

The Mateiaș limestone quarry (Southern Carpathians): changes in spatial extent and local perception on the related environmental issues

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Abstract

The various natural resources and the industrialization policies implemented during the communist regime have resulted in the opening of many mines and quarries, including the Mount Mateiaș exploitation. The aim of this study is to give warning against open pit mining, which has a direct and conspicuous impact on landscape dynamics and the cultural-historical value of Mount Mateiaș.

The research methodology consisted in field observations, accomplished during the period 2009-2012, the analysis of limestone quarry expansion by using GIS techniques, and the application of a semi-structured interview, the results of which were processed subsequently in QSR-Nvivo 10. The analysis and processing of cartographic materials highlighted that during the interval 1979-2012 strip mining has dramatically altered the topography (by excavation works, land leveling, access road construction, accelerated slope erosion, collapses, torrential erosion etc.). These add to other processes and phenomena that have a negative impact on the environment (soil loss, massive deforestations, air pollution with suspended particles etc.). Despite these realities, most people living in the neighborhood of Mount Mateiaș (the Valea Mare-Pravăț, Dragoslavele, Stoenesti and Câmpulung communes) deem that quarrying is vital for the development of local communities. Under the circumstances, the only economically productive and ecologically protective measure advanced by the authors is the identification of possible solutions for the restoration of the quarry, given that limestone exploitation will not end in the medium term. Last, but not least, we suggest that the results of the present investigation be included in the pre-feasibility and feasibility studies of a potential future rehabilitation.

Keywords: Limestone quarry, Spatial extent, Landscape, Local perception, Mount Mateiaș, Romania

Rezumat. Modificări în extinderea spațială și percepția locală asupra problemelor de mediu derivate: Cariera de calcar Mateiaș (Carpații Meridionali)

Resursele minerale variate și politicile de industrializare a țării promovate în perioada comunistă în România au contribuit la deschiderea a numeroase mine și cariere, printre care se află și cariera de calcar de pe Muntele Mateiaș. Scopul acestui studiu este acela de a trage un semnal de alarmă în privința exploatărilor în carieră, care au un impact direct și vizibil atât asupra dinamicii peisajului, cât și asupra valorii cultural-istorice a Muntelui Mateiaș. Metodologia de studiu s-a bazat pe: observațiile efectuate pe teren în perioada 2009–2012, analiza extinderii carierei prin utilizarea tehnicilor GIS și realizarea interviurilor semistructurate, prelucrate ulterior în aplicația QSR-Nvivo 10. În aproape 40 de ani de exploatare a calcarului, peisajul geomorfologic al Muntelui Mateiaș a suferit modificări ireversibile. Analiza și prelucrarea materialelor cartografice a pus în evidență faptul că în intervalul 1979 – 2012 exploatările în carieră au generat modificarea dramatică a suprafeței topografice (prin excavații, lucrări de nivelare, construirea unor drumuri de acces, accelerarea proceselor de versant, prăbușiri, torențialitate etc.). Acestea se adaugă celorlalte procese și fenomene cu impact negativ asupra mediului (eliminarea suportului edific, deteriorarea învelișului vegetal prin despăduriri masive și poluare cu particule în suspensie etc.). În pofida acestor realități, majoritatea oamenilor care locuiesc în vecinătatea Muntelui Mateiaș (comunele Valea Mare-Pravăț, Dragoslavele, Stoenesti, Câmpulung) consideră că exploatările în carieră sunt vitale pentru dezvoltarea comunităților locale. În aceste condiții, singura măsură economic productivă și ecologic protectivă avansată de autori este identificarea unor soluții posibile de reabilitare a carierei, în contextul în care exploatarea de calcar nu se va încheia pe termen mediu. În final, se propune integrarea rezultatelor obținute în materialul de față în studiile de pre- și fezabilitate, obligatorii în cazul unei viitoare reabilitări.

Cuvinte-cheie: Carieră de calcar, Extindere spațială, Peisaj, Percepție locală, Muntele Mateiaș, România

Introduction

For centuries, the mountain has represented for the human kind a symbol of power and greatness, a place of refuge and shelter, and last but not least a

source of unexpected and precious resources: large forests and grasslands, clear springs, minerals and rocks, valuable fauna species etc. Since ancient times, man has been attracted by the mountain's richness, which he has started to appropriate,

timidly in the beginning, then with increasingly ease. The 18th century, the beginning of the industrial revolution also marked the beginning of the ecological disasters for the mountain environment. Undoubtedly, the most aggressive forms of human pressure on the mountain realm are represented by the intensive exploitation – sometimes pushed until the mountain disappearance – of the soil and subsoil resources: building rocks, ores and fossil fuel (coal).

