

KRZYSZTOF SZAMAŁEK*

Rational mineral deposit management in the light of mineral resources theory

Introduction

Year 2011 is characterized by an extraordinary dynamics of growth in prices of most mineral commodities, including those (gold, copper), whose prices are known to rise during world financial crises. Is such rise in mineral commodities prices a proof for reserve depletion, unbalanced mineral economy (Bachowski et al. 2009; Szamałek 2008) or is it a purely economical phenomenon? Is a rational management of mineral resources ever more needed and, as suggested by Nieć (2006), possible? Rational extraction of mineral deposits and their legal protection, as well as functioning of legal instruments, have long tradition in Poland (Dulewski, Sowa 2007), which have been amply discussed in literature (Kozłowski 1989; Ney 1971, 2001; Nieć 2003, 2006; Radwanek-Bąk 2007). Rational mineral resources management is therefore a concept used, discussed – and yet insufficiently well defined. In this paper, it is assumed that this term means a continuous process of improving the rules for extracting and preserving of mineral resources, rather than a single legal measure.

Mineral deposits can be defined as natural accumulations of mineral resources which are exploitable in both technical and economical terms. Extraction of mineral resources is a continuous process of exploring and using of new resources, in most cases under successively worse geological-mining conditions and thus more expensively (cf. the 1817 Ricardo paradigm).

Mineral commodities (reserves), even though increasingly expensive to extract, are still available. Still, Malthus' claim (1798) that there are physical limits to humanity's

* Professor, Faculty of geology, University of Warsaw, Warszawa, Poland; Instytut Ceramiki i Materiałów Budowlanych, Poland; e-mail: krzysztof.szamałek@uw.edu.pl

development, beyond which its needs cannot be met, is valid. This view – explored further in the reports produced by the Club of Rome – is the basis for the static natural resources theory (resources viewed as depleteable, restricted, damageable). Some of the premises behind this theory need to be critically analysed: has any mineral resource been found lacking, in spite of intensive economic growth the world has witnessed in the past 200 years? Is viewing mineral resources as depleteable correct? How is the R/P of basic resources formed? What is the scenario for mineral resources access in the next 500 years?

The static theory is true in a specific, yet long-distant chronological perspective. Still, it is argued here that during the next several hundred years, mineral resources will be still readily available. This argument is formed on the basis of a different model, the dynamic natural resources theory (Dembowski 1989; Szamałek 2007a).

The static and dynamic theories lead to different conclusions concerning the strategy and long-term goals for resources management. Any resource-theory should consider technological development, which leads to shifting the definition of renewable and non-renewable resources (cf. the developments in the 19th century; Szamałek 2007a). The widely-accepted view is that mineral (abiotic) resources are depleteable, whereas organic resources (biotic) are not. If, however, this opinion was to be closely investigated, other conclusions could have been reached, especially if one considers changes over time and human activity (Szamałek 2007a). Ensuring access to mineral resources does not absolve from the necessity of conducting a rational management of mineral deposits. There is therefore a need for new legal, and especially economical instruments, which would ensure meeting the new rules of rational mineral resources management.

1. Are mineral resources being depleted?

It may appear that there is only one possible answer to this question – yes, mineral resources are constantly being depleted through their extraction. In considering this issue, one may take one of two standpoints which can be, somewhat simplistically, called pessimistic and optimistic (Kicki 2011). There is no doubt that mineral resources will be eventually depleted – yet the more important question is when we can expect this to happen. The dynamics of world mineral commodities consumption is caused by the increase of human population needs. The world economy forecast for consumption of energy shows that economic growth ought to rise mostly in OECD countries (Fig. 1). Additionally, the prospected structure of energy supply is composed mostly of natural gas, oil as well as coal – it can be thus expected that the structure of energy resources will change only slightly (Fig. 2). However, when we look at a world balance of mineral resources in a longer perspective, it appears well-balanced, both in the case of basic energy minerals as well metals and others (Bilans 2011; USGS). The supply/demand balance needs to be analyzed from a global perspective, since local, seasonal or national variations may skew the overall picture.

