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Forecast of mineral raw materials utilisation in domestic refractory industry in the nearest future

Key words

Mineral raw materials, refractory industry, domestic refractory minerals, raw materials imports, forecast of minerals usage

Abstract

The paper describes significant changes in raw materials usage in Polish refractory industry in recent years, which are strictly related to the technological development and production structure of domestic refractories' consumers and producers. Evolution of domestic refractory sector caused substantial change of quantity and type of raw materials used in this industry in the last decade. The most important features were: diminishing use of domestic raw materials, significant changes in quantity, geographic structure and quality of raw materials traditionally imported, as well as introduction of new imported raw materials. All these changes are analysed in the paper. As a result of this analysis, forecast of mineral raw materials utilisation in Polish refractory industry in the nearest future is presented.

Introduction

Quantity, structure and type of raw materials consumed by Polish refractory industry depend on many factors. The most important are as follows:

— technological level and production volume of domestic refractories' consumers;

— technological development and production structure of the domestic refractory industry, as well as international trade of these products;

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— type and volume of consumption of domestic raw materials in the refractory industry, which depends on their current demand in this industry, and — in recent years — also on competition with foreign suppliers;

— type and level of consumption of imported raw materials, conditioned by economic and technological reasons, but sometimes also by tradition and political issues.

This paper focuses on significant changes in raw materials usage in Polish refractory industry in the last 10—15 years, which are strictly related to factors mentioned above. Tendencies in their use, as well as significant changes among refractory producers and users, are the basis for forecast of mineral raw materials utilisation in Polish refractory industry in the nearest future, which is the main aim of this paper.

1. Past trends of raw materials usage in Polish refractory industry

The first refractory plants in Polish land were constructed in the second half of the 19th century. They were located just by deposits of refractory clays and shale, kaolin and quartzite, but also not far from refractories' consumers: steelworks, cement plants or non-ferrous metals smelters. Therefore the most important of them were located mainly in Lower and Upper Silesia regions, as well as near Kraków and Kielce (all in southern Poland). Before the Second World War a dozen or so refractories plants, delivering fireclay refractories, worked in Poland's contemporary borders. Local refractory clays' deposits were the principal source for their production. Only two plants, in Chrzanów and Skawina, produced a wider range of refractories (fireclay, silica and basic refractories). Besides local raw materials, they used also imported refractory clays and shales, kaolin and quartzite from Lower Silesia (in contemporary borders of Germany), as well as dead-burned magnesite from Czechoslovakia and Austria. Moreover, three mines and roasting plants in Upper Silesia were delivering dead-burned dolomite to the neighbouring steelworks for open-hearth furnaces (Table 1).

Return of the Lower Silesia to Poland after the Second World War resulted in taking possession of three significant refractory plants in Żarów, Świdnica and Gliwice. Another consequence was the change of quantity and quality of domestic raw materials for refractories production. In the years 1945—1977, Polish refractory industry was reconstructed and developed, simultaneously with development of industries being main users of refractories, especially steelworks. Concentration on domestic raw materials use, with strict limitation of imported materials consumption, was one of the main assumptions of this development. As a result of it, domestic production of refractory clays and dead-burned dolomite increased many times, with high level of refractory shale and quartzite production, as well as continual trials of domestic magnesite use.

However, need for introduction of new types of refractories, as well as for improvement of traditionally produced refractories, resulted in importation development of these raw materials, which were entirely or partly scarce (Table 2). These minerals were imported mainly from other communist countries: dead-burned magnesite from Czechoslovakia and North Korea, bauxite and alumina from Hungary, kaolin and quartzite from Soviet Union (Ukraine), chromite from Soviet Union (Kazakhstan) and Cuba. It was not before 1980s when significant diversification of raw materials imports occurred, but the full diversification was not possible until 1990s (Galos 1999).

TABLE 1

Characteristics of refractory minerals production in Polish lands (Galos 1999)

TABELA 1

Charakterystyka produkcji surowców mineralnych dla przemysłu materiałów ogniotrwałych na ziemiach polskich (Galos 1999)

Mineral	Historical and current sources
Refractory clay	Before 1945: production in four areas: Lower Silesia (within borders of Germany), Upper Silesia, Kilece and Kraków vicinity After 1945: concentration of production in Jaroszów (Lower Silesia, also burned clay) and Opoczno (Kielce area), expiration of production in other areas In 1970s and 1980s: commencement of utilisation of low grade clays in Żary area and variable quality clays from Turów brown coal deposit (both Lower Silesia) After 1990: decrease of supply by 80% due to drop of demand, Jaroszów plant as the almost only supplier, marginal importance of other producers
Refractory shale	Production of burned refractory shale in Nowa Ruda (Lower Silesia) from the end of 19th century to 1979 Periodical utilisation of refractory shale from Upper Silesia hard coal mines from 1930s to 1972
Kaolin	Raw kaolin from Andrzej deposit in Żarów (Lower Silesia) mined from 1843 to 1989 and used for fireclay refractories production In the first half of 20th century (up to ca 1950) raw kaolin from Gola Świdnicka, Gołaszyce, Wyszonowice, Gębczyce, and Kamień deposits used for the same purposes Since 1964, washed kaolin has been produced in Nowogrodziec plant (Lower Silesia) on the basis of Maria III deposit, a major part of production up to beginning of 1990s was used for refractories production, currently its use in refractories is marginal
Quartzite	Quartzite from Bolesławiec area (Lower Silesia) mined and used for silica refractories production from the end of 19th century to 1988 Quartzite from Ostrzeszów area (central Poland) mined and used between 1935—1939 Quartzite sandstone from Świnia Góra (Kielce area) mined and used periodically in 1930s and 1950s Quartzite sandstone from Bukowa Góra (Kielce area) mined and used for silica refractories production since 1972
Quartzite schist	Quartzite schist from Jegłowa (Lower Silesia) mined since 1854, since the end of 19th century to 1971 used for natural fireproof linings production, from 1971 to 1998 for refractory mortars and mixes, since 1999 not used for refractories
Magnesite	Magnesite in Grochów and Ząbkowice Śląskie areas (both Lower Silesia) mined since 1848, dead-burned magnesite for refractories (limited usability) produced since 1936 to 1997
Dolomite	Between 1898 and 1930: commencement of raw dolomite production for steelworks from Ząbkowice Będzińskie, Bobrowniki, Blachówka, Żelatowa-Pogorzyce, and Gródek-Szczakowa mines Between 1926 and 1938: commencement for dead-burned dolomite production in Ząbkowice Będzińskie (stopped in 1980), Szczakowa (currently disappearing) and Żelatowa (still in operation) Commencement of dead-burned dolomite production in Refractory Plant of Lenin Steelworks in Cracow (currently Refractories Works in Cracow) in 1966 on the basis of Żelatowa raw dolomite, but since 1978 on the basis of dolomite from Brudzowice-Siewierz new mine

