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Undeveloped deposits of sand and gravel aggregates with potential strategic importance in Poland

Introduction

One of the postulates of the National Raw Materials Policy until 2050 (2022) is the need to designate and protect the strategic mineral deposits in Poland. Their definition was introduced in the amendment to the Geological and Mining Law of June 16, 2023 (Dz.U.2023.2029). According to it, strategic mineral deposits are undeveloped deposits that, due to their importance for the economy or security of the country, are subject to special legal protection. They constitute a potential resource base for the production of mineral raw materials considered to be strategic. Creating a periodically updated list of strategic deposits based on a consistent methodology is one of the activities within the state's raw materials

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policy. It should be mentioned that natural gravel-sand aggregates (as well as crushed aggregates) were recognized in the National Raw Materials Policy (2022) as strategic raw materials for the national economy.

Taking this fact into account, the Authors attempted to create a list of undeveloped deposits that could potentially be considered strategic for producing sand and gravel aggregates in Poland. For this purpose, various methodologies of valorization proposed in recent years, e.g. by Bromowicz et al. (2003, 2004, 2005), Galos et al. (2016), Nieć and Radwanek-Bąk (2013, 2014), Radwanek-Bąk (2002, 2006), Sermet and Górecki (2007), as well as Wołkowicz et al. (2018) have been reviewed. They take into account different sets of criteria, e.g., geological knowledge, volume and quality of resources, geological and mining conditions, and availability of the deposit resulting from environmental and land-use conditions. The results of these analyses significantly differ as they were often adopted for specific groups of raw materials. Bromowicz et al. (2003, 2005) proposed a valorization method for building and road stones in Poland, while Sermet and Górecki (2007) concentrated on factors that determine the geological and mining attractiveness of the deposits (both developed and undeveloped) classified as crushed and dimension stone (2007). Galos (ed. 2009) evaluated the domestic resource base and prospect areas of glass-grade silica sand. In addition to the listed positions, a hard coal and hydrogen deposits valorization methodology was also developed (e.g., by Jureczka and Galos 2010, Uliasz-Misiak and Winid 2013, Nieć et al. 2007). More uniform criteria of valorization were proposed for undeveloped rock raw minerals by Nieć and Radwanek Bąk (2013) and for all recognized (both developed and undeveloped deposits) by Galos et al. (2016) and Wołkowicz et al. (2018). The concept of mineral deposits evaluation proposed by Galos et al. (2016) additionally included prognostic areas with inferred resources.

Regardless of the methodology and adopted criteria, the common goal of all valorizations carried out was the selection of the most valuable deposits that require protection. The broadest approach presents multi-criteria valorizations proposed by Nieć, Radwanek Bąk (2013, 2014), and Galos et al. (2016). Therefore, the authors selected these two methods as the most optimal for analyses of undeveloped domestic sand and gravel deposits. The results obtained in the course of these valorizations will be compared and deposits of potential strategic importance will be indicated.

1. Characteristic of domestic sand and gravel resource base

Poland has an abundant resource base of sand and gravel deposits for the production of mineral aggregates. At the end of 2022, there were 10,999 deposits recognized in this group of the total volume of resources amounted to 20,664.01 million tons (Mineral Resources Datafile, 2023). Sand and gravel deposits are unevenly distributed throughout the country (Figure 1). Voivodeships located in Southern, South-Western, and North-Eastern Poland have the largest volume of these raw materials resources (Figure 1). However, deposits rec-

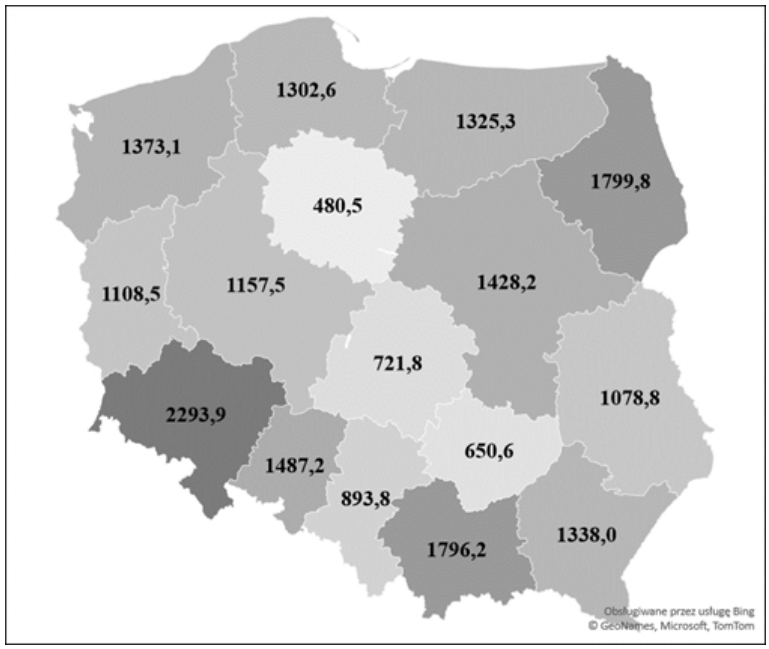

Fig. 1. Resources of sand and gravel deposits in individual voivodeships of Poland in 2022 (in million tons; compiled based on data from Mineral Resources Datafile, 2023)

Rys. 1. Zasoby złóż piasków i żwirów w poszczególnych województwach w Polsce w 2022 r. (w milionach ton)

ognized in the individual regions of Poland strongly varied in terms of the gravel content, and the strong deficit od such aggregates has been regularly reported in central Poland (Galos and Smakowski 2013).

