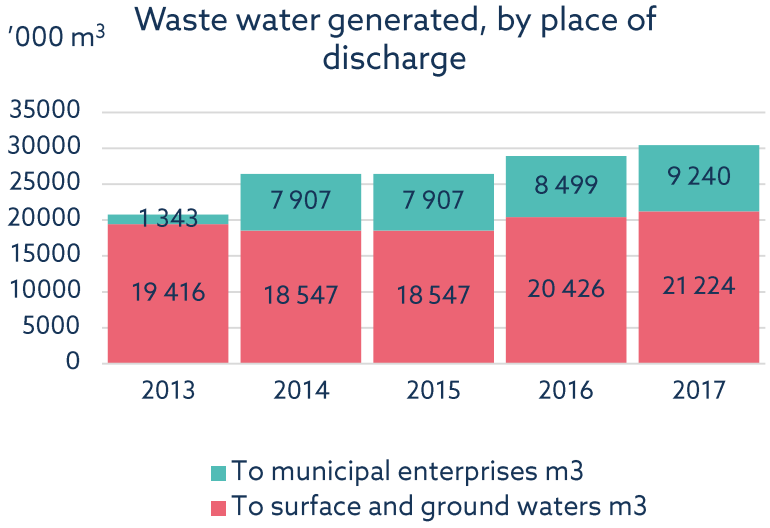
Emission figures

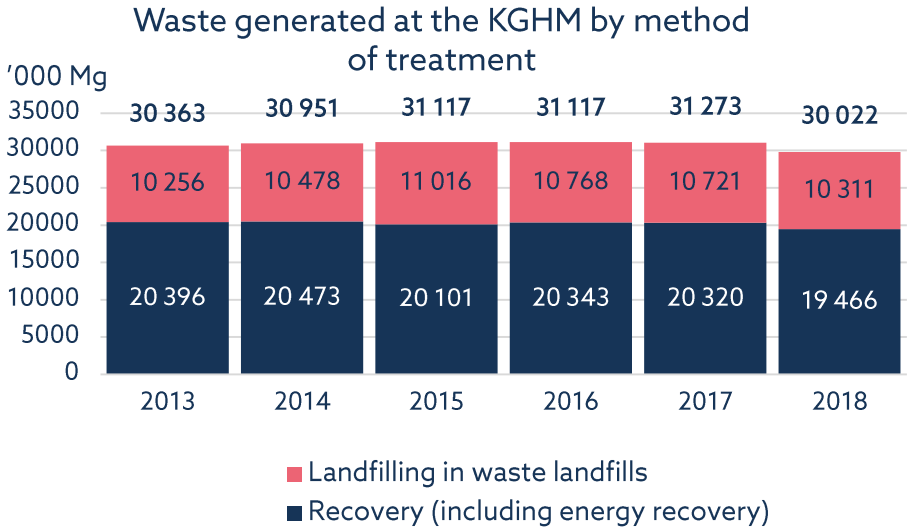


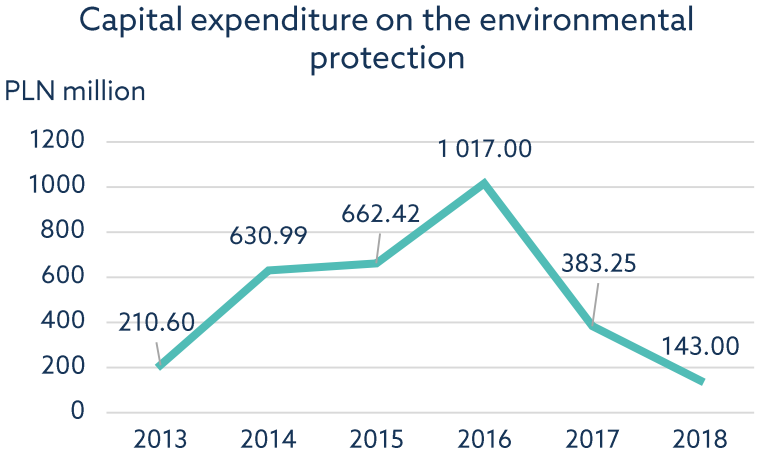
- The level of SO2 emission per tonne of produced copper has been successively going down and in 2017 the amount of emission was approx. 25% of the level recorded in 2011,
- The amount of particulate matter emission per 1 Mg Cu maintains on a permanent level,
- The CO2 emission oscillates around 2.7 Mg/1 Mg Cu.

Source: Integrated Report of the KGHM Polska Miedź SA, years 2013-2018

Generated waste and waste water, expenditure on environmental protection







- In recent years the KGHM was generating a stable amount of waste, which was dumped or recovered. To a small extent the Company is applying also other methods, which are not presented on the graph,
- The Company has been recording a stable increase in the generated waste water, which is to a larger and larger extent directed to municipal enterprises,
- In the years 2014-2016 the Company assigned substantial amounts to the environmental protection, which resulted from the Głogów Copper Smelter modernisation.

Source: Integrated Report of the KGHM Polska Miedź SA, years 2013-2018

Summary

The report on copper ores contains integrated data on the copper and silver ores mining in Poland, and to a smaller degree in the world in the years 2013-2018. Based on that the following trends may be noticed:

- The copper production worldwide increases. Its increasingly bigger share is the copper production from recycling, while in recent years the production by SX-EW methods has slowed.
- Metallic raw material prices in recent years have been falling, but they are still higher than at the beginning of the century - metal prices peaked around 2011.
- In recent years KGHM mines witness a decline in the copper ores extraction and in the copper content in the ore. Because of that the importance of other metals contained in the ore grows, in particular that of silver. Also the need for introducing a module of cobalt, being a valuable mineral raw material, separation to the process of run-of-mine treatment has been increasing.
- KGHM Polska Miedź SA holds concessions for mining securing the resource base of the company for the nearest years, but because of mining going deeper and deeper the geological and mining conditions deteriorate, which will translate into growing copper production costs. The cost increase is also affected by salaries growing in Poland and by the tax on certain minerals mining introduced in 2012. In the next years the impact of growing electricity price can also be noticeable.

Summary

- The KGHM reported financial losses in the years 2015 and 2016, but now the company has reached a profit of PLN 1.66 billion. In the analysed period the Company has also recorded the highest level of liabilities and of current assets.
- The accident rate in the copper ores mining shows a downward trend, albeit in 2018 there were 10 accidents more than in the previous year. Among serious accidents the share of accidents with mechanical reasons - related to the operation of machinery and equipment - has been growing.
- In recent years the KGHM has been recording falls in emission of GHG, both indirect and direct, and also of sulphur oxides and particulate matter to the air. However, the amount of waste (a fall was registered in this category in 2018) and waste water generated by the company has been growing.