TABLE 2

Chronology of main raw materials introduction in domestic refractories industry[1] (Galos 1999)

TABELA 2

Chronologia stosowania ważniejszych surowców mineralnych w krajowym przemyśle materiałów (Galos 1999)

Raw material	Start of use	Type of refractory produced	Source of raw material
Sandstone	first half of 19th century	Natural sandstone shapes	domestic
Refractory clay	after 1850	fireclay	domestic, supplementary imports
Kaolin, raw	after 1850	fireclay	domestic, supplementary imports (since 1989 only imports)
Quartzite schist	ca 1880	natural quartzite schist shapes	domestic
Quartzite	before 1900 (Lower Silesia) 1928 (rest of country)	silica	domestic, supplementary imports
Magnesite, dead-burned	1907 (Lower Silesia) after 1930 (rest of country)	magnesite and related	imports, partially domestic (up to 1996)
Dolomite	1926 1966	dolomite mixes dolomite bricks	domestic
Chromite	ca 1960	magnesite-chromite	imports
Kaolin, washed	1964	fireclay, insulation	domestic
Alumina, calcined	ca 1968	high alumina and corundum	imports, periodically domestic
Alumina, fused	ca 1970	corundum	domestic and imports
Bauxite, raw	ca 1970	aluminous cements	imports
Magnesia, synthetic	after 1970	magnesia and related	imports
Zircon	ca 1977	corundum-zircon	imports
Graphite, flake	ca 1980 ca 1984	fireclay-graphite magnesia-graphite	imports
Alumina, tabular	after 1980	korundum	imports
Olivine	after 1980?	forsterite	imports
Bauxite, calcined	ca 1988	bauxite	imports
Andalusite	1992	andalusite	imports

[1] Together with Lower Silesia, before 1945 within the borders of Germany.

Even in 1980s, differences in type of refractories consumed in Poland, as well as in their quantity — as compared to developed countries — were tremendous. It was a result of obsolete production methods in industries being main refractories consumers, especially in the steel industry. Other factors were mentioned above: intensification of domestic raw materials usage (useful mainly for refractories of decreasing importance — fireclay and silica ones), as well as utilisation of raw materials imported from communist countries, quality of which was commonly much worse comparing to international standards. As a consequence, total and unit consumption of refractories, as well as raw materials for their production, was very high.

2. Changes among refractory users and producers in the last decade

Fundamental changes in Polish refractory industry occurred in the last 10—15 years. Rate of these changes was much faster than in highly developed countries, being a result of fast modernisation of major refractories consumers, especially the steel industry (e.g. reduction of steel production in open-hearth furnaces, expansion of continuous steel casting after 1994). Political and economic transformation of Poland, which started in 1989—90, accelerated the rate of these changes, as well as enabled substantial diversification of geographical structure and type of imported raw materials for refractory industry. Deep decrease of production in all industries being main refractories consumers in the beginning of 1990s (consequence of deep transformation of the entire Polish economy) was another factor affecting refractory industry in this period.

Steel industry remains the main refractories user in Poland. Until recently, it was consuming nearly 70% of their total domestic production, but currently its share has decreased to over 60%. The demand of the steel industry for refractories has entirely changed, due to technological changes.

The Polish steel industry consists of almost 20 steelworks, including two large plants: Katowice and Sendzimir. After achievement of record level of 19.5 Mt in 1980, in 1980s Polish steel production stabilised at 16—17 Mtpy, but on the turn of 1980s it decreased by 40% to ca 10 Mtpy. In 1990s it fluctuated between 9—11 Mtpy (Bilans Gospodarki... 2000). Additionally, changes in technologies used by Polish steel industry (Table 3), as well as introduction of new modern refractories, were the main reasons of huge drop of refractories consumption in this industry (Barański 1996; Czechowski, Wojsa 1996). The most important are as follows:

— continuous elimination of open-hearth furnaces from ca 40% in 1986 to only 5% in 1999 — substiantially diminished consumption of fireclay, silica, magnesite and magnesite-chromite refractories;

— introduction of water cooled panels in electric arc furnaces — decreased use of magnesite-chromite refractories, with increase of magnesia-graphite products utilisation;

— continuous replacement of dolomite refractories by magnesia-graphite ones in basic oxygen furnaces;

— introduction of torpedo ladles with andalusite or bauxite refractories instead of traditional hot metal ladles with fireclay linings;

TABLE 3

Technological structure of Polish steel industry with forecast* (Bulkowski et al. 1995; Lipowczan 1996)

TABELA 3

Struktura technologiczna produkcji surówki żelaza i stali w Polsce z prognozą (Bulkowski et al. 1995; Lipowczan 1996)

Year	Pig iron	Steel production			Steel casting	
		from open-hearth furnaces	from electric arc furnaces	from basic oxygen converters	traditional	continuous
1990	6 plants	16 plants	9 plants	2 plants	17 plants	4 plants
	13 blast furnaces	29%	18%	53%	92%	8%
1997	3 plants	4 plants	11 plants	2 plants	13 plants	9 plants
	5 blast furnaces	9%	26%	65%	51%	49%
2002f	3 plants	—	11 plants [1]	2 plants	4 plants	9 plants
	4 blast furnaces, 1 COREX	0%	43%	57%	5%	95%

* Some steelworks in 1990 and 1997 were using simultaneously open-hearth and electric arc furnaces for steelmaking, as well as traditional casting and continuous casting.
[1] Including electric converter in Czestochowa Steelwork.

