GOSPODARKA SUROWCAMI MINERALNYMI

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Developments, challenges and trends in Austrian magnesite mining

1. RHI AG

RHI AG is a globally operating industrial group with more than 100 production and service offices on all continents. RHI generates annual sales revenues of € 1.5 billion and employs 7,500 people worldwide. RHI is a publicly traded company and listed on the Prime Market of the Vienna Stock Exchange.

RHI AG has a market share of 10% of the total refractories market and is the world's market leader. The company produces nearly 2 million tonnes of refractory materials at 34 locations on four continents. The company produces refractory products, which are mainly based on magnesia. The key customers are the iron, steel, cement, lime, glass, nonferrous metals, energy, chemicals and petrochemicals industries.

In the magnesia refractory field, RHI AG is vertically integrated back to magnesite mines. The company operates three magnesite mines in Austria (Breitenau, Hochfilzen, and Radenthein), one in Turkey (Tutluca), and a dolomite mine in Italy (Marone). RHI's annual magnesia consumption is nearly 1 million tonnes, and approximately 50% is supplied by RHI's own mines.

2. Market situation for magnesite

The main consumer industry for magnesite is the refractories market. For the usage of magnesite in the refractories industries, magnesite is transformed into magnesia. This normally involves a firing process at around 1800°C. The simplified process is:

* RHI AG, Austria.

$$MgCO_3 \rightarrow MgO + CO_2$$

The loss in weight is around 50%, therefore 2 tonnes of magnesite have to be fired for the production of one tonne of magnesia.

The main consumer industry for magnesia in the refractories industry is the steel industry. The overall steel production level is steadily increasing, and in 2006 the annual production reached 1.25 billion tonnes. The specific magnesia refractory consumption is defined as the amount of refractories (kg) required to produce one tonne (t) of steel. During the past decades there has been a trend towards a decrease in specific refractory consumption in the steel industry that is still continuing. The current consumption is approximately 4.3 kg magnesia/t steel. However, the trend is declining and specific consumption has slowed down over the last 12 years, but is still ongoing (Hammerer, Kaufmann 2007).

Table 1 and Figure 1, which is shown above, fits pretty well into the general market, if compared with the worldwide magnesite production, which reached 14.7 million t of magnesite in 2006 (Weber, Zsak 2008). See also Figure 2, which shows the worldwide magnesite mining situation, since 1981. The figure shows an increase in production from 1981 until 1990, then a decline in production, which was driven by the collapse of the economy of the CIS countries during the beginning of the 1990's. Since 1994 production has been growing again, and reached a worldwide production volume of 14.7 million t as shown in Figure 2.

TABLE 1

Steel production and MgO-Refractories Consumption

TABELA 1

Produkcja stali i zużycie materiałów ogniotrwałych z MgO

Year	Steel production million t	Specific consumption kg MgO/t steel	MgO-Refractories million t
1994	725	5.40	3,916
1995	752	5.33	4,009
1996	750	5.25	3,939
1997	799	5.17	4,128
1998	777	5.08	3,946
1999	789	4.98	3,927
2000	848	4.87	4,130
2001	850	4.76	4,047
2002	904	4.64	4,194
2003	968	4.51	4,370
2004	1 054	4.35	4,587
2005	1 117	4.30	4,802
2006	1 250	4.25	5,313

When the world-production is divided into the different continents, Asia is dominant with a share of more than 60%, followed by Europe with 28%, the share of Austria is 5%. The details on the regions are shown in Table 2 and Figure 3.

