MIDDLE POMERANIAN SCIENTIFIC SOCIETY OF THE ENVIRONMENT PROTECTION

Rocznik Ochrona Środowiska

Volume 21. Year 2019 ISSN 1506-218X 98-111

Protecting and Securing an Environment Affected by Industrial Activity for Future Utilization

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1. Introduction

Extraction of minerals is one of the main activities of the world economy involved in creating social goods. However, this activity causes environmental damage, and these negative impacts, along with some socio-economic impacts of extraction, threaten our sustainable development goals. Experts around the world are addressing this issue and are looking for appropriate solutions and methods for environmental safety in extraction industries (Perminova & Lobanova 2018, Sánchez-Sierra et al. 2018, Straka et al. 2016, Trubetskoy et al. 2017, Vartanov et al. 2017, Vilamova et al. 2016).

From the case study "Challenges to access and safeguard mineral resources for society: A case study of kaolin in Portugal" we learn about the importance of mineral raw materials for society (Lopes et al. 2018).

Ensuring the safety of extraction activities in Russia is mentioned in the scientific paper "Risk-oriented provision of extraction operations safety at the enterprises of mineral resources sector in Russia" (Vartanov et al. 2018).

Researchers Vartanov, Petrov and Fedash also deal with the development of "safety in mining" (Vartanov et al. 2017).

The study "A hybrid semi-quantitative approach for impact assessment of extraction activities on sustainable development indexes" was prepared to present a general assessment of the impact of extraction on sustainable development indicators (Amirshenava & Osanloo 2019).

The long-term planning of extraction using the energy triangle is addressed by Marx and Wolff in their publication (Marx & Wolff 2018).

The case study by Hummel, Ruiz and Kelafant addresses the renewal of coal mining in India with environmental and economic perspectives (Hummel et al. 2018).

In northern Spain, experts compiled a study dealing with the effects of extraction on the contaminated Nalón River (Garcia-Ordiales et al. 2019).

The impacts of surface extraction and the subsequent reclamation in Red Hill Mine are discussed in "Post-reclamation Age Effects on Soil Physical Properties and Microbial Activity Under Forest and Pasture Ecosystems" (Adeli et al. 2019).

The case study of the Yanzhou coal area deals with the consequences of underground mining on the surrounding ecosystem (Xiao et al. 2018).

You can read about the environmental safety of the mining industry in "Environmental Impact of Abandoned Mine Wastes on an Urban Area in NW Caucasus" (Drebenstedt & Alekseenko 2018).

The topic of the development of mining and quarrying with regard to the environment is addressed by the conference document "Land-and-Ecological Problems of Kuzbass Mineral Resources Development" (Solovitskiy et al. 2018).

Conditions of extraction of existing mineral deposits are more problematic and complicated. For this reason, the issue of using existing deposits is particularly topical and this is justified by Gridina and Andreev in their article (Gridina & Andreev 2018).

Sustainable development of extractive industries is not possible without the use of modern solutions. A publication on this issue was prepared by Rylnikova et al. 2018.

The several authors commented on the closure of mining enterprises and pointed out that, in addition to improving the ecological situation, closure also leads to activation and emergence of new dangerous geological processes and phenomena (Posephov et al. 2018, Loučanová & Olšiaková 2019).

The specialist article "Natural and formal-legal aspect of the environmental impact assessment of the planned reclamation of mining damage in the Szotkowka valley (Southern Poland)" is also of interest. The article deals with the problem of liquidation of mining damages, using post-extraction waste (Soltysiak et al. 2018).

Other important publications in which the authors deal with the environmental impacts of mineral extraction are "Radon bearing water protection in underground uranium mining - A case study" (Yun et al. 2017), "Thermo-hydraulic modeling of artificial ground freezing: Application to an underground mine in fractured sandstone" (Vitel et al. 2016), and "Regional Impact of Uranium Mining on Piezometric Surfaces in a Multi-layered Water-bearing System, Bohemian Cretaceous Basin, Czech Republic" (Lipansky 2017).

