

Copper Mining in the Sudety Mountains

Room and Pillar

Copper mining in the Sudety Mountains began in the 13th century. However, intensive exploratory works beginning at the middle of the 20th century confirmed a copper ore-bearing deposit 1,000 m below surface with over 0.5% Cu content. The first mines, called the Old Basin, are now closed and replaced by mining of the New Basin, known as Legnicko-Glogowski Okreg Miedziowy, LGOM, situated in the south-west region of Poland. It is based on three big mines with various dates of construction start: ZG Lubin (since 1960), ZG Rudna (since 1970) and ZG Polkowice-Sieroszowice (since 1996). The latter mine results from joining of the former single mines: ZG Polkowice (since 1962) and ZG Sieroszowice (since 1974). All mines belong to a joint-stock company, KGHM Polska Miedz S.A., having its head office in Lubin, comprising ten divisions including three dressing plants, two smelters and one copper rolling mill.

The company workforce was about 18,500 at end-2001, compared with 45,000 in 1991 before the commercialization of the former state-owned company started. About 11,500 employees are engaged in the mining operations.

Geology and Resources

The Legnica-Glogow copper basin extends over an area of 416 sq km. The stratiform mineralization occurs where Permian limestone lies against New Red Sandstone, within varying combinations of sandstone, shale and dolomite. The deposit is of irregular shape, with slight dip up to about 6 degrees. The copper content varies generally between 1.2% and 2.0%. Higher copper contents are characteristic for the thinnest seams, usually in mineralized shales.



Boomer 126 at work in Lubin copper mine.

In the Lubin mine the average copper content is less than 2%, whereas in the Polkowice-Sieroszowice mine, the mean content slightly exceeds 2%. The average copper content for all KGHM mines was 1.86% in year 2001. The ore horizon ranges from 1.2 m to 20 m in thickness, lying at depths of between 600 m and 1,200 m from surface. Known ore reserves are above 800 Mt, which corresponds to a mine life of another 30 years at today's production rate of 28 Mt annually, split between Lubin 7 Mt, Polkowice-Sieroszowice 10 Mt, and Rudna 11 Mt.

Lead, silver and gold are also recovered. In 2001 KGHM was ranked as the world's seventh largest copper supplier at 491,000 t/year, and the second largest source of silver, at 1,145 t/year.

KGHM is also a major salt producer, using roadheaders to mine a deposit that partly overlays the ore-body.

Geotechnical Conditions

The formations are intersected by a multitude of faults. An especially dangerous feature of the rock is its ability to accumulate high amounts of energy, which is the most important factor for rock burst. Even within a strong roof, in some places, weak layers of shales essentially decrease the roof bearing capacity. This is the main reason for extensive rock reinforcement, comprising standard mechanical and resin grouted 1.6 m and 2.6 m bolts, and 5-7 m cable bolting, mainly at drift crossings.

Access workings

The deposit is developed with 26 vertical shafts, 6 m to 7.5 m-diameter, and horizontal drifts. Depths of shafts vary from 632 m in Lubin to 1,120 m in Rudna. The overburden freezing method was applied for shaft sinking. Access to the deposit from the shafts



Haulage, Transportation and Hoisting

Mining Methods

After shaft sinking and recognition of the water threat, the initial mining method utilized backfilling technology. Following this, longwall methods using walking hydraulic supports, armoured face conveyors and belt

With time, and production experience, room and pillar methods with roof caving have become more

General mining layout for 3 m thickness at Polkowice-Sieroszowice Mine.



effective and safer, since it enabled full mechanization to be introduced. The caving methods were more competitive, due to low costs compared to backfilling techniques. Initially, for the exploitation of roof caving, two stages of excavating pillars were used. In the first stage, the area was divided into 25 m x 35 m pillars. In the second stage, each of the pillars, beginning from the abandoned line, was cut into many smaller pillars. From the viewpoint of rockburst risk, the two-stage method is unfavourable, because the pillars in the first stage show a dangerous tendency for accumulation of energy. After 1983, the engineers in Rudna mine decided to adapt the dimension of the pillars to local geo-mechanical conditions. Also, alternating directions of driving stopes were introduced.

