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Some problems of sustainable management of mineral resources in Poland

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Abstract. Management under the framework of sustainable development requires a change in the attitude to ongoing activities, as well as a new value hierarchy in which, instead of direct profit, improvement of the well-being of individuals and societies comes into prominence. In the paper the ways aimed at satisfactory solutions in the case of mining activity are presented. Some difficulties and restrictions are also shown on the example of Polish mining. Owing to the existence of large mineral resources, modern equipment, and services supporting mining activities, Polish mining has long traditions. The future forecast shows the necessity of finding a reasonable compromise which allows for the development of sustainable mining.

Key words: mineral resources, Poland, environmental-spatial planning, sustainable mining.

INTRODUCTION

Poland is a country with a considerable and varied base of mineral resources and with abundant mining traditions dating back to prehistoric times. The oldest evidence of the usage of mineral resources concerns the production of stone tools, use of natural pigments (e.g. hematite-based ones), extraction of clay for ceramics production, use of earth materials and – later – stone materials for building houses.

Another industry with long traditions dating back to the 1st or 2nd century is ferrous metallurgy. Its first centre in the Polish lands was the Staropolski Industrial District in the Świętokrzyskie (Holy Cross) Mountains. It is based on several mineral deposits of iron ore located nearby. Rock salt excavation dates back as far as the 12th century. Already in the 13th century, an underground salt mine was established in Wieliczka near Kraków, and a few years later, a similar one was opened in Bochnia, only about 30 km away. Both mines continued operating until the last years of the 20th century, and at present are being used as museums and underground health spas. Since the 12th century, galena ores have been excavated and used to extract silver and lead in the area of Olkusz near Kraków, whereas gold and hard coal have been excavated in the west of the country, in Lower Silesia. Native sulphur excavation in the surroundings of Kraków, in Swoszowice, also has a long history, dating back to the 15th century. However, the exploitation of native sulphur deposits flourished in the second half of the 20th century, when one of the world's largest deposits of this mineral was discovered in the Tarnobrzeg region. Table 1 illustrates the milestones of Polish prospecting geology and mining development.

PRESENT STATE OF THE MINING INDUSTRY

At present, the Polish resources register includes more than 9000 identified and documented deposits of 51 minerals (Przeniosło 2007). Deposits in the register are of different size and importance, yet the largest group consists of commonly found deposits of sand and natural gravel aggregates (Table 2). The mining activities are regulated by the Mining and Geological Law.

The main condition for predicting the development of the mining industry is evaluation of the size of the resources base. During this evaluation, the following factors have to be considered: the quality of the minerals, sizes of deposits, geological and mining conditions, and the accessibility of the deposits. The last element becomes more and more important considering the growing conflicts in spatial planning, related to the development of these areas and to other limitations resulting from nature, landscape, and cultural heritage protection. Another group of factors also need to be defined, namely, the economic and market conditions, including the development of the demand for particular mineral resources both in global and national markets, the resulting profitability of mining, utilization of new deposits, and constructing new mining facilities (Table 3).

The output of energy minerals, especially hard and brown coal and natural gas, will largely depend on the trends in world markets. In terms of coal, the rate of demand in Asian countries, particularly in China and India, will be of the highest importance. Hard coal and, notably, brown coal will remain an important energy mineral also in Poland, and its supply will be of great significance for the Polish power industry for many years to come. Regarding hard coal, a serious threat to the

Table 1. Milestones in Polish prospecting geology and mining

Date	Event	Region of Poland
1st–3rd centuries	Opencast and underground flintstone mining	Opatów area
1st–4th centuries	Iron ore mining in the Staropolski Industrial District	Holy Cross Mts
1121	First information about lead mining	Cracovian–Silesian District
1253	Beginning of rock salt mining in the underground salt mine in Wieliczka	Kraków area
1290	Establishment of the salt mine in Bochnia	Kraków area
1415	Native sulphur mining in Swoszowice	Kraków area
1740	Discovery of brown coal deposits and building of the first opencast brown coal mine in the current Polish lands (in Poland since 1945)	Turoszów area
1740	Establishment of the first hard coal mine	Upper Silesia
1822	Beginning of zinc and lead ore exploitation in the underground mine at Bolesław	Olkusz area, Cracovian–Silesian District
1854	Beginning of crude oil exploitation in Bóbrka – the first in the world crude oil mine	Gorlice–Krosno–Sanok area
1857	Start of the first crude oil refinery in the world	Jas o-Krosno area
1941	Discovery of brown coal deposits in the surroundings of Konin (1941–1945 excavated by German miners, since 1945 excavation developed in Poland)	Central Poland
1947	Discovery of the salt plug in Kłodawa, building of a mine and the start of mining operations	Central Poland
1953	Discovery of native sulphur deposits in the region of Tarnobrzeg	Tarnobrzeg area
1956	Opening of the first opencast mine of native sulphur in Piaseczno	
1957	Discovery of copper ore deposits in the regions of Lubin and Polkowice	Fore-Sudetic Monocline
1959	Establishment of integrated mining and metallurgy enterprise for copper ore – KGHM	Fore-Sudetic Monocline
1967	Beginning of borehole mining of native sulphur in Jeziórko	Tarnobrzeg area
1967	Discovery of hard coal deposits at Łęczna in the Lublin Basin	Borderland between Poland and Ukraine
1975	Beginning of an opencast mine and start of excavation in Bełchatów	
1982	Start of the underground mine “Bogdanka” and of excavation activity	Borderland between Poland and Ukraine

