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Clean and climate neutral planet and mineral resources in the EU

The directions of EU activities in the field of mineral resources and their extraction, which are important for the development of the economy, are presented herein. The breakthrough in the EU came in 2008 with the announcement of the new Raw Materials Policy (RMP) and its presentation in Brussels in 2007. The long-term negligence of the EU authorities in terms of the lack of investment in research and development in the extractive industry in successive innovation programs implemented by the EU has been noticed. Changes in the global market at the end of the 20th century made the EU economy highly dependent from the import of many raw materials [1, 2]. The RMP plan adopted for implementation included 10 activities covering the EU bodies, member states and the mining industry. In the following years (2011–2012), a program aimed at strengthening the raw materials policy, called EIP on RM – innovative partnership on raw materials, appeared. It also resulted in an increase in expenditure on activities in the area of circular economy. The new innovation program Horizon Europe planned for 2021–2027 also provided for the important role of raw materials in the field of clean energy development and the implementation of the principles of the "green deal" , which is expected to reduce climate change plan in the EU by 2050 [3]. It is assumed that the principles of the EU's "green deal" are to be a model for other countries / continents of the world to follow.

Key words: *EU, resource policy, climate change, mineral resources, critical resources*

1. INTRODUCTION

At the beginning of the 21st century, the mining industry in the EU was considered one of the obstacles to the development of a green economy. It was considered dirty and harmful to the environment, there was a visible lack of social support. The industry itself was not without blame. In the innovative programs implemented under the auspices of this industry, there was no visible support in innovation. In FP6, only a few metal recovery projects received EU funding, but only because they were related to a newly developed field – biotechnology. In 2001, the author of the article managed to establish a consortium implementing projects for the recovery of metals from shale deposits found in non-ferrous deposits in Europe (Poland, Finland, Germany). The established international consortium created and implemented an innovative project called BioShale, the conclusions of which were implemented only in Finland. Another, much broader mining project related to the wider use of biotechnology techniques for metal recovery was called BioMine, implemented by a wider consortium with additional participation from a research centre from outside Europe (Republic of South Africa – Mintek).

2. THE BEGINNING OF THE EU RAW MATERIALS POLICY

As of 2005, the EU authorities began to recognize the need to support the mineral resources sector as an essential factor in ensuring the development of the

European economy. In preparation for the opening of the next edition of the EU innovation program – FP7, the need to support the extractive industries in Europe was recognized and all the more so as Europe had long lost its global leadership in the extraction of many metals (Fig. 1).

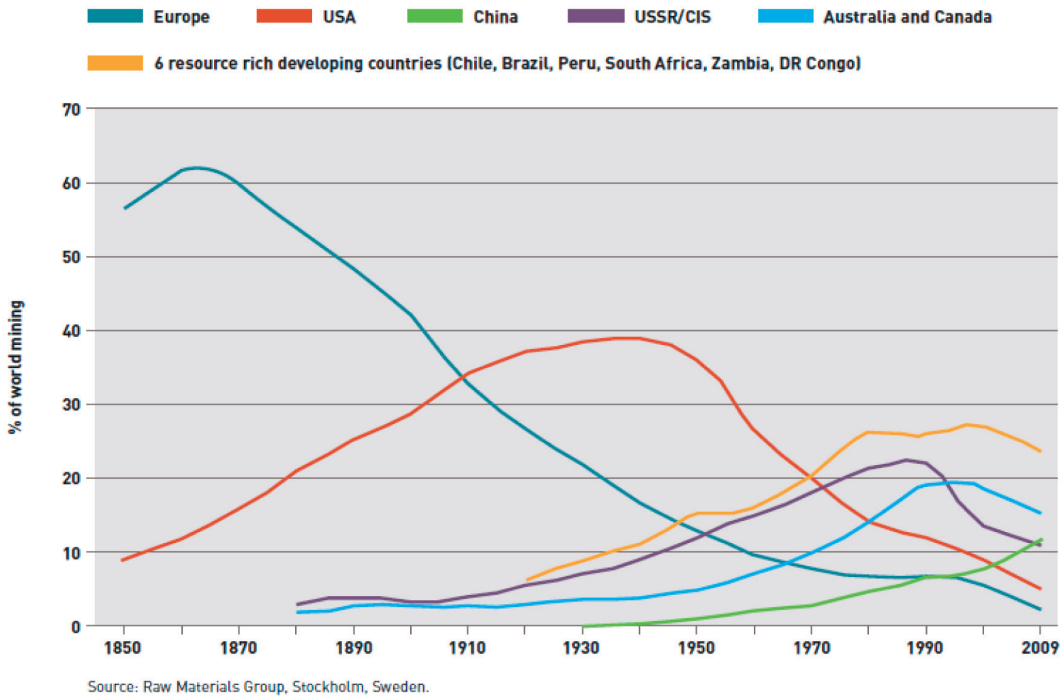

Fig. 1. Activity of the metal mining industry since the XIX century in the world

In the global world, countries such as: China, Republic of South Africa, DR Congo, Chile, Peru, Brazil are currently important in the extraction of metals such as copper, cobalt, aluminium, iron, and rare earths, and the leading role of Europe in innovation and metal mining which had been visible in the nineteenth century had already begun to decline [3]. The situation of high dependence of the economies of the EU member states on the supply of raw materials was shown in a report commissioned by DG Enterprise, the findings of which became the basis for the announcement of the New EU Raw Material Policy in 2008. It was a real breakthrough for the European mining industry and for the new FP7 innovation program.

In the global world, there is a visible pressure to increase the extraction of raw materials (Fig. 2).

