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SUSTAINABLE DEVELOPMENT OF MINING MINERAL RESOURCES

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Abstract

This paper describes mineral resources and the demand for them, taking into account the dynamics and global trends in the economy of raw materials. It presents the importance of mineral resources in the development of the world economy, and the importance of mineral resources that are critical for economic development. The main assumptions presented in this paper are the main assumptions that relate to the sustainable development of the mining sector, the ones that will significantly shape the development of mining in the future.

Key words

mineral resources, sustainable development of mining, mining mineral resources

1. INTRODUCTION

The concept of sustainable development is now a widely used term in many areas of activity related to the life of man. It appeared in the second half of the twentieth century as a reaction to the dynamic economic growth seen in many countries around the world, which was often observed in conditions of excessively intensive and uncontrolled use of natural resources. Therefore, to reduce this unfavourable phenomenon for the world, at the end of the 1960s, a report from the World Commission on Environment and Development of the United Nations called *Our Common Future* was published in 1987. The committee who wrote it was chaired by Gro Harlem Brundtland, hence this report is often defined as the Brundtland report. The essence of this document states that to ensure the further existence of life on Earth, and the possibility of meeting the basic needs of all its people, and those of future generations, it is essential to have sustainable development for all the areas of life and human activity (WCED 1987). It should be emphasised that in Poland the principle of sustainable development gained constitutional status and its definition can be found in the Environmental Protection Act.

The broadest definition of the concept of sustainable development is included in the 27 Principles of Sustainable Development contained in a document signed at the Earth Summit, held in 1992 in Rio de Janeiro. The event was attended by representatives from 172 governments, and 2400 non-governmental organizations. In the matters concerning the future of the world, this document very clearly indicates that there are indispensable new ways to invest in the future in order to achieve, in the twenty-first century, global sustainable development. It also stresses the need for cooperation in the creation of a sustainable economy in the industry

of acquiring mineral resources, and the creation of new technologies for their use.

The implementation of sustainable development means the integration of activities in the following three key areas, namely (Fig. 1):

- technical and economic activities ensuring economic growth
- ecological, ensuring the protection of natural resources and the environment
- social, meaning care for the employee at the workplace and community development in the area of the mining environment

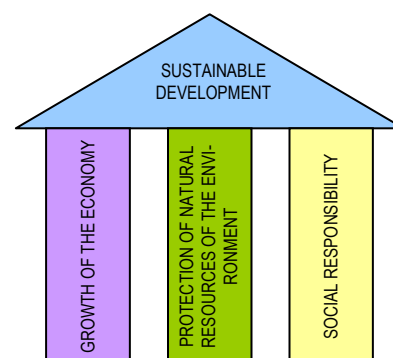


Fig. 1. Elements that create the term of "sustainable development"

It should be emphasised that sustainable development is, in any case, an ongoing process, and not a temporary undertaking. It has clearly defined goals and means of achieving them, in all of the above mentioned key areas (Dubiński, Turek, Wachowicz 2007). It is assumed that these areas are of equal importance. Hence, the emphasis on one area usually leads to a crisis across the entire area of mining activity.

Economic growth means achieving long-term sustainability both in regards to planned production volumes, and in meeting the needs of customers, as well as achieving economic efficiency obtained from the sale of the excavated mineral.

Protection of natural resources and of the environment means concern for the bed and the protection of its resources by its rational acquisition, which is characterised by savings in its depletion. This also means taking measures that minimise the negative impact of the different processes related to the extraction of mineral resources on the various forms of the geological environment and natural environment on the surface.

Social responsibility, taking into consideration the nature of the mining environment, this means above all ensuring safe working conditions, but also concern the social aspects of mining, including the families of miners, the mining environment, etc.