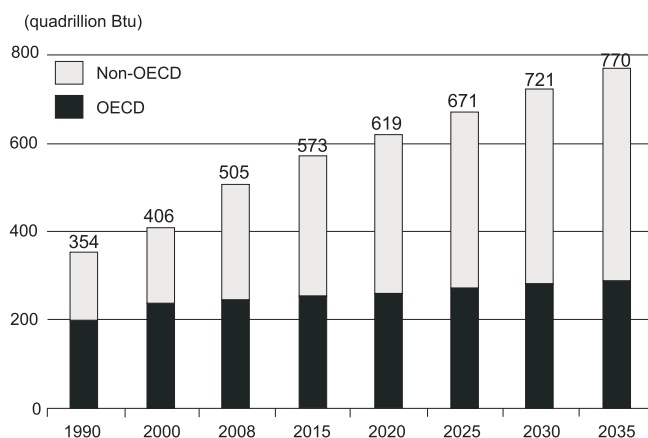


Fig. 1. World energy consumption 1990–2035 (US EIA)

Fig.1. Światowe zużycie energii 1990–2035 (US EIA)

Exajoules per year

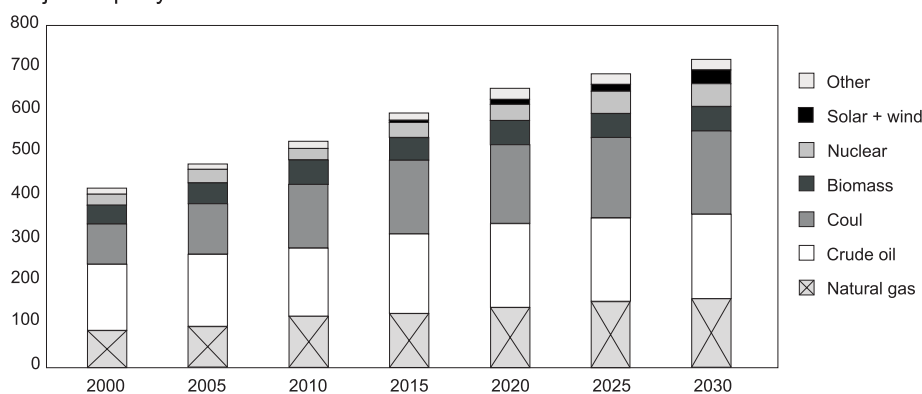


Fig. 2. World-total Primary Energy Supply (US EIA)

Fig. 2. Łączna światowa produkcja energii według źródeł pochodzenia (US EIA)

The general view from the global perspective shows that the resources/production ratio (R/P) for several types of mineral resources are on the same, or similar level as they were 50 years ago – e.g. crude oil reserves in 1961 were calculated to last for the next 41 years. Similarly, the predictions made in 2010 assert that oil resources will last for another 46,2 years (Kicki 2004; BP 2011). A selection of metallic commodities particularly important to world economy show a slight decrease of R/P ratio (Table 1), but recent information about discoveries of new nickel ores deposits (lateritic Ni-ores in Indonesia – Konopka, Szamałek 2011 and primary sulphide deposits – <http://www.mining.com>) shows that new resources continue to be identified. Therefore, even after several decades, the mineral sufficiency is on a similar, and in fact even slightly higher, level. This is due to several factors: discovery of new mineral deposits, mineral substitution, recycling, technological

TABLE 1

The R/P world ratio for selected metals (data from USGS)

TABELA 1

Wartość parametru R/P wybranych metali (wg USGS)

Metal	1987	2008
Copper	39	36
Nickel	63	46
Cobalt	125	111
Indium	15	19

development which allows exploring resources with ever-lower contents of the desired ore or from deeper and more complicated geological formations, new uses for resources hitherto not used or used only in a limited way, exploiting mineral co-products, extracting low-quality resources and exploiting multi-mineral raw material deposits. It is necessary to emphasize that consumption and depletion of mineral reserves reduces proportionally, whereas mineral resources grow by leaps and bounds (Fig. 3).