The data on the structure of sand and gravel resources in Poland, published in Mineral Resources Datafile (2023 and previous editions), revealed that the share of gravel in the total volume of domestic resources did not exceed ca. 5% in the year 2015–2022. The majority of recognized resources constituted sand and gravel (however, with a decreasing tendency in that period and a reduction of the share from 53 to 46%) and sand (with an increasing share from 43 to 49%) (Figure 2).

Guzik et al. (2022) indicate that despite abundant domestic sand and gravel resources, the sufficiency index determined for these raw materials reserves does not exceed 23 years. It was calculated as the volume of the total domestic reserves of sand and gravel deposits referenced to the volume of mining output in 2021. It is worth mentioning that there are no other raw materials produced and utilized in Poland on a comparable scale as sand and gravel.

The total volume of raw materials consumption varied from 2003 to 2022 in the range of 48–112 million tons, with the maximum in 2011 (Figure 3; Galos and Lewicka ed. 2022).

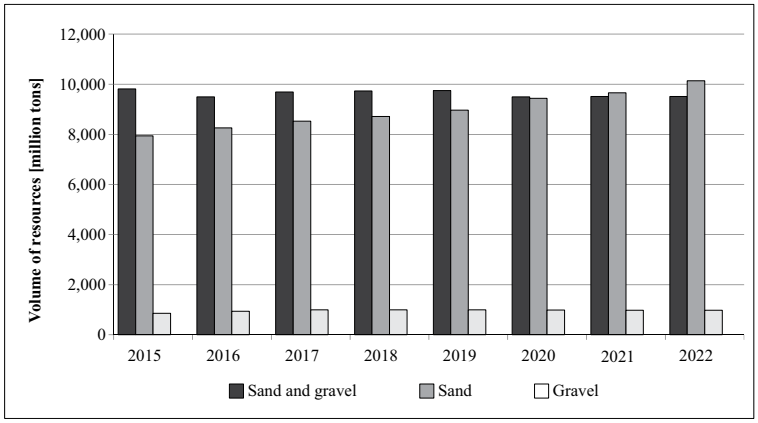

Fig. 2. Structure of sand and gravel resources in Poland in the years 2015–2022
(based on data from Mineral Resources Datafile, 2023 and previous editions)

Rys. 2. Struktura zasobów udokumentowanych w złożach piasków i żwirów w Polsce w latach 2015–2022

These raw materials are crucial for developing the domestic construction industry and realizing any infrastructural investments. At the moment, the demand for sand and gravel in Poland is covered almost entirely by domestic production (Galos, Lewicka ed. 2022; Guzik et al. 2022; Figure 3). Therefore, the selection of deposits of potential strategic importance seems to be a key factor on the path to their safeguarding for future exploitation. These, in turn, will enable to meet increasing industry demand for sand and gravel based on supplies from domestic deposits.

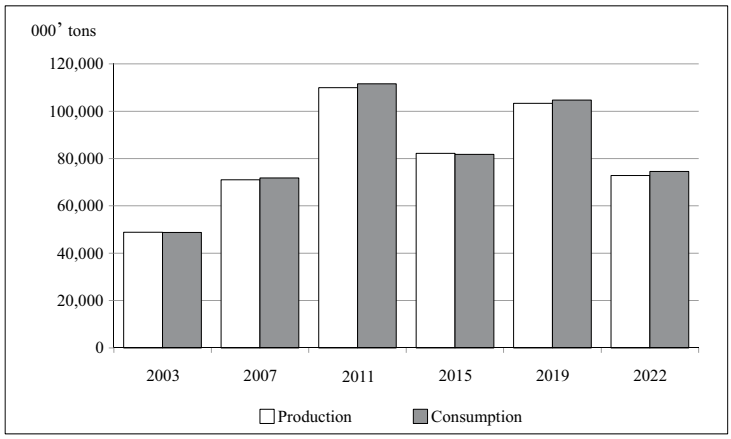

Fig. 3. Volume of sand and gravel aggregates production and consumption in Poland in the years 2003–2022
(own compilation on the basis of data from Statistics Poland, Galos and Lewicka ed. 2022 and previous editions)

Rys. 3. Wielkość produkcji i zużycia kruszyw piaskowo-żwirowych w Polsce w latach 2003–2022

2. Methodology

A selection of the most valuable deposits of potential strategic importance that require protection has been carried out in a few stages, according to the scheme presented in Figure 4. In the first stage, from the total number of recognized sand and gravel deposits in Poland, the largest deposits with the highest quality parameters that meet the threshold for the volume of resources and gravel content were chosen. These deposits will be evaluated using two valorization methodologies in the next step. As a result, deposits of potentially strategic importance have been selected, and the problems specific to the analyzed groups of raw materials have been indicated.