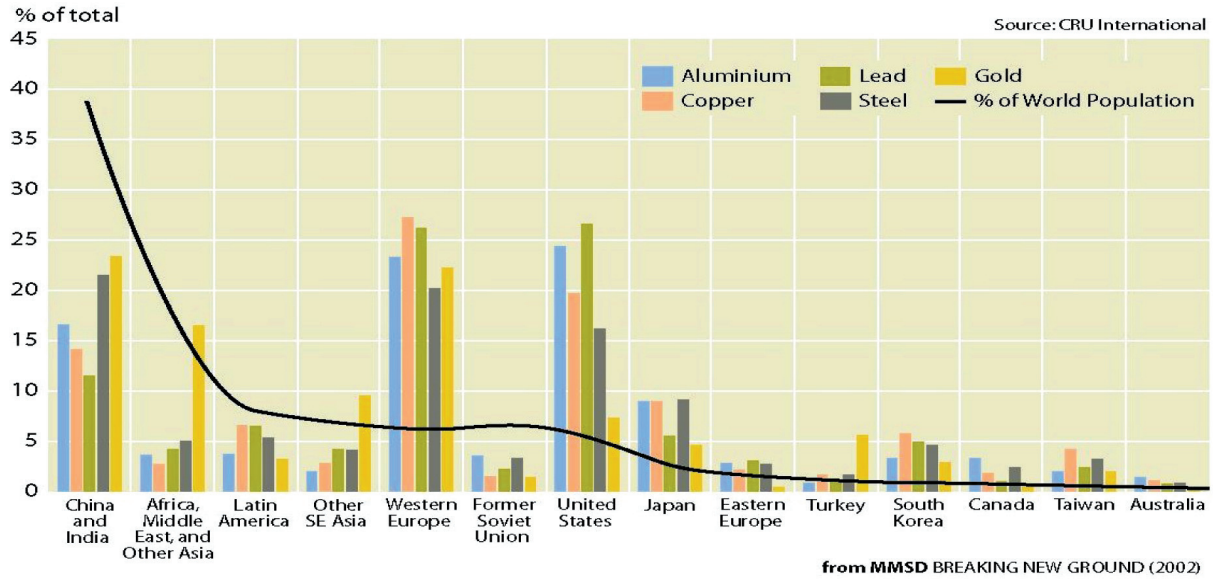

Fig. 2. Metal consumption compared to population in regions and selected countries (2000)

If current trends continue, the intensive use of raw materials will threaten the raw material security of many countries in EU. Hence, in the EU report on the state of the raw materials market published in 2007, there were analyses that revealed unfavourable trends that threaten the security of the EU economy. The EU economy has shifted from relying on raw materials mined in European countries and has become heavily dependent on imports. The further economic development of the EU requires an increasing supply of raw materials, some of which have become extremely important for key sectors of the economy. The unstable political situation in many raw material countries (Africa, South America) also poses a high risk of interrupting their supplies to EU countries. In the EU, little attention has been paid to the search for substitutes for raw materials relevant to key sectors of modern industry (electronics, clean energy). The report provides information on major changes in global commodity markets, indicates export restrictions and restrictions on access to critical raw materials applied by some countries. Half of the raw materials necessary for development are found in countries with very low per capita incomes. After the publication of the EC Communication in 2006 (EC Communication, COM (2006/699), an announcement was made to introduce the principles of the new EU raw materials policy, which were presented in 2008 in the form of 10 main activities. For implementation of these are EU member states, the extractive industries and related research and scientific institutions. The program of the new EU raw materials policy Raw Materials Initiative (RMI) was presented in Brussels in 2008. Additionally it also involved the compilation of a list of critical raw materials for the EU [4]. This list is to be updated every 3 years. There has also been a significant increase in investment in research and innovation in raw materials in EU innovation programs, starting with FP7. When presenting the assumptions and the RMI program, attention was drawn in Brussels to the need to:

– more efficient use of raw materials, recycling and implementation of the 3R principle (*Reuse, Recycle, Repair*),
– stronger cooperation between geological institutes of EU member states,
– greater support for identifying Europe's own raw material resources,
– launching a more vigorous diplomatic action and cooperation with other raw materials countries outside Europe,
– as well as for wider scientific and innovative cooperation in raw materials within the EU as well as with countries outside Europe (in Republic of South Africa, South America, Japan, Canada, the USA).

3. THE NEW EU RAW MATERIALS POLICY

In 2012, the European Commission presented the assumptions of the program dedicated exclusively to the mineral resources sector, called the European Innovation Partnership (EIP) on Raw Materials, which was to be part of the EU's Horizon 2020 innovation program. New program in raw materials was to strengthen the implementation of this policy based on three pillars:

– promote the sustainable supply of raw materials from global markets related to fair trade and address the causes of conflicts due to lack of access to raw materials;
– sustainable supplies of raw materials from European sources and increase financial support for innovation in the raw materials sector (approximately EUR 600 million has been planned);
– direct attention to programs for more efficient use of raw materials and create an action plan to support recycling. This was included in a program called "Circular Economy Action Plan" (Fig. 3).

Prepared in 2011 and announced a year later, the EIP on RM program was to be a network of interconnections and a platform connecting EU Member States, companies operating in the field of raw materials, research centres and non-governmental organizations operating in this area (NGOs). The main objectives of the EIP on RM program published in the communication (COM 2012) 82 Final of 29 February 2012) were:

– reducing the dependence of EU countries on the import of important raw materials (Fig. 4);
– providing alternative solutions in their market supply;
– to push EU countries to the forefront of innovation in the raw materials sector;
– reduce the environmental impact of the EU's extractive industries.

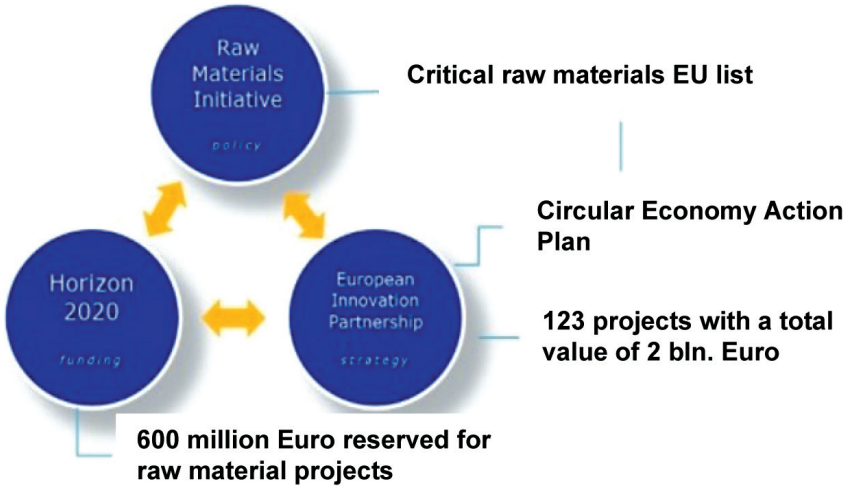

Fig. 3. The EU Raw Materials Initiative and its further development, including funding from the Horizon 2020 innovation program (©EU, 2016)