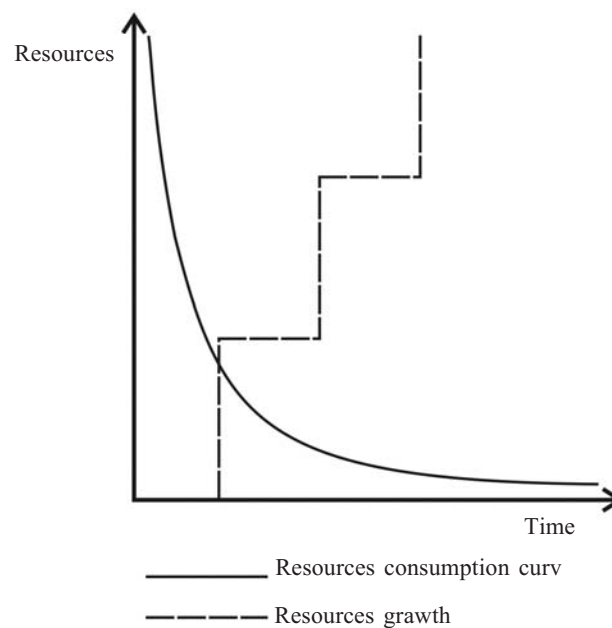


Fig. 3. Relationship between changes in deposits caused by consumption (–) and effect of geological prospecting (+)

Fig. 3. Zależność zmian w zasobach spowodowanych konsumpcją (–) oraz efektem poszukiwań geologicznych (+)

It can be assumed that even though mineral deposits were created through geological processes, they “become” deposits through human activity (searching for new mineral concentrations and assessing their quantity, ever-expanding knowledge and improving technical expertise). Mineral deposits are, in a short term at least, unlikely to be depleted.

Moreover, since the consumption of products is growing, and the period in which they remain in use is shorter, the minerals used for their production can sooner be reclaimed through recycling (chiefly of metallic minerals) (Fig. 4).

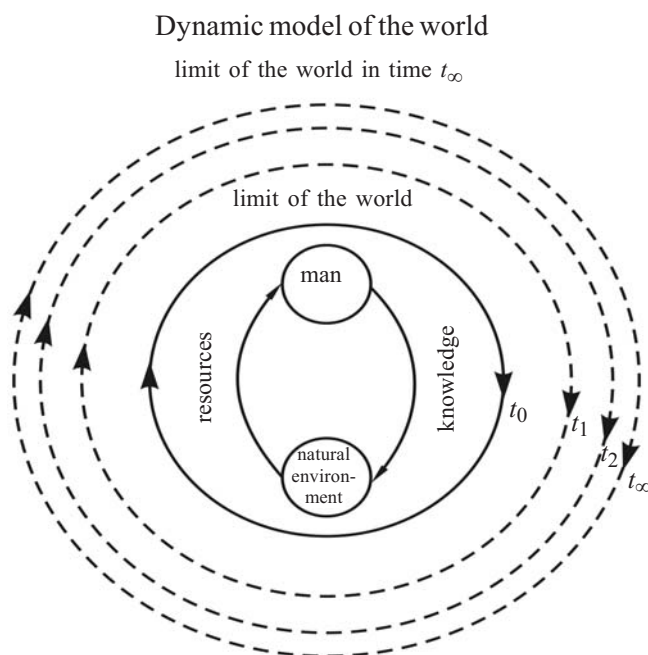


Fig. 4. Deposits as the result of human knowledge (after Krajewski 1982)

Fig. 4. Zasoby jako rezultat wiedzy człowieka (wg Krajewski 1982)

Additionally, humanity has still not tapped the rich resources of the seabed (Mizerski, Szamałek 2009). It appears that in spite of years of on-going research, mineral resources of seas and oceans are still known insufficiently. This applies in particular to polymetallic massive sulphides ores (Szamałek et al. 2011), Co-rich crusts, metalliferous clays or methane gas hydrates. The deposits of crude oil and gas in seas and oceans are still poorly known in the deeper parts of the oceans. Seabed minerals constitute a possible new source for mineral commodities. Marine mineral resources occur in the bedrocks beneath the ocean floor, the ocean floor itself, in the sea water and in the shallow, coastal zones.