further development of this sector of the mining industry is the depletion of its resources in the deposits that are currently being mined. At the present output level, it is estimated that the reserves of the existing mines will suffice for just a few more years. Therefore, it is necessary to start mining investments on new deposits in this area and build new mines. As to natural gas, which is imported by Poland, a continuous increase in output is still expected, taking also into account the necessity of diversification of energy sources. The development of the mining of metal ores, especially copper, zinc, and lead, will be influenced by the economic situation and prices in world markets. The development of metal ores mining in Poland can only be considered a short-term prospect because of the depletion of resources. This concerns particularly the deposits of zinc and lead ores, where the extractable resources are estimated to suffice at most for 5 years. In this case, similarly to the hard coal mining industry, it is necessary to render a new reserve deposit, in order to ensure further excavation of metal ores. The copper ore reserves are assessed to suffice for about 30 years, given the present mining output level.

Rock raw materials deposits are an important element for the future development of the mining industry in Poland. This group includes various sorts of minerals, mostly classified as common and including sand, gravel, common (brick) clays, and different lithological types of solid rocks, used as dimension and crushed stones in

Table 2. Resources of the most important raw materials in Poland (in 10^6 tonnes; as of 31 December 2006)

Minerals	Number of deposits		Intrinsically economic resources		Extraction
	Total	Exploited	Total	Exploited	
Energy sources					
Natural gas	258	184	143.26*	113.33*	5.26*
Crude oil	82	66	23.95	20.44	0.78
Lignite	76	10	13 660.82	1 852.49	60.84
Hard coal	135	47	41 996	15 350	89.34
Metallic raw materials					
Zinc and lead ores	21	3	168.58	29.47	4.30
Copper ores	14	6	1 961.30	1 579.20	25.90
Chemical raw materials					
Native sulphur	18	5	523.06	34.27	0.82
Rock salt	19	5	80 722.34	11 735.12	4.01
Industrial minerals and rocks					
Gypsums and anhydrites	15	5	268.07	97.17	1.35
Common clays	1 207	288	1 988.06**	248.77**	2.40**
Crushed and dimension stones	590	240	8 414.87	3 964.40	36.60
Natural aggregate	5 649	2 143	14 824.68	3 414.25	116.69
Glass sand	30	8	597.25	215.85	1.97
Peat	208	89	75.84	48.36	0.98
Limestone and marls for the cement and lime industry	183	40	18 237.57	6 032.02	34.07

* in 10^9 m^3, ** in 10^6 m^3.

Table 3. Future forecast of the mining development in Poland

Raw material	Resources, economic and spatial planning conditions	Forecast
Crude oil	Limited resources, mostly small deposits and old mines	Limited development
Natural gas	New resources and discoveries are possible, no economic and ecological restrictions	Moderate development
Hard coal	Decreasing reserves in the active mines – some new mines are necessary to be built, reorganization of the mining sector, ecological limitations	Status-quo, stabilization of the output level in the future
Lignite	Extensive identified resources, ecological restrictions	Good conditions despite restrictions, necessary development
Cu ores (+ Ag, Au, Ni, Re, Se)	Limited resources	Economic reserves sufficient for about 30 years
Zn–Pb ores	Economic reserves depleted, closure of active mines is expected in 5 years	Exploitation almost finished, management of reserve deposits necessary
Rock salt	Large identified resources	Stable or increasing production
Natural aggregates, dimension and crushed stones, ceramic common (brick) clays	Large resources on a country scale but shortage in some regions, many strong ecological restrictions, decreasing availability of deposits due to nature protection and land-use planning factors, good economic and market conditions	Increasing environmental and land-use conflicts, stable or increasing output despite of constrains, strong development during 5 years (natural aggregates)