Deposits 5 to 7 m-thick

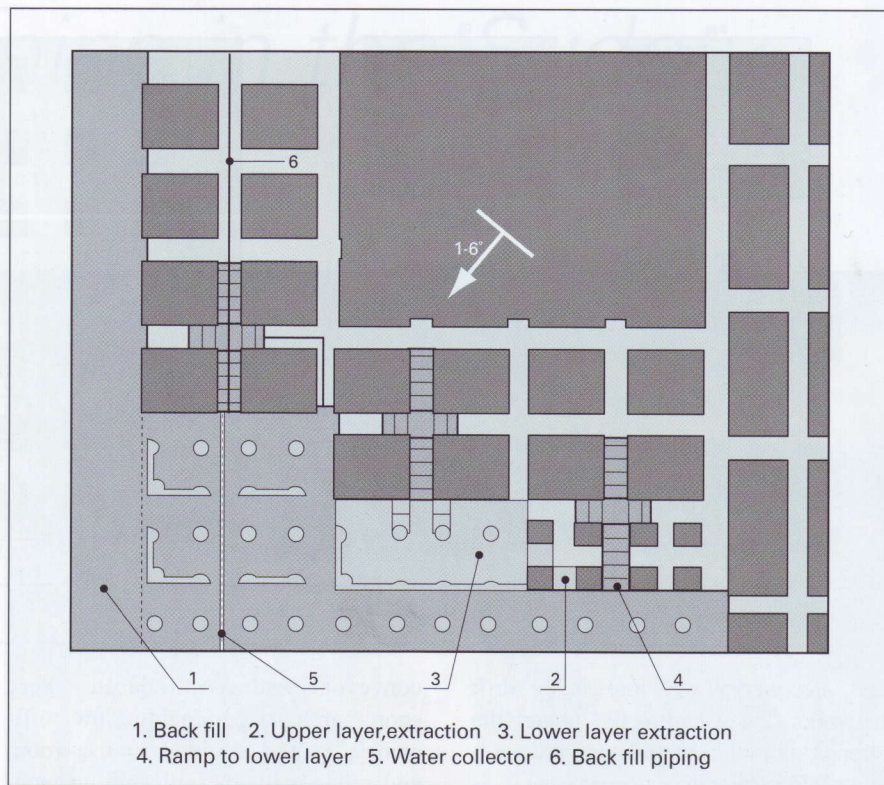
Until recently, the deposits over 5 m-thick used to be mined entirely with backfilling. The newest technology to 7 m-thick is based on the hypothesis of advance-fracturing and post-failure capacity of pillars. The roof opening reaches 150 m, and the longest edges of the pillars are located perpendicular to the exploitation front line.

Within caved areas, the upper layers of roof are not fully supported with broken rock. Such a situation creates real threat of rock bursts, roof falls, or local relief of strata. This results in ore dilution, as well as a requirement for secondary scaling and bolting. Therefore, the practice of blasting residual large-size barrier pillars has been abandoned.

Deposits below 3 m-thick

In the Polkowice-Sieroszowice mine, most of the seams are less than 3 m-thick, and a special selective mining method has been developed for excavation of these thin deposits.

The mining area is typically opened using double or triple entries of preparatory workings. Rooms, entries and pillars are basically 7-m wide. Work in the faces consists of two phases, depending upon the thickness of the layers of waste rock and mineralized ore. First, the upper ore-bearing



Two-stage extraction with backfilling.

layer is excavated and hauled out to special chutes onto the main transportation system. In the second phase, the waste rock adjacent to the floor is excavated and placed in other rooms as dry fill. Each of the entries covers at least two rows of pillars plus one room. The backfill width is 14 m, and maximum length of the mining front is about 49 m. No more than three rows of pillars at the same time, not covered with backfill, are allowable in the mining area. During extraction in the last row of pillars, working occurs only in the ore-bearing layer, until the pillar cross-section reaches approximately 21 sq m. The completion of the pillar mining process before abandoning the area is subject to roof sag, with the strata resting upon dry backfilled entries.

The future aim is to use extra low profile mechanized equipment for drilling, bolting, mucking, scaling, charging and auxiliary transport. This will enable mining in drift heights down to 2 m and 1.5 m, to selectively extract the ore and minimize the amount of waste rock mined.

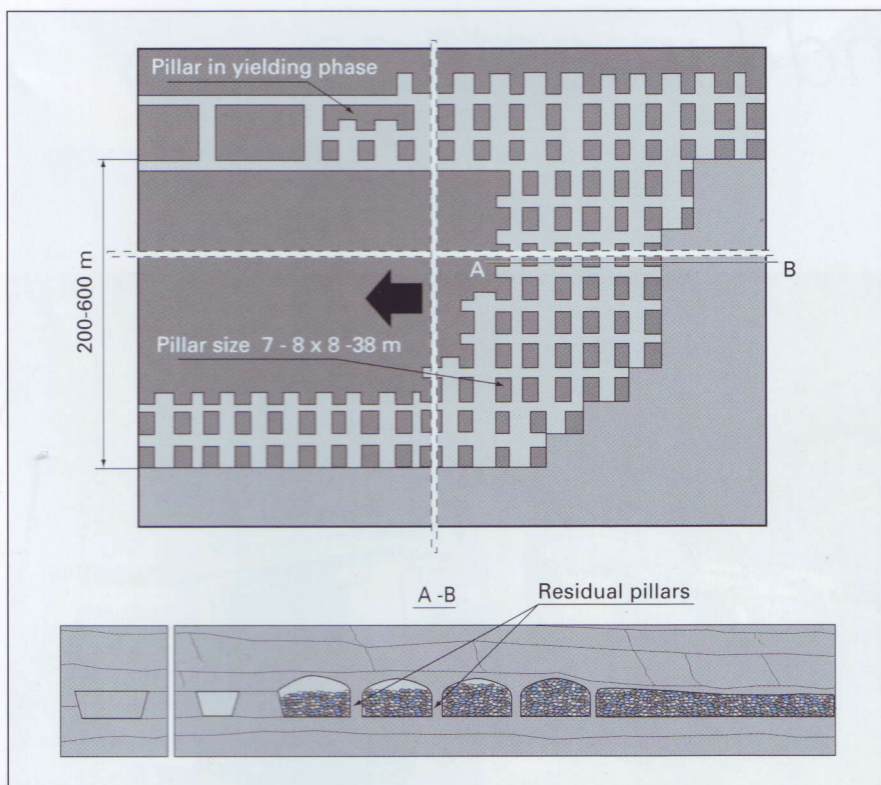
Alternative mining sequences, where the ore-bearing layer is situated at the floor, are shown overleaf.