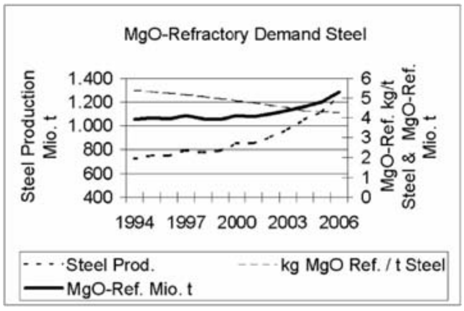

Fig. 1. MgO-Refractory Demand in the steel industry

Rys. 1. Zapotrzebowanie na materiały ogniotrwałe z MgO w hutnictwie

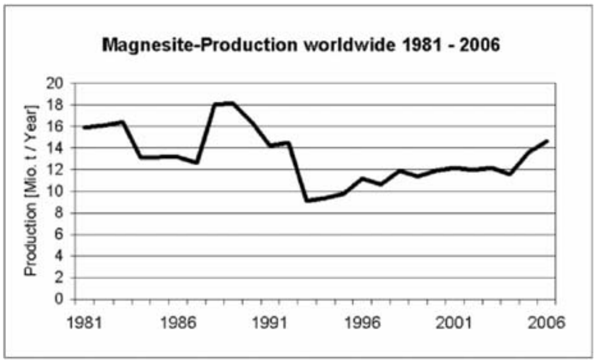

Fig. 2. Worldwide Magnesite Production 1981–2006

Rys. 2. Produkcja magnezytu w świecie w latach 1981–2006

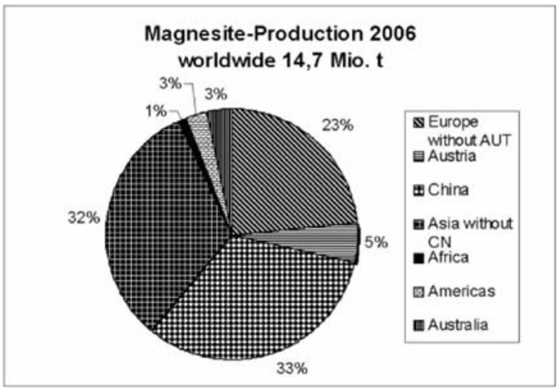

Fig. 3. Worldwide Magnesite Production 2006 by region

Rys. 3. Produkcja magnezytu w świecie w 2006 r. według regionów

TABLE 2

Magnesite Production 2006 by region

TABELA 2

Produkcja magnezytu w 2006 r. według regionów

Region	Absolute [t]	Relative
Europe without AUT	3,420,106	23%
Austria (AUT)	769,188	5%
China (CN)	4,750,000	32%
Asia without CN	4,712,692	32%
Africa	104,000	1%
America	430,200	3%
Australia	475,000	3%
Total	14,661,186	100%

3. Mine Breitenau

The Breitenau Magnesite Mine is situated in the eastern part of the Austrian Alps some 150 km SW of Vienna. The deposit is a sparry magnesite, which is located in the so-called Hackensteiner Formation of the Silurian/Devonian Laufnitzdorf Group – this is part of the Graz Paleozoic Trust system.

The deposit has a length of about 2,000 m, a width of up to 700 m and a max. thickness of 200 m. The general dip of the magnesite body is 25° to the south; this is contrary to the surface, which is why the overburden varies from 0 to about 1,000 m as shown is Figure 4.