2.1. Criteria of selection of potentially strategic deposits

The domestic resource base of sand and gravel for aggregate production includes 4,110 undeveloped deposits of total resources 12,545,18 million tons (as of December 31, 2022,

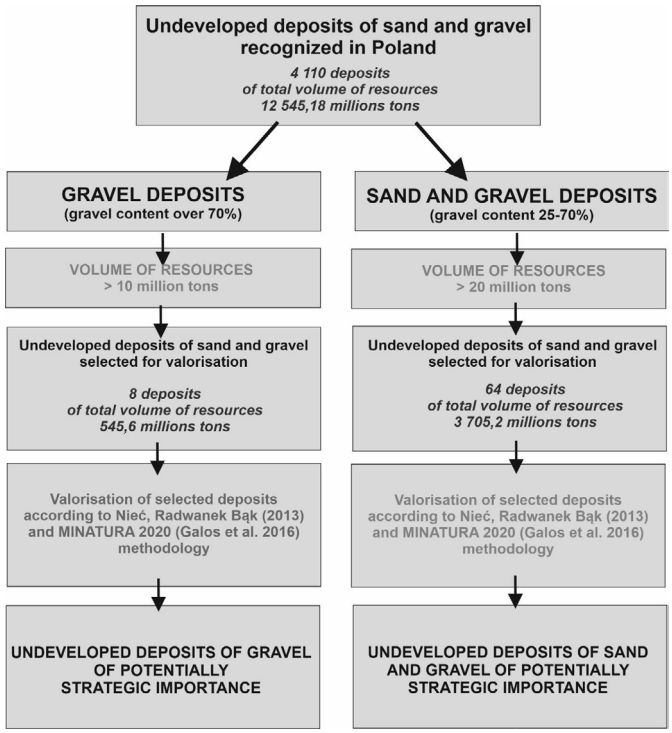

Fig. 4. Scheme of methodology for designation of sand and gravel deposits of potentially strategic importance (the volume of resources calculated as end of 2022 on the basis of Mineral Resources Datafile, 2023)

Rys. 4. Schemat metodyki wyznaczania złóż piasków i żwirów o potencjalnie strategicznym znaczeniu (wielkość zasobów według stanu na koniec roku 2022, obliczona na podstawie danych z BZZK)

Mineral Resources Datafile, 2023). These are primarily small deposits with a volume of resources not exceeding several hundred thousand tons. In order to select deposits of potentially strategic importance, deposits of gravel content above 70% (hereinafter: gravel deposits) and deposits of gravel content of 25–70% (hereinafter: sand and gravel deposits) have been selected according to the division of deposits in the Mineral Resources Datafile. Thresholds for resources have been set separately for each of these groups (Figure 4). In the case of the most valuable gravel deposits, the minimal volume of resources in individual deposits should exceed 10 million tons, and there were only 8 deposits that meet this requirement. However, the total volume of resources recognized in these deposits reaches 545,6 million tons, constituting over 80% of total domestic gravel resources in undeveloped deposits. The threshold set for sand and gravel deposits has been higher as they occur more commonly. For this group of rocks, the volume of resources in individual deposits should exceed 20 million tons. As a result, 64 deposits of total resources of 3,705.2 million tons (representing over 70% of total domestic sand and gravel undeveloped deposits resources) have been selected for further analyses (Figure 4, 5). These deposits of the largest volume of resources have been evaluated according to the methodology of two proposed valorizations in order to indicate deposits of potentially strategic importance.

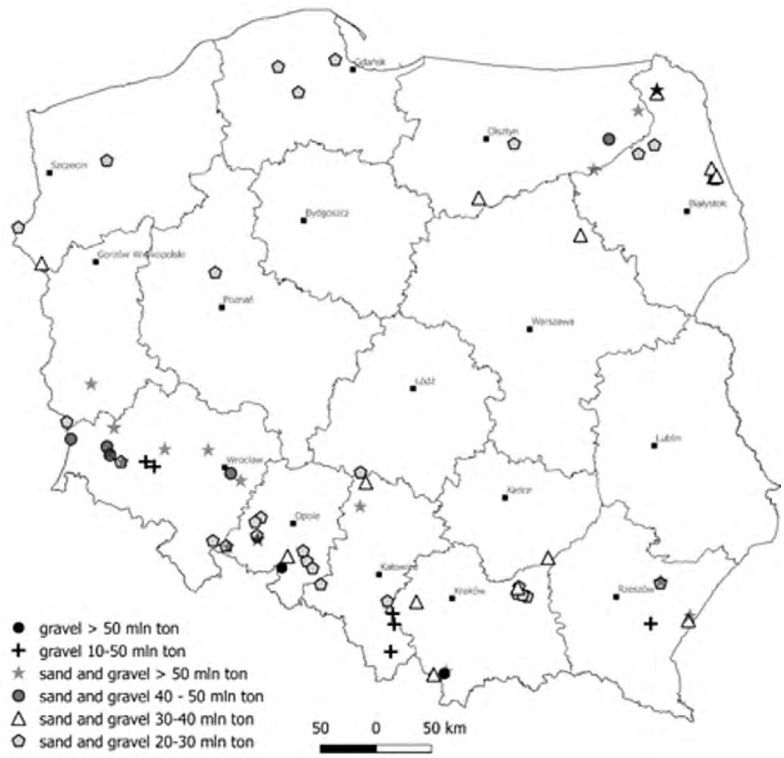

Fig. 5. Location of valorized undeveloped sand and gravel deposits

Rys. 5. Lokalizacja waloryzowanych niezagospodarowanych złóż piasków i żwirów

2.2. Methodology of valorization proposed by Nieć and Radwanek-Bąk (2013, 2014)

The methodology of valorization was developed by Nieć and Radwanek-Bąk (2013, 2014) within the forecast "Strategies and technological scenarios of development and utilization of rock raw materials deposit" (coordinated by the POLTEGOR Institute from Wroclaw). On the basis of the proposed criteria, 5,494 undeveloped sand and gravel deposits listed in the Mineral Resources Datafile have been evaluated (Radwanek-Bąk and Nieć 2013, 2015). The presented methodology consists of four groups of criteria that allow for the creation of a deposits ranking value in each separate domain (Table 1). These are:

- quality and quantity of deposits resources,
- mining conditions,
- environmental conditions,
- land-use planning restrictions.