Mining workings exert both a positive and a negative impact at environmental, social and economic level (Worrall et al., 2010). Limestone quarrying is important for the development of human communities. At the same time, the extraction and processing of the building materials negatively impact the landscape by breaking aggressively and visibly the structure of the natural environment, which in the end affects the functionality, the health state and the aesthetics of the natural and anthropogenic ecosystems. The opening of quarries and the extraction of various rocks are responsible for the mutilation of positive landforms. During operation, the quarries alter significantly the substratum (Stehouwer et al., 2006) changing the

environment's characteristics and integrity (Jomaa et al., 2008). consequently, landslides, rockfalls and soil erosion proliferate, the quarries lying on steep slopes (as in the case of Mateiaș), which are the most prone to landslides and slope failure (Zuquette et al., 2002; Milgrom, 2008). The spoil banks, no matter how small, are built on very inclined slopes and consequently are unstable and prone to sliding down. The visual impact is much stronger than that generated by less visible phenomena like for instance the physical, chemical and biological pollution of water, air etc. (Fodor, 2006).

The complexity of the geological structure of the Romanian territory explains the remarkable diversity of subsoil resources, which over the time have offered extremely favorable conditions for the development of mining, quarrying and processing activities. The multitude of subsoil resources and the industrialization policies of Romania at high levels, promoted during the communist regime, were the premises for the opening of numerous mines and quarries (Fig. 1), including the Mateiaș limestone quarry in Southern Carpathians, Argeș County.

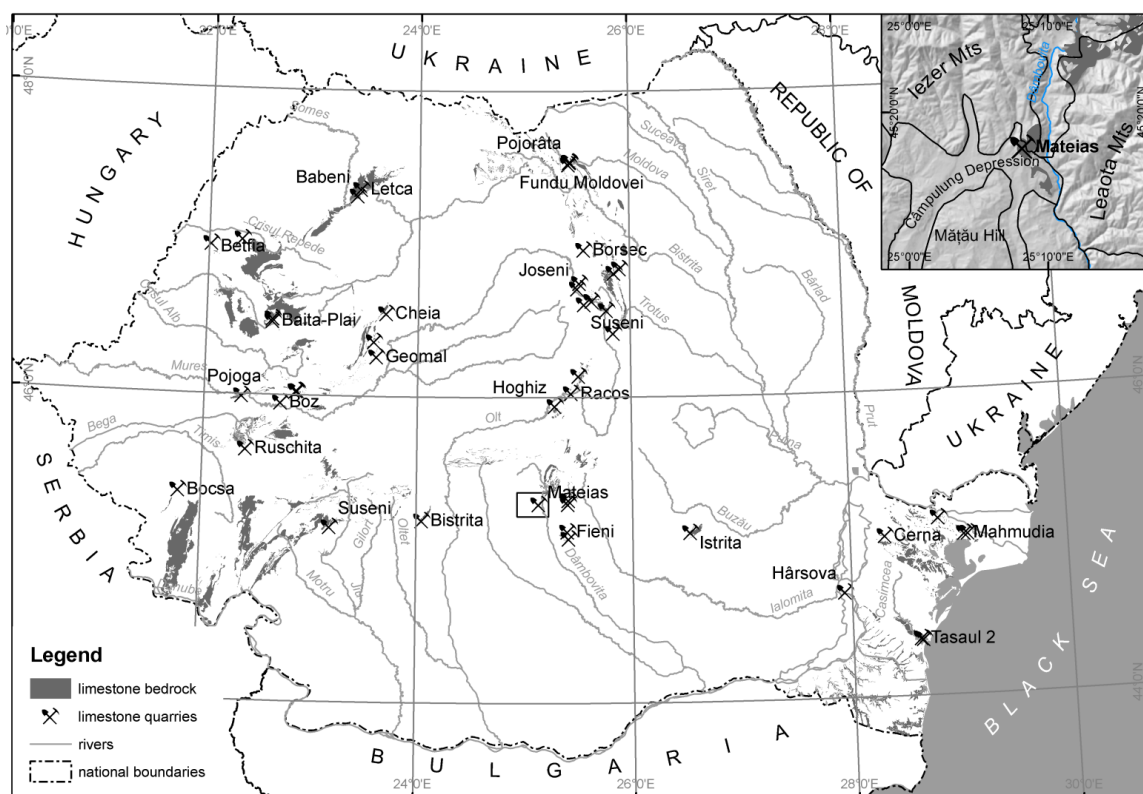


Fig. 1: Romanian limestone resource and quarries. The inset is detailed in the vignette - geographical setting of the Mateiaș Mount and quarry (SRTM3, 2000; DEM by L. Tîrlă)