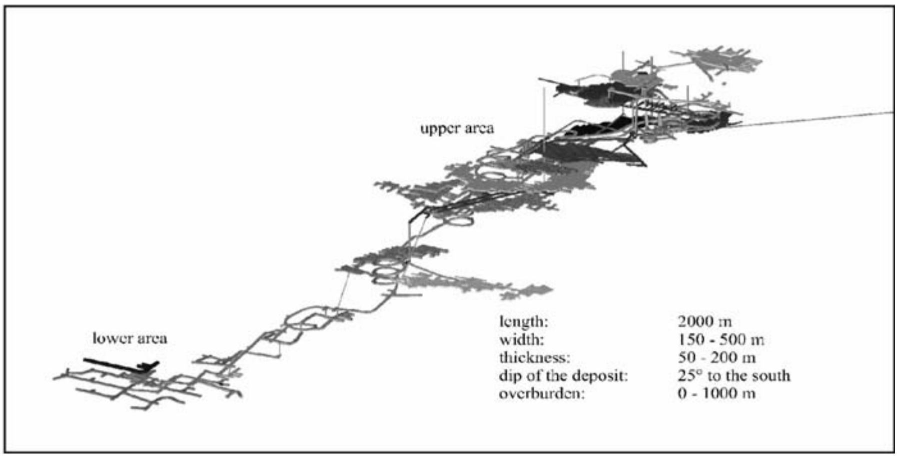

Fig. 4. 3-dimensional plot of mine Breitenau

Rys. 4. Trójwymiarowy wykres kopalni Breitenau

The host rocks of the magnesite ore body are siltstones, sandstones, limestones and metatuffs, which all have very poor mechanical properties.

In 1906 mining exploitation started in Breitenau with open pit mining, but due to higher quantities demanded and the increase in thickness of the overburden, mining activities changed to underground mining in the early 50s of last century. Currently some 90% of the total production is produced in underground mining.

In the upper exploitation areas a post pillar mining system with uncemented backfilling is used. The pillars are rectangular in cross-section, with a width of ~4 m and a length of ~15 m. The height varies due to the different heights of the exploitation areas but may exceed 100 m. The mining of the magnesite itself is done in 3.5-m-high slices. The initial slice is generated by advancing drifts with a height of 7.0 m (width some 6–7 m) at the deepest horizon of the exploitation area. Following that, a layer of 3.5 m is backfilled with uncemented backfilling material, which is produced in the open pit. Afterwards, another 3.5-m-high slice of the roof can be drilled and blasted, thus increasing the height of the room to 7 m again. This process is repeated until the full height of the exploitation area has been extracted.

The big advantage of this mining method is the high flexibility for quality control. The big disadvantage is that the support (i.e. rock bolts) of the roof is destroyed when taking the next hanging wall. New support then has to be installed to protect the miners.

This mining method has proven high efficiency up to an overburden of some 700 m. If the overburden is higher than that, the pillars have to be redesigned due to higher stresses and the increased risk of rock fall. This results in a larger size of the pillars, i.e. a higher loss of magnesite. The new minimum size of pillars calculated with a computer program was 15 to 15 m. The extraction ratio was reduced from 65% to less than 45%.

Therefore the mine management and the Montanuniversity of Leoben designed a new mining method. The deeper areas are divided into sections which are some 50 m wide and some 50 m long. These sections are mined one after the other so that an angular front is created (Fig. 5).

Within a section, a stope is developed up to the border of the section. This stope has a height and a width of 7 m each. A pillar of 5–7 m is left to the next stope. 7 m directly above that bottom stope, another 7-m-high und 7-m-wide stope is developed the same direction as the bottom stope so that they are parallel. The sill pillar between the two stopes will then be extracted using a bench drilling and blasting method. Following that, a stope up to 21 m high is formed.

This stope is then filled with cemented backfill as shown is Figure 6. For that purpose, an emulsion is mixed in the mixing plant at the surface of the mine. This emulsion is pumped through a pipeline of 125 mm by a special concrete pump and passes through a length of up to 2,800 m. Pressure can be up to 160 bar.

In addition to that change in mining method, many processes within the mine were partly or completely automated. The most important step in terms of quality distribution and quality control was the set-up of an operational grade modelling program. With this program, every area of the deposit can be calculated for the quality to be found. This estimate is the basis for

