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The Russian-Ukrainian war versus the mineral security of Poland

Introduction

The events of the past three years have presented the global economy with many challenges. The world experienced a sudden and deep economic slowdown due to the effects of the Covid-19 pandemic and the mitigation measures put in place. Globally, the extraction of some raw materials has declined, supply chains have been severely disrupted or interrupted, accompanied by significant fluctuations in mineral prices, while demand for minerals has continued to increase (Deloitte 2020; Jowitt 2020; Laing 2020; Watari et al. 2021). Also in Europe, mining companies have been reporting declines in mineral production and delays in mining projects (Gałaś et al. 2021). The situation, linked to the global lockdown and economic slowdown, had not had time to improve when Russia's aggression against Ukraine

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occurred in February 2022. The Russian-Ukrainian conflict has increased uncertainty about the ability of the global economy to recover from the pandemic (Guénette et al. 2022; United Nations 2022). Immediately after the outbreak of the conflict, financial markets around the world suffered a shock, and prices of oil, natural gas, metals and foodstuffs, among others, surged (Coface 2022). Because of its dependence on Russian oil and gas, as well as on many other raw materials, Europe – and Central and Eastern Europe in particular – appears to be the region most vulnerable to the consequences of this conflict (Guénette et al. 2022).

The European Union is heavily dependent on energy imports from Russia. In 2021, Russia's supplies to the EU covered more than 40% of its total gas consumption, and 27% of the total consumption of oil and 46% of that of coal. Energy carriers represented 62% of EU total imports from Russia, at a cost of around 99 billion EUR in 2021 (EC 2022a).

The EU's raw material dependence on global markets is also evident in the metallic raw materials sector, including critical raw materials (Simkova et al. 2022; EC 2020a). For years, the source of their supply has been countries known for their positions of almost monopolies (e.g. China, Congo D.R., Brazil, South Africa) (Fraser 2022; Wrede 2022; Shen et al. 2020; Mancheri et al. 2019). In recent months, countries with a high risk of withholding supplies of raw materials have also been joined, for different reasons, by Russia, Belarus and Ukraine. While there is a risk for a ban on Russian and Belarusian mineral exports as a result of sanctions, the possible suspension of raw materials deliveries from Ukraine will directly stem from war damage. The abundance and diversity of Russia's natural resources, especially of energy minerals and some metals, allowed the country to export a significant portion of their production. However, due to the sanctions imposed (EC 2022b), its foreign sales capacity for certain raw materials has been reduced. Furthermore, the isolation of Russia from the international community has substantially restricted its access to advanced technologies and eroded the country's economic growth potential. Russia has rather limited the possibilities for import substitution in high-technology sectors (Simola 2022). This applies equally to Belarus, although its raw material potential is incomparably smaller. In the case of Ukraine, on the other hand, production and export capacities for many important raw materials have been severely reduced as a result of the hostilities on its territory.

Russia plays an important role in supplying the European Union with REE, palladium, germanium, vanadium, lithium and rhodium, among other minerals (EC 2020a; WTO 2022), which are essential for the development of the EU's main strategic sectors: renewables, electromobility, robotics and defense. It is estimated that the share of Russian raw materials in the European robotics sector is 9%, and in European 3D printing technology, it is around 12% (Gehrke 2022). Similarly, the development of fuel cell and hydrogen technologies in the EU requires raw materials imported from Russia – platinum (13%), titanium (23%) and vanadium (34%) (Gehrke 2022). Russia is also the world's third-largest supplier of nickel used, inter alia, in the production of batteries for electric vehicles as well as of stainless steel, which is a basic raw material in many industries. Nickel ranked among the top twenty commodities imported into the EU from Russia. For its raw materials, the dependency rates of the EU on

Russian supplies are very high (42% for metal and over 80% for nickel ores and concentrates in 2021) (Ragonnaud and Szczepanski 2022; EUROSTAT 2022). The previously mentioned energy minerals – natural gas, oil, hard coal – also figure prominently in this ranking, as do coke and iron ore, which are two key raw materials used in steel production, with dependency ratios of 44% and 12%, respectively (Ragonnaud and Szczepanski 2022). Ukrainian companies, meanwhile, controlled about 50% of the world's supply of neon used in semiconductor manufacturing but primarily supplied a range of raw materials and low-processed products to the European automotive industry (WTO 2022). Ukraine was also an important supplier of not only graphite, titanium, nickel, manganese and magnesium but also iron and steel (JRC 2022a). In 2021, the EU and Ukraine signed a strategic partnership on raw materials to diversify, strengthen and secure the supply of critical raw materials on both sides (Ministry of Climate and Environment 2021).

Taking into account the aforementioned phenomena concerning the whole EU, this work is an attempt to answer the question about the scale of threats to Poland's raw material security with respect to non-energy raw materials. In particular, it aims to identify those industries whose proper functioning may be threatened in the face of restrictions on the supply – from Russia, Belarus and Ukraine – of raw materials necessary for the production of industrial products in these sectors. While pointing out the high risk of a collapse in the supply of these raw materials from the three countries mentioned, the identification of other possible sources of the supply of these raw materials, along with an assessment of the real possibilities of a rapid change in the directions of their import to Poland, have also become an element of the analysis.

The article does not analyse threats in the area of energy resources. These matters are widely discussed at the national level, particularly in the area of energy policy. The war conflict in Ukraine made it necessary to update the document of Energy Policy of Poland until 2040, which was initiated in March 2022 (Ministry of Climate and Environment 2022a; PEP2040). This document is consistent with the resolution on the adoption of the Mineral Policy of Poland (Ministry of Climate and Environment 2022b), approved on 1 March 2022.

1. Materials and methods

Taking into account the objectives of the aforementioned work, about 140 non-energy raw materials applied in the Polish economy were analyzed in terms of foreign supply sources. This was carried out using the mineral resources management database maintained by the author's team, which collects, inter alia, data from the Central Statistical Office (GUS) on the imports and exports of all mineral raw materials in Poland. The analysis was based on the period of the last decade (2011–2020, official 2021 data not available) that allowed the selection of raw materials coming from at least one of the three countries (Russia, Ukraine, Belarus) in any year; this period was considered sufficient to show the scale and economic importance of shipments from these directions.

Table 1. Quantity and value of non-energy raw-material imports from Russia, Belarus and Ukraine to Poland in 2020

Tabela 1. Wielkość i wartość importu surowców nieenergetycznych z Rosji, Białorusi i Ukrainy do Polski w 2020 r.

CN	Raw material	Total imports		Russia		Belarus		Ukraine		Total quantity from three countries (tons)	Total value from three countries (thousand PLN)
		Quantity (tons)	Value (thousand PLN)	Quantity (tons)	Value (thousand PLN)	Quantity (tons)	Value (thousand PLN)	Quantity (tons)	Value (thousand PLN)		
27171020, 25171080	Aggregates, crushed	2,700,787	137,576	0	0	0	0	2,383	272	2,383	272
25171010	Aggregates, natural sand and gravel	745,848	33,103	0	0	400,920	16,159	177,770	8,612	578,690	24,771
760110	Aluminum, non-alloyed	191,495	1,341,495	90,728	613,325	0	0	0	0	90,728	613,325
250850	Andalusite-kyanite-sillimanite	13,205	21,837	0	0	0	0	423	755	423	755
25070080, 250830	Ball clays and refractory clays	479,155	137,021	0	0	0	0	412,504	76,635	412,504	76,635
2803	Carbon black	317,838	923,757	223,454	588,397	2,632	5,947	34,011	90,037	260,098	684,381
252329	Cement, Portland	1,302,283	298,738	0	0	439,934	93,738	32,530	8,095	472,464	101,833
811221	Chromium metal	65	2,104	4	95	0	0	0	0	4	95
281810	Corundum, synthetic	38,871	181,516	4,870	13,839	0	0	3,134	9,946	8,004	23,785
2512	Diatomite	5,561	13,094	526	668	0	0	0	0	526	668
252910	Feldspathic raw materials	400,762	67,295	0	0	0	0	68,864	6,928	68,864	6,928
7202	Ferroalloys	184,637	901,797	813	9,771	0	0	48,795	193,043	49,608	202,813
251320	Garnet	19,062	15,452	0	0	0	0	6,901	3,128	6,901	3,128
251611, 251612	Granite dimension stone	149,033	162,944	0	0	0	0	6,874	3,019	6,874	3,019
2504	Graphite, natural	9,236	92,867	0	0	0	0	1,242	367	1,242	367
260111, 260112	Iron, ores and concentrates	5,208,749	1,984,905	125,010	62,425	0	0	4,070,254	1,568,998	4,195,264	1,631,423