The safe and efficient development of underground resources is addressed in the paper "Ensuring the Environmental and Industrial Safety in Solid Mineral Deposit Surface Mining" (Trubetskoy et al. 2017).

The implementation of a long-term strategy for sustainable technological development in the mining industry is discussed by Berger, Director, Fedoseev, Geologist and Saraskin (Berger et al. 2017).

2. Theoretical base

2.1. Capacity of the deposit and its importance for future use

The reserved deposit of andesite at Ruskov and the extraction area of Ruskov I are located about 1 km east of the village of Ruskov, about 10 km as the crow flies east of Kosice. At present, the Ruskov I extraction area has two parts, the new Strahuľka deposit, which has been quarried since 2008 and the currently unused part, the Ruskov – Old Quarry deposit (Fig. 1).

The main reason for writing off the deposits at Ruskov – Old Quarry was in particular the special and complex extraction and technical conditions as well as the economics of extraction (Dobrovic et al. 2018).

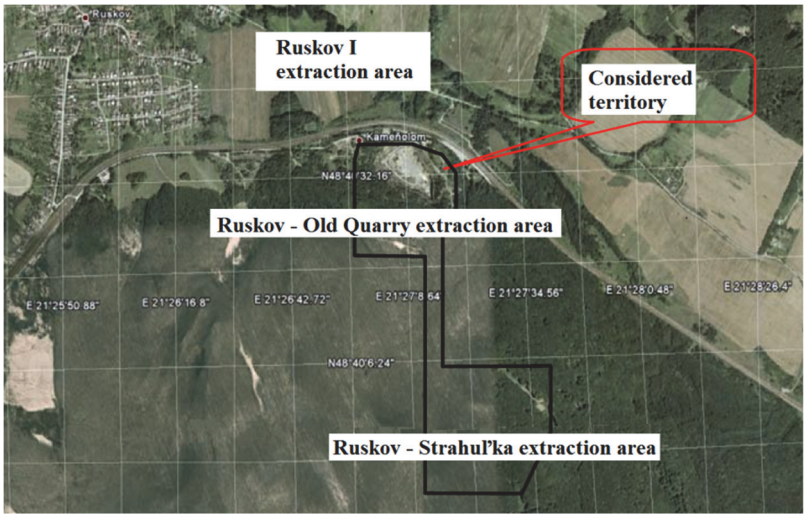

Fig. 1. Organization of extraction in the Ruskov I extraction area

In effect, this ended activities in the quarry and it is now only being maintained in terms of security and stability. The high walls of the quarry have gradually weathered and become overgrown with trees. Occasionally, under the influence of weathering, blocks of stone or stone debris have fallen. Access to the quarry was blocked, the original equipment gradually lost its functionality, it was technologically abandoned and written off.

In 2010, the demand for processed commodities from the Strahuľka quarry increased to such an extent that it would not be sufficient to cover construction demand. Therefore, the overall level of deposits at Ruskov, including the existing unused extraction area of Ruskov – Old Quarry, was reviewed. For this purpose, four exploratory boreholes were drilled and the results from past exploratory drilling work were re-examined.

At the same time, the parameters of the overburden for the expected quarrying were also examined. Based on the above-mentioned geological survey and calculation of deposits, it can be stated that this survey confirmed that the body of the andesite deposit is continuous, in particular in the direction of the depth from the floor of the quarry, to a depth of at least 30 m. The second analysis verified the anticipated deposits in the south-south-west direction from the walls of the current quarry so that the safety inclination ratios of the side walls are preserved and the limit of the existing extraction area, or more precisely, to retain the current safety distance around the extraction area to the edge of the highest cut. The total area of both blocks of represents a total area of 8.7 ha. Of this, 5.2 hectares are in the current quarry area and 3.5 hectares are the new extraction area in the southern direction.