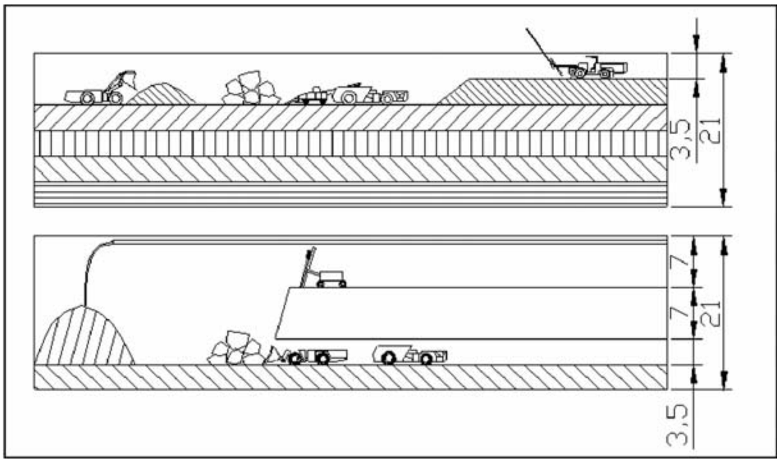

Fig. 5. Mining System Breitenau in upper and lower levels

Rys. 5. System kopalni Breitenau na górnym i dolnym poziomie

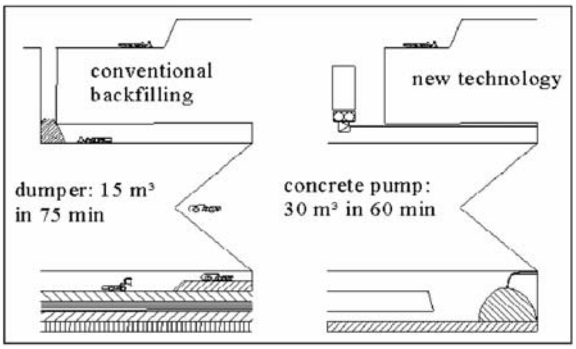

Fig. 6. Current system of backfilling – new system of pump backfilling

Rys. 6. Obecny system podsadzania – nowy system podsadzania za pomocą pompy

the daily mining activities. The extracted magnesite passes an automated quality control section just before it is delivered to the sintering plant. This plant indicates the accurate quality, which replaces the estimate of the operational grade model, thus giving new figures to the computer program and improving the next assumption. For that system an accurate analysis is most important. A new aggregate was installed in 2006 (a so-called OXEA), which makes an online analysis of the samples taken possible. The results are passed on directly to the computer to recalculate the quality distribution within the mine.

A new drilling rig generation was bought and set up allowing the partly automated advance of drifts. These drilling rigs are equipped with a computer allowing the operator to choose the best drilling pattern for the various rock conditions and showing the holes to be drilled on the screen of the computer. Some of the holes can be drilled completely automated, which provides better accuracy and therefore improves the results of the blasting process.

4. Mine Radenthein – MillstätteR Alpe

Millstätter Alpe is situated some 40 km north of Villach. The sparry magnesite has been mined since 1908. The current production is 90,000 t a year and is mined completely underground. The deposit is divided in three parts, the so-called Nordfeld, Mittelfeld und Südfeld (Fig. 7). The total length of the deposit is some 1,000 m, the height is max. 250 m left.

The deposit was extracted in surface mining at the beginning and then changed to underground mining due to increasing overburden height. Various mining methods were tested. Finally block caving was used until the end of the 90s of the last century. Due to the reduction of the production to a level of some 90,000 t a year a new mining system had to be installed.

Currently, sublevel caving is used. The mine is separated into sublevels, which are some 20 m high. Within each sublevel, two drifts are advanced until they reach the host rock. The 1st drift is then enlarged by drilling and blasting 3-m-long holes in the top. The 2nd drift is enlarged by drilling holes up to 12 m long. Blasting of drift 2 follows some 20 m after drift 1. Thus a stope which is some 20 m wide, 15 m high and up to 30 m long is formed. Because of safety reasons the stope is then forced to collapse by drilling holes longer than 12 m, thus blasting the sill pillar. Loading is carried out remote controlled LHD.

The next sublevel is currently in progress. The system will be improved by the following: only one drift is developed to the host rock. A pillar of 24 m is left until the next drift is advanced. The drifts are then enlarged by drilling fans of 12-m-long holes around these drifts.