The overall improvement in resource-access may lead some to thinking that rational extraction of mineral resources is unnecessary. This, however, is a wrong view; there is no alternative to rational mineral resources management. The call for rational management is based on the broader idea of sustainable growth. Since the Rio de Janeiro conference (1992),

the guidelines for sustainable growth (among them e.g. inter-generation justice, managing “borrowed resources”; Tilton 2003) are accepted world-wide, and in some countries, such as Poland, are among the goals set by the constitution. The need for sustainable growth is dictated by both the need for avoiding the Malthusian crisis as well as the widely-accepted views on humanity (Legowicz 1991).

There can be little doubt that there is a number of constraints in mineral access. These factors can be classified as follows: technical, environmental, economical, social, deposit-related.

Proper understanding of each of these constraints should allow undertaking actions which will ease their impact. Ultimately, mineral-access constraints can be expected to be local/ regional, temporal, qualitative and price-related.

2. Mineral Deposit Management vs consumption of mineral resources

On the one hand, the rational utilization of natural resources is based on economical and environmental considerations, on the other – it is shaped by the law. Rational resource management is inseparably connected to the issue of protection of both managed and as yet unmanaged mineral deposits. The legal protection of mineral deposits (an idea introduced in Poland already in the 1930s) is regulated not only by geological and mining law (1994, 2011), but also by other bills (Prawo ochrony środowiska 2001 – Environment Protection Law; ustawa o planowaniu i zagospodarowaniu przestrzennym 2003 – Land Use Planning and Space Management Law) as well legal acts (mainly regulations introduced by the Ministry of Environment concerning the deposit development plan, technical and economic criteria for deposit development as well as preparing of geological study).

In spite of wide literature on the rational management of mineral deposits, there is no widely accepted and legally sanctioned definition of this term. All views on this issue have a descriptive and postulatable character.

Since 1989, when Poland reintroduced market economy, the crucial goal of investors has been to receive positive economic results of mineral extraction. Each decision related to managing mineral resources must have an economical reason, connected with the profitability of exploitation. The existing legal regulations concerning mineral deposit management are relatively easy to circumvent. Some investors ignore legal requirements, as it allows to make additional profit. Developing of accompanying minerals and co-occurring useful trace elements, managing of mineral wastes, by-products and multi-mineral deposits will be done more efficiently when investors will be stimulated to do so by relevant economical instruments. Mining investors must enjoy financial profits from widening their activity. Legal and economic instruments might be employed when deciding on the exploitation fees on particular resources, rewards for establishing of mining usufruct agreement, local tax rates or tax allowance in company income taxes on mining (CIT). It appears that the role of

economical instruments in mining development has been abandoned too soon (Szamałek 2001a, b; Szamałek et al. 2003). We are now in a good moment to recommence this discussion and come with conclusions acceptable to all parties involved.

The currently existing rules of Geological and Mining Law do not contain legal measures which could protect undeveloped mineral deposits or areas likely to contain mineral resources sufficiently well. This problem is discussed with urgency by Professor Nieć, the head of the Sustainable Resource Management Committee Polish Academy of Sciences, who suggests passing a new bill to protect undeveloped deposits (Nieć, Radwanek-Bąk 2011). It is possible that such legal instruments could be implemented to new geological and mining laws. The author of this paper supports integral, holistic legal acts, which deal with issues in their entirety, rather than with their particular aspects in individual bills. The latter model makes the law difficult for the business, local government bodies and the citizens, and leads to creating unclear, and sometimes incoherent laws.

Rational mineral deposits management is the main field of study for mineral economy (Bolewski, Gruszczyk 1980; Szamałek 2007b) and one of the key areas of concern of the Ministry of Environment, the body responsible for the country's geological resources, as well as the Ministry of Economy, which regulates the extraction of resources by the business. These two ministries should therefore play a chief role in rational deposits management process.

In between 1994 and 1995, the Ministries of Environment and Economy – which at that point bore different names – prepared a document called *Guidelines for Mineral commodities state policy (Założenia polityki państwa w dziedzinie surowców mineralnych)*, passed in 1996 by the Cabinet of Poland. A similar solution should be prepared today. The issue of resources is ever-more widely discussed and better understood in Poland as well as in the EU (Galos, Smakowski 2008; EU 2010; Radwanek-Bąk 2011). Such process should be initiated by the Minister of Environment.