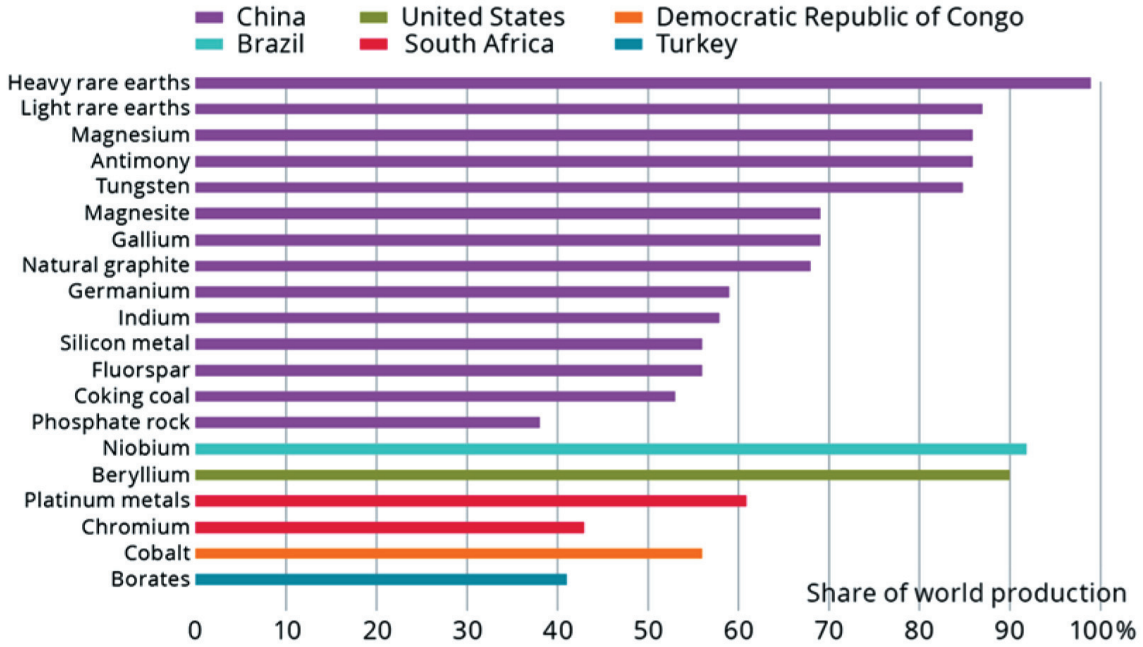

Fig. 4. The geographic concentration of some raw material reserves creates supply risks for Europe – 2015 (European Commission 2014. The European Environment State and Outlook 2015; EEA)

There are also other initiatives and studies carried out by a number of global institutions emphasizing the role of raw materials in the economy and problems with their availability:

1. Critical Metals for Future Sustainable Technologies and their Recycling Potential: United Nations Environment Program (UNEP, 2009),
2. World Economic Forum: Future Availability of Resources (WEF, 2014),
3. Yale Study on Materials Criticality (Graedel & Beck, 2015),
4. British Geological Survey Risk List (BGS, 2015),
5. German Fraunhofer Institute for Systems and Innovation Research and the German Mineral Resources Agency (BGR, reports since 2009),
6. The European Union (EU): Supply Risk Assessment (European Commission, 2017),
7. Forecasting demand and supply of key minerals (P. Christmann, 2017).

These studies analysed the impact of the following factors on the volume and directions of raw material

extraction in the world, such as: market prices, technology development, politics, population growth, economic growth, mutual cooperation in the field of politics, economy, substitutability of certain raw materials with others, the amount of recycling, stability policy of raw material countries, the state of development of mining and innovation, distribution channels, legal regulations, supply channels, resources and their distribution, degree of resource concentration, restrictions on access to raw materials, the impact of resource depletion, demand for renewable energy, development of the middle class and the degree of country urbanization.

The first list of EU critical raw materials, in line with the EC recommendation, was published in 2011. It included 14 mineral resources (Fig. 5).