For safety reasons (rescue shaft) and the ventilation of the mine, a new shaft will be raised in 2008, which will be 145 m high. This way, the ventilation of the whole mine will be improved. In addition, this shaft will be used as an emergency escape for the miners.

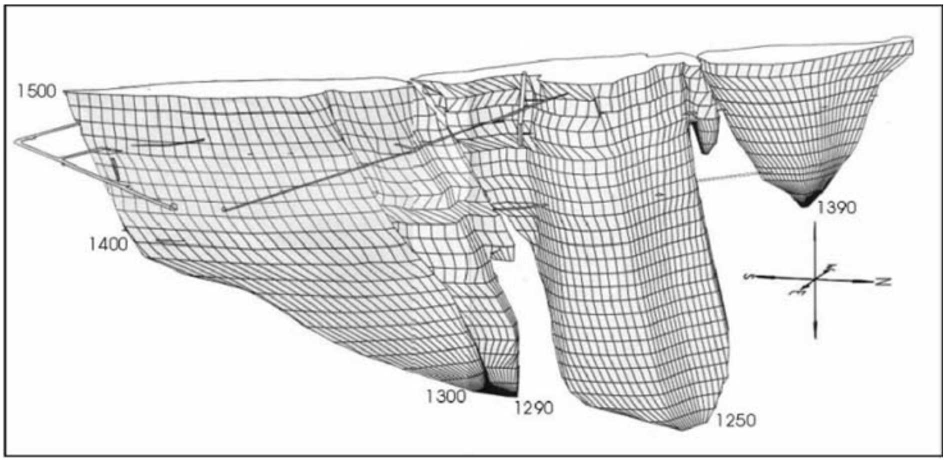

Fig. 7. Millstätter Alpe Deposit

Rys. 7. Złoże Millstätter Alpe

A new drilling rig to drill the fans was bought in 2007 allowing to drill the holes once started automatically until they have a length of 12 m.

5. Weißenstein Magnesite Mine – Development of the so-called "Westfield"

The Bürgl and Weißenstein magnesite deposits, located in Hochfilzen, Tyrol, were discovered until a magnesite flotation process was developed in 1957 and the plant of Hochfilzen was built. In 1971 the mining operation moved from the Bürgl open pit to the newly developed Weißenstein mine, which has been the sole magnesite source for RHI's Hochfilzen plant since then. The overall production from this mine has totalled 8 million tonnes so far.

For quite a long time an extension of the deposit to the west has been assumed. Several core drilling campaigns were carried out to investigate the close surroundings of the ore body and to get information about the stability of the foot wall rocks. These drilling programmes proved reserves which doubled the remaining tonnage within the existing pit layout. A geostatistical model is currently being developed.

New pit designs were planned to maximise ore extraction at a reasonable overburden-to-ore-ratio. In order to ensure the stability of the final pit slope the general dipping angle was defined at just 40° in the upper part of the new pit and 54° in the more stable carbonate rocks of the lower benches.

For mining of the magnesite 2.5 million m^3 of overburden have to be removed in total. Because of the topography there is a high amount of initial overburden and therefore the overburden capacity has to be increased to 300,000 m^3/year in the first four years of the development, which started fully in 2007. As the mine runs only from May to October all loading and transport activities are performed by a contractor.