The most important aspects of the above key areas will be discussed further in this paper – the pillars for the sustainable development of mining, and the use of natural resources in the form of minerals. Each of them is made up of a wide and constantly increasing range of problems, the solutions bring this important industry closer to achieving the objectives of ensuring full sustainability. It is a challenge which requires multi-directional support from the side of science and the mining industry. Currently, the basic tools for such support include methods and technologies developed within the scope of Earth sciences and mining sciences.

2. RATIONAL ACQUISITION AND USE OF NATURAL RESOURCES

Analysing the meaning of the term ‘sustainable development’, it should be noted that it gains particular resonance in the case of mining that is activity connected with the acquisition of various kinds of natural resources. An integral feature of this activity is the fact that it applies to non-renewable resources. Thus, the first and guiding principle of sustainable development must be the reasonable and economical acquisition and use of mineral resources (Dubiński, Drzęzła 2005).

Historically, the mining industry is one of the oldest documented kinds of human activity, since mankind for many centuries and even millennia, and also today, has benefited from acquiring the riches of the earth. Natural resources that have been mined and used by man have always conditioned the economic and civilizational development of societies and states, which was very clearly emphasised in the motto of the 18th World Mining Congress, held in 2000 in the USA – *Everything begins with mining*. The famous physicist Max Planck said, however: *Mining is not everything but without mining everything is nothing*. It is possible to specify a number of areas, both in the past and present, which owe their development to the development of mining – in Poland these include, for example, Lubin, Polkowice, Bełchatów, Turoszów.

The aim of contemporary mining activities is to gain a wide variety of natural resources, which are used to satisfy the diverse needs of men, starting with energy, construction, chemical, pharmaceutical, automotive, electronics and even the construction of spaceships. The extraction of mineral

resources in a global scale continues to increase, as shown in the diagram below (Fig. 2).

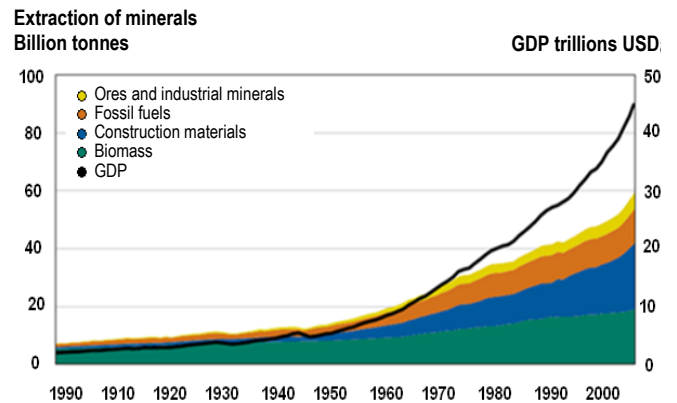


Fig. 2. Growth in demand for mineral resources in the world economy (SERI 2011)

In the last 50 years, a noticeable change in the dynamics of this growth has been observed. For example, between 1980 and 2008 it amounted to about 30 billion Mg – with ca. 38 billion Mg in 1980 to ca. 68 billion Mg in 2008 – Fig. 3 (SERI 2011).

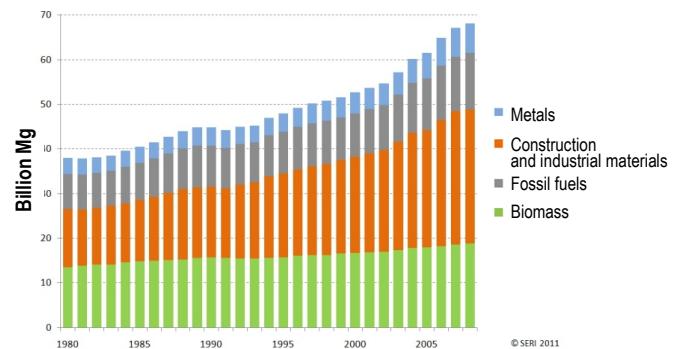


Fig. 3. Global extraction of mineral resources in the years 1980–2008 (SERI 2011)

As the diagram shows, the growth rate differed significantly in each group of mineral resources. The largest growth was observed in the group of industrial and construction materials – Asian countries such as China or India were mainly responsible for this. This fact clearly indicates the relationship between the extraction of these resources and economic growth.