A pragmatic and rational management of mineral deposit should lead to such practices, in which the quality of the mineral is adequate to quality of requested mineral commodity used in production processes. In other words, the mineral commodity should meet minimum quality criteria. Using minerals characterized by higher-than-minimal features is an example of non-rational mineral resources management (but may be recognized as rational mineral deposit management). The problem of non-rational use of minerals having better quality parameters for production of low-grade products was discussed by Wyrwicka & Wyrwicki (1992). Their suggestion was to establish a link between the extraction fee with the quality of the extracted mineral and, more importantly, with utilizing of extracted mineral for named product.

A good solution of rational mineral deposit management is introduction of well balanced practice of state agencies as well mining investors. In mineral managing, which constitute a common good, one cannot pay attention solely to economical considerations. The controlling and stimulating role of the state is above any current economical interests of the mining business. Geologists, economists, mining investors, miners and representatives of

local governments need to debate the directions and possible changes in the economy of mineral resources. The author of this paper believes that such debates were lacking in the past years when new mining and geological law was being prepared.

Conclusions

A rational management of mineral resources, including management of mineral deposits, is necessary and should be undertaken by both the state and the mining industry. The history of world supply and demand of mineral resources suggests that the dynamic model of resource accessibility could be adopted, even with a long chronological perspective of up to several hundred years in mind. The static theory of unrenovable resources is objectively right, just as the view of the inevitability of the ultimate end of the entire universe we inhabit. In both cases, it is essential to consider the timeframe in which one operates. In both cases, the ultimate ends are in distant future, although the perspective of depleting natural mineral resources is admittedly many times closer than the end of the planet. Mineral access constraints are likely to be of regional/local, temporal, qualitative and price-related character. In the perspective of the next several hundred years, a global mineral resource crises is unlikely to happen, as technical progress and research open up new, previously untapped mineral deposits. Great quantities of minerals are to be found and extracted from the seabed, deeper parts of Earth crust, industrial mineral refuse, and through recycling.

Legal instruments ought to be used mostly to protect undeveloped but documented deposits as well as areas with potential deposits. Additionally, appropriate legal means ought to be used to regulate the licensing process (prospecting and exploring licence).

During licensing process for resource extraction, it is necessary to put more emphasis on economical instruments (tax allowances for licence fee, extraction fee, mining useful agreement, income tax, local taxes).

It is also crucial to begin discussing a code for searching and exploiting mineral resources, which would constitute a coherent collection of legal measure regulating all issues pertaining to the goal of rational resources (deposits) management. The Ministries of Environment and Economy should work to prepare a national strategy for managing mineral resources which would consider the processes and actions of the EU.

The paper was presented during Conference “Sustainable production and consumption of mineral resources – integrating the EU’s social agenda and resource efficiency”, supported by the National Fund for Environmental Protection and Water Management.