Based on the data in the quarry and the allocation of raw material blocks, the stock of raw materials was calculated as 6 279 000 m^3 (Fig. 2).

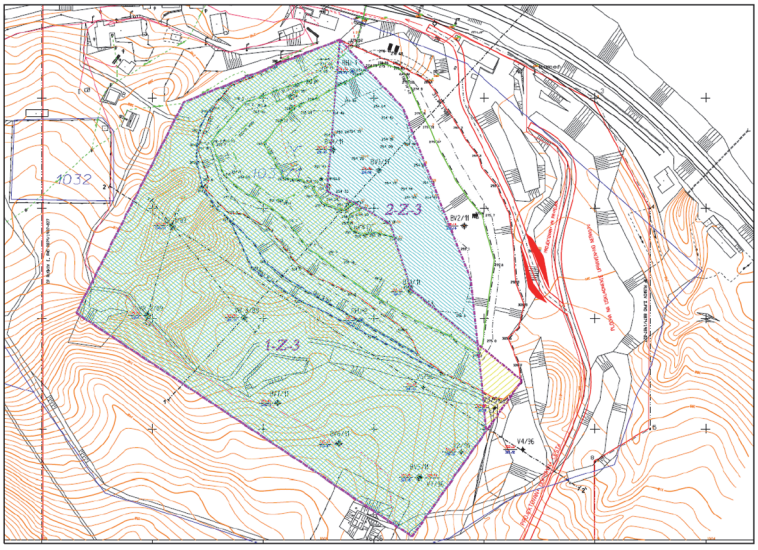

Fig. 2. Geological map of deposit blocks

Verification of the deposits of building stone in the Ruskov I extraction area "based on the results of the final report and the calculation of reserves at the Ruskov reserved deposit, was prepared for the years 2012-2032, which continues the activity previously performed.

Overburden applies only to the area of exploitation outside the existing quarry to the south and southwest. The overburden ratio of 1:8 is currently very unfavourable (despite its partial removal in the past with the assumption of continued extraction) and its volume was calculated to be about 770 000 m^3. Overburden mainly consists of a small volume of soil (partly removed in the past or eroded) but mainly a relatively large volume of weathered material, debris and fillings of fissures, grooves and erosion or tectonic depressions often at a considerable size of up to 18 m.

The expected maximum annual volume of extraction in the old quarry extraction area is 800 000 tons, but fluctuations in extraction are expected, influenced by the implementation of larger investment projects in the region, especially in connection with the construction and modernization of transport infrastructure.

2.2. Regulations and standards defining safety of the extraction site

When carrying out extraction activities, the prepared safety plan must be adhered to, based on the decision of the District Mining Authority of Košice for the permit for extraction activity, Act no. 44/1988 as amended, Act no. 51/1988 as amended, and other implementing regulations issued on their basis, Act no. 311/2011 the Labour Code as amended, operational documentation, basic documentation, the emergency plan, Act no. 124/2006 as amended.

Particular attention should be paid to the Decree of the Slovak Mining Office no. 29/1989 on health and safety protection at work and safety of operations in mining and surface extraction operations.

The operating documentation consists of technical procedures, operating procedures, operating and maintenance instructions, traffic rules. Pursuant to Government Decree no. 117/2002 on minimum requirements for the protection of the health and safety of employees in mining activities and in the extraction of non-reserved mineral deposits, the organization ensures the updating of operational documentation with proposals of safety measures to protect the health and safety of employees in ordinary and emergency situations. Everyone affected who must be in the workplace will be demonstrably instructed in it.

Compliance with safety regulations and safety is the responsibility of the organization and all personnel within the scope of their powers and responsibilities as specified in the Code of Conduct, applicable operating documentation, and safety regulations. This part of this chapter also includes the

assessment of the risk of extraction activity on the surface, and evaluation of the unavoidable danger and unavoidable threats inherent to extraction activities and the proposal of protective measures, which are prepared in accordance with Act no. 124/2006 on Occupational Health and Safety Protection at Work, as amended.