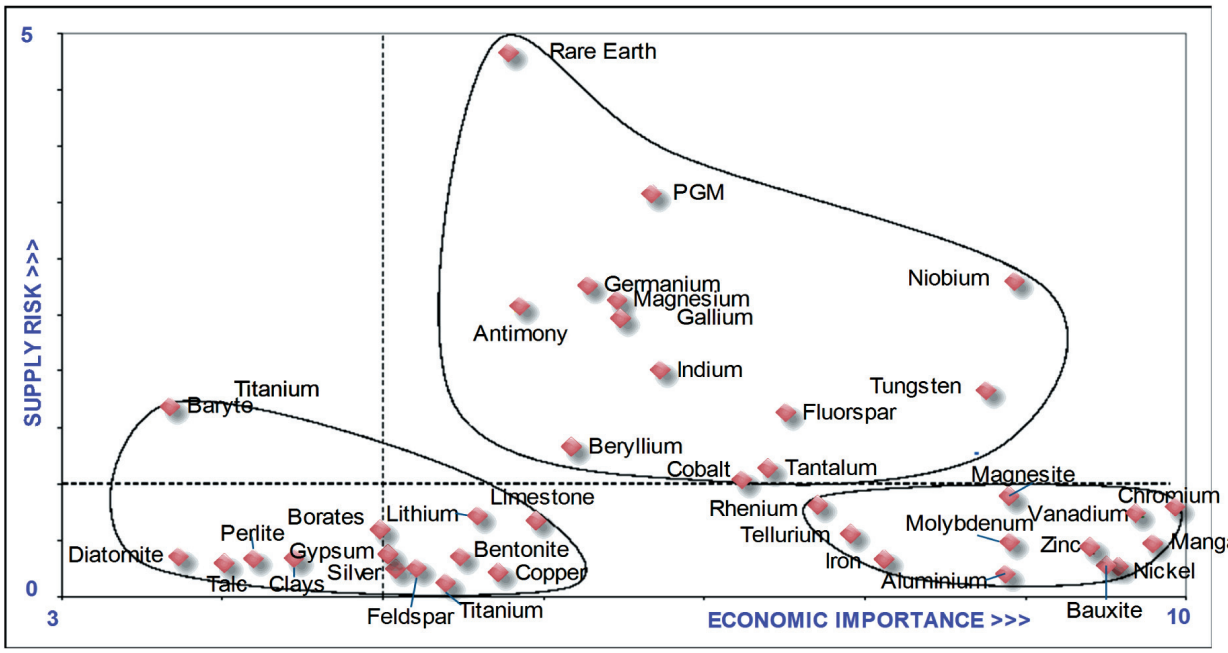

Fig. 5. The first list of EU critical raw materials – 2011 [4]

The following factors were taken into account in its preparation: the highest market value of a given raw material compared to others; the greatest risk of supply disruption due to the political stability of the producing countries; the greatest risk of supply disruption, taking into account ecological contamination or the amount of recycling and the possibility of obtaining them from another source. The economic value was calculated taking into account the main applications of a given raw material and the possibility of its substitution by another.

EU countries also have quite large opportunities to start the extraction and acquisition of critical raw materials from their own resources (deposits and recycling). Europe has its own raw material resources, including aggregates, industrial raw materials for construction or road construction and metals such as copper or zinc. But it has less success in the development of deposits of critical raw materials, although it has considerable potential for their extraction and production. Figure 6 shows the EU geological resources including their occurrence in the deposits. There are many reasons for this condition:

- no investment in exploration and extraction of these raw materials,
- long permit procedures to initiate their reconnaissance and extraction,
- lack of social acceptance for mining activities in many EU countries.

The latest 2020 list of critical raw materials already contains 30 raw materials, while the 2014 and 2017 lists contain 20 and 27 raw materials, respectively. Raw materials such as bauxite, lithium, titanium and strontium were added to the 2020 list for the first time.

Figure 7 shows from which countries the EU Member States import the most critical raw materials necessary for the functioning of modern and developing sectors of their economy.