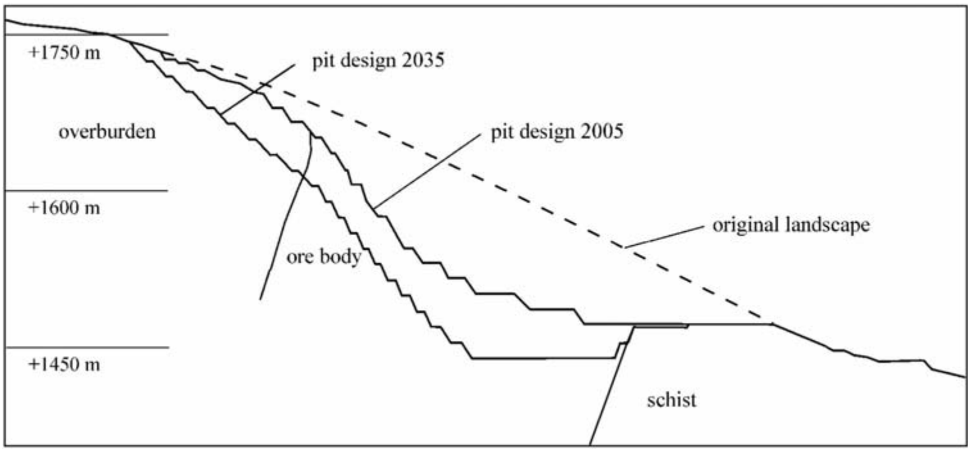

Fig. 8. Cross section NW-SE open pit Hochfilzen

Rys. 8. NW-SE przekrój odkrywki Hochfilzen

A high amount of dolomite which is suitable for production of refractory material is included in the overburden volume. Hence the system of overburden dumps was adapted in a way that selective dumping of dolomite is possible to enable future usage of this material.

All overburden dumps are built up in benches of 3–4 meters. This type of construction allows full rehabilitation of the dump slopes, which can be used again as meadows after three years. This also minimises the impact on the natural scenery. The details are shown in Figure 8.

6. Outlook

In the future, the demand for steel and cement will increase further, mainly driven by the growth of BRIC and the N-11 countries. The trend of a decrease in specific refractory consumption will continue; however, the rate of decrease will slow down further. It is also predicted that the growth rate in steel production will compensate for the effect of the decreasing specific refractory consumption; which will lead to a further increasing magnesite demand in the future.

The magnesite producers will have to take the described measures (or extensions) in the mines to supply this increasing demand. An effect which should be also mentioned is emission trading and limiting of CO_2 emissions that can have a negative impact on the Austrian and European magnesite producers. In that effect a carefully implemented Post-Kyoto (or Bali) Process is necessary.

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ROZWÓJ, WYZWANIA I TRENDY W GÓRNICTWIE MAGNEZYTU W AUSTRII

Słowa kluczowe

Magnezyt, kopalnia odkrywkowa, technologia, produkcja

Streszczenie

Magnezyt jest wydobywany w Austrii od połowy XIX wieku. Magnezyt jest głównym źródłem tlenku magnezu, który jest stosowany głównie w przemyśle materiałów ogniotrwałych.

Firma RHI lub jej spółki wydobywają magnezyt w Austrii od 1881 r. Proces ten zaczął się w kopalni w Veitsch. W 1903 r. otworzono kopalnię w Breitenau, a następnie kopalnię Radenthein w 1908 r. Działalność w Hochfilzen zaczęła się w 1957 r.

Kopalnie istniejące obecnie są rozbudowywane dla pokrycia rosnącego zapotrzebowania na tlenek magnezu przez przemysł stalowy świata. Niniejsze opracowanie opisuje firmę RHI, sytuację rynkową materiałów ogniotrwałych z tlenkiem magnezu oraz, szczegółowo, nowe prace prowadzone w kopalniach w Breitenau, Radenthein i Hochfilzen.

DEVELOPMENTS, CHALLENGES AND TRENDS IN AUSTRIAN MAGNESITE MINING

Key words

Magnesite, open pit, technology, production

Abstract

Magnesite has been mined in Austria since the middle of the 19th century. Magnesite is the main source for magnesia, which is mainly used in the refractories industry.

The company RHI, or its forming companies have been mining magnesite in Austria since 1881. It started with the mine in Veitsch. In 1903 the mine in Breitenau followed, and then the Radenthein mine in 1908. Operations in Hochfilzen began in 1957.

Today the existing mines are expanded further to cover the growing demand for magnesia from the world's steel industry. This article describes the company RHI, the magnesia refractories market situation and, in detail, the new developments at the mines in Breitenau, Radenthein and Hochfilzen.