REFERENCES

- Bachowski C., Kudełko J., Szamałek K., Worsa-Kozak M., 2009 – Wpływ fazy cyklu gospodarczego na światowy rynek poszukiwań geologicznych. Mat. Konf. Aktualia i perspektywy gospodarki surowcami mineralnymi. Ryto, listopad 2009.
- Bilans gospodarki surowcami mineralnymi Polski i świata 2009. IGSMiE PAN, Kraków, 2011.
- Bolewski A., Gruszczyk H., 1989 – Geologia gospodarcza. Wyd. Geol., Warszawa, 320 s.
- BP Statistical Review of World Energy. 2011. www.bp.com
- Dembowski J., 1989 – Zarys ogólnej teorii zasobów naturalnych, PWE Warszawa, 224 s.
- Dulewski J., Sowa A., 2007 – Ochrona zasobów złóż kopalni w Polsce – teoria i praktyka. [W:] Mat. XVII Konferencji Aktualia i perspektywy gospodarki surowcami mineralnymi, Sympozja i Konferencje nr 71, s. 9–36, IGSMiE PAN.
- EU 2010. Critical raw materials for the EU – Report of the Ad-hoc Working Group on defining critical raw materials. EU Commission Enterprise and Industry. 2010.
- Galos K., Smakowski T., 2008 – Nowa polityka surowcowa krajów Unii Europejskiej w obszarze surowców nieenergetycznych. Gospodarka Surowcami Mineralnymi t. 24, z. 4, s. 76–89.
- Kicki J., 2004 – Wystarczalność surowców mineralnych – wystarczalność zasobów złóż – historia i aktualia. Gosp. Sur. Min. t. 20, z. spec. 1, s. 45–60.
- Kicki J., 2011 – Czy wystarczy nam surowców mineralnych? Portal Trybuny Górniczej, <http://nettg.pl>
- Krajewski W., 1982 – Prawa nauki: przegląd zagadnień metodologicznych i filozoficznych. Książka i Wiedza.
- Konopka G., Szamałek K., 2011 – Mineral Expert's Report on Exploration Results and Inferred Resources on Nickel laterite deposit in Halmahera Island, Indonesia. Report prepared for Halmahera Resources Perkasa (unpublished).
- Kozłowski S., 1989 – Ochrona złóż kopalni użytecznych. Gosp. Sur. Min. t. 5, z. 1, s. 129–171.
- Legowicz J., 1991 – Człowiek istota ludzka. DW Sz. Szymański, s. 396.
- Mizerski W., Szamałek K., 2009 – Geologia i surowce mineralne oceanów. PWN Warszawa, 212 s.
- Ney R., 1971 – Racjonalna gospodarka surowcami mineralnymi i ochrona ich zasobów. Zesz. Nauk. AGH, Sozologia 1, s. 121–156.
- Ney R., 2001 – Ochrona złóż i zasobów kopalni. [W:] Przemiany środowiska naturalnego a ekorozwój. Kotarba M. (red.), s. 73–83, Wyd. Geosfera, Kraków.
- Nieć M., 2003 – Problemy ochrony złóż kopalni. Prz. Geol. 51, 10, s. 870–875.
- Nieć M., 2006 – Czy w Polsce możliwa jest racjonalna gospodarka złożami kopalni? Górn. Odkryw., r. 48, nr 1–4, s. 57–62.
- Nieć M., Radwanek-Bąk B., 2011 – Propozycja ustawowej ochrony niezagospodarowanych złóż kopalni (artykuł dyskusyjny). Bezpieczeństwo pracy i ochrona środowiska w górnictwie Miesięcznik WUG nr 7 (203) 2011, s. 12–17.
- Prawo geologiczne i górnicze 1994. Ustawa z dnia 4 lutego 1994. Dz.U. z 2005 r. Nr 228, poz. 1947, z późn. zm.
- Prawo geologiczne i górnicze 2011. Ustawa z dnia 9 czerwca 2011 r. Dz.U. nr 163, poz. 981.
- Prawo ochrony środowiska 2001. Ustawa z dnia 27 kwietnia 2001 roku. Dz.U. z 2008 r. Nr 25, poz. 150, z późn. zm.
- Radwanek-Bąk B., 2007 – Kierunki i bariery ochrony zasobów kopalni. [W:] Mat. XVII Konferencji Aktualia i perspektywy gospodarki surowcami mineralnymi, Sympozja i Konferencje nr 71, s. 213–227, IGSMiE PAN.
- Radwanek-Bąk B., 2011 – Zasoby kopalni Polski w aspekcie oceny surowców krytycznych Unii Europejskiej, Gosp. Sur. Min. t. 27, z. 1, s. 5–19.
- Szamałek K., 2001a – Kopaliny towarzyszące – wydobywanie, składowanie i zbywanie w świetle obowiązującego prawa. Górn. Odkryw. XLIII, nr 2–3, 2001, s. 1–9.
- Szamałek K., 2001b – Studium opłaty eksploatacyjnej w gospodarce złożem kopaliny. Wyd. Naukowe Scholar, 2001, 130 s.