the construction and road building industry (e.g. basalts, diabases, amphibolites, gneisses, gabbros, quartzites, melaphyres, porphyries and keratophyries, serpentinites, limestones, sandstones, and dolomites), as well as in the cement and lime industry (limestones and marls). The geological resources of most of these minerals are large, but they are unevenly distributed in different regions of Poland, which sometimes causes their local shortage. Rock mineral deposits occur in the subsurface zone and are suitable for opencast mining. This fact triggers diverse conflicts related to the development of the areas above the deposits. Over the past few years, the accessibility of deposits for future exploitation has decreased drastically. This concerns both the prospected or explored but still unused deposits and other areas with mineral deposit prospects. This situation is a result of the fast development of built-up areas and permanent infrastructure (transport infrastructure, power supply infrastructure, etc.), accompanied by investment pressure in attractive areas. Although regulations have been adopted, stating that mineral deposits should be included in spatial land use planning documents, they do not ensure proper protection and do not guarantee the accessibility of deposits for exploitation. The reasons for such a situation are (1) the ownership of mineral deposits found in the subsurface zone is connected with the ownership of land (mostly they are private properties) and (2) the decisions regarding land development planning are made on the lowest level of local government administration, on the level of commune (*gmina*) and often depend on local lobbies and particular interests.

Another source of conflict and limitations for the development of opencast mining is the growing requirements of nature and landscape protection (Radwanek-Bąk 2005). It is well known that mining activities, and especially opencast excavation, cause topographic and landscape transformations and affect the natural environment. Minimizing these negative effects is nowadays a norm, and mining entrepreneurs are obliged to take comprehensive actions to reduce or compensate for the effects of exploitation on the environment and the inconvenience suffered by local residents. There are several good examples of minimizing negative effects of open-pit mining and reclamation of post-mining areas (Figs 1, 2).

However, these effects are often exaggerated and the restrictions of nature protection are inadequate for the scope of the existing or planned excavations. It seems that mining is discriminated in a way when compared to other forms of human activity, which, despite their strong impact on the environment, are more acceptable for local communities.

PROPOSED MEASURES FOR SUSTAINABLE MINING

So what is the future of mining? The only reasonable solution is sustainable mining and sustainable management of mineral resources. It means that mining activities should be reconciled with the principles of sustainable development. This statement concerns all stages of deposit usage and management, from the documentation phase, through the exploitation phase to the processing of the output and utilization of the final raw materials, including recycled materials.

In the field of geology the following measures could be suggested:

1. elaboration of environmental management principles in the areas where minerals are extracted:
   – geological studies and pre-feasibility studies considering the environmental factors;
   – environmental impact assessments;

Fig. 1. Large sand and gravel open-pit mine near Ostróda (North Poland).

Fig. 2. Example of reclamation of post-mining areas: morphology rebuilding and planting – Kalbornia sand and gravel deposit near Ostróda (North Poland).

2. inventory of mineral deposits and their resources and registration of the mining areas;
3. classification and valorization of the deposits according to:
   - their recent and future protection (accessibility);
   - possible conflicts between their management, environment, and land use planning;
4. compilation of the geological–economic–environmental maps of Poland (on a scale 1 : 50 000);
5. promotion of activities for mineral waste utilization (investigations and tests, preparation of maps showing the location of dumps of mineral waste useful for road construction, etc.);
6. identification and assessment of the anthropogenic mineral deposits.

In the field of mining activity the possible solutions include:

1. decreasing negative impacts of mining;
2. reasonable management and utilization of mineral resources;
3. protection of the unutilized mineral reserves in abandoned deposits for the future development;
4. reclamation and redevelopment of mining sites and post-mining areas;
5. geodiversity protection:
   - development of geoparks in post-mining areas;
   - elaboration of geotourism attractions and/or geosite studies.

During the last decade considerable progress has been made in Poland in the implementation of sustainable mining rules, but reaching the compromise in some conflict areas seems to be a long-term process.

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Maavarade jätkusuutliku haldamise mõnest probleemist Poolas

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Jätkusuutliku arengu kontseptsioonist lähtuv maavarade haldamine nõuab suhtumise muutumist toimuvatesse tegevustesse ja uut väärtushinnangute skaalat, mis otsese kasu asemel peaks oluliseks üksikisikute ning ühiskonna heaolu parandamist. Artikli peamiseks ülesandeks on esitada tegevusviise, mis viiksid rahuldavate tulemusteni kaevandamisega seotud juhtumite lahendamisel. On käsitletud ka mõningaid raskusi ja piiranguid, mis on seotud ühe Poola kaevandusega. Mäetööstusel on Poolas pikaajalised traditsioonid, mis tuginevad maavarade rikkalikele varudele, heale tehnilisele varustatusele ja kogenud kaevurkonnale. Tulevikuhinnangud näitavad vajadust leida eri huvide vahel mõistlik kompromiss, mis tagaks maavarade kaevandamisel jätkusuutlikkuse.