The first of the presented criteria allows us to indicate the importance of deposits on a domestic scale. Based on resource volume and quality parameters, deposits can be classified into the following categories:

- H – high value – nationally important deposit,
- M – medium value – regionally important deposit,
- C – common – locally important deposit.

The analyzed sand and gravel deposits can belong either to M or C category depending on the threshold for the volume of resources and content of gravel in the deposit presented in Table 1. Deposits of gravel content above 50% and volume of resources meeting the threshold of 5 million tons have been classified in category M, while in the case of deposits of gravel content between 25 and 50%, the volume of resources needs to exceed 20 million tons. Category C includes deposits of gravel content above 50% and volume of resources below 5 Mt as well as deposits of gravel content 25–50% and the volume of resources below 20 Mt. Deposits of gravel content below 25% were not evaluated in the group of sand and gravel deposits, and they were valorized as sand deposits.

The second evaluated parameter, mining conditions, in the approach presented by Nieć and Radwanek-Bąk (2013) is determined by potential difficulties related to future exploitation and includes some transportation aspects (ability to deliver commodity to customers). In the case of sand and gravel deposits that are exploited using the open-cast mining method, the crucial factors influencing the technical conditions are: overburden (thickness of overburden and stripping ratio), water floodings (determining the methodology of exploitation either dry pit or underwater) and complexity of geological settings of deposit (Table 1). On the basis of this criteria, deposits can be classified to 4 categories of mining attractiveness (H – best, M – fair, C – low, X – unsatisfactory). For sand and gravel deposits, only dry deposits or those intended for exploitation from underwater are considered.

The last criteria are related to the accessibility of deposits for future exploitation and include environmental and land use conditions. The first refers to restrictions caused by nature and underground water protection as well as usable groundwater resources, soil, and forest

Table 1. Criteria of undeveloped sand and gravel deposits valorization proposed by Nieć and Radwanek-Bąk (2013, 2014)

Tabela 1. Kryteria waloryzacji niezagospodarowanych złóż piasków i żwirów według Niecia i Radwanek-Bąk (2013, 2014)

Evaluation criteria	Evaluation results		
Quality and quantity conditions			
Volume of deposit resources in Mt	**Rock quality**		
	Gravel[1] content over 50%	Gravel[1] content 25–50%	Gravel[1] content below 25%
>20	M (medium value)	**M (medium value)**	valorized as sand
20–5	M (medium value)	C (common)	
<5	C (common)	C (common)	
Mining and supply conditions			
Overburden thickness			
Stripping ratio	**Thickness of the overburden (m)**		
	<2	2–8	>8 or <8 if built of very hard rock (blasting needed)
<0.5	1 point	2 points	3 points
0.5–1	2 points	2 points	3 points
>1	3 points	2 points	3 points
Geological structure of the deposit	**Geological setting and water flooding of the deposit**		
	Dry pit or underwater exploitation	Deep pit with only rainwater flooding[1]	Deep pit with water flooding from aquifer[1]
Simple	1 point	not the case	not the case
Complex	2 points	not the case	not the case
Very complex	3 points	not the case	not the case
Transport availability	**Location of deposit with respect to access routes and distance to potential delivery points**		
	Close to deposit (sand and gravel < 50 km)	Far (50–100 km)	Very far or lack
Favorable (<10 km to main roads)	1 point	2 points	3 points
Limited (>10 km to main roads)	2 points	2 points	3 points
Lack of local roads	3 points	3 points	3 points

Evaluation criteria	Evaluation results			
Summary of mining criteria evaluation (deposit rating)				
The total sum of points (mining attractiveness)	**3–4 (H – high)**	**5–6 (M – fair)**	**7–8 (C – low)**	**9 (X – unsatisfactory)**
Environmental conditions				
Underground water protection	**Nature and landscape protection**			
	Non	Areas of landscape protection or bordering Natura 2000 areas	Landscape Parks areas Natura 2000 areas	
Non	1 point	2 points	3 points	
Utility aquifer	2 points	2 points	3 points	
The main underground water reservoir	3 points	3 points	3 points	
Soil and forest protection				
Forest protection (% of deposit area covered by forest)	Soil protection (% of deposit area covered by high-quality soil)			
	Soil class IV–VI	Soil class I–III < 30%	Soil class I–III > 30%	
No	1 point	2 points	3 points	
<30%	2 points	2 points	3 points	
30–90%	3 points	3 points	3 points	
>90%	6 points	–	–	
	Summary of environmental criteria evaluation (deposit rating)			
The total sum of points (environmental accessibility)	**2–3 (H – highest)**	**4–5 (M – conditional)**	**6–7 (C – restricted)**	
Housing and industrial land use conditions				
	Terrain built-up to 10%	Terrain built-up from 11 to 30%	Terrain built-up from 31 to 90%	Terrain built-up in over 90%
Classes of deposit accessibility	**H – high**	**M- medium**	**C – restricted**	**X – no accessibility**

[1] In the case of sand and gravel deposits either dry pit or underwater exploitation method can be applied.

protection (Table 1). Regarding land-use conditions, a percentage of deposit area covered by infrastructure (built-up) was the only assessed criterion. In terms of environmental and land use conditions, deposits can be categorized into the following classes of accessibility: H – high, M – conditional, C – restricted, X – no accessibility.