CN	Raw material	Total imports		Russia		Belarus		Ukraine		Total quantity from three countries (tons)	Total value from three countries (thousand PLN)
		Quantity (tons)	Value (thousand PLN)	Quantity (tons)	Value (thousand PLN)	Quantity (tons)	Value (thousand PLN)	Quantity (tons)	Value (thousand PLN)		
25070020	Kaolin	80,170	63,593	0	0	0	0	3,840	2,850	3,840	2,850
780110	Lead metal	37,030	286,847	1,698	12,438	1,698	12,438	1,804	13,667	5,200	38,544
282520	Lithium, oxides	172	4,925	128	3,369	0	0	0	0	128	3,369
2602	Manganese, concentrate	117,175	82,771	0	0	0	0	539	339	539	339
750210	Nickel metal	4,276	221,082	1,486	80,441	0	0	0	0	1,486	80,441
2703	Peat	289,477	101,980	51,454	12,551	61,813	17,141	0	0	113,267	29,691
7201	Pig iron	193,340	270,467	97,141	137,256	0	0	24,387	32,877	121,528	170,134
3104	Potash	1,066,067	1,097,100	351,046	347,410	286,830	301,631	0	0	637,876	649,042
250620	Quartzite	30,379	2,482	0	0	0	0	30,327	2,346	30,327	2,346
2501	Salt	475,432	136,056	0	0	42,128	5,653	85,902	10,436	128,030	16,089
280461, 280469	Silicon metal	31,246	212,928	175	1,383	0	0	0	6	175	1,389
6801	Stone, cubes and curbs	46,969	26,619	0	0	0	0	6,940	3,605	6,940	3,605
810820	Titanium metal	96	2,407	0	0	0	0	19	432	19	432
261510	Zircon	1,893	13,350	12	304	0	0	947	5,458	959	5,762
	TOTAL				1,883,672		452,708		2,041,851		4,378,232

Source: GUS 2020.

At the preliminary stage of the analysis, about thirty raw materials were found that met the above criterion. Information on their importation in 2020 is given in Table 1. It should be noted that the total value of imports of non-energy raw materials to Poland in 2020 was, in the case of Ukraine, around 2,041 million PLN, in the case of Russia, around 1,884 million PLN, and in the case of Belarus, it was around 453 million PLN (Table 1). Among these thirty raw materials, the largest values of imports were recorded for:

- from Ukraine: iron ores and concentrates, ferroalloys, carbon black, ball and refractory clays, and pig iron
- from Russia: non-alloyed aluminum, carbon black, potash, pig iron, iron ores and concentrates, and nickel metal
- from Belarus: potash and Portland cement.

The potential impact of withholding or disrupting the supply from the analyzed countries may particularly apply to raw materials for which the share of these three countries in total imports to Poland is significant, and in view of the scarcity of a given raw material for the Polish economy, the share of these supplies in covering the demand for a given raw material in Poland is also considerable (at least 20%). Additionally, the total value of these imports is undoubtedly a determinant of the importance of the supply of raw material from these three countries to Poland. In order to properly take these two factors into account, the following criteria were used to determine the raw materials for which the interruption or disruption of supplies from Russia, Belarus or Ukraine to Poland could have the most serious impact on the functioning of certain sections of the Polish economy:

- the total share of imports from the three analyzed countries in covering the demand for a given raw material in Poland in 2020 – min. 20%; such a share was considered by authors as significant, i.e. having an important impact on the domestic market of a given raw material;
- the total value of imports of a given raw material to Poland from the three analyzed countries in 2020 – min. 20 million PLN (ca. 4 million EUR); this threshold was set at this level due to the fact that the value of imports of subsequent minerals analyzed was significantly lower, i.e. much less than 10 million PLN (ca. 2 million EUR).

Of the thirty raw materials analyzed, eight raw materials met both of the stated conditions (Table 2), including four metallic raw materials and four non-metallic raw materials. In the case of the remaining twenty-two raw materials, the share of the aforementioned three suppliers in covering the demand for a given raw material in Poland in 2020 either did not exceed 20%, despite a sometimes significant value of these imports (e.g. Portland cement, sand and gravel aggregates, salt, pig iron, peat, feldspar raw materials, lead, dimension stone), or the value of total imports from these three countries was a few million PLN (i.e. 2–6 million PLN for lithium oxides, quartzite, zircon and garnets or less than 2 million PLN for others).

The eight raw materials selected for detailed analyses are raw materials for various industries: iron and steel metallurgy (iron ores and concentrates, ferroalloys), non-ferrous metals (aluminum, nickel), rubber (carbon black), fertilizer (potash), ceramics (ball clays) and abrasives (synthetic corundum).

Table 2. Raw materials, for which Russia, Belarus and Ukraine were principal suppliers to Poland in 2020

Tabela 2. Surowce mineralne, dla których Rosja, Białoruś i Ukraina były kluczowymi źródłami dostaw do Polski w 2020 roku

Raw material	CN	Unit	Total imports	Imports from Russia		Imports from Belarus		Imports from Ukraine		Total share of three countries in imports to Poland (%)	Total value of imports from three countries (thousand PLN)	The share of total imports in covering the domestic demand (%)	Total share of imports from three countries in covering the domestic demand (%)
				Quantity	Share (%)	Quantity	Share (%)	Quantity	Share (%)				
1. Iron ores and concentrates	260111-12	‘000 tons	5,208.7	125.0	2.4	–	–	4,070.3	78.1	80.5	1,631,423	100.0	80.5
2. Carbon black	2803	‘000 tons	317.8	223.5	70.3	2.6	0.8	34.0	10.7	81.8	684,381	66.6	54.5
3. Potash	3104	‘000 tons	1,066.1	351.0	32.9	286.8	26.9	–	–	59.8	649,042	100.0	59.8
4. Aluminum, non-alloyed	760110	‘000 tons	191.5	90.7	47.4	–	–	–	–	47.4	613,325	89.9	42.6
5. Ferroalloys	7202	‘000 tons	184.6	0.8	0.4	–	–	48.8	26.4	26.8	202,813	44.8	12.0
6. Nickel metal	750210	tons	4,276	1,486	34.7	–	–	–	–	34.7	80,441	100.0	34.7
7. Ball clays and refractory clays	25070080, 250830	‘000 tons	479.2	–	–	–	–	412.5	86.1	86.1	76,635	85.6	73.7
8. Corundum, synthetic	281810	‘000 tons	38.9	4.9	12.5	–	–	3.1	8.1	20.6	23,785	100.0	20.6

Source: GUS 2020; own calculations.

