Revista Minelor – Mining Revue
ISSN-L 1220-2053 / ISSN 2247-8590
vol. 31, issue 3, pp. 112-117, selected paper from the First International EnviroMining Virtual Conference 2025

REHABILITATION PLAN METHOD FOR AN ANDEZITE OPEN PIT

Ioan BUD[1,4], Dorel GUȘAT[2,4], Dinu DARABA[3,4]*

[1]Technical University of Cluj Napoca, North University Center of Baia Mare, Romania, Ioan.Bud@irmmm.utcluj.ro
[2]Technical University of Cluj Napoca, North University Center of Baia Mare, Romania, Dorel.Gusat@irmmm.utcluj.ro
[3]Technical University of Cluj Napoca, North University Center of Baia Mare, Romania, Dinu.Daraba@imtech.utcluj.ro
[4]European University of Technology, European Union

DOI: 10.2478/minrv-2025-0034
received – 21.01.2025 / revised – 11.02.2025
accepted – 18.02.2025 / published – 22.09.2025

Abstract: *The exploitation of andesite in open-pit mining must adhere to the specific provisions of Romanian mining law, which emphasizes environmental protection and sustainable resource management. This study focuses on integrating mine planning with environmental assessment and rehabilitation works to ensure compliance with legal requirements. The research examines how comprehensive environmental assessments can guide the design of effective rehabilitation strategies, minimizing the ecological footprint of andesite extraction. Key aspects include land reclamation, restoration, and post-mining land use planning. The findings underscore the importance of aligning mining operations with Romanian legal standards to promote sustainable development and responsible resource extraction.*
Keywords: *andezite open pit, rehabilitation works, environmental assessment, mine planning*

1. Introduction

The andesite is an essential volcanic rock used extensively in the construction industry due to its durability, strength, and aesthetic appeal. In Romania, the exploitation of andesite plays a critical role in the development of infrastructure and urbanization, serving as a valuable material for road construction, building facades, paving stones, and decorative elements.

Some key points on the importance of andesite exploitation in Romania:

- **Durability and Strength**: Andesite's toughness makes it highly suitable for construction purposes, particularly in regions requiring high resilience, such as roads, bridges, and pavements. In Romania, where the climate can vary dramatically, andesite offers excellent resistance to wear and weathering.
- **Abundance and Availability**: Romania has abundant andesite deposits, particularly in areas such as the Maramures and Satu Mare Counties (Fig. 1). This local availability reduces transportation costs and enhances the sustainability of construction projects.
- **Versatility in Construction**: Andesite's aesthetic qualities and ease of processing make it ideal for both practical and decorative purposes. It is widely used in the construction of public spaces, monuments, and even architectural facades, contributing to Romania's rich architectural heritage.
- **Economic Impact**: The exploitation of andesite not only supports the construction industry but also creates jobs and stimulates local economies. Mining and processing facilities in areas rich in andesite, such as the Apuseni Mountains, contribute to regional economic growth.
- **Environmental Considerations**: While andesite exploitation is important for construction, sustainable extraction practices are essential to mitigate environmental impacts. Responsible mining can help ensure that andesite remains a resource for future generations.

The Neogene Basaltoid Andesites refer to a specific type of volcanic rock formed during the **Neogene period** (approximately 23 to 2.6 million years ago). These rocks are part of the wider andesitic family but are distinguished by their composition and the geological era in which they were formed. Neogene basaltoid andesites are a hybrid between basalt and andesite, meaning they have characteristics of both rock types, with certain features that make them important in geological and construction contexts.

* Corresponding author: Ioan Bud, Prof.Eng.Ph.D, Technical University of Cluj Napoca, North University Center of Baia Mare, Romania, Dr. Victor Babes Street 62/A, Baia Mare, +40264-202975, Ioan.Bud@irmmm.utcluj.ro