A key element of sustainable development within the scope of acquisition and the use of natural resources is, as mentioned above, the rational and cost-effective extraction of minerals. However, modern man, accustomed to the availability of mineral resources, forgets a most important fact, which is the inevitable depletion of, still, non-renewable resources of raw materials. Recent decades in world history have seen dynamic economic development for many countries in the world and their economies, particularly those belonging to the group of developing countries. This is associated with an extremely fast-rising demand for various kinds of mineral resources. It is particularly pronounced in the case of energy resources, so in many countries, including Poland, it has raised the issue of energy security. Unfortunately, the European Union, of which Poland is a member, is becoming increasingly dependent on importing fossil fuels, which is

clearly shown in Fig. 4. Currently (data for 2011), the EU’s energy dependency stands at a level of 53.8%, with the dependence on oil imports being 84.9% and gas 67% (Eurostat Database 2013).

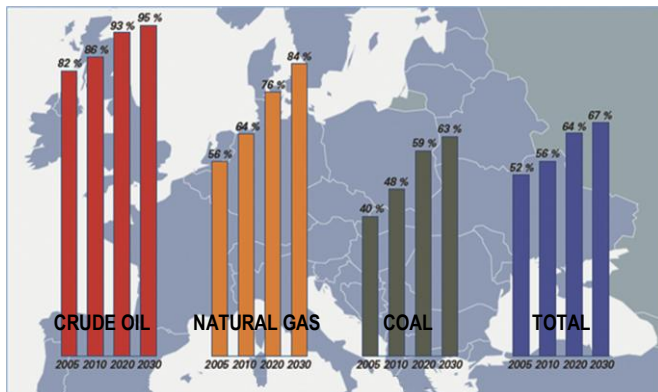


Fig. 4. Energy dependence of EU and its forecast for 2030 (EU Trends... 2010)

The problem of increasing demand for mineral resources has a much wider dimension today, and more and more often the world is talking about a more general problem regarding the security of raw materials. This security is becoming particularly important in relation to strategic raw materials that are crucial to the development of many new technologies.

Analysing the problem of the security of raw materials, one should pay close attention to an important issue, uneven distribution of various mineral deposits in geographical terms. This phenomenon means that access to certain groups of raw materials, especially those most often sought after on the market, is limited, thus this creates a privileged position for some countries. The problem concerns both the access to raw materials and the implementation in some countries of policy regarding raw materials. As a consequence, it pushes countries less rich in raw materials, or not having them at all, being on the margin of economic development and civilization out of the economic loop. Such an extreme example of the above inequality is people’s access to energy resources. Today, in the twenty-first century, 1.3 billion people worldwide do not have access to electricity, and 2.7 billion exclusively use biomass fuel for cooking food (WEO 2011). These are usually the areas on the globe where either there are no fuel deposits, or they have not been identified, or are not extracted because of the high cost of its acquisition. This phenomenon is illustrated in Figure 5.

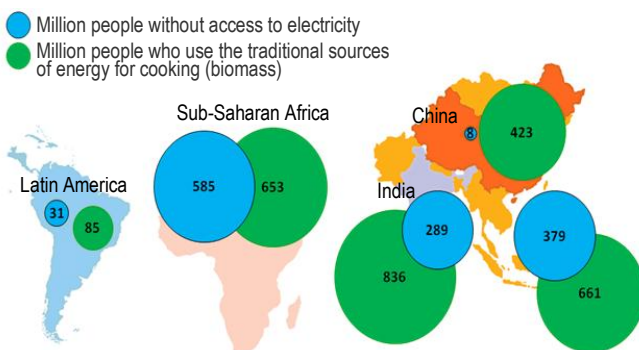


Fig. 5. Distribution of poverty areas in the world (WEO 2011)

There is no doubt that the safety problem associated with the availability of mineral resources will continue to grow. It is connected not only with the aforementioned dynamic economic development of new regions in the world, such as China, India and other countries in Southeast Asia. A significant factor is also the rapid growth of the world’s population. This number has already exceeded 7.0 billion, and demographic forecasts predict that by the year 2044 human population will exceed 9 billion. (U.S. Census... 2011).