2. Results of detailed analysis for the twelve most important minerals imported from Russia, Ukraine or Belarus

2.1. Iron ores and concentrates

The demand for iron ores and concentrates in Poland strongly depends on the condition of the domestic iron and steel industry. Over the past decade, it has risen from nearly 6.0 million tons in 2011 to a record high of around 7.5 million tons in 2018, before reducing by 25–30% to between 5.2–5.6 million tons/year in 2019–2021 (Figure 1), which was associated with a significant reduction in the production of pig iron and steel during this period (Smakowski and Szlugaj 2015; Resources management... 2021). Iron ores and concentrates in Poland are entirely consumed in the iron and steel industry for the production of pig iron – the main component for the production of various grades of steel. The main domestic user of iron ores and concentrates is ArcelorMittal Poland SA, which currently has one blast furnace at its Dąbrowa Górnicza steelworks (the other, operating in Kraków, was idled in 2020).

In the absence of domestic sources, the demand for iron ore and concentrates is entirely covered by imports, which in the last decade have shown comparable fluctuations to domestic demand for this raw material. Supplies came primarily from Ukraine (about 70%/y), as well as from Russia (about 10%/y). Russia's share of imports was nearly 19% as recently as in 2017, but in subsequent years, it has fallen to just a few percent (Figure 1). Declining supplies from Russia were supplemented by growing imports from Ukraine, whose share of total supplies approached 80%. In the last decade, the following countries have been smaller suppliers of iron ore and concentrates to Poland: Brazil, Bosnia and Herzegovina, South Africa, and most recently, Mauritania and Sweden.

2.2. Carbon black

The volume of carbon black consumption in Poland in the last decade has shown quite large fluctuations, from about 110,000 tons/year to almost 200,000 tons/year (Figure 2), showing no sustained trend (Kamyk 2015a; Resources management... 2021). Carbon black is mainly used as a filler in tire production. Its main consumers are Firma Oponiarska Dębica, Michelin Polska, Bridgestone Poland and Stomil-Poznań; they produce about 35 million tires a year. Of much lesser importance is the use of carbon black as a filler for plastics as well as in the production of sealants, coatings, paints, printer inks and cosmetics.

The demand for carbon black in Poland is met mainly by imports, with the share of a few domestic manufacturers (in particular, PSF Energia in Wilków) not exceeding 15%. For many years, Russia has been the most important supplier of carbon black to Poland (around a 70% share in covering demand, Figure 2), with smaller suppliers including the Czech

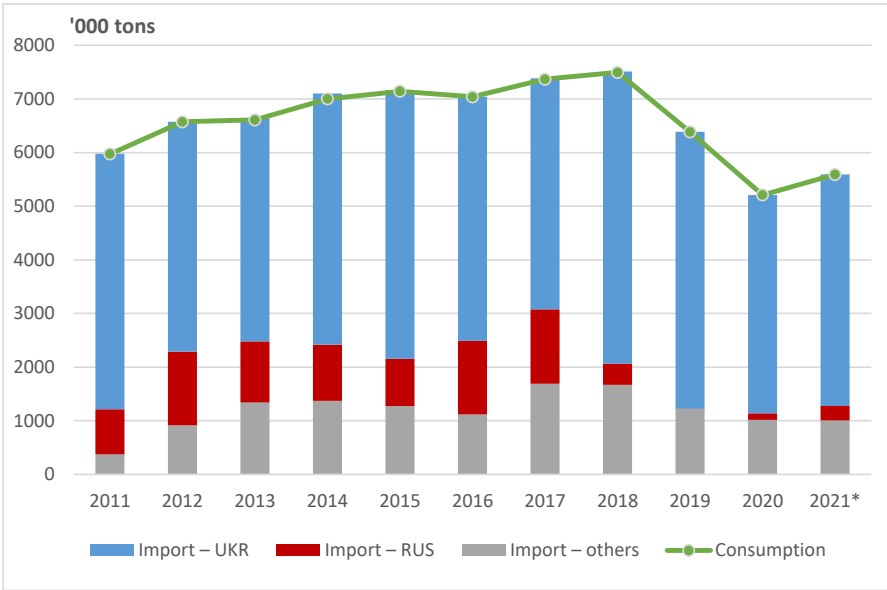

Fig. 1. The supply sources and consumption volume of iron ores and concentrates in Poland, * preliminary data

Rys. 1. Źródła dostaw i wielkość zużycia rud i koncentratów żelaza w Polsce, * dane wstępne

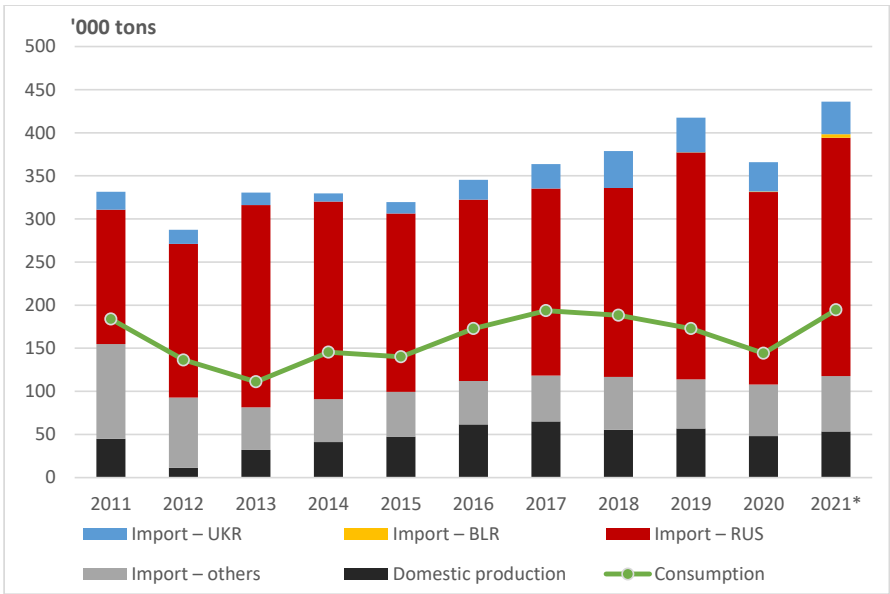

Fig. 2. The supply sources and consumption volume of carbon black in Poland, * preliminary data

Rys. 2. Źródła dostaw i wielkość zużycia sadzy w Polsce, * dane wstępne

Republic and Ukraine (5–10% each). During the period under analysis, there were re-exports of mainly Russian technical carbon black to European markets, carried out by such companies as Koninpex, Ekogranulat and Chemical Worldwide Business. The subject of such re-exports was up to 50% of the carbon black imported from Russia or Ukraine.

2.3. Potash (potassium salts)

Demand for natural potash (potassium salts) in Poland over the past decade has increased from less than 800,000 tons in 2011 to nearly 1,100,000 tons in 2021 (Figure 3). The volume of domestic demand is closely related to the prosperity of broadly understood agricultural crop production (Kamyk 2015b; Resources management... 2021). Virtually all of the imported natural potassium or potassium-magnesium salts are destined for the production of mineral fertilizers for agriculture, horticulture, fruit growing and vegetable farming, manufactured at a few large chemical plants – ZCh Police, GZNF Fosfory, ZA Chorzów and Agrochem Puławy (in the Azoty Group) – as well as Luvena in Luboń, ZCh Siarkopol in Tarnobrzeg, Fosfan in Szczecin and Alventa in Alwernia. The largest domestic user of potassium salts is ZCh Police (about 40% of domestic consumption), which uses them to produce NPK and PK compound fertilizers. The remaining large chemical plants, which produce NPK compound fertilizers, potash fertilizers and potassium chemicals, together account for up to 50% of the domestic consumption. The share of smaller companies that blend, granulate or package imported crude potash salts and potassium-magnesium salts does not exceed 10%.