— development of secondary steelmaking in ladles — growth in use of magnesia-graphite, dolomite, andalusite and bauxite refractories; decreased importance of traditional steel ladles — reduced consumption of fireclay refractories, and high alumina refractories from synthetic grogs;

— regular growth of continuous steel casting from 5% in 1988 to ca 80% in 1999 — growth in usage of magnesia-graphite and dolomite refractories for ladle linings, andalusite and magnesite bricks for tundish linings, as well as alumina, alumina-graphite, zirconia-graphite etc. for special elements (nozzles, tube etc.);

— parallel reduction of traditional steel casting — again significant drop in fireclay refractories usage;

— continuous growth in non-shaped refractories use (mainly alumina, andalusite, bauxite, mullite and spinel mixes, castables etc.).

Current level of domestic steel production, i.e. 9—10 Mtpy, should be maintained in the next years. Therefore, further changes of refractories usage in that industry will be a result of continuation of the above mentioned technological improvements. Consequently, the consumption of magnesia-graphite, alumina, alumina-graphite and zirconia-graphite bricks and shapes, as well as high alumina castables should be still improved. Current level of andalusite, bauxite, mullite and dolomite refractories is likely to be maintained, with some reduction in case of magnesite and magnesite-chromite products. Decrease in fireclay and silica refractories use will be continued.

Technological improvements in other consuming industries significantly influence the changes in type of refractories manufactured, as well as raw materials used for their production. The most important are the following:

— cement plants (10% of domestic refractories consumption) — introduction of andalusite and bauxite bricks instead of fireclay ones in calcining, cooling and discharge zones of rotary kiln, introduction of magnesia-spinel bricks instead of magnesia-chromite ones in sintering and transition zones; total consumption of refractories in this industry should be rather stable (growth in clinker production, decreased unit consumption);

— non-ferrous metals smelters (especially copper smelters) — the third refractories consumer in Poland (5—7%), their consumption should be slightly reduced due to use of better magnesite-chromite refractories for copper smelters;

— glass industry (4—5% of domestic refractories consumption) — growing use of fused alumina-zircon-silicate (AZS), alumina-chromite, alumina-zirconia and mullite refractories in melter, as well as spinel-bonded magnesia bricks and andalusite bricks in regenerators; consumption of silica refractories and high alumina refractories from synthetic grogs is still going down.

Fast and fundamental changes among the refractories users, especially in steel industry, resulted in five-fold reduction of refractories production in Poland between 1987 and 1999 (Fig. 1), as well as in significant changes in the structure of refractories production. The Polish refractory industry had to accept a challenge from refractories' consumers. Each refractory plant tried to expand the range of refractories produced, and to improve their quality, but this was achieved on different scale and with variable success. From among dozen or so existing refractory plants, significant improvement has been noted e.g. in Skawina, Gliwice, Żarów (high alumina and specialised products), as well as in Ropczyce and Kraków (mainly basic refractories). On the other hand, a few plants have gone bankrupted (e.g. Opoczno), whereas others fought for survival.

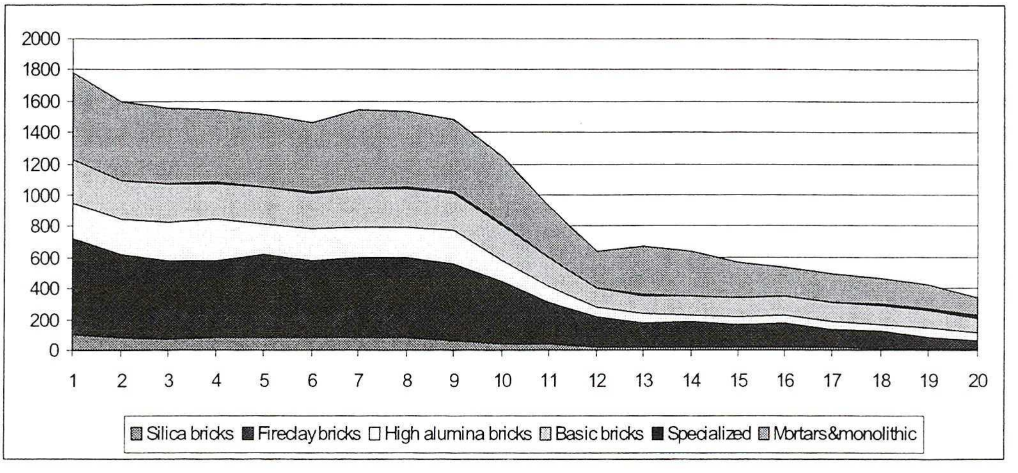

Fig. 1. Refractories production in Poland

Rys. 1. Produkcja materiałów ogniotrwałych w Polsce

In the production structure, tremendous fall of a few product groups was observed in the period 1987—99, i.e.: silica brick, fireclay brick and high alumina brick on the basis of synthetic grogs by 90%, non-shaped refractories by over 70%. Production of magnesite and magnesite-chromite bricks, as well as dolomite mixes, was also sharply reduced. On the other hand, production of magnesia-graphite products was quickly developed, with commencement of production of such refractories as andalusite and bauxite bricks, high alumina castables for steel ladles, alumina and alumina-zirconia shapes for continuous steel casting, or magnesia-spinel bricks for cement kilns. As a result, share of silica bricks in total production has been reduced from 5.7% in 1987 to 2.1% in 1999, whereas fireclay bricks' share from 32.3% to only 17.4%, respectively. However, in spite of production drop of high alumina and basic bricks in terms of quantity, their share in total production has increased. It is worth mentioning that specialised refractories production share has increased a few times to 3.5% in 1999 (Fig. 2).