Study area

The study area is represented by Mount Mateiaș, which is lying on the southern edge of the Iezer Massif (Southern Carpathians). With an altitude of 1239 m, it resembles a solitary piece of rock which offers a

viewpoint not only on the surrounding mountains (Iezer, Piatra Craiului and Leaota-Bucegi), but also on the mountain and sub-Carpathian corridor of the Dâmbovița River (Manea et.al., 2012). Mount Mateiaș corresponds to the boundary between the Iezer Mts.

and the Argeș Hillocks, making the transition from the Jurassic limestone to the marl, sandstone and disodilic schists in the eastern part of the Câmpulung Depression (Fig. 2). Mount Mateiaș consists of massive reef limestone of Kimmeridgian-Tithonian age (Upper Jurassic), a remnant of the Getic Carbonate Platform, which covered large areas during the Austrian-Laramian orogenesis. The Mateiaș limestone is the most similar to Vânturarița formation in the Vânturarița-Buila Massif, other remnant of the former carbonate platform (Dragastan, 2010). The limestone

deposits overlay the metamorphic basement (Lerești Group), resembling many common features of the marginal area of the Getic Unit, a major structural entities of the Southern Carpathians (Oncescu, 1965; Patrulea, 1969).

The aggression on Mount Mateiaș began in 1969, when the Cement Binders Factory at Câmpulung came into existence. This production unit is situated in the northeastern part of the Valea Mare-Pravăț commune. In 1989 it changed its name into CIMUS S.A., while in 1999 was taken over by Holcim S.A. Company.