The demand for natural potassium salts in Poland has been met entirely by imports for many years, supplemented by the production of small quantities of synthetic potassium nitrate at the Chorzów and Alwernia plants. Potassium chloride is mainly imported into the country (about 95% of total imports), mostly from Russia (30–60%, decreasing share, Figure 3), Belarus (usually more than 30%), Germany (up to 30%), and recently in increasing amounts from Canada. Small amounts of potassium sulphate (mainly from Germany) and small amounts of other crude natural K and KMg salts are also imported to Poland.

2.4. Aluminum, non-alloyed

Over the past decade, the demand for non-alloyed aluminum in Poland (primary and secondary combined) has shown a clear upward trend. After 2015, it was in the range of 160,000–185,000 tons/year (Figure 4). Non-alloyed aluminum is a light metal used in 90% by the non-ferrous metal industry in Poland (Kamyk and Smakowski 2015; Resources management... 2021). Aluminum alloys and products made from primary (imported) and secondary (imported and domestic) aluminum are produced at several processing plants. The largest domestic producer is Gränges Konin SA, which holds around 50% of the domestic production of rolled products from aluminum and aluminum alloys (strips and sheets), and

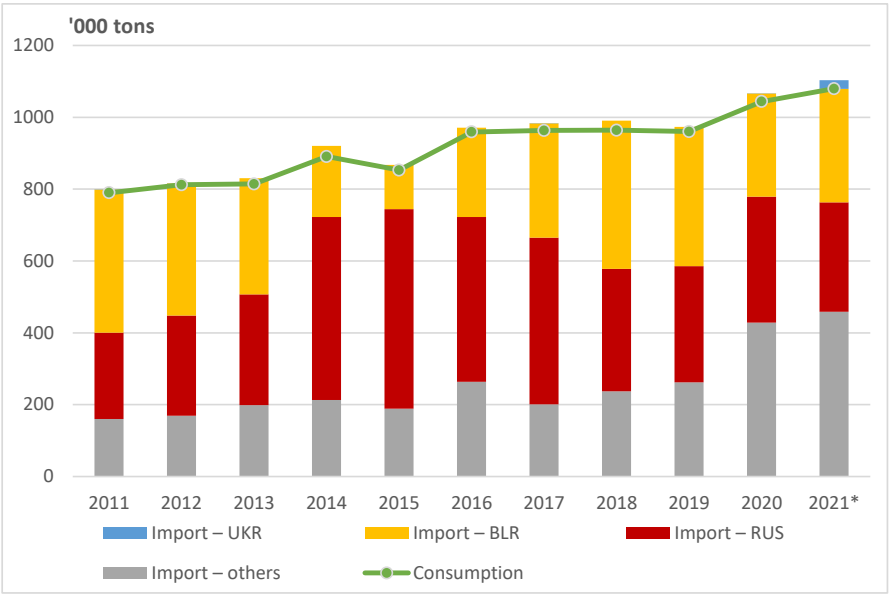

Fig. 3. The supply sources and consumption volume of potassium salts in Poland, * preliminary data

Rys. 3. Źródła dostaw i wielkość zużycia soli potasowych w Polsce, * dane wstępne

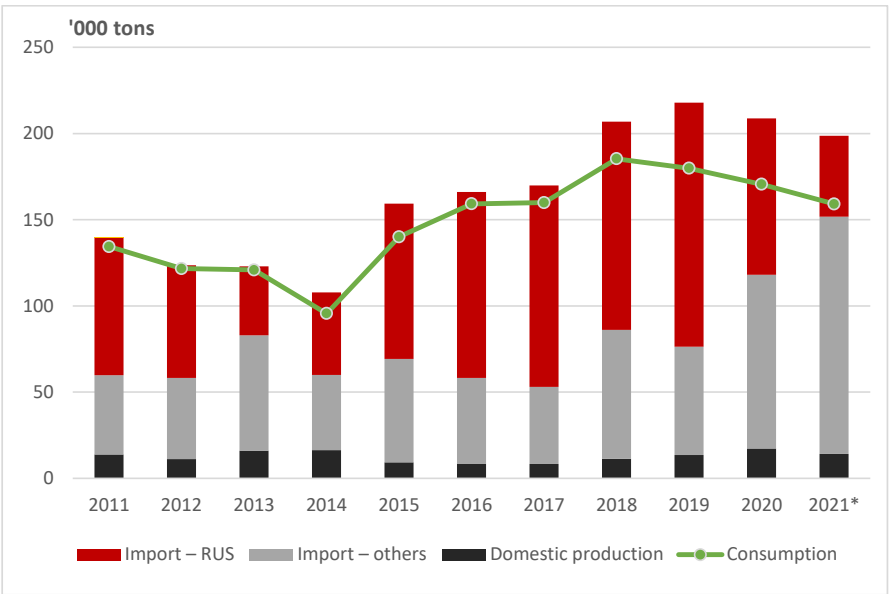

Fig. 4. The supply sources and consumption volume of non-alloyed aluminium in Poland, * preliminary data

Rys. 4. Źródła dostaw i wielkość zużycia aluminium niestopowego w Polsce, * dane wstępne

additionally it produces alloyed aluminum as a semi-finished product. The Gränges took over the Konin plant from Grupa Boryszew SA in late 2020. The Boryszew SA Group is another large manufacturer (with around a 30% share in the production of rolled products) with a plant in Skawina producing aluminum alloys, while from aluminum and its various alloy varieties – the so-called wire rod, wires, conductors and flat products are manufactured. The third major user of aluminum is Grupa Kęty SA with plants in Kęty and Tychy, producing alloyed aluminum, casting alloys, profiles, pipes, rods and wire from aluminum and aluminum alloys (about 30% of domestic production of extruded products). Several smaller companies, on the other hand, produce extruded products from non-alloyed aluminum. Final products made from aluminum and its alloys are widely used in the production of transportation equipment (e.g., engine blocks, radiators, water pumps, rims, etc.), in the construction industry (building structures and systems) and in the manufacture of some machinery. Small amounts of unalloyed alumnium are used for deoxidizing steel as well as in the food and chemical industries.

In Poland, only small quantities of non-alloyed aluminum are recovered from aluminum waste and scrap, which should be improved. The rest of the domestic demand is covered by imports. Russia has been the main supplier of non-alloyed aluminum for many years (40–55%). Recently, deliveries from this direction declined to about 25% in 2021 (Figure 4), while shipments from competitive suppliers (in terms of comparable unit costs of importation to those of Russian metal) such as Mozambique and Iceland as well as from other countries appeared. As a result, the aluminum trade pattern has become more diversified.

2.5. Ferroalloys

The demand of the Polish economy for ferroalloys ranged from about 124,000 tons in 2012 to about 194,000 tons in 2018 (Figure 5), which was associated with fluctuations in the volume of steel production in Poland during this period (Szlugaj 2015; Resources management... 2021). Ferroalloys in Poland are entirely consumed in the iron and steel industry for the production of a wide range of alloyed and quality steels, e.g. low carbon, stainless, acid resistant etc., mainly in: ArcelorMittal Poland SA, CMC Zawiercie SA, Celsa Huta Ostrowiec sp. z o.o., Huta Stalowa Wola SA, Liberty Steel Poland sp. z o.o., Huta Batory sp. z o.o. and Ferrostal Łabędy sp. z o.o.

