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Logistical aspects of mining rescue in Slovakia – status, challenges and perspectives

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Keywords: mining rescue, logistics, occupational safety, emergency service, Slovakia.
Abstract: Mining rescue in Slovakia represents a specific component of the rescue system with a long tradition and a significant position in the field of occupational health and safety. Its main task is to resolve underground emergencies, including accidents, collapses, fires or gas leaks, while the activities of mining rescue workers require high professional preparedness and logistical coordination. The article focuses on the analysis of the strengths and weaknesses of the mining rescue system in Slovakia with regard to organizational, technical, logistical and social aspects. The paper presents findings from literature, legislation and practical experience, supplemented by the international context and recommendations for further development.

1 Introduction

Mining is a risky activity. Underground accidents often require immediate intervention by specialized units that have expert knowledge, physical preparedness and specific technical means. Mining rescue in Slovakia has a tradition of more than a century and is one of the professions that require a high level of solidarity, dedication and logistics of interventions.

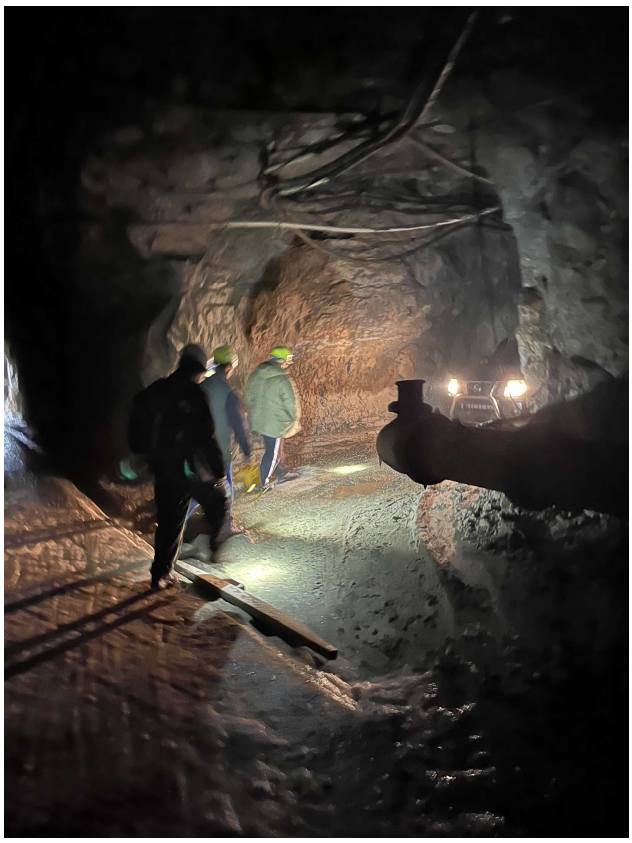

Figure 1 Mine rescuers inspecting parts of the mine

Mining is one of the traditional sectors of the Slovak economy, and its historical importance is linked to mining towns, metallurgy and industrial development. Despite the decline of coal and ore mining, mining rescue remains an important part of the country's security system. Its importance goes beyond the mining operations themselves, as the know-how and capacities of the Main Mining Rescue Station (HBZS) are also used in interventions in the chemical industry, in construction or in solving accidents in underground structures (tunnels, collectors) (Figure 1).

The purpose of this article is to analyze the current state of mining rescue in Slovakia, identify its strengths and weaknesses, and emphasize its social and moral significance [1]. At the same time, attention is also paid to aspects of logistics and the organization of interventions, which are key to effective management of crisis situations. It clarifies why it is necessary to examine this area also from the perspective of logistics. Logistics is a key element in the management of human resources, technology, materials, and time factors in crisis situations. Effective logistics can decide the speed and success of the intervention, and thus the saving of human lives.

2 Literature review and legislative framework

The issue of mining rescue is enshrined in the legislation of the Slovak Republic, in particular in Act No. 51/1988 Coll. on mining activities, explosives and state mining administration and in related decrees. The role of coordination and methodological management is fulfilled by the Main Mining Rescue Station (HBZS) in Prievidza and the Main Mining Office (HBÚ) [1]. Mining rescue is presented rather marginally in the professional literature. In Slovakia, the basic source of methodological and technical knowledge is the Main Mining Rescue Station in Prievidza (HBZS), which regularly publishes activity

reports, intervention statistics and professional methodologies.