Therefore, a very important question should be asked – what will be the impact of these global phenomena on the sustainable development of acquiring mineral resources? Assuming that the average annual population growth of more than 1% translates into an average annual growth in electricity demand by about 2% – based on analysis of the International Energy Agency, according to the basic New Policies Scenario, the demand for electricity in the year 2035 will have increased by more than 70% and reach the value of almost 32 000 TWh. From this overall increase, 60% will fall to developing countries such as China, India and the Middle East (WEO 2012). It is also important to note that not only will the demand for energy resources increase, but – according to global estimates – the demand for other material resources will also rise too.

In the context of the above-mentioned determinants, it is not surprising that a great number of leading world economies are interested in access to mineral deposits. Today, there is no doubt that in fact resources will not only directly influence further economic growth, but first of all the position of a given state in creating policy regarding global raw materials. When analysing the trends described above on the world mining market of mineral resources, attention should be paid to the fastest growing economies in the world. This is roughly a group of countries known as BRICS that is Brazil, Russia, India, China and South Africa, which, in 2009, took an initiative to identify the opportunities for joint activities, among other things, on the global market of raw materials. It should be noted that these countries are extremely rich in resources, and were already between 2000 and 2008 responsible for 50% of global economic growth (Pitfield and others 2010). According to various forecasts, the economic potential of the BRICS countries puts them in a position of the world ranking leaders of the most developed economies by 2050.

Unfortunately a different situation in terms of mining development forecasts, can be seen in the European Union, which additionally took up an ambitious fight against global warming, and is moving away from fossil fuels, and thus from native resources. This fact will undoubtedly have a negative impact on the previously mentioned energy security of the EU countries. In the case of raw materials, the security policy of the European Union shows consciousness of this problem, which is reflected, among other things, in the search for stable foreign suppliers of mineral resources defined as “critical” for the economies of the EU countries (Hebestreit 2011). Their location is shown on the map in Figure 6.

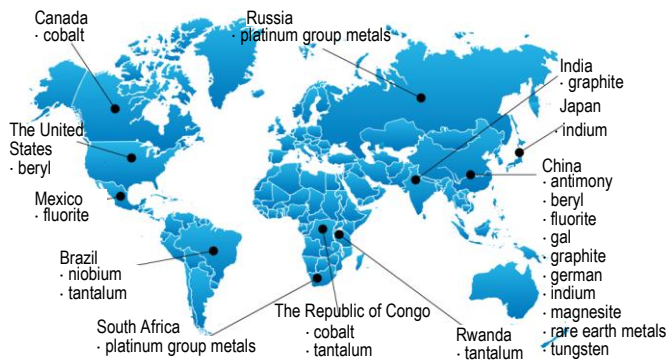


Fig. 6. Location of the countries with the raw materials which are deemed "critical" raw materials for the economy from the point of view of the European Union

The presented specific global problems of mining mineral resources unambiguously points at the necessity for further functioning and development, being of vital importance to the present and future of humanity. But still, they need to answer a key question, namely: are the rules of sustainable development being applied to this kind of industrial activity? Is the world aware that the idea of sustainability in mining activities must entail saving raw materials? Only by consistently applying this rule can we ensure that the non-renewable resources of mineral materials will beneficially serve, not only the present, but also many future generations.

Meanwhile, the problem of sustainable development in the domain of acquiring and utilizing mineral materials is far from reaching the expected status. Namely, one can observe, especially in rich, highly developed countries of the world, excessive and continuously increasing consumption, of which mineral materials are an extremely important element. This is clearly illustrated in Fig. 7, depicting the current situation in the USA.