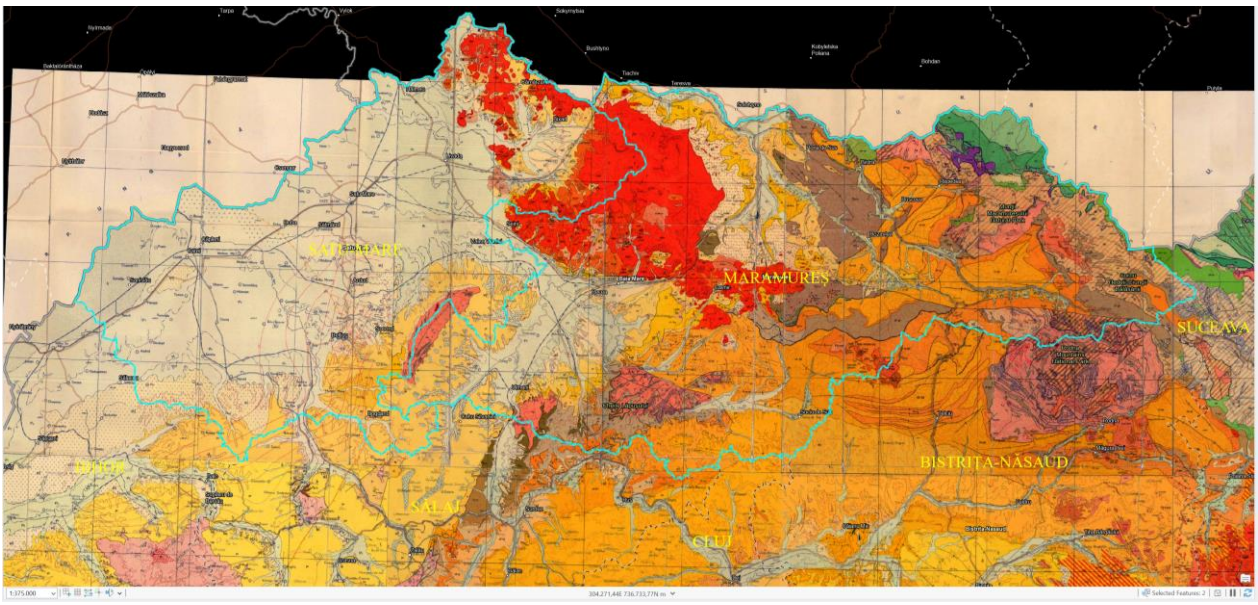

Fig.1. Highlight of the geological map for Maramures and Satu Mare Counties (Neogene basaltoid andesites – reddish color) [1] imported and georeferenced in ARCGIS Pro

Some Key Features of Neogene Basaltoid Andesites:

- **Geological Formation:**
  - **Age**: These rocks were formed during the **Neogene** period, a time of significant tectonic activity and volcanic eruptions, especially along convergent plate boundaries. In regions like Romania, the Neogene basaltoid andesites are associated with volcanic activity linked to tectonic movements in the Carpathian-Pannonian area.
  - **Volcanic Activity**: Neogene basaltoid andesites are typically formed from medium to high-temperature volcanic eruptions. The basaltic parent material undergoes partial crystallization, leading to a rock composition that includes both basalt (rich in iron and magnesium) and andesite (higher in silica).
- **Composition:**
  - **Mineral Content**: Neogene basaltoid andesites typically contain minerals like plagioclase, pyroxenes, and amphiboles. They may also contain varying amounts of feldspar, quartz, and magnetite, which contribute to their overall chemical composition.
  - **Silica Content**: The silica content of these rocks is typically between 52% and 63%, which is characteristic of both basalt and andesite but leans more toward the andesitic composition due to the presence of more silicon.
- **Physical Properties:**
  - **Density and Durability**: Neogene basaltoid andesites are dense, strong, and durable, which makes them highly suitable for construction, particularly for road building, aggregate production, and infrastructure projects.
  - **Color and Texture**: These rocks are typically gray to dark gray, with a fine-grained texture. Their porphyritic texture (containing visible crystals) is common, as the mineral crystallization process often occurs at different rates.
- **Tectonic Settings and Distribution:**
  - **Volcanic Arcs**: Neogene basaltoid andesites are commonly found in volcanic arcs associated with subduction zones or continental rifting. The Carpathian Basin in Romania, which was affected by tectonic compression during the Neogene period, is home to significant deposits of these rocks, particularly in the Apuseni Mountains and surrounding areas.
  - **Romanian Occurrence**: In Romania, Neogene basaltoid andesites are found in various regions where volcanic activity was prominent during the Neogene. These rocks contribute significantly to the local geology and have been important in shaping the landscape.
- **Economic Significance:**
  - **Construction Industry**: Due to their hardness and resistance to weathering, Neogene basaltoid andesites are highly valued in the construction industry, especially for use as aggregates, road building materials, and in the production of concrete. Their durability makes them ideal for infrastructure that requires long-lasting materials.