As a result of the valorization procedures performed in the four described stages, a rank of deposits is obtained. Each of the deposits is assigned a four-letter code (e.g., MMHH) referring to the evaluated category in order from quality and quantity of deposit conditions through mining attractiveness to environmental and land-use restrictions.

2.3. Methodology of valorization proposed within the MINATURA 2020 project

The purpose of preparing the concept and methodology of valorization developed in the framework of the MINATURA 2020 project was to indicate the Mineral Deposits of Public Importance (MDoPI). The term 'public importance' was understood as the provision of social and economic benefits to the society that owns or administers such mineral resources (Galos et al. 2016).

According to the MINATURA 2020 project aims, Mineral Deposits of Public Importance (MDoPI) have been distinguished at three levels: EU, country, and regional (Galos et al. 2016). However, the highest (EU) level is not the case when we analyze the rock minerals deposits. Kot-Niewiadomska et al. (2017) and Galos et al. (2018) presented a comprehensive description of the methodology proposed within the project. Therefore, in this paper, we present only major principles of valorization in relation to undeveloped deposits with recognized mineral resources. The valorization of these deposits has been carried out according to the set of criteria in the three dimensions (Table 2). These were:

- geological knowledge (GK) with a constant value of 3 points,
- technical and economical (including geological features, TE) with a total score from 1 to 3 points,
- competing land use (CLU) with a total score from 0 to 4 points.

As a result, we obtained the total score MDoPI, which is a sum of points in the assessed dimensions, ranging from 4.0 to 10.0 points. Taking into account the obtained results of the valorization, deposits of the analyzed raw materials were classified into the following groups:

1. MDoPI-CL (deposits of importance at country level) – MDoPI>9.0 points,
2. MDoPI-RL (deposits of importance at regional level) – MDoPI from 7.5 to 9.0 points,
3. Non-MDoPI (deposit not reaching the threshold set for deposits of domestic importance) – MDoPI <7.0 points.

The methodology developed within the MINATURA 2020 project was tested in some European countries. In Poland, analyses were limited to the Dolnośląskie Province territory and included undeveloped deposits belonging to a selected group of raw materials (magmatic and metamorphic crushed and dimension stone, feldspar raw materials, kaolin, and glass sand (Kot-Niewiadomska et al. 2017). Deposits of sand and gravel have not been analyzed so far, as they have not been taken into consideration in testing procedures within the MINATURA 2020 project.

Table 2. Criteria of undeveloped deposits valorization proposed within the MINATURA 2020 project

Tabela 2. Kryteria waloryzacji niezagospodarowanych złóż zaproponowane w ramach projektu MINATURA 2020

Criteria	Subcriteria	Analysed parameters	Total score
Geological knowledge (GK)	–	Availability and quality of the geological information and knowledge for the area	3.0[1]
Technical and economic dimension (TE)	Mineral quality and quantity (0.5–1.5)	Mineral quality and quantity	1.0–3.0
	Mining attractiveness (0.5–1.5)	For open-pits: overburden thickness, stripping ratio, water flooding, complexity of the geological setting, some transportation issues	
Competing land use dimension (CLU)	Nature protection and underground water protection (0.0–1.5)	Occurrence of national parks, nature reserves, landscape parks, NATURA 2000 areas, landscape protection areas, underground water protection, utility aquifer, main underground water reservoir	0.0–4.0
	Forest protection and soil protection (0.0–1.5)	Occurrence of forest protection areas and high-quality soils	
	Housing, infrastructure and heritage (0.0–1.0)	Existing and planned housing development of a deposit area, transport infrastructure, transmission networks, presence of World Heritage areas and objects of cultural heritage	
Total scoring **MDoPI = GK + TE + CLU**			4.0–10.0

[1] Constant value for all mineral deposits in Poland with recognized mineral resources.

3. Results

3.1. Gravel deposits valorization

The results of valorization carried out according to Nieć and Radwanek-Bąk (2013) methodology for 8 deposits classified to the group of gravel (in two deposits, the content of gravel is slightly lower than 70%; however, according to Mineral Resources Datafile, they belong to gravel deposits) revealed that in terms of quality and quantity conditions, all of them were classified to category M (medium value) and when analyzing mining and supply conditions they obtained the highest grades (H – high, M – fair, Table 3). The result of the assessment of environmental conditions as well as housing and industrial land-use conditions was not as satisfactory as the previous two groups of criteria. Only 3 out of 8 analyzed deposits have the highest rate (H) in relation to environmental accessibility. In contrast, the rest of the deposits have conditional (M) or restricted (C) accessibility. In relation to housing and land-use conditions, only 2 deposits obtained the highest (H) grade, while another 6 deposits have been classified to category M (medium), C (restricted) or X (no accessibility, Table 3).

The majority of deposits valorized using the MINATURA 2020 methodology have been classified as deposits of regional-level importance (MDoPL-RL). Only one deposit has been classified as Non-MDoPI (Table 3).