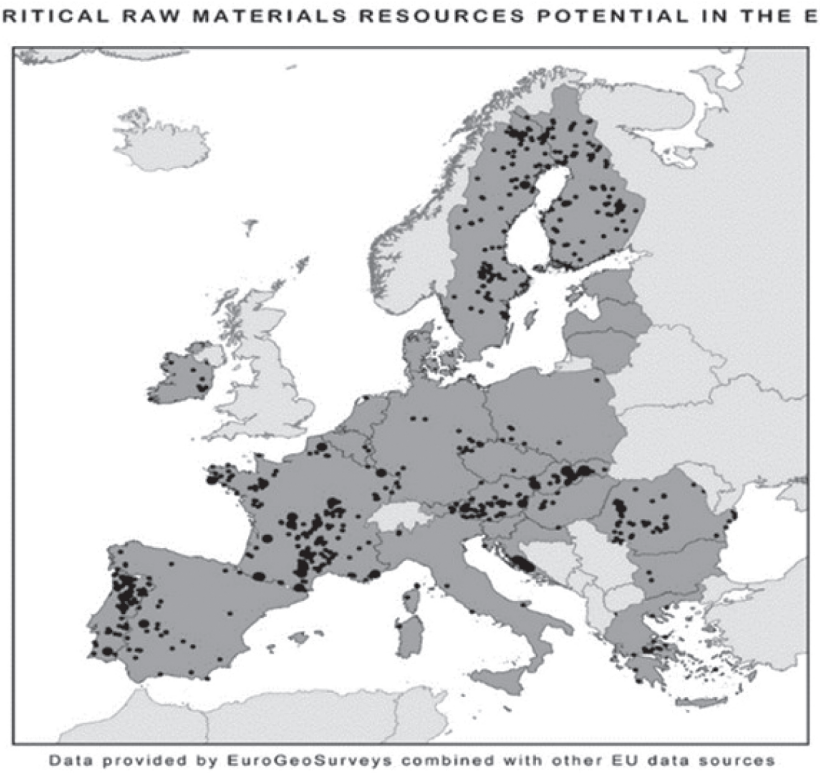

Fig. 6. Location of deposits of critical raw materials resources in the EU

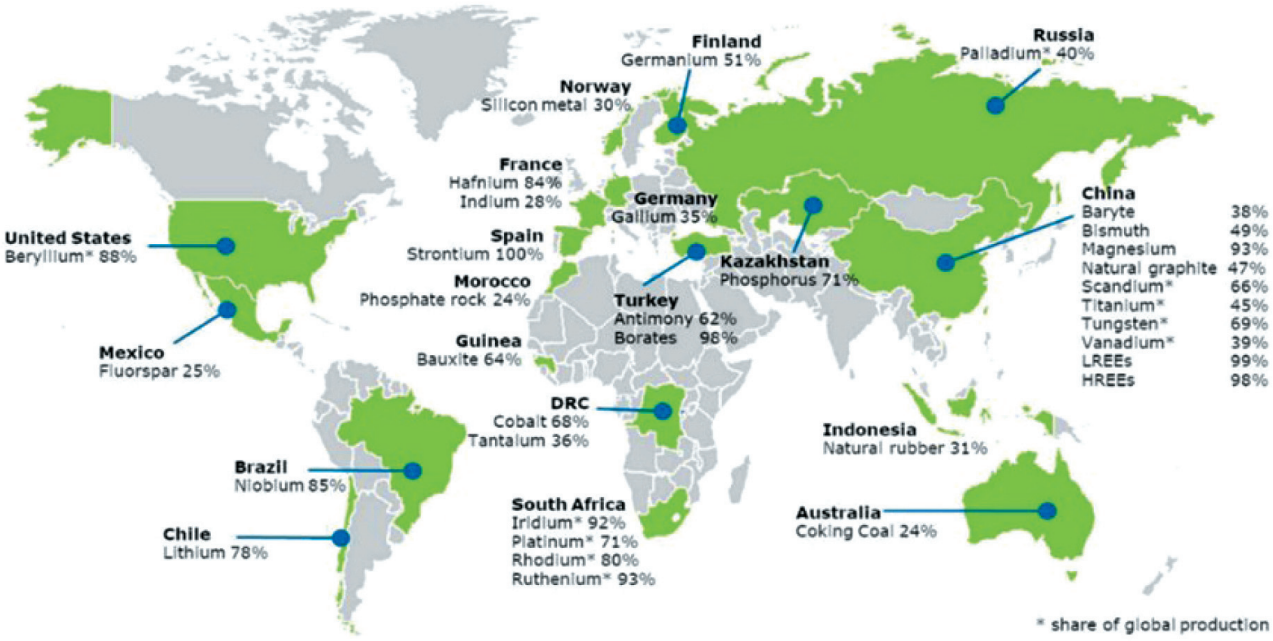

Fig. 7. Import of critical raw materials from non-European countries and share in global production [5]

Thanks to the launch of the EIP on RM program in 2015. within the European Institute of Innovation and Technology in Budapest (EIT) a knowledge and innovation node (EIT on RM) dedicated only to mineral resources was established. It has its headquarters in Berlin and branches (CLC) in individual EU countries (Fig. 8).

In the innovative program Horizon 2020, planned for the years 2013–2020, raw materials played an important role. This program took steps to use them more effectively and to search for innovative solutions in their acquisition. The assumptions of the Europe 2020 strategy and the place of raw materials in this strategy are presented below (Fig. 9).

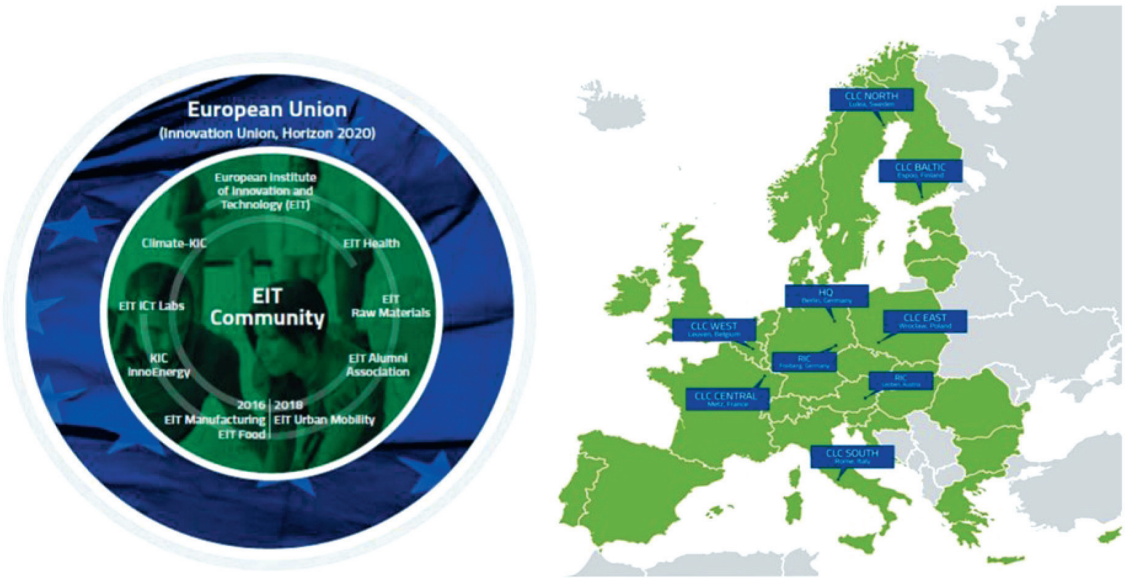

Fig. 8. EIT – Branches of the knowledge and innovation centres in mineral resources in the EU countries [6]

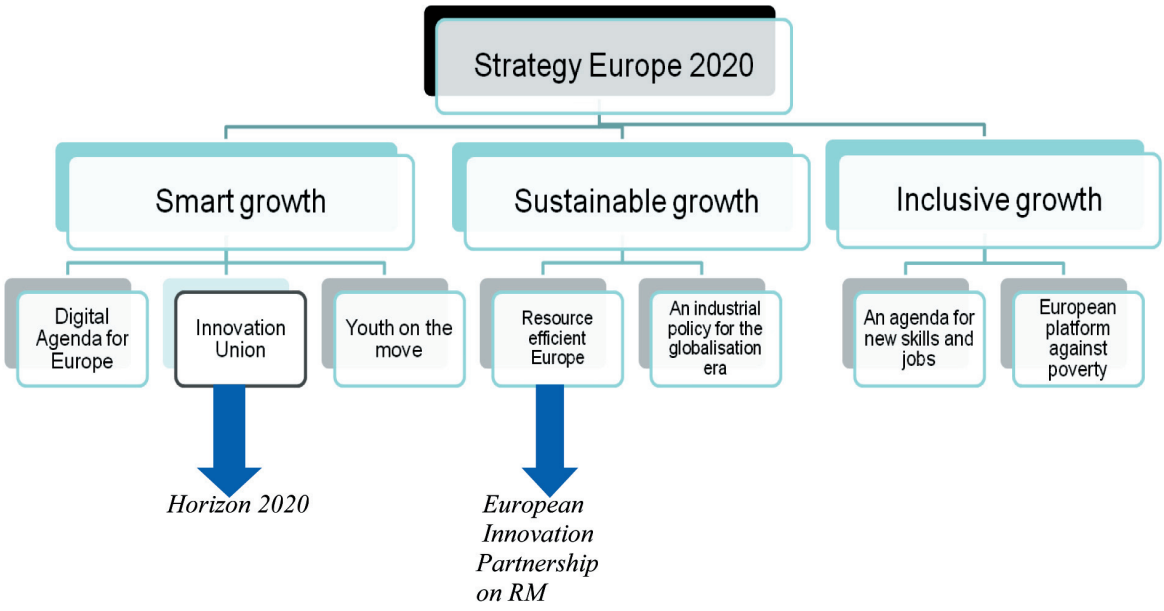

Fig. 9. Europe 2020 strategy and the place for raw materials in it [7]

In the Horizon 2020, a program on raw materials was planned in the Societal Challenge theme. This theme was supplemented with additional environmental tasks that are affected by the activities of the mining industry. It was a preparation for the next innovative program Horizon Europe which was taking into account actions to put some limits on climate change. These were:

- sustainable management of natural resources and ecosystems,
- sustainable supply of non-energy and non-agricultural minerals,
- moving towards a green economy through eco--innovations,
- global environmental observations and information systems,
- cultural heritage.