There are no old mining works, mines or quarries in the area of the Ruskov quarry or in its vicinity, with respect to the occurrence of explosive gases and dust, spontaneous combustion, fractures of rocks, coal and gases, water and mud flows and other dangerous phenomena.

3. Case study

3.1. Securing the technical properties of the quarry

The reason for securing the quarry in the Ruskov – Old Quarry extraction area is the interruption of extraction and termination of the drainage of the deposit and the removal of extraction waters formed by rainwater and groundwater inflows from the rock massif, for economic and technical reasons, resulting in the flooding of the lower quarry. The reason for the technical modifications - is to ensure safety and protection from falls into the unsecured space, the open depth. Currently, the quarrying company does not intend to continue extraction in view of the market situation, which however may change in the future due to market conditions.

The whole area of the quarry and other structures located outside the quarry which were not used for quarrying (waste management, sanitary building, etc.) are located in the area, which is guarded by a guard service outside working hours and during working hours there is a shipping employee on the access road, i.e. entry to the premises is only possible on the basis of an entry permit. The quarry itself is partly fenced on the top of the highest cut (crown) and partly protected with embankments. On the access roads there are signs with a ban on unauthorized entry.

The quarry will be secured in such a way that access to the quarry itself is prevented by a boom barrier and there will be a sign stating that there is to be no unauthorized entry. Access to crowns above the highest cuts with the danger of people falling into the quarry will be prevented by appropriate technical measures, embankments or similar (adding wires with warning tape) and “Danger Quarry” and "No Entry” signs with appropriate pictograms will be placed at regular distances. Technical adjustments to the quarry floor will not occur due to permanent flooding.

No significant adverse effects on the surface are anticipated at the time of securing the quarry. The risk of water erosion and landslides is minimal due to the area of the quarry. Sufficient measures against landslides were taken during

the extraction activity. This was mainly about adhering to the set parameters of final slopes.

Ruskov I – Old Quarry, is currently spread over three levels of varying heights from 15 to 20 m. Adjusting the quarry slopes is not considered during the process of securing and technical refinement, the bottom of the quarry is flooded. Tippings are not found in the Ruskov I quarry.

When performing adjustment works, checks will be performed once per shift. Checking the status of safety features (fences, barriers, warning boards) will be carried out by a shift technician at intervals of once per week, or at more frequent intervals as needed. In the case of damage to the safety equipment, repairs will be arranged with possible supplementation. The inspection results will be monitored and recorded (Laboš 2017).

3.2. Securing the environmental properties of the quarry

Securing the territory of the Ruskov quarry is also includes management of extraction water. Drainage of the deposit and removal of quarry water consisting of rainwater and groundwater inflows from the rock massif was designed by catching it and pumping it from the sump in the lowest parts of the excavated area. At higher levels, the inclination and utilization of the terrain morphology, will ensure the drainage of rainwater outside the quarry area.

In 2014, extraction activity ceased and pumping water from the quarry stopped. During extraction, water from the quarry was pumped out of the built-in sumps, according to the amount of water flowing in. Pumping was not continuous.

According to information from the customer, there were no problems with leakage of extraction waters outside the extraction area when draining the quarry. Since 2014, when pumping water from the quarry ceased, until now, no springs or waterlogging of slopes in the surrounding area have emerged, which would indicate leakage of quarry water outside the extraction area of the deposit.

According to the measurements, the water levels in the quarry were normal. The area of the flooded part of the quarry is 19 400 m^2. With an average level of approx. 3.4 m, it is possible to expect approx. 67 000 m^3 of water in the quarry.

On the basis of this data and knowledge and hydrogeological conditions, it is possible to estimate the amounts of rainfall and groundwater flowing into the quarry.

Bystrý stream represents the local drainage base for the area of the Ruskov quarry. Infiltrated water, which has not flowed into local subsystems, descends to larger depths and integrates into the intermediate flow subsystem (Olšava Valley). The measured runoff of groundwater, calculated from hydrogeological flows, balance and runoff from springs, in the assessed area mostly ranges from 0.8 to 1.1 l/s per square km.

