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Editorial

Mining Technologies Innovative Development: Industrial, Environmental and Economic Perspectives

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This Special Issue of *Energies* contains the successful invited submissions [1–20] gathered in a book [21] on the subject area of "Mining Technologies Innovative Development".

The fuel and energy complex is currently undergoing a technological transition associated with the convergence of innovative information-cognitive, nano-material, biotechnologies, and traditional technologies for the extraction and preparation of minerals. At the moment, it is clear that in the 21st century, technological transition in mining is inevitable, which will finally solve two intersecting tasks. The first task is to meet the growing demand for raw materials, including energy sources, in the conditions of expanding digitalization, growing global cargo transportation and developing countries' urbanization. The second task is securing the sustainable development of countries whose well-being is determined by mining, both environmentally and economically, with simultaneous reducing the global impact of mining on the climate.

In this regard, mining science should, on the one hand, ensure the innovative development of minerals extraction, and on the other hand, create a new balance of productivity of traditional and advanced technologies. The latter means equalizing the investment attractiveness of mining and high-tech sectors of the economy. Therefore, it is precisely the innovative support for the development of mining that is today entrusted with the mission of creating the basis for future technological, economic and social progress. The growth in production and consumption of raw materials in the world will reduce the gap between developing and developed countries without increasing the burden on the environment. The growing dependence of modern civilization on the consumption of minerals makes the innovative development of mining technologies a key factor in achieving UN Sustainable Goals 7, 8, 9, 12, 13 (Affordable and clean energy, Decent work and economic growth, Industry, innovation and infrastructure, Responsible consumption and production, climate action) [22].

The innovative technological transformation of mining is in its infancy as digital and robotic technologies transform traditional geotechnology, both on the surface and underground. With volatile global raw material prices, rising safety requirements, tightening environmental regulations and shrinking profits, the mining industry must improve its productivity through the adoption of smart mining systems in order to survive in a competitive market.

Such systems, called "Smart Mining" or Mining 4.0, being the top of the modern stage of innovative development of minerals extraction, are able to solve complex operational tasks, provide Big Data analysis, and present a person in a new capacity as a system integrator of all dynamically changing mining processes. At the same time, the diffusion of advanced technologies of Industry 4.0 into mining cannot be the only goal of its innovative

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transformation. The specificity of mining lies in its dependence on such performance factors as the reliability and safety of machines and equipment, advances in geotechnology, the scale of reclamation and post-mining, labor safety and losses caused by accidents.

Therefore, the development of innovative mining technologies should contribute to the achievement of sustainable development goals by solving four issues of providing humanity with high-quality raw materials and energy, while reducing the impact on natural and social ecosystems, and accelerating their recovery.

The first issue is the modernization of existing mining machines (surface and underground) to radically increase productivity, reduce material consumption and energy intensity of minerals extraction. Its solution is improving the material basis on which Mining 4.0 will be developed in the 21st century.

The second issue of the innovative development of mining technologies is the replacing of existing nature-intensive geotechnology—both on the surface and underground—with new ones, such as the integrated extraction of minerals and the reduction of their losses in the subsoil, the reduction of the seismic impact of mining operations and water resources damage. This requires further research in the field of managing technological processes in mines, optimizing for the use of different types of equipment.

The third issue is the reduction in the natural intensity of mining, which should be embodied post-mining and in green mining. We are talking about the convergence of mining and environmental technologies, as a result of which, land and water-saving, recycling and biodiversity restoration should become an integral part of the mining process, and be included in the "fair" price of mineral resources.

The fourth issue relates to the imperative of safe work and achieving zero fatalities in mining. With regard to its innovative development, this means expanding the range of labor safety studies in the context of the widespread introduction of the achievements of Industry 4.0, such as Smart Sensors and Cloud Analysis in the study of the stability of natural and artificial rock arrays, the operation of equipment and the state of people.

Innovative solutions to these issues are featured in the Special Issue of *Energies* entitled "Mining Technologies Innovative Development". All articles address a broad range of mining innovative technologies development, highlighting the complex nature of securing a prosperous future for the mining sector.

In accordance with the contribution of this Special Issue to the solution of the above issues of the innovative development of mining technologies, the submitted articles are devoted to the following topics:

- Reducing energy consumption and improving the quality of ore preparation;
- Automatic control of a powered roof support and improving the roof bolting systems;
- Development of conveyor belts for underground mines;
- Development of surface mining equipment (dump trucks, loaders, drilling rigs) and quarrying technology;
- Increasing the productivity of the boreholes;
- Mine ventilation systems development;
- Post-mining and reclamation;
- Smart sensors in underground and surface mines development;
- Search and rescue operations in mines development;
- Seismic and landslides prediction in intensive mining clusters.