This evolution of the tasks provided for in the EIP on RM program clearly shows a change in the attitude of the European Commission striving to develop solutions for recycling, green energy production, decarbonisation, and paying attention to more efficient use of raw materials [8]. On December 2, 2015, the European Commission adopted a package called Circular Economy Plan for implementation, consisting of a communication, an action plan, and proposals for new legal regulations related to waste management [5].

These plans included:

- creation of jobs, support for economic growth and investments towards a circular economy and promoting economic growth based on the principles of the green economy;
- energy Union – changes towards decarbonisation of the economy (renewable energy, electricity market, new solutions for transport);
- internal market – unleashing the full potential of one market – New Industrial Strategy;
- trade policy to tackle the risks of globalization in raw materials, economic diplomacy and the inclusion of raw materials in cooperation agreements with other countries;
- the EU is to become a stronger and more active partner on the global market, focused on cooperation and international development.

At the same time, further activities and actions planned for 2017–2020 were undertaken in the Horizon 2020 program. At the expert level, a high-level group (HLG), operational groups implementing the SIP strategic plan, functioned until the end of the EIP on Raw Materials program.

A framework for action has been developed, including a new EU resource policy guide and provisions on procedures related to granting consent to mining activities. These were projects:

1. MIN-GUIDE (2016–2018) „Minerals Policy Guide";
2. MINLEX (2017) – Legal framework and permitting procedures in the NEEI in EU28.

Mining regions were also addressed by creating a cooperation network of mining region:

- MIREU program – EU network of mining and metallurgy regions (2017–2020);
- REMIX program – Smart and Green Mining Regions of EU (2017+).

Access to important raw materials in Europe and the assessment of their potential were to provide the following programs:

- MINLAND (2017–2019) – mineral resources in sustainable land-use planning and
- MINATURE2020 (2015–2017) – mineral deposits of public importance.

4. IS MINING RETURNING TO ITS IMPORTANCE IN THE EU?

The Vice-President of the European Commission, Maroš Šefčovič, in an appeal to members of the Supervisory Board of the EIB argued: "We cannot sit idly when China controls most supplies of critical raw materials. More investment is needed to acquire them in EU countries". Some EU member states are prepared to launch 10 mining projects for lithium production, which is to increase their supply in the EU from 1% to 30% of global production.

These calls from the EU are starting to take effect. The policy of major EU banks to finance energy investments has changed. Lending for investment projects related to the extraction and production of energy from coal was limited, and loans for the extraction, processing and recovery of critical raw materials from the CRM list were considered. There are projects in Europe to exploit rare earth metals in Norway, cobalt in Finland, lithium in Spain, the Czech Republic and Portugal. Similar actions were taken in the USA. On December 20, 2017 president D.J. Trump ordered the preparation of a US resource security strategy (Executive Order 13817 – A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals [9]. It covers following actions:

- increasing funds for research and development and education in the field of critical raw materials,
- strengthening access to resources of critical raw materials and securing them for the purposes of national defence,
- improve trade relations and cooperation in the field of critical raw materials,
- better identification of and access to domestic resources of critical raw materials,
- shortening the procedures for authorizing the extraction of critical raw materials.

Scheduled for the period 2021–2027, the EU innovation program Horizon Europe (Fig. 10) is the largest and most ambitious EU research and innovation program [7].

Its main goal is to put the EU at the forefront of research and innovation in two areas: digitization and the green economy. The EC proposed fi100 billion to finance research and development, of which fi 15 billion was allocated for closed-loop industries (minerals) and low-carbon industries (decarbonisation) and clean energy industries. As part of the new growth strategy for the EU economy (The European Green Deal), Europe intends to be the first climate neutral continent by 2050. This strategy was announced on 10/03/2020. It is based on two main directions of changes: ecological and digital, and it is to affect every aspect of the economy and society. This will require new technical solutions, investment in innovation to create new products, services, markets, business models, new jobs and skills. It is also intended to ensure a conflict-free transition from a linear economy (the dominant one at present) to a circular economy.

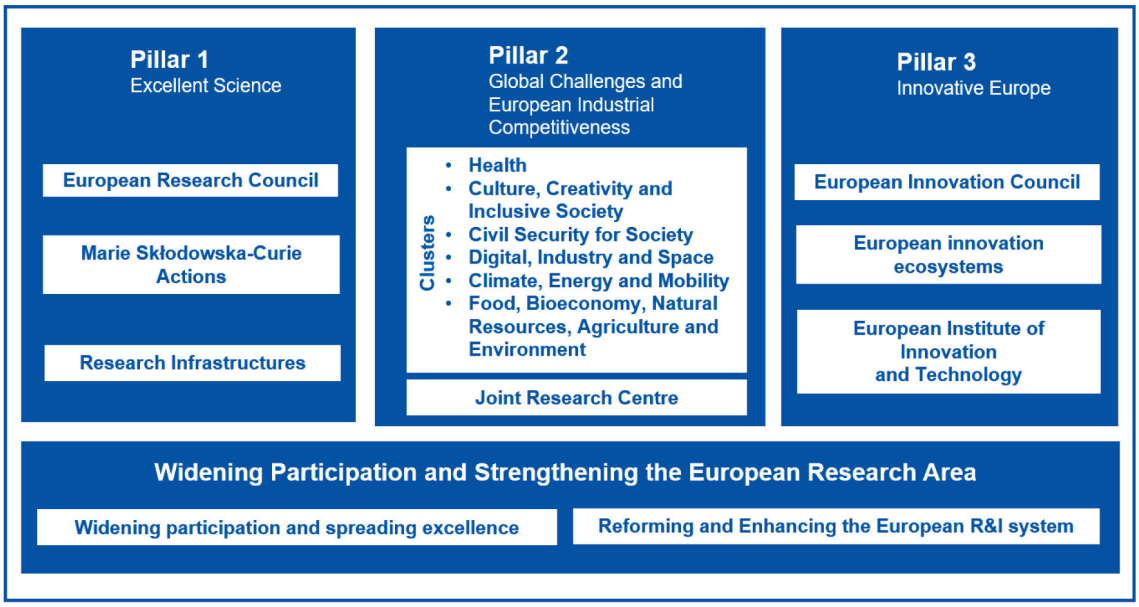

Fig. 10. Scheme and planned activities of the Horizon Europe innovation program (2021–2027) [6]