According to the physical and chemical analysis of the water sample, the water in the quarry is of a basic highly magnesium-bicarbonate type. Total mineralization is 375 mg/l, ph – 8.4, contents Na – 13.4 mg/l, Ca – 41.1 mg/l, Mg –
26.2 mg/l, Fe – 0.04 mg/l, Mn – 0.012 mg/l and in hydrogeological investigation the mineralization of precipitation water ranged from 25.8 to 48.0 mg/l, pH 6.0-6.6.

By comparing the values for the tributaries in to the pit of the old Ruskov quarry and the values of groundwater runoff in the volcanic massif, we can state that only a part (approx. 50%) of the groundwater from the volcanic massif is involved in inflow into the quarry. The greater part of the underground runoff is into the local flow sub-system in the local erosion base, which is represented by the valley of the Bystré stream, or incorporated into the intermediate flow stream (Olšava valley, erosion base).

In the previous extraction activity in the Ruskov Old Quarry, as well as after was flooded in August 2014, no adverse effects on the flow and groundwater regime were observed in the evaluated area.

Based on the re-evaluation of the hydrogeological conditions of the area, we can state that after the interruption of extraction at the Ruskov – Old Quarry deposit and the end of pumping of quarry waters, there is no expected adverse influencing on the flow and groundwater regime in the evaluated area (Fabian 2017).

3.3. Ensuring the safety features of the quarry

There are no old mining works, mines or quarries in the area of the Ruskov quarry or in its vicinity, with respect to the occurrence of explosive gases and dusts, spontaneous ignition, rock falls, coal and gases, water and mud slides and other dangerous phenomena.

The danger and hazard assessment of the safety of the Ruskov quarry according to established site criteria is analysed in Table 1.

A danger is understood to be a condition or property of a factor of the working process or the working environment that can harm health. Another state is a hazard, meaning a situation in which it cannot be excluded that the health of an employee will remain unaffected. Other conditions are unavoidable dangers and unavoidable hazards, dangers and hazards that cannot be ruled out or limited with current scientific and technical knowledge.

Table 1. Assessment of Danger and Hazards in Securing the Ruskov Quarry

No.	Working process and environmental factor	Unavoidable danger	Unavoidable hazard	Place of occurrence	Proposal of protective measures
1	Human factor	Lack of discipline, forgetfulness, physical fitness, indisposition and so on	Injuries of varying nature	The whole area of the quarry	Regular inspection of the quarry by the supervisory authority and other technicians
2	Walking in the quarry area	Fall while walking	Various injuries	Quarry site	Keep walking paths in a safe condition
3	Working with fire – welding in mechanisms during maintenance	Occurrence of fire	Burns	Locations with increased fire hazard	Prohibition of open flames, no smoking
4	Intrusion of persons into unauthorized areas	Damage to equipment damage	Various injuries	The whole area of the quarry	Exclude the presence of persons in dangerous working and driving areas

Table 1. cont.

No.	Working process and environmental factor	Unavoidable danger	Unavoidable hazard	Place of occurrence	Proposal of protective measures
5	Weather conditions	Freezing, fog, rain, storm activity	Various injuries	Quarry site	Maintenance of traffic routes, control of water drainage system from working areas
6	Possibility of landslides	Threats to people and mechanisms	Various injuries	Quarry area	Perform loading and unloading in accordance with the operating documentation. Machine operators and drivers must constantly observe the quarry walls, and in the event of danger, stop work at and move away from the danger area

4. Results, discussion and conclusion

The proposed activity is caused by the exceptionally increased interest in building aggregates in connection with the intensification of construction development in eastern Slovakia and abroad. Therefore, the investor has decided

to review its levels of deposits within the existing extraction area of Ruskov I and restore extraction activity in it without opening a new quarry and a new intervention in the landscape. After the geological survey, it was confirmed that there is a sufficient amount of extractable reserves of raw materials in the deposit, using existing equipment and technology used in extraction in another part of the Ruskov I extraction area, in the Strahuľka quarry. This concerns in particular the raw material processing equipment. There will be no new intervention in the landscape outside the existing quarry, and this will be rationally exploited until the deposits are fully exploited. At the end of extraction, the final disposal of the quarry and its landscaping and biological reclamation will be carried out so that the final landscape of the quarry is harmonized with the wider surroundings.