The demand for ferroalloys in Poland is currently met half from domestic sources and half from imports (Figure 5). The main ferroalloy produced in the country (about 65% of domestic production) is ferrosilicon, while the remaining 35% of production is ferrosilicomanganese and low-carbon ferrosilicochromium, produced in electric furnaces by RE Alloys sp. z o.o. in Łaziska. Ferroalloy production at this plant has fluctuated in the range of 73,000–97,000 tons/year over the past decade.

A wide range of imports and exports of various ferroalloys is carried out (including re-export of some imported ferroalloys). Over the past decade, imports of all types of

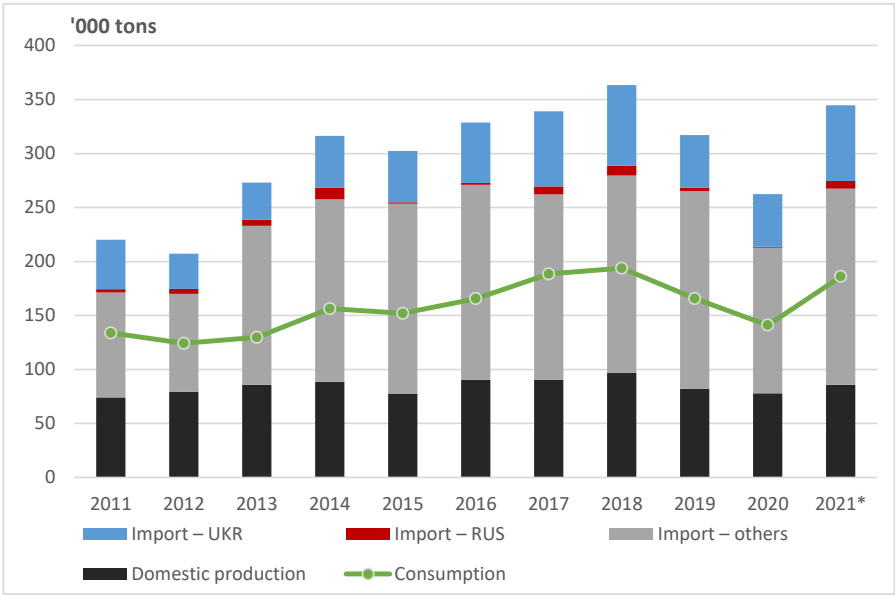

Fig. 5. The supply sources and consumption volume of ferroalloys in Poland, * preliminary data

Rys. 5. Źródła dostaw i wielkość zużycia żelazostopów w Polsce, * dane wstępne

ferroalloys to Poland ranged from around 128,000 tons in 2012 to around 266,000 tons in 2018. Up to 20% were imports of blast furnace ferromanganese, more than 80% were imports of various types of ferroalloys from electric furnaces, in particular ferrosilicomanganese, ferromanganese and ferrosilicon. The most important suppliers of the raw material to Poland were: Norway (about 38%/year) and Ukraine (about 28%), while smaller quantities were imported from France (6%), Slovakia (5%), South Africa (4%), Germany (4%), Russia (2%) and other countries. The combined share of Ukraine and Russia in total ferroalloy imports to Poland has averaged about 30% over the past decade, including about 28% from Ukraine (Figure 5). Ukraine was primarily the leading supplier to Poland of ferrosilicomanganese (recently more than 60% of its total imports), ferrotitanium (about 65%) and ferrotungsten (40%). Russia, in turn, was a significant supplier of ferrotungsten (about 40% of its total imports), ferrotitanium (10%) and ferrovanadium (<10%).

2.6. Nickel

The volume of calculated apparent consumption (imports minus exports) of nickel in Poland shows large fluctuations as a result of the variable volume of its supply from abroad and its highly variable re-exports (Lewicka 2015; Resources management... 2021).

Thus, although the demand for nickel in Poland can be estimated to have been around 2,000 tons/year in the last decade, negative values of apparent consumption were recorded during periods of increased re-export (e.g., in 2014). Since 2017, there has been an increase in its demand to about 3,000 tons/year (Figure 6). In Poland, the main direction of nickel use is the production of stainless and alloyed steels, as well as of non-ferrous alloys (including high nickel brasses and cupronickel), high-temperature superalloys, casting alloys, and electroplating coatings. The exact consumption structure is not known. The main domestic consumer of nickel (also in the form of stainless steels scrap and high nickel alloys) is ArcelorMittal Poland – Huta Warszawa, a leading manufacturer of stainless and special steels. Several percent of nickel consumption in Poland can be attributed to the production of rolled, extruded and drawn products from nickel and nickel alloys, for example, at the Walcownia Metali Nieżelaznych Gliwice-Łabędy in Gliwice, Walcownia Metali Dziedzice in Czechowice-Dziedzice and the Hutmen plant in Wrocław. Small amounts of nickel and stainless steel scrap with Ni (min. 9%) are used in the production of structural, tool, stainless and heat-resistant steels, in several plants, including: HSW – Huta Stali Jakościowych in Stalowa Wola, Ferrostal Łabędy in Gliwice, ISD Huta Częstochowa in Częstochowa and Huta Batory in Chorzów. There is no information on the use of nickel in Poland for the production of modern batteries and cells.

Almost all of the domestic supply of metallic nickel is imported (the share of domestically sourced nickel scrap is marginal). Russia has been the largest supplier of the metal over the past decade, generally accounting for 40–50% of total imports, while in 2021, this share dropped to 30% (Figure 6).

2.7. Ball clays and refractory clays

Ball clays and refractory clays are clayey raw materials whose main component is kaolinite and whose iron content is usually at low levels. The demand for these clays in Poland, has shown, with some fluctuations, an upward trend, recently exceeding even 600,000 tons/year (Figure 7). It remained closely dependent on the prosperity of the domestic ceramic tile industry. Ball clays or refractory clays are used in Poland primarily for the production of ceramic tiles (at least 60% by, among others: Paradyż Group, Rovese Group, Tubądzin Ceramics, Ceramika Nowa Gala, Końskie Group), refractory moulded and unmoulded products (at least 20%, among others: Vesuvius Skawina Materiały Ogniotrwałe, PCO Żarów) and ceramic sanitary products (around 10%, mainly Rovese Group, Geberit Group, Roca Polska). The remaining few percent are for other uses (Galos and Lewicka 2015; Resources management... 2021).

Only less than one-fifth of the domestic demand is currently met from domestic sources. The total domestic production of these clays has been on a downward trend in recent years, ranging from less than 100,000 to more than 180,000 tons/year, including 40,000–80,000 tons/year of ball clays (Ekoceramika Suszki, Bolesławieckie Zakłady Materiałów

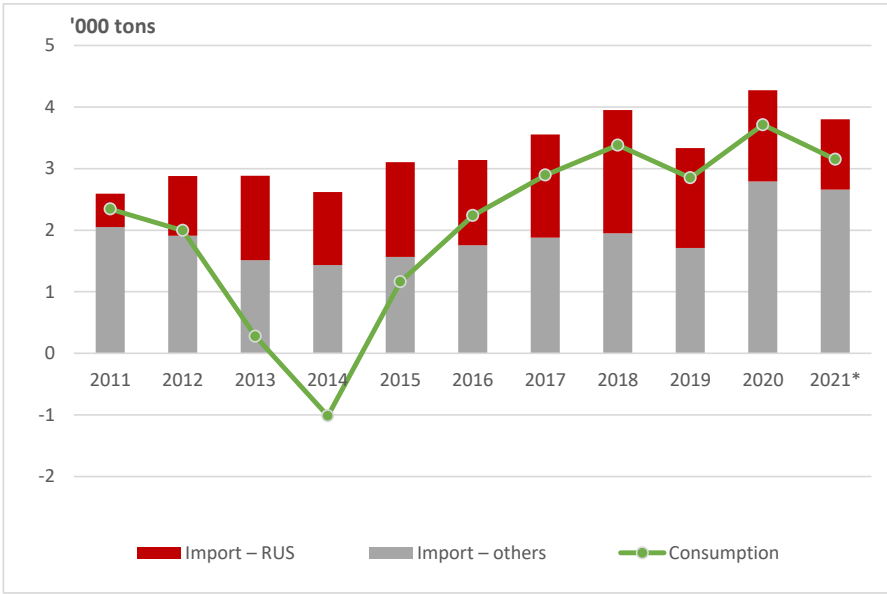

Fig. 6. The supply sources and consumption volume of nickel in Poland, * preliminary data