Response to our call for manuscripts from the mining science society was excellent. We could attract many high quality papers with the following statistics:

- Submissions: (25);
- Publications: (20), among them: Review Articles: (2);
- Rejections: (5).

The authors of published articles are distributed geographically in the following way:

- Poland: (57);
- Australia: (1);

- China: (2);
- Russia: (1);
- Slovakia: (1);
- Ukraine: (6);
- Germany: (2);
- Finland: (1).

All published articles are devoted to a broad range of innovative mining technologies interfacing subsoils extraction with mining machinery, labour safety, "green mining" and post-mining development, as exemplified in Figure 1.

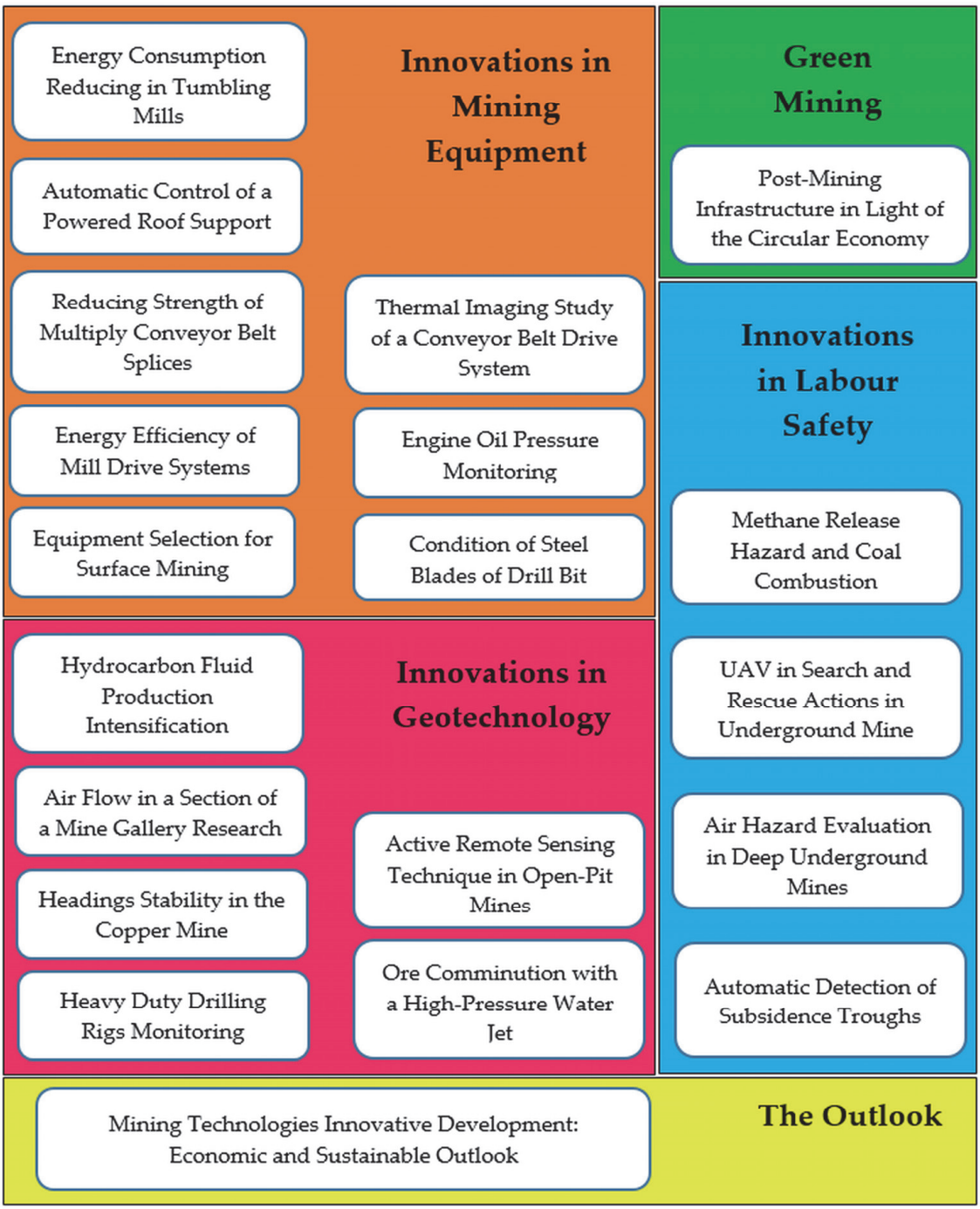

Figure 1. The spectrum of the articles published in the Special Issue "Mining Technologies Innovative Development".

We are proud to take a part in editing and selecting papers for this Special Issue, and also would like to thank the reviewers for their contribution. The further progress in academic thought in the field of mining science depends on consolidating and popularizing the ideas of innovations in basic industries.

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