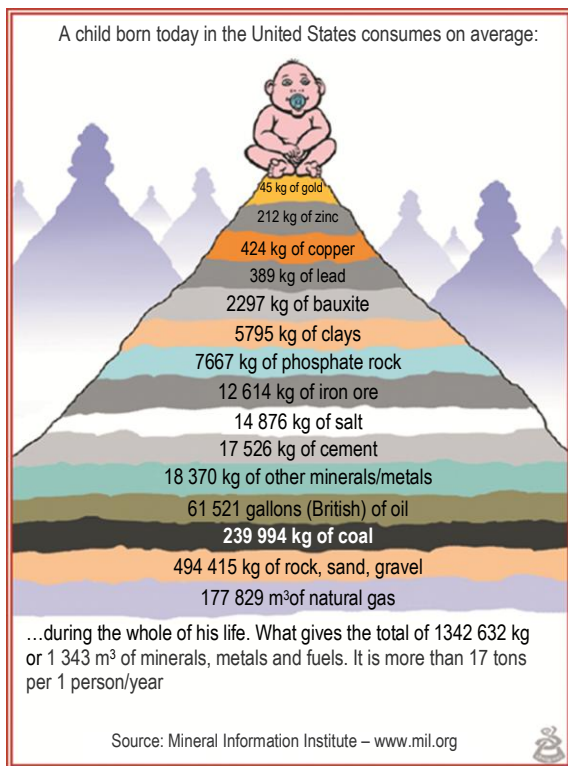


Fig. 7. Model consumption of various mineral resources by U.S. citizen.

Related to the rational and economical management of mineral materials, is the problem of continual activity of mining companies towards increasing the reserve base. This is made both through geological and geophysical recognition in licensed areas, and new ones.

3. CHALLENGES RELATED TO ENVIRONMENTAL PROTECTION IN MINING-AFFECTED AREAS

Environmental challenges are also an important problem for the mining industry. These are ones which, together with the protection of deposits of mineral materials, and their national management, as discussed above, constitute the content of the second pillar of sustainable development. In the global mining scale, they cover a wide scope of problems, and relate to all the elements of the natural environment, which are ground surface, water and air (Drebenstedt 2008; Dubiński, Turek 2006). In practice, every mining activity disturbs, more or less, the condition of the natural environment. These changes mainly include the following:

- deformations of ground surface in the form of subsidence, horizontal deformations, discontinuous deformations, etc.
- seismicity induced thanks to mining activities
- various changes of water relations
- impoverishment of soils
- emission of gas and dust
- noise and others

Hence, it is necessary to develop technologies for extracting mineral resources which will eliminate, or minimise the negative effects of mining processes. It is also necessary to develop technologies to repair the effects of mining so as to restore the lands used for further use. Both in the Polish and world mining sectors, various technologies have been developed and implemented for the reclamation of post-mining areas. It should be emphasised that the activity of mining plants regarding the care of the natural environment is now one of the most important elements of the social responsibility of mine operators.

4. SAFETY AT WORK AS KEY ELEMENTS OF SUSTAINABLE DEVELOPMENT

Social responsibility, being one of the pillars of sustainable development, concentrates, in the case of mining mineral resources, first of all, on the issue of health and safety, on the care of employee health and the conditions of the workplace (Dubiński 2011). It should be emphasised that the scope of the notion "social responsibility" is currently understood by mining companies much more broadly. This is also the case regarding vocational development, the stability of the workplace, of their remuneration, assuring their families adequate living conditions and many more. For quite a time now, the concept of "social responsibility of the business", has included the local communities living in the surrounding areas of mines. There are also the factors involved in gaining social acceptance for the mining activities being conducted, which can itself create various difficulties.

The concept of health and safety in mining includes a number of inter-related elements: technical, social, organisational and legal. Their level and degree of implementation

which form the so-called best practices have a decisive impact on safety.