- **Mining and Quarrying**: Regions rich in Neogene basaltoid andesites are often sites of active mining and quarrying, providing raw materials for construction and contributing to local economies.

- **Environmental Considerations:**
  - **Mining Practices**: Extracting Neogene basaltoid andesites from quarries requires careful management to minimize environmental impact, especially in sensitive regions like mountainous ***or protected areas***. Sustainable mining practices are essential to preserve natural habitats and manage the resources effectively.

Using the database of the **Ministry of Environment, Waters and Forests** ([2]), we can overlay the protected areas with the occurrence of the basaltoid andesites, providing a good raw materials deposits occurrence relative to these areas. This is important do to the limitations of the mining activities imposed on these areas.

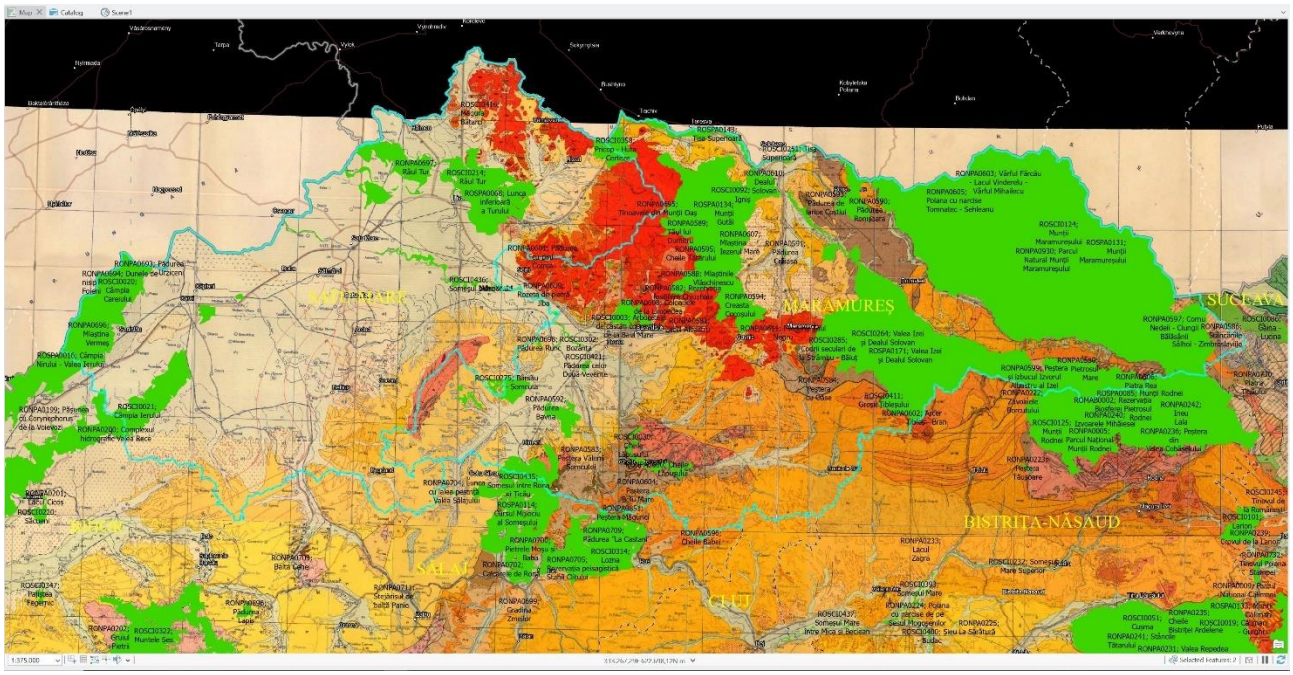

Fig.2. Overlayed protected areas (green colored) over the geological map [1, 2] imported in ARCGIS PRO

2. Specific needs for the environmental authorization

For obtaining the environmental authorization, following the existing analysis of the documents and the verification, based on Government Decision no. 43/28.01.2020 regarding the organization and functioning of the Ministry of Environment, Water and Forests, Government Decision no. 1000/2012 regarding the reorganization and operation of the National Agency for Environmental Protection and the public institutions subordinated to it, with subsequent amendments and additions, of Government Emergency Ordinance no. 195/2005 on environmental protection, approved with amendments by Law no. 265/2006, with subsequent additions and amendments and MMDD Order no. 1798/2007 for the approval of the Environmental Permit Issuance Procedure, with subsequent amendments and additions the open pit situated in an protected area will comply with the:

• GEO (Government Emergency Ordinance) no. 195/2005 on environmental protection, approved with amendments by Law no. 265/2006, with subsequent amendments and additions;
• Law no. 219 of November 15, 2019 for the amendment and completion of art. 16 of the Government Emergency Ordinance no. 195/2005 on environmental protection;
• Order no. 1150 of 27.05.2020 regarding the approval of the Procedure for applying the annual environmental authorization visa and the integrated environmental authorization;
• GEO no. 196/2005 regarding the Environmental Fund, with amendments, additions and subsequent approvals, as the case may be;
• Water Law no. 107/1996, with subsequent amendments and additions
• GEO no. 68/2007 regarding environmental liability with reference to the prevention and repair of damage to the environment, approved by Law 19/2008, with subsequent amendments and additions;
• GEO No. 92 of August 19, 2021 regarding the waste regime, with subsequent amendments and additions;
• Ordinance no. 2 of August 11, 2021 regarding waste storage;
• HG no. 1061/2008 regarding the transport of hazardous and non-hazardous waste on the territory of Romania;

• HG no. 856/2002 regarding the record of waste management and for the approval of the list including waste, including hazardous waste, with amendments and additions later;
• HG no. 188/2002 regarding the conditions for discharging waste water into the aquatic environment, with subsequent amendments and additions;
• GEO 57/2007 regarding the regime of natural protected areas, conservation of natural habitats, flora and fauna, approved with amendments and additions by Law no. 49/2011, with subsequent amendments and additions;
• HG no. 235/2007 regarding the management of used oils;
• HG no. 1132/2008 regarding the regime of batteries and accumulators and waste batteries and accumulators;
• HG no. 170/2004 regarding the management of used tires;
• The standard regulation for noise - 10009/2017

3. Description of the main phases of the technological process or activity

Andesite mining works: - description of the main phases of the technological process or of the activity: the exploitation method is in descending steps along the entire length of the front through blasting works carried out by specialized companies; the extraction the stone (mechanical extraction) in descending horizontal slices and loading the blasted material into means of transport; the raw material will be transported to the crushing station; the waste is transported to the temporary dump; the topsoil will be stored separately and will be used to restore the topsoil layer after the cessation of exploitation works, in accordance with the environmental restoration technical project. The products and by-products obtained - quantities, destination: raw and crushed stone - on average 6250 t/month (approx. 75000 t/year), mixture of stone and earth (saleable) - variable quantities, tailings - variable quantities.

Processing works: Primary crushing will be done with a mobile crusher; No water is used in the technological process;

Dumping works: since the deposit does not have a layer of soil or altered rock except in a very small proportion in the upper part, it is not necessary to build a waste dump, the entire amount of andesite being exploited.

In order to comply with the special requests, in the perimeter must be executed:

- Stations and installations for the retention, evacuation and dispersion of pollutants in the environment, provided (according to environmental factors): gutter provided with settling basin for rainwater from the quarry premises;
- Other special arrangements, facilities and measures for environmental protection: no hold;
- The concentrations and mass flow rates of pollutants, the level of noise and radiation, allowed for discharge into the environment, permitted exceedances and under what conditions:
  - water - compliance with GD 188/2002 for the approval of some rules regarding the conditions for discharging waste water into the aquatic environment, with subsequent amendments and additions;
  - air - compliance with the maximum allowed concentrations at the boundary of the enclosure provided by STAS 12574/1987 "Air from protected areas. Quality conditions";
  - noise - according to STAS 10009/2017, compliance with the provisions of the water management authorization.

4. Applied methods

In order to create the real geometry of the open pit, a number of 7,5 Mio points were created using the drone flight (Fig. 3).