It is worth highlighting that the conducted study revealed that almost all the analyzed deposits of high gravel content have some limitations in terms of accessibility related either to environmental or land use conditions. Particularly in the case of the largest deposits that occupy a significant land area, more than one constraint usually occurs (e.g., soil and water protection, NATURA 2000 area, infrastructure). Analyzed gravel deposits often occur in the area of usable water protection. One deposit is located within the border of the drinking water reservoir, which excludes the possibility of future exploitation. A road infrastructure (not only local but also major road) in the deposits area is also not an isolated case. It might prevent future exploitation of such deposits (at least partly) and lead to a reduction in the volume of available resources. Some constraints related to land-use conditions are related to housing that is located in some parts of the deposits. There is also one case when, in the central part of an undeveloped deposit, another deposit has been documented and is currently being exploited. In such situations, the resources of this undeveloped deposit also need to be diminished.

Some deposits are located in the area where a portable water reservoir is planned to be built. This creates prospects for the exploitation of such deposits in the future.

Table 3. Results of valorization of undeveloped sand and gravel deposit based on: Nieć and Radwanek-Bąk methodology (2013) and MINATURA 2020 methodology (Galos et al. 2016)

Tabela 3. Wyniki waloryzacji niezagospodarowanych złóż piasków i żwirów na podstawie metodyki Nieć i Radwanek-Bąk (2013) oraz MINATURA 2020 (Galos i in. 2016)

No	Deposit	Voivodeship	The volume of mineral resources (000' tons)	Results of the valorization	
				Nieć and Radwanek-Bąk (2013)	MINATURA 2020 (2016)
Gravel deposits (gravel content over 70%)					
1	Czarny Dunajec	Lesser Poland	380,859	MHMH	MDoPI-RL
2	Racławice Śl.-Głogówek	Opole	57,220	MMCM	
3	Rzymówka-Zbiornik	Lower Silesian	45,690	MHCM	
4	Babice	Subcarpathian	13,264	MMHC	
5	Kobiernice	Silesian	13,185	MHHH	
6	Wieprz	Silesian	12,050	MMMC	
7	Bielany-Nowa Wieś pole A	Lesser Poland	10,542	MHMM	
8	Słup (Zbiornik)	Lower Silesian	12,825	MMHX	Non-MDoPI
Sand and gravel deposits (gravel content 25–70%)					
1	Nowogród Bobrzański-Zbiornik	Lubusz	364,054	MHMH	MDoPI-RL
2	Czarny Dunajec-Zbiornik	Lesser Poland	294,438	MHMM	
3	Legnica-pole Wschodnie	Lower Silesian	281,293	MHMM	
4	Otmuchów-Zbiornik	Opole	110,361	MMMH	
5	Wyszatyce	Subcarpathian	99,059	MMMH	
6	Wincenta-Kumielsk	Warmian-Masurian.	93,375	MMCH	
7	Potasznia[2]	Podlaskie	93,345	MMMH	
8	Lenartowice[2]	Lower Silesian	68,262	MHMM	
9	Bród Nowy VII[1]	Podlaskie	66,678	MHHH	
Sand and gravel deposits (gravel content 25–70%)					
10	Starosty	Warmian-Masurian	57,567	MMHH	MDoPI-RL
11	Potasznia II-1[2]	Podlaskie	55,950	MMMH	
12	Bielanka (p. E)	Lower Silesian	55,919	MHMH	
13	Potasznia II[2]	Podlaskie	54,417	MMMH	
14	Nowa	Lower Silesian	50,554	MMMM	
15	Mokry Dwór	Lower Silesian	46,317	MHMH	

No	Deposit	Voivodeship	The volume of mineral resources (000' tons)	Results of the valorization	
				Nieć and Radwanek-Bąk (2013)	MINATURA 2020 (2016)
16	Lipowskie	Warmian-Masurian	46,004	MMMH	MDoPI-RL
17	Włodzice Wielkie	Lower Silesian	42,764	MMHH	
18	Otok	Lower Silesian	41,364	MMMH	
19	Bielawa Dolna	Lower Silesian	41,220	MHMH	
20	Zofiówka	Swiętokrzyskie	39,058	MMMM	
21	Rębielice Królewskie[2]	Silesian	38,422	MHHH	
22	Bohoniki III	Podlaskie	37,257	MMHH	
23	Jabłonka	Subcarpathian	35,068	MMMH	
24	Wał Ruda-Zabawa	Subcarpathian	33,782	MHMM	
25	Starowlany	Podlaskie	33,342	MCHH	
26	Zaborowo	Greater Poland	31,342	MCMM	
27	Kuków XII	Podlaskie	30,852	MHHH	
Sand and gravel deposits (gravel content 25–70%)					
28	Namyślin	West Pomeranian	31,028	MHCH	MDoPI-RL
29	Kierpień	Opole	30,379	MMCH	
30	Bielanka (p. W)	Lower Silesian	28,752	MHMH	
31	Częstkowo Pole A i Pole B	Pomeranian	26,969	MHHC	
32	Białe Ługi	Lesser Poland	25,810	MHMM	
33	Otmuchów-Zbiornik I	Opole	25,251	MHMH	
34	Bielice-Zbiornik 1	Opole	25,086	MHCH	
35	Szymany	Podlaskie	24,882	MCCM	
36	Turze	Silesian	24,417	MMCH	
37	Poborszów	Opole	24,278	MHCH	
38	Bojszowy II	Silesian	23,092	MHCH	
39	Gąsiorowo	Warmian-Masurian	22,257	MMCH	
40	Gracze	Opole	22,212	MMHH	
41	Bobrowniki-Skałka	Lesser Poland	22,058	MHMM	
42	Kobylice IV	Opole	21,528	MHMH	