According to available sources [1,2], Slovakia is one of the few European countries where mining rescue is still systematically developed and maintained as an independent organizational unit. The European Agency for Safety and Health at Work [3] emphasizes the importance of specialized rescue services in preventing and resolving crises, with logistical preparation and the availability of equipment being among the decisive factors for the success of the intervention. An international perspective is provided by EU-OSHA, which analyzes occupational risks in mining and related industries. Studies by the Technical University of Košice (TUKE), especially in the area of process safety and reliability, contribute to the issue of crisis management logistics. On the academic campus, the Department of Mining and Geotechnics regularly publishes studies on safety and rescue [4-6]. Czech literature is also worth mentioning (Mining Rescue Corps, HBU), which presents experiences from acute interventions in the Ostrava-Karvinský district. This knowledge is transferable to Slovak conditions due to the similarity of the legislative environment and the nature of mining operations [7].

3 Organization of mining rescue services in Slovakia

Mining rescue services in Slovakia are centrally organized through the HBZS in Prievidza. The HBZS provides [1,4,7]:

- emergency units for mining operations,
- professional training and education of rescuers,
- special equipment (breathing equipment, detection devices, measuring equipment),
- research and development of technical means,
- coordination of interventions throughout the territory of the Slovak Republic.

The legislative framework is determined by the Mining Act No. 44/1988 Coll. and implementing regulations, which stipulate the obligation of employers to provide mining rescue services.

4 Logistic processes in mining rescue

The intervention of mine rescuers is a complex logistical operation. Logistics plays a key role in three basic levels [8]:

Personnel logistics – selection, training and emergency provision of teams, mobilization of the team at short notice.

Material logistics – management and maintenance of special equipment (breathing apparatus, vehicles, measuring equipment), preparation of equipment and transport to the intervention site, supply of oxygen equipment and energy.

Information logistics – flow of information between the intervention team, HBZS, operations and state administration bodies, cooperation with other components (firefighters, paramedics, police).

According to HBZS, logistics represents up to 40% of the overall success of the intervention, since even a top-trained team without the necessary resources and coordination is unable to intervene effectively.

4.1 Strengths of mining rescue services in Slovakia

Strengths include:

- Long tradition and experience: Centralized structure and high expertise of HBZS, Slovakia has a built system of mine rescue stations, which have a number of successful interventions.
- Expertise and preparedness: Mine rescuers undergo specialized training, regular exercises and psychological preparation. Experience from interventions outside mining (tunnels, chemical operations).
- Technical equipment: Modernized breathing apparatus, monitoring equipment and special transport vehicles increase the effectiveness of interventions.
- Logistical coordination: A clearly set command and communication system enables rapid mobilization of forces and resources.
- Social credit: The profession of a mine rescuer is associated with a high degree of respect and trust of the public. Connections with international rescue organizations.

4.2 Weaknesses and challenges

Weaknesses and challenges include:

- Decline in mining activity: Insufficient funding due to the decline in mining in Slovakia leads to a reduction in the number of active rescuers and threatens the continuity of the system.
- Financial constraints: Outdated technology and the need for its modernization, insufficient resources for modernization of technology and infrastructure limit the development of services.
- Personnel capacities: Personnel weakening due to the departure of experienced experts, recruiting new rescuers is difficult due to specific requirements and risks.
- International isolation: The Slovak system is less connected to foreign initiatives compared to other EU countries.
- Administrative burden: A high level of bureaucracy slows down the process of innovation and flexibility of the system.

4.3 Social and moral significance

Mining rescue is not just a profession, but also a mission. Rescuers protect human lives, property and the environment through their work (Figure 2). In the eyes of the public, they are a symbol of solidarity and courage. Their work goes beyond mining itself - their experience is

also applied in emergency situations outside mining, such as floods or technological accidents (Figure 3).