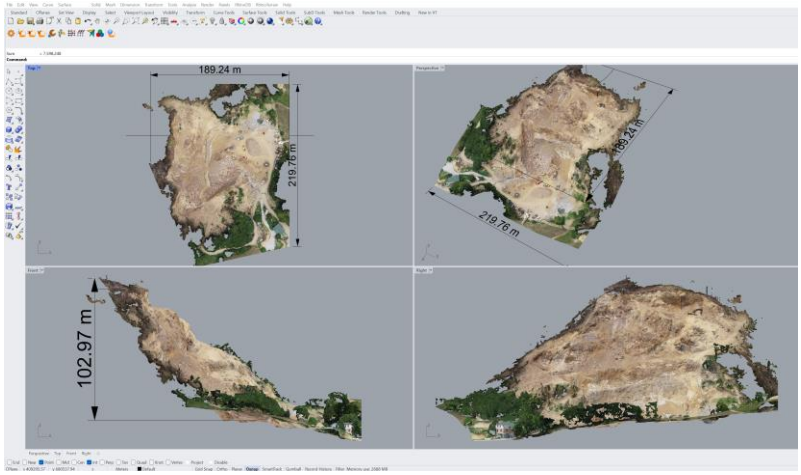

Fig.3. Points cloud created in Rhinoceros 3D

In the Rhinoceros3D, the plug-in of RhinoTerarain was used to create the surfaces using the points cloud imported in the software (Fig. 4), so a number of 15,18 Mio triangles were created to compute the exposed surface to the environment.

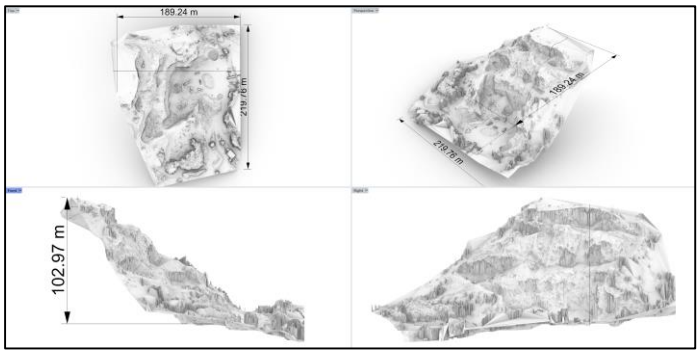

Fig.4. NURBS (Meshing created in Rhinoceros 3D using the RhinoTerrain pug-in [3])

Also the stations and installations for the retention, evacuation and dispersion of pollutants in the environment, provided (by environmental factors) is needed:
- guard ditch for the collection of rainwater from the upstream part of the quarry - perimeter ditch with a length of 213 m;
- collection and settling basin with a capacity of 12 m^3, from where the overflow is discharged through a metal pipe into the Spânului Valey stream, with final discharge into the Cavnic river;
- waste dump located inside the exploitation perimeter used for the opening of works, storage of topsoil and waste dumping;
- the vegetable soil will be used to restore the layer of vegetable soil after the cessation of exploitation works.

The mining perimeter of is part of the Gutâi Mountains massif which falls within the Neogene eruptive Oaș-Gutâi-Țibleș. The andesite in this perimeter shows a lava flow and is pyroxenic. The useful mineral resource has been known for a long time and was the object of exploitation and capitalization for constructions in raw and crushed form resulting from shooting.

The deposit surfaced and represented a structure formed by compact intrusions alternating with alteration zones, on the western slope of the hill, where the open pit developed. The andesite has good mechanical characteristics, identified in areas where the structure is compact and unaltered. Good quality reserves are limited and geomining conditions are becoming more and more difficult due to the topography of the land. Under these conditions, the company's administrator turned to another exploitation located on land owned by the family and in much more favorable topographical conditions and with a very good quality resource. From the deposit, exploitation will be gradually reduced, and the perimeter at the base of the quarry will be used for crushing and storing the grades and raw stone, resulting from the new perimeter, located near the existing one.

From a genetic point of view, the deposit is part of the structure of Neogene volcanism in northern Romania, which was the object of numerous geological, geomechanical, petro-chemical studies, with predilection and in connection with the metallogenesis of deposits in the Baia Mare mining region. From the point of view of the possibilities of exploiting the rocks used in construction, the studies are insufficient, especially on the geomechanical characteristics and the technical quality conditions for use in road works, constructions, railways, etc.

According to the geo-chemical features of the volcanism in the Oaș-Gutâi Mountains, two types of vulcanites can be distinguished: dacitic (older) and andesitic and calc-alkaline intermediate. Volcanic activity began with the acid-calc-alkaline (rhyolite-rhyodacite) explosive phase of Badenian-Lower Sarmatian age. Widespread pyroclastic products were generated in the southwestern part of the Gutâi Mountains. This activity would represent the first volcanic cycle [4]. The rhyodacitic products appear as predominant forming the volcano-clastic complex and the volcano-sedimentary complex.

The andesitic volcanism occurred in the second and third cycles [5] and generally has a meditative, explosive-effusive and intrusive character up to basaltoid aspects.