No	Deposit	Voivodeship	The volume of mineral resources (000' tons)	Results of the valorization	
				Nieć and Radwanek-Bąk (2013)	MINATURA 2020 (2016)
43	Topola-Śrem	Lower Silesian	20,964	MHMH	MDoPI-RL
44	Sanice	Lubusz	20,754	MMCH	
45	Wólka Ogryzkowa	Subcarpathian	20,499	MMHH	
46	Brzeźnica II	Lesser Poland	20,048	MMMH	
47	Bielice-Zbiornik	Opole	322,679	MHCM	Non-MDoPI
48	Trzebień-Zbiornik	Lower Silesian	86,346	MMCH	
49	Siedlce	Lower Silesian	80,866	MHCH	
50	Kuleje	Silesian	64,134	MMCH	
51	Drogoszów	Opole	54,914	MMCH	
52	Ubieszyn	Subcarpathian	52,110	MHHM	
53	Bolestraszyce	Subcarpathian	37,260	MHCH	
54	Kamionka-Drahle[2]	Podlaskie	36,996	MCHH	
55	Rozkochów	Lesser Poland	35,397	MMCM	
56	Rostki-Borowce p. S	Masovian	31,925	MMCH	
57	Zdarzec	Lesser Poland	29,751	MHMM	
58	Kozin	Pomeranian	27,988	MMCH	
59	Kamionka-Drahle 3	Podlaskie	26,363	MHMH	
60	Dobropole I	West Pomeranian	25,781	MHMH	
61	Węże	Łódź	23,230	MHCH	
62	Bielinek IV pole A	West Pomeranian	22,932	MMCH	
63	Woźna Wieś	Podlaskie	22,824	MCMM	
64	Krępna	Opole	21,230	MMCM	

[1] Mining licence issued in 2021.
[2] Partly within boarder of other deposits.

3.2. Sand and gravel deposits valorization

The results of valorization carried out according to Nieć and Radwanek-Bąk (2013) methodology for 64 deposits classified to the group of sand gravel revealed that in terms of

quality and quantity conditions, all of them were classified to category M (medium value, Table 3). In terms of mining and supply conditions the most deposits have been classified to the highest categories (H – 30 deposits, M – 29 deposits). Only 5 analyzed deposits had low mining attractiveness (C category), and no deposit was classified as the lowest category X (unsatisfactory). Favorable conditions in terms of environmental accessibility of deposits have been confirmed only in the case of 12 deposits classified to the highest (H) category, while another 30 deposits have some limitation resulting from environmental constraints and have been classified to category M (conditional). A significant part of the analyzed deposits (22 deposits) have some serious constraints related to environmental conditions and have been classified to the lowest category C (restricted). In terms of land-use conditions, most deposits have been classified into category H (highest accessibility – 47 deposits) or W (medium accessibility – 16 deposits). Only one analyzed deposit has been classified to category C (restricted), and no sand and gravel deposits have been classified to the lowest category X (no accessibility).

Most deposits valorized using the MINATURA 2020 methodology have been classified as deposits of regional level importance (MDoPL-RL). Out of 64 analyzed deposits, 18 were classified as Non-MDoPI (Table 3).

Most of the analyzed deposits have some serious limitations regarding accessibility related to environmental conditions. They often result from the need for water protection, nature and landscape protection. Many deposits have been located in the valleys of rivers. Analyzed sand and gravel deposits have often been recognized as separate fields of different environmental and land-use conditions. Moreover, there is often a situation in which some parts of larger deposits have been separated and recognized as new deposits which have been currently exploited.

Conclusions

According to Geological and Mining Law (Dz.U.2023.2029) a mineral deposit is recognized as a strategic if, due to the land use development, there is access to the deposit and: the mineral deposit is of fundamental importance for the country's economy or the state's raw material interests, or

- the mineral deposit has an above-average amount of resources for a given mineral,
- the mineral contained in the deposit is characterized by unique parameters.

The selection of strategic deposits based on consistent methodology should constitute a coherent source of information for all administrative bodies that carry out tasks within their competencies in the raw material area. Availability is one of the basic conditions of national raw materials security, and at the same time, a country's economic development also includes securing the population's demand for building raw materials (Radwanek-Bąk et al. 2020).

On the basis of the results of conducted valorization using both methods, there are only eight deposits of regional importance (MDoPI-RL) and favorable environmental and land-use conditions (Table 3). These are:

- One gravel deposit (Kobiernice),
- Seven sand and gravel deposits (Bród Nowy VII, Rębielice Królewskie, Kuków XII, Starosty, Bohoniki III, Gracze I i Wólka Ogryzkowa). It is worth mentioning that the mining license for the Bród Nowy VII deposit has already been issued.