It is assumed that EU industry will need secure access to clean energy and raw materials to become more competitive as it becomes more recycling and green energy oriented. It is expected to increase investment in research, innovation, investing in new solutions and modern infrastructure, which will allow to develop new production processes and create new jobs, the mining industry, including mines, processing of raw materials, metallurgy, is an energy-intensive sector, and the emphasis on extraction and greater production of mineral resources from primary deposits strengthens the pursuit of a more closed loop in production technologies. The extraction of iron ores and the production of steel in them, the production of cement, the operation of refineries, the petrochemical industry and the production of agricultural fertilizers are already responsible for over 70% of CO_2 emissions – according to EU ETS data. Hence the decarbonisation program (abandoning coal as the main source of energy in many EU countries. The process of phasing out coal and lignite as an energy source will be implemented in many EU countries (Germany, Poland, Spain, Portugal, Greece). Figure 11 explains the steps taken by the EU related to decarbonization.

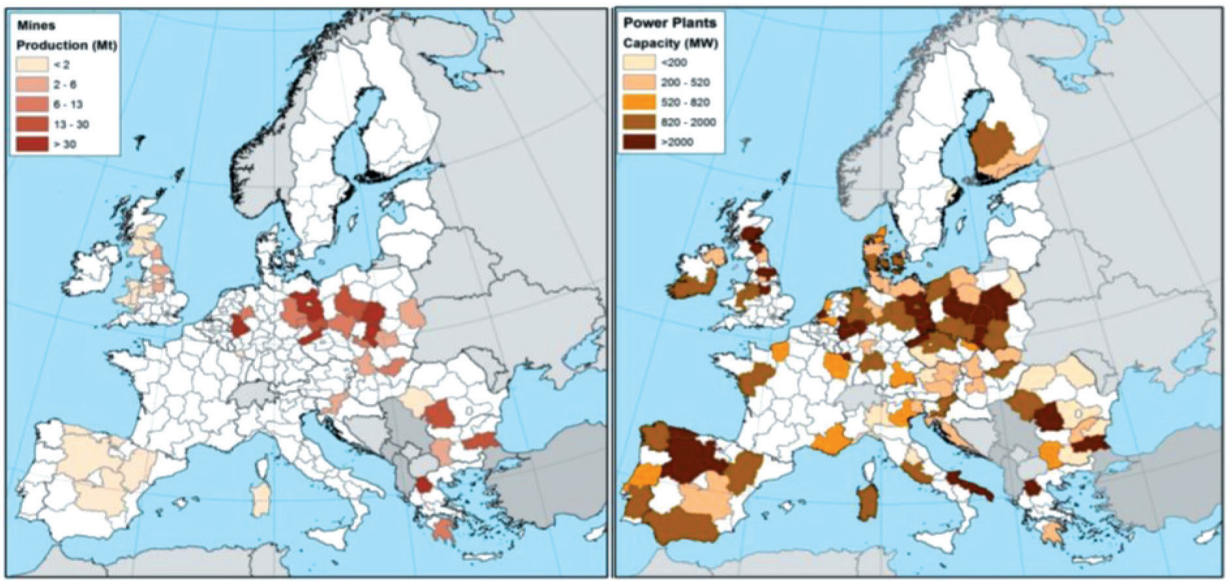

Fig. 11. EU regions with operating coal mines and coal-based power plants (The European Commission's science and knowledge service Joint Research Centre High Level Event Smart Specialisation Platform on energy (S3PEnergy); 2018)

Key technologies are important for the future of industry in Europe. Some of them are closely related to the critical raw materials that must be used in the development of these technologies. Support for recycling and the use of secondary raw materials will reduce the dependence on primary minerals. To meet these ambitious goals, safe access to raw materials will be required and which meets the following technological challenges:

- Lithium-ion battery technology that is being developed for the application and commissioning of electric transport and clean energy production. Importantly, this technology is becoming more and more useful for military applications.
- Fuel cells (FCs) are an important technology for energy conversion based primarily on hydrogen as an energy source. Hydrogen-based cells offer the possibility of a rapid departure from coal in energy production systems in the future and will create conditions for the implementation of e-mobility, although such solutions are not yet available on a large scale.
- Wind energy is one of the most effective technologies in the production of clean energy supporting the implementation of climate change reduction programs. It is expected to remain one of the main sources of energy for EU industry.
- Engines for vehicle propulsion are to be an essential component of electric vehicles. These rare earth permanent magnet motors are particularly efficient and attractive for current and future electric transport applications.
- Photovoltaic (PV) technology, including solutions using wind energy, will transform the entire energy sector in the world. Solar panels are already widely used in space research.
- Robotics is an emerging new technology with a growing role to play in the factories of the future including the defence and aerospace industries. It is also expected to be used in energy and automation.
- Drones (UAV) their importance is growing in civil and military applications.
- 3D Printing and Associated Manufacturing – Additive Manufacturing (3DP /AM) which can quickly change traditional delivery channels and replace traditional manufacturing, particularly in the defence and aerospace industries. It is also expected to lead to significant changes in the use of raw materials used in process processing
- Development of digital technologies whose task will be to support the huge developing digital sector ensuring the implementation of the above solutions.