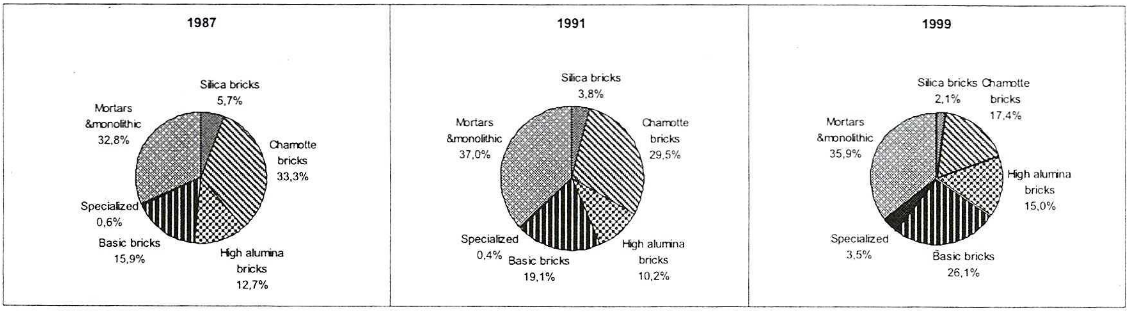

Fig. 2. Structrure of refractories production in Poland in 1987, 1991 and 1999

Rys. 2. Struktura produkcji materiałów ogniotrwałych w Polsce w latach 1987, 1991 i 1999

Further technological restructuring of the main refractories users will result in continuous changes in quantity and type of refractories produced in Poland. However, these changes will not be so rapid as in the last decade. Expected significant development of refractories' international trade will influence economic situation of the Polish refractory industry, as well as type and level of utilised raw materials. Current predominance of exports over imports (result of high basic refractories exports) will be probably not continued.

3. Diminishing importance of domestic refractory minerals

The evolution of both refractories' consumers and producers caused substantial change of quantity and type of raw materials used in the refractory industry in the last decade. The most important features were:

— diminishing use of domestic raw materials;

— significant changes in quantity, geographic structure and quality of raw materials traditionally imported;

— introduction of new imported raw materials.

Importance of domestic raw materials in the Polish refractory industry is decreasing year by year. This results from the fact, that in Poland only production of such raw materials is possible, which are consumed in diminishing quantities (examples: refractory clays, kaolin, quartzite). Therefore the share of domestic raw materials used in the Polish refractory industry decreased from 77% in 1980 to 62% in 1998 in terms of quantity. It is also estimated that value of domestic raw materials consumed by this industry constitute only 25% of total value of utilised raw materials.

Use of domestic silica raw materials (quartzite from Bukowa Góra, quartz schist from Jegłowa) dropped twenty times, as compared to 1980, to only ca 10,000 tpy (Table 4). This is simple result of continuous decrease of demand for silica refractories. In the nearest future, silica raw materials use will slightly decrease again, with Bukowa Góra quartzite remaining as the sole domestic material used.

Due to considerable drop of fireclay refractories consumption, utilisation of refractory clays, both raw and burned (almost all domestic), was reduced from over 1,200,000 t in 1980 to only 130,000 t in 1998. Dominance of the major producer — JARO Jaroszów — is even larger than before, with marginal importance of other domestic producers. Significance of foreign suppliers, especially from Ukraine, proportionally increases. It affects adversely the economic situation of JARO, which is difficult enough. In the nearest future, the demand for raw refractory clay will diminish to 60—70,000 tpy, whereas for burned clays to 40—45,000 tpy (Table 4). Domestic supplies will cover 70—90% of needs, imports from Ukraine — the remaining 10—30%.

Domestic raw kaolin was used in the refractory industry until 1989, when its producer — Andrzej open pit in Żarów — was shut down. Consumption of washed kaolin from Surmin-Kaolin achieved 20,000 tpy at the end of 1980s. Since 1993 it dropped to less than 1,000 tpy due to decline of production of these fireclay and high alumina refractories, where this kaolin was used.

Dead-burned dolomite production in Poland achieved almost 600,000 t in 1980. There were consumed mainly lower grades for production of dolomite mixes for open-hearth and electric arc furnaces. Use of these grades decreased fourfold, as a result of open-hearth furnaces closing. Consumption of higher grade dolomite for dolomite bricks production is rather stable. Total consumption of dead-burned dolomite was reduced threefold to ca. 160,000 tpy (Fig. 3). In the nearest future, it will continue to decline to even 130,000 tpy (Table 4). Only two dolomite deposits are currently operated for dead-burned dolomite production: Brudzowice-Siewierz and Żelatowa. Other pits were shut down in the last few years.

Raw magnesite from Braszowice pit was utilised for many years for the production of dead-burned magnesite. However, due to its high SiO_2 content, it was useful only as a component for the lowest grades of magnesite mixes. Finally, production of dead-burned magnesite in Braszowice was halted in 1997.

As it is seen, use of a few domestic raw materials in the refractory industry was terminated in the last ten years (Fig. 3). A few other raw materials, i.e. refractory clays, dead-burned dolomite, quartzite, will be still used by this industry, but their consumption will be diminished. On the other hand, some of these raw materials have significant alternative applications: kaolin and refractory clay in ceramics, quartzite in ferrosilicon production, magnesite for magnesium fertilisers production (Galos 1999).

TABLE 4

Sources of raw materials for Polish refractory industry in 1980 and 1998 with forecast ('000 t)

TABELA 4

Źródła surowców mineralnych dla polskiego przemysłu materiałów ogniotrwałych w 1980 i 1998 r. z prognozą (tys. t)