When analysing the problem of work safety in mining, in a global scale, one can say that the industry of acquiring mineral materials, in particular, in underground mining, belongs to sectors of economy characterised by a high level of accident risk, the risk bringing often catastrophic consequences. This level is diversified, both relative to individual countries, representing different levels of technological development, and in relation to different types of mining.

The essence of work safety in mining has been presented taking an example of the Polish hard coal mining industry. It should be emphasised that this industrial sector is well developed in Poland which assures its safe functioning. Since 1990, this mining industry has passed through the process of drastic restructuring processes that have affected all key spheres of its activity – technical, economic, employment-related (Karbownik, Turek 2011). This is justified by the data for the mining industry, as presented in table 1 below.

Table 1. Technical and social effects of restructuring the Polish hard coal mining industry – the years 1989–2012

Index	Years						
	1989	1995	2000	2005	2010	2011	2012
Production of coal, m. Mg	177.4	135.4	102.2	97.1	76.1	75.7	79.2
Employment, thousand	407	272	155	123	112	111	113
Number of mines	70	63	42	33	31	30	30
Number of active longwalls	861	415	183	130	116	112	114
Efficiency, tonne/working day	3957	4869	6635	8011	6543	7066	714
Average depth of mining, m	510	560	600	645	700	705	–

One should say that these processes have favourably affected the implementation of sustainable development in the domain of health and safety. Favourable changes have occurred in mining legislation, also it must be noted that these change have taken place in the social perception of mining by inhabitants of the regions where mining is conducted.

The underground work environment in Polish mines, particularly, hard coal mines, is characterised by the occurrence of natural hazards known in the world of mining (Fig. 8). Most of them are catastrophe-generating. This is a great challenge for the safety of mining crews, and also regarding the issue of balance between production and gained economic effects, the requirements of safety and outlays for its improvement (Bradecki, Dubiński 2005).

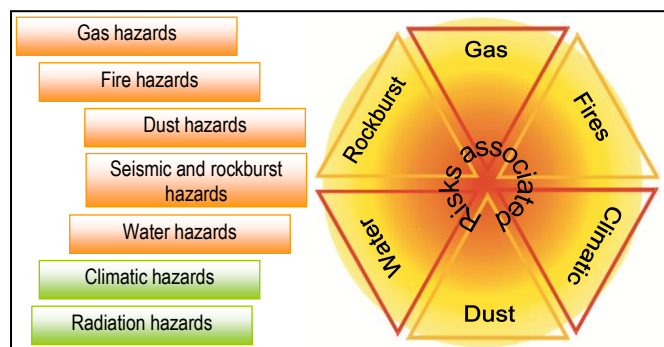


Fig. 8. Basic natural hazards in hard coal mining

An important element, in the situation of so many natural hazards occurring, is the continuous monitoring of them,

connected with specialist interpretations and analysis of measurement data. Geophysical methods, and other physical methods are widely used for this (Dubiński 2005). There have also been rules worked out for planning extraction processes in conditions where the hazards mentioned above occur, and the technologies used to lower their level (Konopko ed. 2010). One should emphasise the role of management regarding safety in the mines, as the human factor is still

a frequent cause of accidents taking place. For that reason, questions related to work organisation, training of employees, and formation of safe behaviour are of vital importance. One must also be aware that all these actions need continuously increasing financial means oriented towards the sphere of safety, but this is a necessity determined by the objectives of sustainable mining.