According to the physical and chemical analysis of the water sample, the water in the quarry is of a basic high magnesium-bicarbonate type. The total mineralization 375 mg/l, ph – 8.4, content of Na – 13.4 mg/l, Ca – 41.1 mg/l, Mg – 26.2 mg/l, Fe – 0.04 mg/l, Mn – 0.012 mg/l and in the hydrogeological investigation the mineralization of precipitation water ranged from 25.8 to 48.0 mg/l, pH 6.0-6 6.

In terms of future investments, it is necessary to take into account activities and structures that may have a negative impact on conservation objectives in the area under discussion and which create additional research opportunities.

Important activities affecting further development:

- landfill,
- introduction of telecommunication masts and transformer stations,
- introduction of long-distance and local electricity distribution,
- construction of buildings,
- performing activities changing the state of wetlands or watercourses,
- geological work,
- extraction of building stone,
- discharge of waste water,
- the spread of non-native plant species,
- the spread of all non-native animal species.

Important structures affecting further development:

- landfill,
- telecommunication masts and transformer stations,
- long-distance and local electricity distribution,
- building,
- extraction works,
- roads of classes I to III.

The submitted paper is a part of the projects "Research and development of new smart solutions based on principles of the Industry 4.0, logistics, 3D modelling and simulation for production streamline in the mining and building industry", VEGA 1/0317/19 and "Transfer of knowledge from the field of logistics into the preparation of innovative teaching materials for selected study units of the newly accredited study program, Commercial logistics", KEGA 006TUKE-4/2019.

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Abstract

At the present time, there are many abandoned areas and places that are affected by extraction activity, but which continue to be of importance due to valuable mineral resources. This article deals with environmental protection for their future use in terms of potential mineral resources. The area of Ruskov in Eastern Slovakia is typical with its rich deposits of andesite. Currently, there is no extraction activity at the site. The problem is related to effectively securing and protecting the environment for future use. The aim of the article is to indicate the possibilities for securing and protecting the area. The procedure can be applied universally to similar types of areas.

According to the physical and chemical analysis of the water sample, the water in the quarry is of a basic high magnesium-bicarbonate type. The total mineralization 375 mg/l, pH – 8.4, content of Na – 13.4 mg/l, Ca – 41.1 mg/l, Mg – 26.2 mg/l, Fe – 0.04 mg/l, Mn – 0.012 mg/l and in the hydrogeological investigation the mineralization of precipitation water ranged from 25.8 to 48.0 mg/l, pH 6.0-6 6.

From the comparison of values for inflows to the pit of the old Ruskov quarry and the values of groundwater runoff in the volcanic massif, we can state that only a part (approx. 50%) of groundwater from the volcanic massif is involved in the inflow to the quarry. The greater part of the underground runoff flows in the local sub-system to the local erosion base, which is represented by the valley of the Bystré stream, or it joins the flow of the intermediate stream (Olšava valley, erosion base).

In the previous extraction activity in the Old Quarry of Ruskov, as well as after it was flooded in August 2014, no adverse effects on the flow and groundwater regime were observed in the evaluated area.

Based on the previous evaluation of the hydrogeological conditions of the area, we can state that after the interruption of extraction at the Ruskov – old quarry deposit and the termination of pumping of quarry water, there is no expected adverse influence on the flow and groundwater regime in the evaluated area.

Keywords:
safety, environment, protection, risks, principles