In the past, most equipment and consumables were manufactured in nearby factories belonging to the state-owned company. Lately, the quantities and types of imported equipment have gradually increased.

In 1998, Polkowice-Sieroszowice Mining Department started to cooperate with Atlas Copco in the development of modern machinery. Due to the successful introduction of COP 1238 and COP 1838 hydraulic rock drills, followed by the low-built Boomer rigs, the cooperation has been strengthened. The mine currently operates ten Atlas Copco rigs, and there is a total of 16 Boomers on the mines as a whole.

The supplier service has been extended to include a drillmetre based contract for Secoroc Magnum 35 drill rods and shank adapters, and for COP rock drills.

Working an effective 4.5 h/shift, one Boomer drills 110-125 holes with hole lengths varying from 3 m at the face and 1.5-2 m at side walls and roofs. Some of the Boomers feature the BSH 110 rod extension system to facilitate drilling of 6 m stress-relieving holes.



Room and pillar mining with roof sag.

In the first 8 months of 2002, one Boomer drilled more than 58,000 holes totalling 174,000 drill metres, with availability of 92.6 %. Downtime comprised technical malfunctions 3.7%, planned service 3.4%, and others 0.3%.

Room and Pillar mining with roof sag

This method is especially suitable in barrier pillars of drifts, heavily faulted zones, and in direct vicinity of abandoned areas. Maximum allowable deposit dip is up to 8 degrees, and seam thickness 3.5-7 m. The area is developed with double gate roads, located close to the roof of the ore-bearing layer for thickness above 4.5 m. Optimum length of the mining front ranges from 50 to 600 m. The ore is extracted with 7 m-wide and 7 m-high rooms. The roof is supported by pillars of 7-10 m x 2.5-4.5 m. Thereafter, the smaller pillars are successively decreased. The roof that has been opened must be bolted immediately.

The next stage is mining of the floor down to the ore zone boundary. The extracted area is closed off for people and equipment, using timber posts or chocks. Length of the roof sag blast holes is 8-12 m.

Room and Pillar mining – two stages mining

The two stage mining system using hydraulic backfill known as Rudna 1 has been used mainly in the Rudna mine.

In the first stage, the orebody is cut into large pillars, which are subdivided in the second stage. Finally, the abandoned area is filled up to the roof with hydraulic fill. The drawback of this system is high stress concentration occurring in the large size pillars just in front of the second stage mining.

Blasting techniques

In the past, the mines tried to use dynamite, which is a water-resistant explosive of high density and energy concentration. Due to the sensitivity to detonation, and lack of possibility for mechanical charging, dynamite is today almost completely superseded by pneumatically charged ANFO. Initiation is by electric delay detonators, coupled with detonating cord in holes longer than 6 m. Recently, electric detonators have been successively replaced by Nonel.

Bulk and emulsion explosives are used in room and pillar mining areas

described in the hydraulic backfill method above.

Future plans

The alternative room and pillar mining methods described are some examples from a large variety of adaptations to prevailing geological and geotechnical conditions, in order to continuously increase productivity and safety, while minimizing waste rock into the ore stream. The following measures are put into focus for the future: further development of the rock mass monitoring stream; changes in work organization and introduction of a four-team system; developing new systems for rockburst-proof bolts; introduction of low built equipment for thin ore deposits, lower than 1.5 to 2 m; modernization of mining methods by further minimizing waste dilution; and projects for access to deeper ore zones, below 1,200 m, by cake mining, with cake thickness of 0.8 to 1.5 m, using 15 m-long blast holes.

All mines are facing thinner seams, and this constitutes a major challenge for equipment manufacturers. The problem is especially acute at Polkowice-Sieroszowice, where machinery height from 2003 onwards on all types of equipment cannot exceed 1.4 m, to enable efficient operations in 1.6 m-high workings. Atlas Copco manufactured a special low-built version of the Rocket Boomer S1LP for delivery in May, 2003 for a 3 month test period. ■

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