Type of raw material	1980			1998			2003f			Domestic suppliers in 1998	Main foreign suppliers in 1998
	total	domestic	import	total	domestic	import	total	domestic	import		
Raw materials for silica refractories:											
Quartzite	180	165	15	10	8	2	6—10	5—7	1—5	KiZWK Bukowa Góra	Ukraine
Quartz schist	63	63	—	3	3	—	—	—	—	DZM Świdnica	—
Raw materials for fireclay and high alumina refractories:											
Refractory clay, raw	918	907	11	76	70	6	60—70	45—60	5—25	JARO, KWB Turów, Lubuskie ZMOiB	Ukraine, Czech Rep., France
Refractory clay, burned	337	256	81	53	45	8	40—45	35—40	5—10	JARO	Ukraine
Refractory shale, burned	28	28	—	<1	—	<1	1—2	—	1—2	—	China
Kaolin, raw	94	44	50	5	—	5	0—3	—	0—3	—	Ukraine
Kaolin, washed	15	15	—	<1	<1	—	<1	<1	—	KSM Surmin—Kaolin	—
Andalusite-kyanite-sillimanite	—	—	—	15	—	15	12—16	—	12—16	—	South Africa, France
Bauxite, raw (for aluminous cement)	2	—	2	3	—	3	3—6	—	3—6	—	Croatia, Greece, Hungary, Bosnia
Bauxite, calcined	—	—	—	13	—	13	10—15	—	10—15	—	China, Brazil, Guyana
Alumina, calcined	95	—	95	11	—	11	10—12	—	10—12	—	Hungary, Germany
Alumina, reactive	—	—	—	<2	—	<2	3—4	—	3—4	—	Germany, Hungary
Alumina, tabular	—	—	—	2	—	2	3—4	—	3—4	—	Germany, Hungary
Alumina, white fused	—	—	—	<1	—	<1	<1	—	<1	—	Hungary, Germany, Austria
Alumina, brown fused	3	2	1	4	2	2	2—4	<1	2—4	FMiWŚ Korund	Ukraine, China, Russia
Mullite, synthetic	8	8	—	4	2—3	1—2	2—4	1—2	1—3	ZSO Górka	Germany, United Kingdom
Spinels $MgO{\cdot}Al_2O_3$	—	—	—	<1	—	<1	1—2	—	1—2	—	United Kingdom, Germany
Raw materials for basic refractories:											
Magnesite, dead-burned	292	9	283	74	—	74	60—75	—	60—75	—	Brazil, Slovakia, China, Australia
Magnesia, dead-burned	34	—	34	5	—	5	4—8	—	4—8	—	Ireland, Italy, Israel, Netherlands
Magnesia, fused	—	—	—	6	—	6	3—8	—	3—8	—	China, Australia, Israel
Mg-Cr co-clinkers	6	—	6	6	—	6	4—6	—	4—6	—	Austria, United Kingdom
Chromites	55	—	55	10	—	10	5—8	—	5—8	—	Turkey, South Africa, Kazakhstan
Dolomite, dead-burned	582	582	—	159	158	1	130—140	130—140	—	PMO Kraków, KiPD Żelatowa, ZD Szczakowa	—
Olivine	<0,1	—	<0,1	<0,2	—	<0,2	<0,2	—	<0,2	—	Norway
Other raw materials:											
Graphite, flake	<0,1	—	<0,1	2,0	—	2,0	2,2—2,8	—	2,2—2,8	—	Germany, Canada, China, Brazil Mozambique, Madagascar, Ukraine
Zircon	0,3	—	0,3	0,3	—	0,3	0,3—0,5	—	0,3—0,5	—	Australia, South Africa
Baddeleyit & synthetic zirconia	—	—	—	0,04	—	0,04	<0,10	—	<0,10	—	France, Netherlands, USA

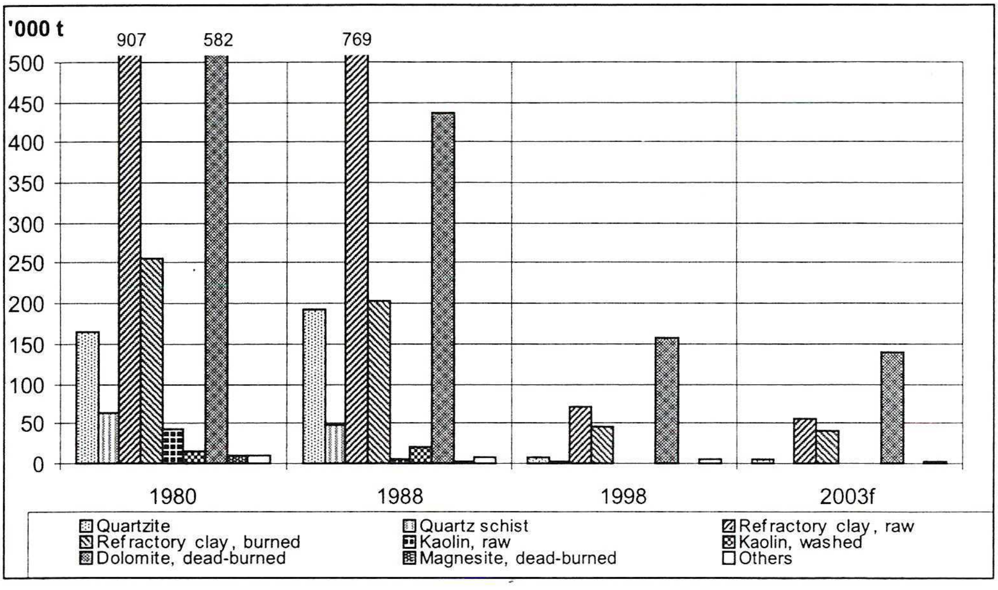

Fig. 3. Consumption of domestic raw materials by Polish refractory industry with forecast

Rys. 3. Zużycie krajowych surowców mineralnych w polskim przemyśle materiałów ogniotrwałych z prognozą

4. Imported refractory raw materials — new materials and new sources

Imported minerals were used in the Polish refractory industry for the first time in 1930s. Due to the fact, that domestic deposits are suitable only for the production of minerals for fireclay, silica and dolomite refractories, production development of high alumina, basic (besides dolomite) and specialised refractories had to be developed on the basis of imports. Some tendencies of these imports until 1980s were presented above. On the turn of 1980s, significant changes took place in their structure, being continued in 1990s. These developments can be divided as follows:

— change of imported minerals' type — introduction of new materials, decrease in imports of the majority of usually imported minerals;

— change in geographic structure of traditionally imported minerals;

— improvement in quality parameters of traditionally imported minerals.

Minerals purchased to Poland for many years, imports of which were substantially reduced, are mainly: dead-burned magnesite and magnesia (decrease by 75% in the period 1980—98); calcined γ alumina and raw kaolin for high alumina grogs production (decrease by 90%), chromite (over 80%) and some grades of quartzite (over 85%). Moreover, supplementary imports of refractory clays are still continued, but in variable amounts (Table 4, Fig. 4). Use of these minerals decreased as demand for refractories manufactured on their basis was reduced, and new competitive minerals were introduced.