Rys. 6. Źródła dostaw i wielkość zużycia niklu w Polsce, * dane wstępne

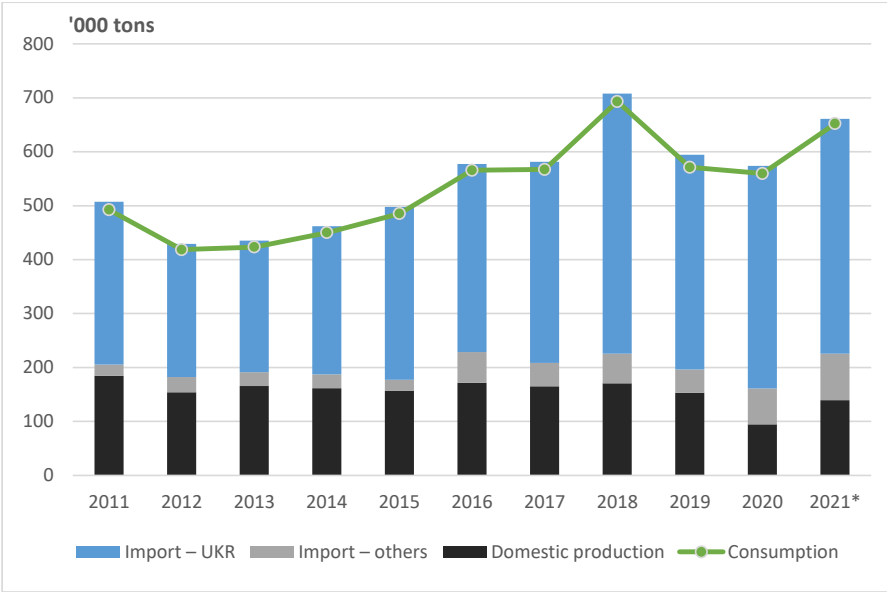

Fig. 7. The supply sources and consumption volume of ball and refractory clays in Poland, * preliminary data

Rys. 7. Źródła dostaw i wielkość zużycia iłów biało wypalających się w Polsce, * dane wstępne

Ogniotrwałych, KSM Surmin-Kaolin) and 50,000–130,000 tons/year of refractory clays (Jaro SA) (Szuflicki et al. 2012–2020). Between 70 and 85% of demand are met by imports, mainly from Ukraine (85–90% of total imports, Figure 7), as well as from the UK, Germany and, more recently, Italy.

2.8. Synthetic corundum

Natural corundum is a mineral that occurs infrequently and is of marginal economic importance (as is the metamorphic rock, emery, in which it is the dominant component); the synthetic corundum (so-called electrocorundum) obtained in electric furnaces is of the primary economic importance. The total demand for electrocorundum in Poland over the past decade has fluctuated in a fairly wide range of 25,000–45,000 tons per year (Figure 8), showing an upward trend until 2018 (Guzik 2015; Resources management... 2021). In Poland, the main user of this commodity is the abrasives industry, represented by companies such as: Saint-Gobain Abrasives in Koło, Andre Abrasive Articles in Koło, Fabryka Tarcz Ściernych in Grodzisk Mazowiecki and Hermes Polska in Gądki near Poznań. Another direction of its use, which has been growing rapidly in recent years, is abrasives in the blast cleaning of, inter alia, glass, stone and metal parts. Subordinately, electrocorundum is used in water-jet cutting technology, where it gives way to garnets, more commonly used for this purpose.

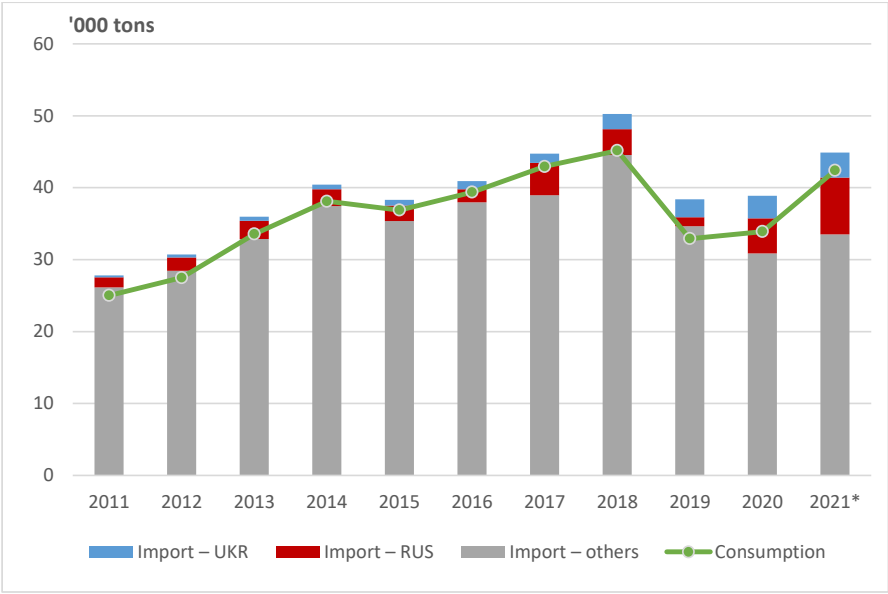

Fig. 8. The supply sources and consumption volume of synthetic corundum in Poland, * preliminary data

Rys. 8. Źródła dostaw i wielkość zużycia elektrokorundu w Polsce, * dane wstępne

In small quantities, electrocorundum is used in the production of corundum refractories – at the Vesuvius Poland plant in Skawina and PCO Żarów – and precision castings, including at Pratt & Whitney Rzeszów.

In the absence of domestic sources, the demand for electrocorundum in Poland is covered entirely by supplies from abroad. In the last decade these deliveries have ranged from 28,000–50,000 tons per year (Resources management... 2021). Typically, 45–60% of electrocorundum came from China, followed by other suppliers, especially in the last few years: Russia (variable share from 4 to 18%) and Ukraine (up to 8%, Figure 8), with the combined share of these countries in imports to Poland recently falling to the 10–25% range. Other traditional suppliers of electrocorundum to Poland are Hungary and Germany (usually 7–8% each). It should also be mentioned that some of the electrocorundum present on the Polish market was re-exported to other countries, including Russia and Belarus.

3. Discussion

According to preliminary data for 2021 (Comtrade 2022; EUROSTAT 2022), an increase in total imports compared to the previous year was recorded for almost all selected raw materials, with the exception of aluminum and nickel (Figures 1–8). The shares of the analyzed countries in the supply of some of these raw materials to Poland have not changed much. The exception was aluminum from Russia (a decrease of the share in total imports to Poland from 47% to 25%). In contrast, synthetic corundum from Russia increased its share in supplies to Poland, from 12% to 17%.