The valorization carried out according to the methodologies described in the article required an additional individual analysis of each deposit, highlighting the challenges faced in determining strategic deposits. The study revealed that most undeveloped domestic sand and gravel deposits of the highest quality (in terms of gravel content) and the largest volume of resources have limited accessibility due to environmental or land-use conditions (or both). The specificity of sand and gravel deposits is also related to their origin and, therefore, location (e.g., in river valleys), which requires a deeper analysis of local conditions. Additionally, several problems and aspects that are not taken into account in any of the valorization methods are indicated. Deposits with the largest resources usually cover large areas, which increases the complexity of environmental and spatial conditions. Most often, they occur in different parts of the deposit, significantly reducing the surface area without restrictions on use. Moreover, there are numerous cases when deposits of significant volume of resources are divided into a few separate fields with different land accessibility. These fields are often located a considerable distance from each other, preventing potential exploitation in a compact area. There are also some examples of large deposits from which smaller parts have been divided and exploited. Often, the part exploited within the boundaries of this new deposit is located in the central part of the original deposit, at the same time, taking advantage of the lack of availability restrictions. In such cases, the volume of resources should be verified and reduced. Conditions in the immediate vicinity of the deposit also require analysis, especially if it is adjacent to an already exploited deposit.

It needs to be highlighted that the designation of deposits of strategic importance at the country/regional level needs to be, in each case, preceded by comprehensive analyses of documents related to spatial planning and geological documentation of deposits in terms of quality and quantity of resources. This information requires to be regularly updated. A criterion of valorization needs to be adopted for sand and gravel deposit specificity, and the volume of resources available for exploitation in individual deposits should be verified.

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UNDEVELOPED DEPOSITS OF SAND AND GRAVEL AGGREGATES WITH POTENTIAL STRATEGIC IMPORTANCE IN POLAND

Keywords

strategic deposits, sand and gravel aggregate, undeveloped deposits, valorization

Abstract

The paper presents the results of the valorization of sand and gravel aggregate deposits in Poland. The study aims to identify the most valuable deposits of potentially strategic importance that require protection. Undeveloped gravel deposits (gravel content above 70%) with resources exceeding 10 million tons and sand and gravel deposits (gravel content 25–70%) with resources above 20 million tons were selected for analysis. The valorization of deposits was carried out using two multi-criteria methodologies. The first of them was proposed by Nieć and Radwanek-Bąk (2013, 2014), while the second one was developed as part of the MINATURA 2020 project (Galos et al. 2016). They include criteria regarding a degree of geological knowledge, raw material quality and quantity, mining attractiveness,

and the accessibility of deposits for future exploitation resulting from environmental and land-use conditions. Out of 4,110 undeveloped deposits that constitute the national resource base for producing sand and gravel aggregates, only 8 gravel deposits and 64 sand and gravel deposits exceeded the threshold set for the volume of resources. As a result of the valorization, it was determined that most of the analyzed deposits, which can be considered as deposits of potentially strategic importance at the regional level, have limited availability due to environmental and land-use conditions. Only one gravel deposit and 7 sand and gravel deposits have simultaneously high resource quantity and quality and favorable geological and mining, environmental, and land-use conditions. The article also presents some recommendations regarding the need to adapt the valorization criteria to the specificity of deposits recognized for sand and gravel aggregate production.

NIEZAGOSPODAROWANE ZŁOŻA KRUSZYW PIASKOWO-ŻWIROWYCH O POTENCJALNYM ZNACZENIU STRATEGICZNYM W POLSCE

Słowa kluczowe

złoża strategiczne, kruszywa piaskowo-żwirowe, złoża niezagospodarowane, waloryzacja

Streszczenie

W artykule przedstawiono wyniki waloryzacji złóż kruszyw piaskowo-żwirowych w Polsce. Celem badań była identyfikacja najbardziej cennych złóż o potencjalnie strategicznym znaczeniu, które wymagają objęcia ochroną. Do analizy wytypowane zostały niezagospodarowane złoża kruszyw żwirowych (zawartość żwiru powyżej 70%) o zasobach powyżej 10 mln ton oraz złoża kruszyw piaskowo-żwirowych (zawartość żwiru 25–70%) o zasobach 20 mln t. Waloryzacja została przeprowadzona przy użyciu dwóch wielkokryterialnych metodyk oceny złóż, z których pierwsza zaproponowana została przez Niecia i Radwanek-Bąk (2013, 2014), a druga opracowana została w ramach projektu MINATURA 2020 (Galos i in. 2016). Ocenie podlegają w nich kryteria dotyczące stopnia rozpoznania budowy geologicznej, walory surowcowe kopaliny (wielkość i jakość zasobów), atrakcyjność górnicza oraz dostępność złóż dla potrzeb ich przyszłej eksploatacji wynikająca z uwarunkowań środowiskowo-przestrzennych. Spośród 4 110 niezagospodarowanych złóż stanowiących krajową bazę zasobową do produkcji kruszyw piaskowo-żwirowych tylko 8 złóż żwirów oraz 64 złoża piasków i żwirów przekroczyło wyznaczony próg zasobów. W wyniku przeprowadzonej waloryzacji ustalono, że większość analizowanych złóż, które mogą być rozważane jako złoża o potencjalnym znaczeniu strategicznym na poziomie regionalnym, posiada ograniczoną dostępność z uwagi na uwarunkowania środowiskowe i planistyczne. Tylko jedno złoże żwirów oraz 7 złóż kruszyw piaskowo-żwirowych posiada jednocześnie korzystne walory surowcowe, geologiczno-górnicze, środowiskowe oraz planistyczne. W artykule przedstawiono rekomendacje dotyczące potrzeby dostosowania kryteriów waloryzacji do specyfiki złóż udokumentowanych w grupie piasków i żwirów wykazujących przydatność do produkcji kruszyw.