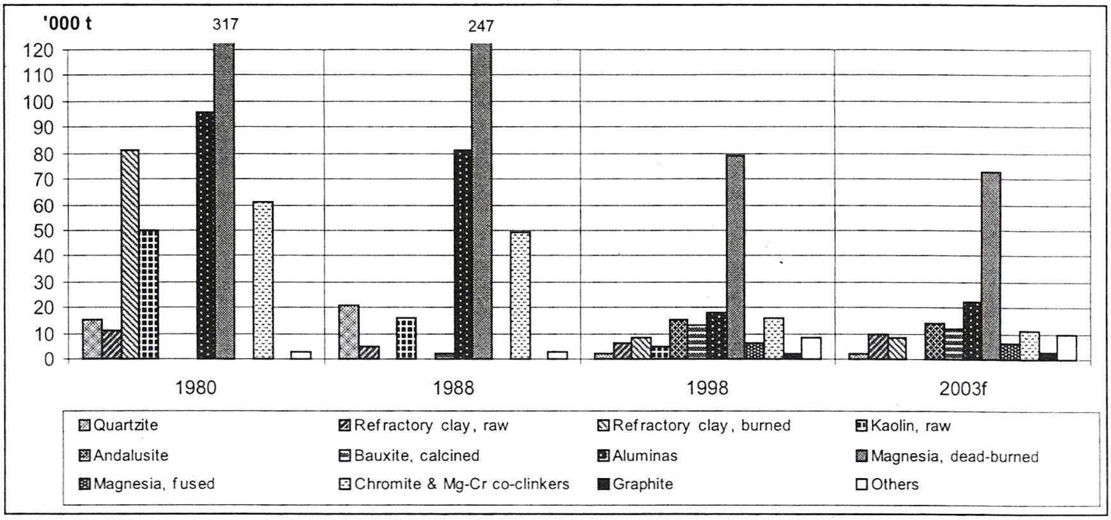

Fig. 4. Consumption of imported raw materials by Polish refractory industry with forecast

Rys. 4. Zużycie importowanych surowców mineralnych w polskim przemyśle materiałów ogniotrwałych z prognozą

A list of imported minerals recently introduced in the Polish refractory industry is much longer: andalusite concentrates, calcined bauxite, reactive, tabular and fused alumina, synthetic mullite, spinels $MgO{\cdot}Al_2O_3$, fused magnesia, flake graphite and synthetic zirconia. In most cases, the volume of these minerals imports is small or even marginal (e.g. zirconia <50 tpy). Larger imports are recorded in case of andalusite, calcined bauxite and fused magnesia (Table 4, Fig. 4). However, all these minerals, together with new high quality grades of dead-burned magnesia, contributed to improvement in quality and durability of refractories manufactured in Poland.

Significant changes in geographic structure of imports were also noted, for example:

— introduction of a wide range of minerals from China (dead-burned and fused magnesite, calcined bauxite, fused alumina, flake graphite) and the Republic of South Africa (andalusite, chromite, zircon), with development of imports from Brazil, Turkey and other non-European countries;

— decrease or disappearance of raw materials imports from former communist countries: raw bauxite and calcined alumina from Hungary, dead-burned magnesite from Slovakia (decrease) and North Korea (disappearance), chromites from Kazakhstan and Cuba;

— development of imports of many highly specialised raw materials, for example: reactive, tabular and fused alumina, spinels and synthetic mullite, coming from Western Europe and Hungary.

Improvement of imported minerals quality can be illustrated by examples of dead-burned magnesite and magnesia, aluminas and chromium materials. In case of dead-burned magnesite, share of high grades (>96% MgO) is still growing, with substantial increase of highest quality grades, e.g. Dead Sea Periclase from Israel (99.4% MgO). Simultaneously, share of traditional low grades (90—93% MgO) is decreasing. In the group of aluminas, use of calcined γ alumina is still diminishing, whereas utilisation of calcined α alumina (including reactive grades), tabular or fused alumina is continuously developed. Chromite concentrates are gradually replaced by Mg-Cr co-clinkers.

As it was mentioned above, probably the most important changes were observed among mineral raw materials, which were imported for high alumina refractories production (andalusite, bauxite, aluminas). Introduction of andalusite concentrates use in 1992 was one of the most characteristic events. Their imports achieved the level of 15—20,000 tpy (Fig. 4) and should be stabilized in the nearest future, because andalusite refractories will maintain their importance in torpedo ladles, steel ladles and tundish linings in continuous steel casting. Due to limited world sources of high quality andalusite concentrates their dominant suppliers for domestic refractory industry should remain producers from the Republic of South Africa (three companies, six mines), with supplementary imports from France. Choice of suitable grades will depend on their quality/price ratios.

Development of calcined bauxite use in domestic refractory industry dates from the end of 1980s. Currently, it finds common application in refractories for steel ladles and torpedo ladles, minor quantities for electric arc furnaces vaults etc. Next years, calcined bauxite use in this industry should stabilise in the range 12—18,000 tpy (Fig. 4), depending on demand for bauxite refractories, as well as on competition with andalusite refractories. Structure of calcined bauxite imports will depend on price/quality ratios of Chinese, Guyanese and Brazilian grades. Share of South American grades can rise from 20% to 30%.

Raw bauxite in domestic refractory industry will still be used in limited amounts for production of lower grades of alumina cements in Górka plant. Utilisation of such cements in this industry is still diminishing, with some increase in industrial construction or mining. So, the total raw bauxite consumption for alumina cements will probably not cross 4,000 tpy. Their imports will originate from Croatia, Bosnia and Hungary (high iron grades), as well as from Greece (low iron grades).

Different alumina varieties had different usage tendencies in refractories in the last decade. Use of calcined γ alumina decreased ten times to only ca 10,000 tpy, due to drop of high alumina grogs and alumina cements production in Górka plant (result of newly introduced andalusite and bauxite refractories competition). On the other hand, use of calcined α alumina (including reactive grades), as well as tabular alumina is gradually developing up to 2—3,000 tpy and ca 2,000 tpy respectively. The last one is the result of production development of non-shaped refractories on their basis. In the nearest future demand for calcined γ alumina will be maintained at the current level or slightly diminished (continuous decrease of high alumina grogs production), whereas demand for calcined α alumina and tabular alumina can rise twice. Undoubtedly, main aluminas' suppliers to Poland will remain Hungarian and German producers, but imports structure can be extended to U.K. and French suppliers. White and brown fused alumina will remain the main aggregate component for >97% Al_2O_3 refractories production. Their current level of use in Polish refractories industry is estimated at ca 1,000 tpy (white fused alumina) and 3—4,000 tpy (brown fused alumina). In the next years, some increase of >97% Al_2O_3 refractories production is expected. However, use of tabular alumina — instead of fused alumina — will be increasing there. That is why current demand for both types of fused alumina will only be maintained. In case of white fused alumina, there is a lot of its European producers, so the choice of suppliers will mainly depend on the price of raw material. On the contrary, brown fused alumina supplies will probably be dominated by Ukrainian, Russian and Chinese producers, with decreasing share of domestic producer — Korund Koło enterprise.