Of the eight raw materials selected for detailed analysis, the most important in terms of the value and scale of supply are the key raw materials for the iron and steel industry, i.e., iron ores and concentrates. It should be noted that in recent years, most of the supplies of iron ores and concentrates to Poland came from Ukraine (about 80%) (Resources management... 2021), which is also the largest exporter of these raw materials to the European market (in 2020, a total of around 40 million tons) (EC 2020b). Before the outbreak of the war in Ukraine, Poland was the third-largest customer of these raw materials, delivered by rail. Most of Ukraine's iron ore and concentrate production is concentrated in the Kryvyi Rih region (Stupnik and Shatokha 2021). In the face of Russian aggression against Ukraine, there is therefore a particular risk of the disruption of their supplies to Poland. The alternative is to import raw materials from Brazil, Australia, Sweden, among others, by sea to ports in Gdańsk, Szczecin and Świnoujście. However, it should be taken into account that in view of the maritime blockade of Ukrainian ports, it may be necessary to perform exports of Ukrainian bulk goods through ports in Poland. Back in June this year, Ukraine's Ferrexpo iron ore mine announced that it was cutting production due to a buildup of iron ore stockpiles and limited barging operations due to damage to infrastructure caused by a Russian missile strike in south-eastern Ukraine (S&P Global 2022a). The company currently conducts all of its sales through the rail network, while holding talks with other Central European

ports. The Kryvyi Rih mines also saw a decline in output of nearly 16% in January–March 2022 alone compared to 2021, and they are prioritizing the search for alternative routes to transport the material (GMK Center 2022). Thus, taking into account the current handling capacity of domestic ports, there is a possible threat of supply piling up and disruptions in the unloading of ships with imported iron ores and concentrates. Another possible solution to mitigate insufficient supplies of primary raw materials is the development of the recycling of iron and steel scrap, which has been relatively low (40% of charge in the production of raw steel, but 60–70% – in the input for cast iron and cast steel manufacturing, Smakowski and Szlugaj 2015).

Around 30% of carbon black on the European market has come from Russia and Belarus or Ukraine. Currently, these sources are largely unavailable. Alternative sources in India are sold out, and the cost of sourcing from China is double that of Russia, taking into account the increase in transportation costs. Nevertheless, there is already a nearly threefold increase in imports of the raw material from China to Europe (ERJ 2022). A noticeable further increase in demand for carbon black in Poland, mainly from the tire industry, is expected in the coming years. The suspension of carbon black supplies from Russia (and to a lesser extent from Ukraine) could cause short-term problems in meeting its needs. It is also to be expected that the recent phenomenon of re-exporting Russian and Ukrainian carbon black from Poland to Western Europe will be halted. In the slightly longer term, the development of domestic production of carbon black and imports from countries other than Russia should be assumed, but the price of carbon black from these sources will undoubtedly be higher than that of Russian carbon black (in long-term contracts, this commodity was very cheap, and therefore it has been re-exported in quite large quantities, i.e. around 60% of domestic supply in recent years). Consumers can therefore expect higher tire prices due to increased costs as well as difficulties in purchasing certain types of tires.

Potash is among the basic raw materials of the fertilizer industry. Withholding supplies of potassium salts from Russia and Belarus in the short term will cause serious disruptions in the Polish mineral fertilizer market in view of the fact that these countries are among the world's largest producers of these raw materials (FAO 2022; RMG Consulting 2022). It should be noted that the package of sanctions imposed by the EU and the US on Belarus (dated March 2022) specifically covered imports of potassium chloride from that country (JRC 2022b). In addition, filling the supply gap in the European market, particularly by Canada and to a lesser extent Germany, may not be achievable in the short term. Certainly, the unit prices of potash purchases from these countries will be much higher. In the long term, it should be taken into account that Poland has significant proven reserves of potassium and potassium-magnesium sulphate-type salts in the Łeba uplift (Szuflicki et al. 2012–2021). However, these were explored more than fifty years ago and require more detailed exploration works and reassessment of their economic value. Nevertheless, they may provide the basis for the development of the production of sulphate potassium salt in Poland in the future. Of marginal importance are small reserves of low-quality chloride-type potash salts in the mined Kłodawa rock salt deposit.

The important raw material of the analyzed group is non-alloyed aluminum. The reduction in supplies from Russia may initially cause some disruption in the Polish aluminum market. It is worth mentioning that European primary aluminum smelters have been forced to decrease production due to the energy crisis that has occurred in 2022 by reducing the supply of Russian natural gas (S&P Global 2022b). In the long term, however, the cessation of aluminum imports from Russia to Poland may be compensated by purchases from other countries, although this may be associated with an increase in the cost of these imports. Moreover, in such a situation, it will be desirable to further develop the domestic recovery of aluminum and its alloys from scrap, while inhibiting their exports.

In the face of Russian military aggression against Ukraine, there is also a particular risk of disruption of supplies from Ukraine to Poland of one of the most important ferroalloys – ferrosilicomanganese, produced at the Nikopol and Zaporozhye plants (JRC 2022a). However, this deficit can be offset by importing more expensive grades of it from, for example, Norway or Slovakia. Similar measures may apply to other ferroalloys, although some specialized ferroalloys (e.g., ferrotungsten, ferrotitanium, ferrochromium) will have to be imported from non-European countries such as China, Brazil and Kazakhstan. This is part of a broader phenomenon resulting from, among other factors, climate policy and energy costs, which caused the gradual reduction of ferroalloy production in European Union countries, with their development in such countries as China, India, South Africa and Brazil (Arens et al. 2021). In the longer term, this fact may also affect Poland's mineral security in terms of the supply of ferroalloys.

The situation is slightly different for nickel. Russia is one of the world's top manufacturers of nickel. The growing demand for this metal in the face of dwindling stocks and concerns about disruptions to its supply due to sanctions imposed on Russia (including the exclusion of Russian banks from the SWIFT system) have caused significant turbulence in the global market and a dramatic increase in its quotations (EC 2022a, 2022b). Therefore, the possibility to expand the recycling of nickel and stainless steel scrap should be developed in Poland (like aluminum, nickel is 100% recyclable).

Among the analyzed raw materials of the ceramic industry, ball and refractory clays are of the greatest importance and can even be described as being crucial. There are currently around forty recognized refractory and ball clay deposits in Ukraine amounting to more than 600 million tons in resources, with most deposits located in the Donbas region, near Donetsk, eastern Ukraine (McDonald 2022). The lack of Ukrainian clay imported in large quantities may cause fundamental supply problems for numerous Polish ceramic tile manufacturers, especially unglazed porcelain stoneware tiles. Kaolinitic clays of similar quality to Ukrainian clays can be imported only from the UK or the USA, at prices that are even several times higher (Galos 2011). Other sources of such clays, both domestic (currently exploited and some potential resources) and foreign (e.g., Germany, Italy, Spain), may offer lower-quality raw materials. There is therefore concern that the lack of kaolinitic clays from Ukraine on the Polish market may result in the temporary reduction of the production of certain types of ceramic tiles and a decrease in the competitiveness of their domestic

manufacturers, which may consequently lead to the need to modify the raw material sets for their production.

Electrocorundum is of particular importance among the raw materials for abrasives and abrasive blasting. To date, the share of supplies of this raw material from Russia and Ukraine in meeting the needs of the Polish economy, although significant (10–20%), is not dominant. The cessation of its supplies from these directions can probably be compensated for by an increase in purchases from other countries. First of all, continued growth in the role of China should be expected (Global Trade 2022), and that of some European countries as well as the development of supplies from outside Europe (Resources management... 2021). The enhanced use of numerous available substitutes is also possible. A reduction in the re-export of electrocorundum from Poland should also be expected. The development of domestic demand for this raw material, mainly from the abrasive blasting industry, is also an open question, which in turn apparently remains dependent upon the situation in the domestic construction industry (in view of the expected reduction in investment in residential, office and industrial construction, including housing).