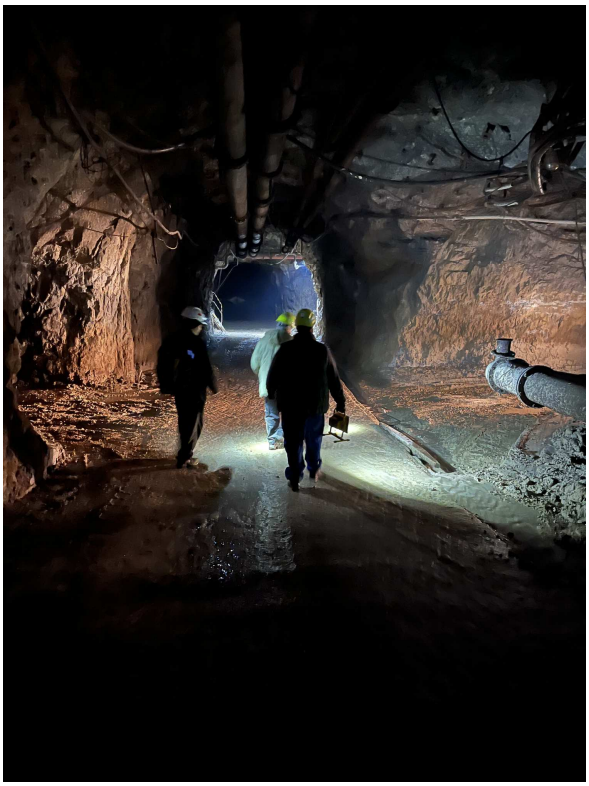

Figure 2 Mine rescuers in the mining area

Figure 3 Technology in the mining area

5 Comparison of mining rescue services

Mining rescue in Slovakia is based on strong traditions and many years of experience, but for an objective assessment of its current level, it is necessary to compare it with foreign models that offer inspiring solutions in the field of organization, technical support and financing. Countries with the most significant standards in the field of mining safety include Germany, the Czech Republic, Poland and Australia, each of which represents a different approach to the systemic provision of rescue services [8].

Germany is characterized by a high degree of centralization and state funding, which ensures the stability and continuity of rescue services. Preventive measures, mandatory training and strict legislation are at the forefront, which significantly reduces the risk of serious incidents. An important element is the use of advanced monitoring technologies - for example, systems for continuous monitoring of gas concentrations, movement of people or stability of mining areas. Logistical readiness is supported by a network of centralized rescue stations, which enable rapid mobilization of units and equipment.

Poland represents a different model, in which there is a noticeable greater involvement of private entities in the organization of the mine rescue service. Although the state retains a regulatory and supervisory role, a significant part of the responsibility lies directly with the mine operators. This model brings advantages in the form of higher technological variability and more flexible financing, but at the same time creates challenges in the area of coordination and a unified approach to large-scale interventions. Poland is an example of a country where modern technologies (e.g. robotic devices or thermal imaging systems) significantly improve intervention readiness, but the problem remains the lack of qualified personnel and the need for their systematic replenishment.

Australia is an example of a comprehensive approach to industrial safety, in which mining rescue is fully integrated. Rescue units operate within a broad framework of industrial protection, which combines legislation, trade unions, inspectorates and employers themselves. There is a significant emphasis on transparency - all incidents are systematically recorded and publicly analyzed. The Australian model is among the most technologically advanced: it uses drones, remotely controlled robots, automated monitoring systems and sophisticated simulation technologies that allow for the prediction of risks and the optimization of interventions.

Slovakia can boast a long tradition and high level of expertise of rescue workers, who are also respected in the international environment. A strong point is also a strong connection to state authorities and security forces. However, a weak point is the lack of technological modernization and financial sustainability of the system, which is associated with the gradual decline of mining. Compared to countries such as Germany or Australia, Slovakia has not yet reached the level of automation and

use of modern technologies, which represents room for future development.

The future of mining rescue is inextricably linked to the challenges of energy transformation, the decline of traditional mining and the changing risk environment. Inspiration from the experiences of developed countries is therefore a key prerequisite for the Slovak system to remain functional, effective and socially recognized.

6 Discussion

A comparison with foreign countries shows that the Slovak system has a high professional quality but lags behind in the financial and technical areas. In the Czech Republic and Poland, the financing of rescue services is tied to state resources to a greater extent than in Slovakia. In addition, modern digital technologies are used in Germany and Austria to monitor interventions in real time. Logistics is therefore an area where the Slovak mining rescue service has significant room for improvement - especially in the areas of digitalization, predictive maintenance of equipment and modern human resource management [9,10].

7 Conclusions

Mining rescue in Slovakia is a unique system that, despite the decline in mining activities, plays an important role in the country's safety infrastructure. The analysis showed that the strengths are expertise and centralized structure, and the weaknesses are financing and technical support.

The aim of the article was to point out the importance of mining rescue not only from the point of view of logistics, but also from the point of view of the social and moral dimension. In the future, it is necessary to look for solutions that will ensure its sustainability and adaptation to new challenges. Logistics is a determining tool for increasing the efficiency of rescue interventions. The result is a recommendation to focus in the future on:

- ensuring a stable and sustainable financing model,
- a higher level of technological modernization (modernization of equipment, digitalization of information flows)
- more intensive international cooperation in training, exchange of experience and transfer of know-how.

Only in this way will it be possible to maintain a high level of safety and preparedness of mining rescue workers in the 21st century.

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