Raw materials relative to aluminas, which also find application in refractories, are: synthetic mullites and spinels. The level of demand for mullite refractories in their main applications (glass melters and regenerators, special elements of steel ladles) will probably be maintained, however products of still increasing quality will be required. That is why total demand for synthetic mullite and mullite grogs should be maintained at the level of ca 4,000 tpy, with growing share of imported sintered and fused mullite, and decreasing significance of mullite grogs produced by domestic Górka plant. Spinels $MgO{\cdot}Al_2O_3$ were used up till now mainly for production of magnesia-spinel refractories used in cement kilns. Current level of consumption does not probably exceed 1,000 tpy, but in the next years it can cross this level. Magnesia varieties of spinel were used till now, with start of alumina spinel grades use in the last three years. The utilisation of the last ones can be expanded ten times to a few hundred tpy, due to the development of non-shaped products on their basis. The main supplier of spinels will remain German plant of Alcoa company, which has dominant position on European market.

Dead-burned magnesite and magnesia are the main imported raw materials for Polish refractory industry. Level of dead-burned magnesite used by domestic refractory plants stabilised recently at ca 80—85,000 tpy. Future level of demand will depend not only on domestic needs for a wide range of basic refractories, but also on possibilities of maintenance of their significant exports. If these exports will be maintained, demand for dead-burned magnesite will be only slightly lowered. It will be a result of wider introduction of higher quality dead-burned magnesia and fused magnesia grades use in modern types of refractories (e.g. magnesia-graphite ones) instead of lower grade dead-burned magnesite used in traditional magnesite and magnesite-chromite refractories. Directories of dead-burned magnesite imports will be slightly modified, with development of higher grade imports (e.g. Slovakian Hamag, Brazilian M-30, Australian QMAG) and decrease of lower grades use (e.g. Chinese 90/10 and 90/15 grades, Brazilian M10 grade). Introduction of some amounts of Turkish grades is also possible. Level of dead-burned magnesia usage will depend — among others — on price competition with fused magnesia. As it was seen in 1998, level of their use decreased twice to ca 5,000 tpy due to increase of fused magnesia consumption to almost 6,000 tpy (Fig. 4). The last one was the result of low prices of Chinese fused magnesia. Significance of particular suppliers can vary, for example growing share of producers from Israel or the Netherlands can be expected. Still increasing quality of these raw materials will be the rule, as well as introduction of some special grades, e.g. calcium zirconate bonded ones. Imports of fused magnesia to Poland will probably be dominated by Chinese producers, whereas grades from other suppliers will be used for the highest quality products.

Other important raw materials used in basic and/or specialised refractories, which are imported to Poland, are: chromium raw materials (chromites, Mg-Cr co-clinkers), graphite, zirconium raw materials (zircon, zirconia). Level of demand for chromite in Polish refractory industry was reduced a few times to ca 10,000 tpy in the last dozen or so years. It was connected with liquidation of open-hearth furnaces (where the majority of magnesite-chromite refractories was used), as well as with gradual elimination of magnesite-chromite refractories from electric arc furnaces (by magnesia-graphite products) and from cement clinker kilns (by magnesia-spinel products). Moreover, usage of Mg-Cr co-clinkers, instead of traditional set of chromite and dead-burned magnesite, is still growing. Current use of these co-clinkers is estimated at ca 5—6,000 tpy. In the nearest future, Mg-Cr co-clinkers consumption can slightly increase or stabilise, whereas chromite use will decline again to even less than 5,000 tpy. The main suppliers of chromite will remain the Republic of South Africa, Kazakhstan and Turkey (with variable shares of particular exporters), whereas Mg-Cr co-clinkers will still come mainly from Austria. However, development of fused Mg-Cr co-clinkers imports from the United States or the Republic of South Africa, is also possible.

Use of flake graphite in Polish refractories industry, stimulated by development of magnesia-graphite refractories production, achieved the level of ca 2,000 tpy in 1998. Good future prospects for these type of refractories will probably result in continuous growth of demand for flake graphite to 2,500—2,800 tpy. They will still be imported from a wide range of producers, but prospects for new suppliers are limited (Table 4). The significant share of imports from Madagascar, Mozambique and Canada should be maintained.

Imports of zircon concentrates for Polish refractories industry is currently estimated at ca 300 tpy. They are used for production of fused alumina-zircon refractories, in Górka and Skawina plants only. Some increase in production of the mentioned above refractories, as well as development of manufacture of some other high alumina-zircon products, can cause some increase of zircon concentrates, but still below 500 tpy. The main sources of these raw materials will remain Australia and the Republic of South Africa, with some possible supplementary imports from Ukraine and the United States. Current level of synthetic zirconia use, i.e. 30—40

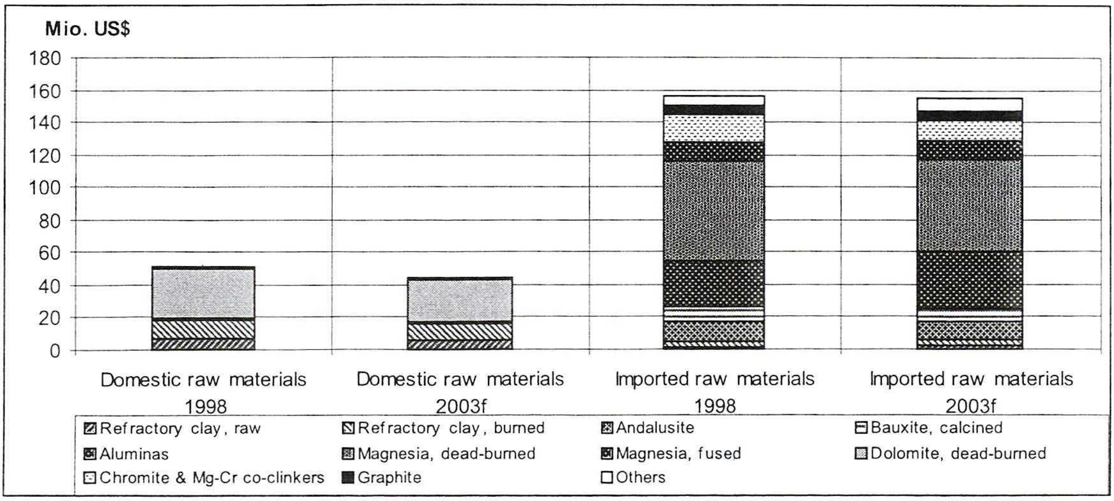

Fig. 5. Estimated value of raw materials consumend by Polish refractory industry in 1998 and 2003 (forecast)