Conclusions

Russia's hostilities in Ukraine, with the participation of Belarus, are resulting in imbalances in commodity markets. This is due to concerns about shortages of raw materials, especially those necessary for the development of modern technologies and the energy transition. At the outbreak of the war, prices of some raw materials (e.g., aluminum and nickel) had already risen to record levels, even though their availability had not yet been disrupted. At the same time, Ukraine, which is engulfed in war, is experiencing a decline in the extraction of many raw materials, which, on the one hand, is related to a periodic shortage of labour, and on the other, to the limited possibilities of exporting them not only by sea but also by rail, due to regular attempts to destroy the infrastructure. This is especially true for iron ores and concentrates. Any alternatives being introduced in this regard are only temporary. The aforementioned factors have been compounded by sanctions imposed on Russia and Belarus by the EU, other countries in Europe (especially the UK) and elsewhere in the world (the USA). However, it should be clearly emphasized that the EU's sanctions package against Russia has to date only covered energy commodities – oil and coal, iron and steel, and against Belarus additionally potash salts (EC 2022a, 2022b; JRC 2022b).

As a result, shortly after the conflict erupted in March 2022, prices of some metals reached record highs, while stocks dropped to historically low levels. The disruption of supply chains caused by the Covid-19 pandemic and compounded by the war in Ukraine, coupled with the sanctions imposed on Russia, has resulted in the need to diversify purchases of certain raw materials and look for alternatives. While the dependence of European Union countries on oil and natural gas imports from Russia is very acute, shortages of certain metallic raw materials (including iron ore and concentrates, steel, aluminum, nickel, palladium,

titanium), or the persistence of their high prices, could have an equally devastating impact on European industry and the economy (Troll and Arndt 2022). It is worth noting that the EU is also heavily dependent on China when it comes to some metals and rare earths, which are indispensable for the EU's energy transition and digitization. It should be assumed that this country will seek permanent dominance in some sectors in Europe, which is not a favorable phenomenon (Wrede 2022; Yi et al. 2021; Mancheri et al. 2019).

Of the eight selected raw materials imported to Poland mainly from Russia, Ukraine and Belarus, the need to change the direction of supply concerns, to the greatest extent, iron ores and concentrates as well as aluminum and nickel, and in the case of non-metallic raw materials, ball and refractory clays, and potash. These are among the most important raw materials necessary for the proper functioning of the national economy, while a shortage or disruption in the continuity of their supply means a real threat to Poland's mineral security. It is expected that the collapse of their supplies will result in serious problems that will be faced by branches of fundamental importance for the entire national economy, i.e. the steelmaking, ceramics, construction, and fertilizer industries. This may include a decline in production, the stoppage of operation and significant increases in prices charged to the final customer. The supply of the other analyzed raw materials in the domestic market can be provided from alternative directions, which may often involve higher costs, or through substitution. As long as the overall demand keeps rising steadily, more efficient recycling can also mitigate the problem. Nevertheless, periodical shortages in these raw materials deliveries may cause an increase in the product prices on the domestic market.

Changes and supply disruptions that affected the domestic economy, in addition to affecting the local market, will have a strong impact on the competitiveness of Polish producers in Europe and in the world. Strong reshuffles and attempts to take over the markets should be expected. Countries and producers independent of supplies from Russia, Ukraine and Belarus will be in a privileged position. Moreover, the uncertain geopolitical situation and the still extremely restrictive climate policy of the European Union towards its own member states may in the near future result in the disappearance of the production of, for example, ferroalloys in the EU. The only source of supply will then be countries that do not implement restrictions related to the limitation of CO_2 emissions, e.g. China, India and Brazil (Arens et al. 2021). It seems that some of these, such as China, may use the position of dominant suppliers to achieve their own political and economic goals, which do not coincide with the goals of the European Union (Wrede 2022; Mancheri et al. 2019).

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THE RUSSIAN-UKRAINIAN WAR VERSUS THE MINERAL SECURITY OF POLAND

Keywords

Russian-Ukrainian war, mineral security, raw materials dependence

Abstract

This work is an attempt to determine the scale of threats to the mineral security of Poland in the area of non-energy raw materials resulting from Russia's invasion of Ukraine. In particular, it aims to identify those industries whose proper functioning may be threatened in the face of the limited supply of raw materials from three directions – Russia, Belarus and Ukraine. An element of the analysis was also the indication of possible alternative sources of the supply of these raw materials. For this purpose, the directions of imports to Poland of about 140 non-energy raw materials in 2011–2020 were analyzed. As a result, about thirty raw materials were selected, the supplies of which came from, among others, at least one of the three mentioned countries. To determine the raw materials for which the disruption of supplies may have the most serious impact on the functioning of the Polish economy, the following criteria were adopted: a minimum 20% share of these countries in covering the domestic demand in 2020, and a minimum value of these imports in 2020 of 20 million PLN. These threshold conditions were met by eight raw materials: iron ores and concentrates, carbon black, potash, aluminum, ferroalloys, nickel, ball clays and refractory clays, and synthetic corundum. Among these, the need to change the directions of supplies applies to the greatest extent to iron ores and concentrates, aluminum and nickel, while in the case of non-metallic raw materials, it applies most to ball clays and refractory clays and potassium salts. These are among the most important raw materials necessary for the proper functioning of the national economy, but their shortage or disruptions in the continuity of their supplies pose a real threat to the mineral security of Poland.

WOJNA ROSYJSKO-UKRAIŃSKA A BEZPIECZEŃSTWO SUROWCOWE POLSKI

Słowa kluczowe

wojna rosyjsko-ukraińska, bezpieczeństwo surowcowe, uzależnienie od surowców mineralnych

Streszczenie

Niniejsza praca jest próbą określenia skali zagrożeń, wynikających z inwazji Rosji na Ukrainę w zakresie bezpieczeństwa surowcowego Polski w obszarze surowców nieenergetycznych. W szczególności ma ona na celu wskazanie tych branż przemysłu, których właściwe funkcjonowanie może być zagrożone wobec ograniczenia dostaw surowców z trzech kierunków, tj. Rosji, Białorusi i Ukrainy. Elementem analizy było również wskazanie możliwych alternatywnych źródeł zaopatrzenia w te surowce. W tym celu przeanalizowano kierunki importu do Polski około 140 surowców nieenergetycznych w latach 2011–2020. Wyłoniono około 30 surowców, których dostawy pochodziły m.in. z co najmniej jednego z trzech krajów objętych konfliktem. Do wyznaczenia surowców, dla których zakłócenie dostaw może mieć najpoważniejszy wpływ na funkcjonowanie polskiej gospodarki przyjęto następujące kryteria: minimum 20-procentowy udział wymienionych krajów w pokryciu krajowego zapotrzebowania w 2020 r. oraz minimalna wartość importu z tych krajów w 2020 r. – 20 mln zł. Warunki te spełniało 8 surowców: rudy i koncentraty żelaza, sadza, sole potasowe, aluminium, żelazostopy, nikiel, iły biało wypalające się i ogniotrwałe oraz korund syntetyczny. Wśród tych surowców konieczność zmiany kierunków dostaw dotyczy w największym stopniu rud i koncentratów żelaza oraz aluminium i niklu, a w przypadku surowców niemetalicznych – iłów biało wypalających się i ogniotrwałych oraz soli potasowych. Należą one do najważniejszych surowców niezbędnych do właściwego funkcjonowania krajowej gospodarki, natomiast niedobór bądź zakłócenia ciągłości ich dostaw oznaczają realne zagrożenie dla bezpieczeństwa surowcowego Polski.