The Circular Economy Action Plan adopted is meant to support the implementation of these challenges. By providing consumers with better information about products and consumer rights, the EU expects them to play a more active role. The EU will also support the development of these key technologies that are strategically important for the future economy of the Union. This applies to: robotics, microelectronics, fast data processing and infrastructure, blockchain technology, quantum technologies, photonics, industrial biotechnology, biomedicine, nano-technology, pharmaceutical industry and advanced materials.

5. RECOMMENDATIONS FOR THE EU'S FUTURE POLICY

The EU remains at the forefront of countries that implement production with significant added value. However, this does not apply to all member states. Hence, the EU will expect significant investment in research and development to keep these technologically advanced countries and regions in line with others, more advanced. Therefore, there is a need to develop such production to maintain at least a minimum of opportunities for the following high-priority products:

- Batteries – increasing production of raw materials, their processing and potential for their production will require investments to reduce dependence on Asian markets.
- Insufficient production capacity for solar cells to meet the current demand turns out to be the weakest point of the implementation programs in this field in the EU. Hence, it is necessary to improve their production possibilities in Europe, with Chinese competition is very visible here.
- Drones (UAVs) – the EU faces a serious risk of failing to keep pace with other global manufacturers in this key technology that intelligently integrates knowledge of the possibilities offered by real-time drones based on data from the ground.
- Digital technologies – technological leadership requires the EU to secure safe access to and processing of key raw materials and redevelop the capacity to manufacture and assemble key ingredients in EU countries.
- Fuel cells – the main course of action is to improve operational reliability and reduce costs by increasing research expenditure in order to reduce the use of platinum in fuel cell catalysts.

- Wind, safer supply of rare earths to Europe – possibly by recycling them, which would secure the EU's ability to produce magnets.
- Robotics, securing access to raw materials and improving component production, as well as preparing a skills program for employees to maintain the EU's competitive position in the global market.
- Maintaining leadership in 3D printer materials in relation to the specific needs of technology is key to maintaining the EU's competitive advantage.

The European Commission intends to develop and implement these priority objectives and action plan with the help of member states, in particular the platform implementing the EIP on RM program and the expert group associated with the RM Supply Group. The Commission also counts on the support and expertise of the European Institute of Technology in Raw Materials (EIT on RM) based in Berlin. The new SIP strategic program of the EIP on RM platform should strengthen the transition of the EU industry to a climate neutral industry, i.e. a large energy-consuming industry such as the mining industry, to achieve climate neutrality in 2050 in line with the EU strategy. This will also be helped by focusing on activities and technologies that reduce CO_2 emissions from current processes. This can be achieved by:

- energy efficiency – production of the same levels with less energy consumption,
- the use of electricity from renewable energy sources,
- use of geothermal energy,
- biomass; hydrogen or other synthetic fuel,
- CCS (carbon capture and storage) technology.

To accelerate these activities, the EU intends to create the European Raw Material Alliance with strong industry support and implement a raw material policy through this body in the years 2021–2027. The following actions to implement are predicted:

1. Launch the activities of the European Raw Materials Alliance in the third quarter of 2020. Initially building an action program for rare earths and magnet production before this activity is extended to other raw material areas (responsible: industry, EC, investors, European Investment Bank (EIB), shareholders, member states, regions).
2. Prepare a proposal of criteria for financing the entire value-added chain in the extractive industry by the end of 2021 (Delegated Acts on Taxonomy) (responsible: Sustainable Finance Platform, European Commission).
3. To start a program in 2021 covering innovation and research in the field of critical raw materials based on waste processing, advanced materials and substitutes using the Horizon Europe program, the European Regional Development Fund and national research and development programs (responsible: EC, member states, regions, R&D community).
4. Collect and analyse potential sources of secondary critical raw materials and identify critical raw materials from waste and storage sites in the EU and feasible recovery projects – by 2022 (responsible: responsible: EC, EIT Raw Materials).
5. Identify mining and processing projects and investment needs along with the possibilities of financing them for critical raw materials in the EU that can be launched by 2025 with priority for mining regions in which there was / is coal mining (responsible: EC, member states, regions, shareholders).
6. Prepare expertise on the knowledge of mining, processing and processing technologies as part of a strategic program for regions undergoing changes from 2022 (responsible: EC, industry, trade unions, member states and regions).
7. Launch earth observation programs for deposit exploration, monitoring of mining operations and the state of the environment after completion of these operations (responsible: EC, industry);
8. Prepare innovative projects for the Horizon Europe program regarding the exploitation and processing of critical raw materials in order to reduce the environmental impact – starting from 2021 (responsible: EC, R&D community).
9. Develop strategic partnerships and related funds in 2021 to secure the safe supply of critical raw materials including secure trade agreements and investment conditions in cooperation with the Canadian government, African countries concerned, EU neighbouring countries (responsible: EC, Member States, industry and third countries).
10. Support responsible mining practices for critical raw materials through EU legal regulations (proposals from 2020–2021) and appropriate international cooperation (responsible: EC, member states, industry, civil organizations).

6. SUMMARY

Despite the introduction of a circular economy strategy, savings programs in the use of raw materials and the assumptions of the climate policy, mineral

resources are still the basic pillar of economic development in the world and raw materials are becoming necessary in the implementation of many activities resulting from the current mega-trends of the world economy (new low-emission technologies, urbanization, decarbonization, digitization). It seems that traditional energy fuels (coal, gas, oil) will continue to play a fundamental role in the economy of many EU countries (although decreasing) and in ensuring energy security of many countries, including Poland and Germany (lignite). The role and supervision of the state in the creation of raw material policy instruments supporting the economic development and security of individual countries is growing. In view of the declining content of metallic raw materials in deposits and the increasing difficulties in accessing them, the EU mining sector must find its own innovative solutions (e.g. effective and safe exploitation of deep-lying deposits, profitable extraction and processing of poor metal deposits, management of raw materials from waste and secondary raw materials (3R principle – Reuse, Repair, Recycle) more effective methods of separation. I believe that in the case of raw materials and the mining sector, it will be necessary to develop cooperation with countries outside the EU: Australia, Canada and the USA, Japan, which are leaders in many solutions in the mining and processing sector (automation, robotics, digitization, improving work safety, monitoring technological operations).

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