Rys. 5. Szacunkowa wartość surowców mineralnych zużwanych w polskim przemyśle materiałów ogniotrwałych w 1998 r. i 2003 r. (prognoza) tpy, due to further development of special elements for continuous steel casting, is able to increase even to 100 tpy. This raw material will continuously come from Western Europe (Galos 1999).

In the last twenty years, significance of imported raw materials in Polish refractory industry considerably increased. Share of imported raw materials used in Polish refractories industry increased from 23% in 1980 to 38% in 1998 in terms of quantity. It is also estimated that value of imported raw materials consumed by this industry constitute currently as much as 75% of total value of utilised raw materials (Fig. 5).

5. A look for the future

Last decade was really difficult time for the Polish refractory industry. It had to make a huge technological "jump", with respect to type, quality and quantity of manufactured products, due to revolutionary changes in the consuming industries (especially steelworks). Evolution of refractories production resulted in fundamental changes in type, quantity, quality and structure of raw materials used by this industry (Fig. 6). Share of raw materials for fireclay refractories production (refractory clays, kaolin) was lowered twice, whereas share of raw materials for silica refractories — four times. On the opposite, share of raw materials for high alumina refractories production increased from ca 4% to ca 12%, whereas share of raw materials for basic refractories from 35% to 56% (Fig. 6).

It seems that technological delay of the Polish refractory industry, which was a fact ten years ago, does not occur today. That is why we can expect that future changes of raw materials use in this industry will be evolutionary, not revolutionary, being compliant to world trends (Table 4, Fig. 6).

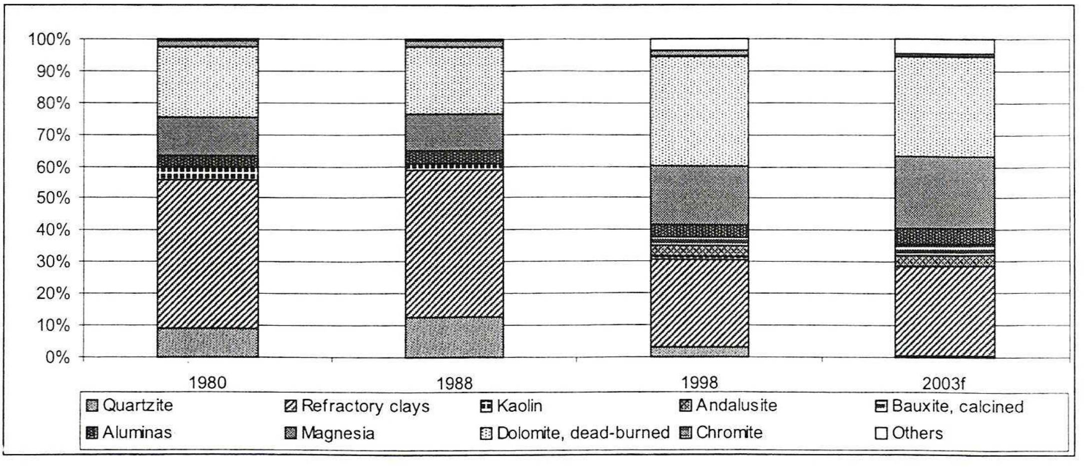

Fig. 6. Structure of raw materials consumption in Polish refractory industry, by volume

Rys. 6. Struktura zużycia surowców mineralnych w polskim przemyśle materiałów ogniotrwałych w ujęciu ilościowym

Dependence of domestic refractory industry on imported raw materials will be increasing, with restriction of domestic minerals use. Share of domestic minerals consumed by this industry in terms of volume will decrease from 62% in 1998 to ca 58% in 2003 (Table 4), but in terms of value from 25% to 20—22%, respectively (Fig. 5). It is unavoidable, because the domestic minerals, available to this industry, are only refractory clays, quartzite, and dolomite, demand for which is still being reduced.

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KRZYSZTOF GALOS

PROGNOZA UŻYTKOWANIA SUROWCÓW MINERALNYCH W KRAJOWYM PRZEMYŚLE MATERIAŁÓW OGNIOTRWAŁYCH W NAJBLIŻSZEJ PRZYSZŁOŚCI

Słowa kluczowe

Surowce mineralne, przemysł materiałów ogniotrwałych, krajowe surowce ogniotrwałe, import surowców mineralnych, prognoza użytkowania surowców

Streszczenie

W artykule zaprezentowano znaczące zmiany w użytkowaniu surowców mineralnych w polskim przemyśle materiałów ogniotrwałych w ostatnich latach, które były ściśle powiązane z rozwojem technologicznym i strukturą produkcji krajowych użytkowników i producentów materiałów ogniotrwałych. Ewolucja krajowego sektora materiałów ogniotrwałych spowodowała fundamentalne zmiany w rodzaju i ilości surowców mineralnych użytkowanych przez ten przemysł w ostatnim dziesięcioleciu. Najważniejsze zjawiska w tym zakresie to: malejące znaczenie krajowych surowców mineralnych, znaczne zmiany w ilości, jakości i strukturze geograficznej importu surowców tradycyjnie sprowadzanych do Polski, a także wprowadzenie do użytkowania nowych rodzajów surowców importowanych. Wszystkie te zjawiska poddano analizie w niniejszym artykule. Jego rezultatem końcowym jest prognoza użytkowania surowców mineralnych w polskim przemyśle materiałów ogniotrwałych w najbliższej przyszłości.