5. CONCLUSIONS

1. The sustainable development of mining mineral resources is a major challenge for today’s global world, addressed to mining companies, people of science associated with mining and many other institutions and organisations.
2. Today, the sustainable development of mining is the key to the security of raw materials and energy for many countries in the world, with a special importance also to Poland.
3. Public awareness that mineral resources are non-renewable assets, is, unfortunately, small and therefore improvements or changes to the situation in this area is another key challenge, it should be followed by concrete actions.
4. Modern mining, which usually negatively affects the environment, and also causes more or less discomfort for people living in mining areas or their immediate surroundings, must have the public acceptance for its activities. Thus, the real concern about the environment is becoming an important factor for obtaining it.
5. Mining in the twenty-first century, while striving for sustainable development, must provide employees with a safe working environment, therefore the problems regarding safety, due to its complexity, is a major challenge for mine operators. The trend of increasing the depth of mines, observed in the world, means that work safety is, and will continue to be a key area for the sustainable development of the mining industry.
6. The complexity of the problems for the sustainable development of mining and the resulting diversity on a global scale point at the need for the continuous exchange of experience in the field of knowledge, methods, technologies and other solutions. They should provide a sustainable and socially acceptable development and continued operation of mining, invariably needed by people, to provide necessary mineral resources.

References

1. Bradecki W., Dubiński J. (2005): Effect of the restructuring of the Polish coal-mining industry on the level of natural hazards. *Archives of Mining Sciences* Vol. 50, issue 1, pp. 49–67.
2. Drebenstedt C. (2008): Responsible mining – approaches and realization. *Proc. 22nd World Mining Congress – Innovations and Challenges in Mining*, Vol. 1, Istanbul, pp. 135–147.

3. Dubiński J. (2005): New safety technologies in underground mines. Proc. of the 20th World Mining Congress – Mining and Sustainable Development, Vol. 1, Teheran, pp. 21–31.
4. Dubiński J. (2011): Safe and environmental friendly coal mining – global challenge for the XXI century, Beijing.
5. Dubiński J., Drzeźła B. (2005): Problemy zrównoważonego rozwoju w polskim górnictwie węgla kamiennego. Sympozja i Konferencje nr 65. Warsztaty Górnicze 2005 z cyklu „Zagrożenia naturalne w górnictwie”. Kraków, IGSMiE PAN, pp. 105–117.
6. Dubiński J., Turek M. (2006): Proces restrukturyzacji a ochrona środowiska na terenach górniczych. *Bezpieczeństwo Pracy i Ochrona Środowiska w Górnictwie* No. 12, pp. 4–9.
7. Dubiński J., Turek M., Wachowicz J. (2007): Hard coal mining and the idea of sustainable development. Proc. Intern. Scientific Conference – School Underground Exploitation, Dniepropetrovsk, pp. 27–38.
8. EU Trends to 2030. UPDATE 2009, Publications Office of the European Union, 2010.
9. Eurostat Database:
<http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=en&pcode=tsdcc310&plugin=1>
10. Hebestreit C. (2011): Resources efficiency and innovation policies in Europe. Proc. 22nd World Mining Congress – Innovations and Challenges in Mining”, Vol. 1, Istanbul, pp. 149–155.
11. Karbownik A., Turek M. (2011): Zmiany w górnictwie węgla kamiennego – geneza, przebieg, efekty. *Przegląd Górniczy* No. 7–8, pp. 11–18.
12. Konopko W. red. (2010): Warunki bezpiecznej eksploatacji pokładów węgla zagrożonych metanem, tapaniami i pożarami endogenicznymi. Katowice, Główny Instytut Górnictwa.
13. Pitfield P.E.J., Broun T.J., Longharts I.A., Hill A. (2010): Mineral Information and Statistics for the BRIC Countries, British Geological Survey, Keyworth, Nottingham.
14. SERI (2011): Global resource extraction by material category 1980–2008. <http://www.materialflows.net>.
15. U.S. Census Bureau, U.S. Department of Commerce, Population Division, International Data Base, June 2011 update. www.census.gov.
16. WCED (1987): World Commission on Environment and Development – Our Common Future: Report of the World Commission on Environment and Development, United Nations 1987. http://conspect.nl/pdf/Our_Common_Future-Brundtland_Report_1987.pdf.
17. WEO (2011): World Energy Outlook International Energy Agency 2011.
18. WEO (2012): World Energy Outlook International Energy Agency 2012.