- Szamałek K., 2007a – Kopaliny i surowce mineralne w świetle teorii zasobów naturalnych. [W:] Mat. XVII Konferencji Aktualia i perspektywy gospodarki surowcami mineralnymi, Sympozja i Konferencje nr 71, s. 327–334, IGSMiE PAN.
- Szamałek K., 2007b – Podstawy geologii gospodarczej i gospodarki surowcami mineralnymi. PWN Warszawa, 266 s.
- Szamałek K., 2008. Cykle koniunkturalne a strategie działania w sektorze mineralnym. Gosp. Sur. Min. t. 24, z. 2/4, 2008, s. 51–64.
- Szamałek K., Jędrzejewska A., Wiśniewski W., 2003 – Zmiana funkcji opłaty eksploatacyjnej w prawie geologicznym i górniczym. *Górnictwo Odkrywk.* r. 45, nr 6, s. 9–12.
- Szamałek K., Marciniowska A., Nejbort K., Speczik S., 2011 – Sea-floor massive sulphides from the Galapagos Rift Zone – mineralogy, geochemistry and economic importance. *Geol.Quarterly*, 55 (3): 187–202.
- Tilton J.E., 2003 – On borrowed time? Assessing the threat of mineral depletion. *Resources for the future*. Washington D.C.
- USGS <http://minerals.usgs.gov/minerals/pubs/commodity/>
- Ustawa o planowaniu i zagospodarowaniu przestrzennym z dnia 27 marca 2003 roku. Dz.U. Nr 80, poz. 717, z późn. zm.
- Wyrwicka K., Wyrwicki R. 1992 – Wartość gospodarcza kopalni ceramiki budowlanej jako podstawa wysokości opłaty koncesyjnej i eksploatacyjnej. *Prz. Geol.* nr 6 (470), s. 353–359.
- <http://www.mining.com/2011/11/04/anglo-american-discovers-huge-nickel-deposit-in-finland>
- Założenia polityki państwa w dziedzinie surowców mineralnych. Dokument zaakceptowany przez Radę Ministrów RP w dniu 14 maja 1996 r.

RACJONALNA GOSPODARKA ZŁOŻEM W ŚWIETLE TEORII ZASOBÓW MINERALNYCH

Słowa kluczowe

Zasoby mineralne, surowce mineralne, racjonalna gospodarka zasobami kopalni, statyczna i dynamiczna teoria zasobów

Streszczenie

Cywilizacja techniczna wymaga stałego dostępu do złóż kopalni stanowiących źródło surowców mineralnych. W analizie zasobów surowców uwzględnić należy statyczny lub dynamiczny model zasobów. W obu jednak przypadkach pożądane jest prowadzenie racjonalnej gospodarki surowcami mineralnymi. Racjonalna gospodarka surowcami nie jest pojęciem w pełni zdefiniowanym, lecz jest ciągłym procesem doskonalenia przepisów prawa oraz dostosowywania techniki i technologii do zagospodarowania złóż kopalni. Na różnych etapach zagospodarowania zasobów należy stosować adekwatne instrumenty prawne bądź ekonomiczne. Istnieje potrzeba opracowania przez ministrów środowiska i gospodarki strategii kraju w zakresie wykorzystania surowców mineralnych uwzględniającej rozważania i decyzje podejmowane w ostatnich latach w Unii Europejskiej. Należy dążyć do odpowiedzi na pytanie jak długo ludzkość może wykorzystywać zasoby mineralne. Gdzie i kiedy pojawi się końcowa granica zasobów mineralnych? Autor wyraża opinię, że w dającej się przewidywać przyszłości ludzkości nie zabraknie zasobów mineralnych, bowiem następuje stały rozwój wiedzy, nauki i techniki, co dostarcza nowych zasobów kopalni do gospodarczego wykorzystania.

RATIONAL MINERAL DEPOSIT MANAGEMENT IN THE LIGHT OF MINERAL RESOURCES THEORY**Key words**

Mineral resources, mineral commodities, rational mineral deposit management, static and dynamic resources theory

Abstract

Modern civilization requires constant access to mineral resources. In analysing of the amount of available resources, one can approach it with either a static or dynamic resource model. In both cases, however, it is a key to manage resources rationally. Rational resource management is not a well-defined concept; it is rather an ongoing process of law improving and adapting the technology to particular resources. Different phases of resource management require different economical and legal tools. There is a need for a state-wide strategy for mineral resources extracting, which would consider the discussions and decisions made by EU in recent years. It is necessary to determine how long the mineral resources will be sufficient. The author presents his opinion that in a predictable time horizon the limits of mineral resources will not be met, since an ongoing development of knowledge, science and technique continuously extends the number of mineral deposits suitable for economic extraction.