5. Conclusions

Works for the stabilization of natural slopes, quarry/dump slopes

There are no problems with the stability of the slope where the exploitation perimeter is located, being made of very hard rocks, without a consistent soil and with a medium slope, which leads to a very high coefficient of stability. The quarry will be developed through a geometry that does not involve stability problems of partial or final slopes. The waste dump consisting of altered andesites and the soil dump will not have a large volume that implies slope angles with limit stability or quasi-stability.

The slope angle of the soil dump will be a maximum of 18º (cf. the Technical Regulations on waste storage). This dump will have a provisional character. The slope angle of the waste dump will be 25º in the safety zone considering that the internal friction angle of the altered andesites within the perimeter is between 35-40º (the dump with a provisional character). The maximum height of the open steps is 15m. The minimum width of the final berms will be 3m. The general slope angle of the quarry will be a maximum of 60º.

Monitoring of atmospheric emissions (dust, gas emissions)

The operation will generate emissions only during the period in which the machines and trucks with internal combustion engines are used, for which the operating status will be checked periodically. The powders generated by the dust resulting from the blasting and processing activity will not exceed the permitted limits as they do not represent an important generating source, and in the case of crushing, the wetting and/or dust removal facility will be used. In the case of drilling the boreholes/mine, installations equipped with dust removal systems will be used, and for the blasting operation, the requirements set forth will be respected.

Monitoring of renaturation

The restoration of the environment will be monitored by checking the type of vegetation that is installed and compared with that outside the perimeter, which was not affected by other works, but in more distant time periods using the remote sensing and in-situ observations ([6-8]).

Estimated period of monitoring works

The monitoring will be carried out during the entire period in which the company will carry out exploitation or processing and storage works as well as afterwards, because the land is the property of the administrator's family (the entire activity of exploitation and capitalization of andesite is a family business) and there is every interest to preserve the stability and integrity (to the extent of restoration possibilities or with a new geometry and destination) of the land after the partial or total completion of the works

Maintenance and/or restoration works

Following the monitoring through which irregularities or degradations are found, restoration works will be carried out, as often as necessary.

Acknowledgements

We would like to thank to prof. Dorian Gorgan (UTCN) for his engagements in developing the platform. The paper was supported by the CLOUDUT Project, cofunded by the European Fund of Regional Development through the Competitiveness Operational Programme 2014-2020, contract no. 235/2020.

References

[1] **Ianovici V., Rădulescu D., Patrulius D.**, 1968
Harta Geologică Foaia Vișeu. L-35-l. M.-35-XXXI. Scara 1:200.000; Base map: Server WMS www.IGR.ro

[2] *** * ***
https://www.mmediu.ro/categorie/date-gis/205

[3] *** * ***
https://www.rhinoterrain.com/en/rhinoterrain.html

[4] **Ianovici V., Giuşcă D., Manilici V., Gherasi N., Jude R., Gheorghiţă I., Dimitrescu**, 1961
Privire generală asapra geologiei regiunii Baia Mare. Asoc.geol. Carpato-balc. Congr al V-lea, Ghid al excursiilor

[5] **Giuşcă D., Borcoş M., Lang B., Stan N.**, 1973
Neogene Volcanism and Metallogenesis in the Gutâi Mountains. Symp. Volcanism and Metallogenesis, Ghidul excurisei 1AB, Bucharest, 48 pag.

[6] **Gușat D., Bud I.**, 2024
Remote sensing environmental data integration for a quarry. In Scientific Bulletin Series D: Mining, Mineral Processing, Non-Ferrous Metallurgy, Geology & Environmental Engineering. Vol 38. No 1., DOI: 10.37193/SBSD.2024.1.09

[7] **Gușat D., Bud I., Daraba D.**, 2023
Digital environmentally specific needs of a small open pit exploitation in a protected area (part II). In Scientific Bulletin Series D: Mining, Mineral Processing, Non-Ferrous Metallurgy, Geology and Environmental Engineering. Vol. 37. No. 1. DOI:10.37193/SBSD.2023.2.05

[8] **Bud I., Gușat D.**, 2022
Measures to reduce the environmental impact of a small andesite exploitation. In Scientific Bulletin Series D: Mining, Mineral Processing, Non-Ferrous Metallurgy, Geology & Environmental Engineering. Vol 36. No 1. DOI: 10.37193/sbsd.2022.1.04