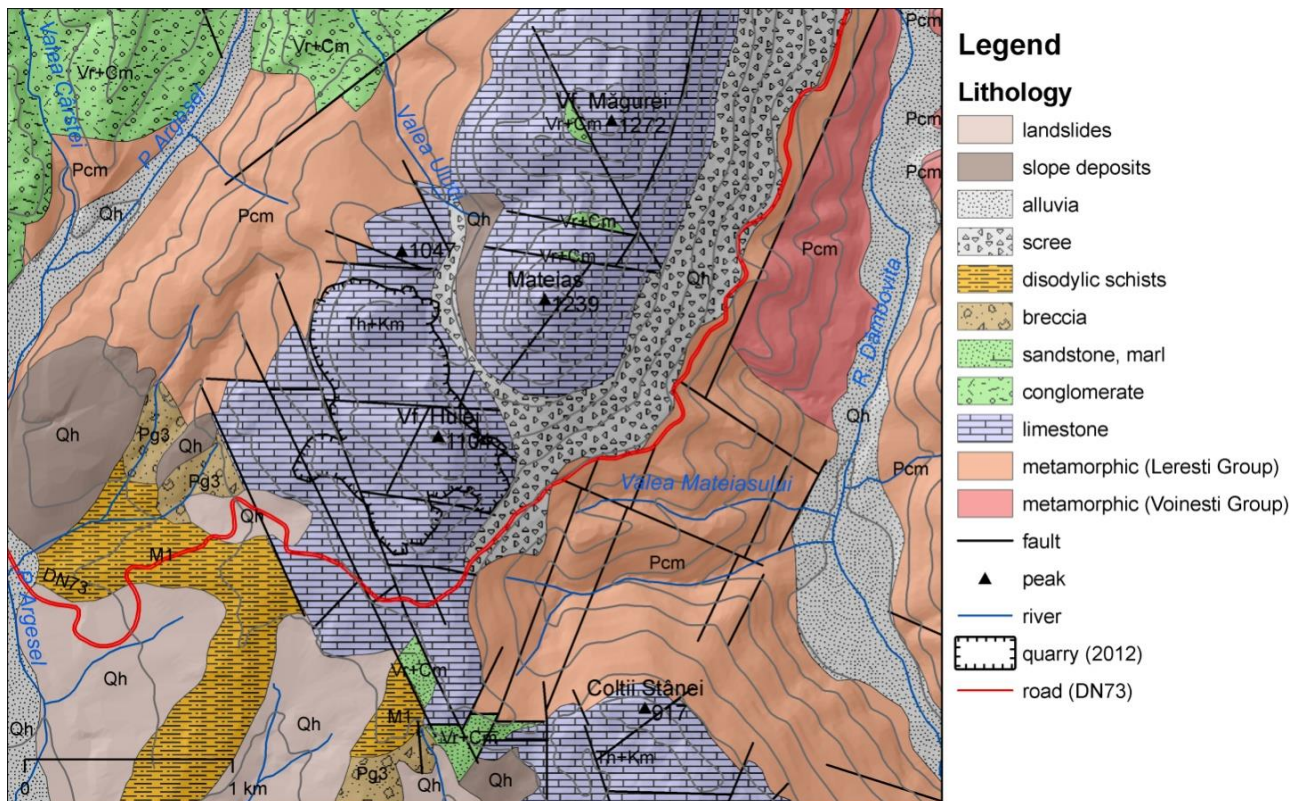


Fig. 2: Geology of Mount Mateiaș area (processing by L. Tîrlă after Ștefănescu et al., 1983). Significance of geological symbols: Pcm – Precambrian; Th+Km – Thitonian+Kimmeridgian; Vr+Cm – Vraconian+Cenomanian; Pg3 – Oligocene; M1 – Lower Miocene; Qh – Quaternary (Holocene)

The landscape, strategic and economic role of Mount Mateiaș

Apparently, the name of the mountain comes from Mateiaș, the adopted son of Matei Basarab (1632-1654), the ruler of Wallachia principality. Over the time, Mount Mateiaș has witnessed many events that left their imprint on Wallachia, and later on Romania (Cornățeanu, 1996). Thus, Mihai Viteazul, the artisan of the first union of the Romanian Principalities (1600), while waiting for the military support from Sigismund Bathory (prince of Transylvania) to fight the Ottomans who had invaded the country, withdrew his troops as far as Stoenestî (a commune lying to the southeast of the Valea Mare-Pravăț) and further to the Valea Mare Pravăț. Here, he chose as strategic point the Mateiaș peak, orienting his cannons to the south, then attacking and repulsing the Turks who were advancing from the

Dâmbovița valley (Cornățeanu, 1996). At the outset of the 20th century, during World War I, Mount Mateiaș was the resistance point of the Romanian Army during the battle of Pravăț, when thousands of soldiers died in the line of duty. The fighting in the area of Mateiaș and Căpitanu Mountains is part of what historian Nicolae Iorga used to call the "mountain pass epic" (Cornățeanu, 1996). In 1916, the prefect of Muscel stated that the Romanian army defended at Dragoslavele and Câmpulung "the sacred origins of the Romanian state", while Mateiaș was compared with a huge mountain of our past. Later on, Ferdinand the 1st "King of Romania by the grace of god and by national will" awarded the "Mihai Viteazul" order to the 70th Infantry Regiment, "for the courage and enthusiasm of its soldiers (...) in the battles fought in 1916 in Dobruja and north of Câmpulung (...), as well as for the fierce

resistance (...) against the elite German troops that intended to pass through the Valea Pravățului and conquer Câmpulung City" (www.cjarges.ro). In the memory of the soldiers who perished in the war between 1927 and 1935, the authorities built, according to the project of architect Dimitrie Ionescu-Berechet, a mausoleum, which today is one of the most important sights of the Argeș County (Fig. 3). After 1980, the monument was completely restored and completed with a permanent exhibition dedicated to the battles fought in the area during the World War I.

Apart from its remarkable landscape and tourist value, Mount Mateiaș has also a significant eco-protective value in relation with the territories lying west and southwest of it (Câmpulung Depression). At the same time, it is important from the economic

point of view, because the limestone reserves have been estimated to ensure production for about 100 years. Unfortunately, the quarrying activities will lead in the end to the disappearance of this isolated mountain. On a national level, Mount Mateiaș has been perceived differently: as a physiographic unit of strategic importance for the military defense plans; as landscape element with eco-protective and economic-productive role; as natural tourist sight; as fundamental economic resource for the development of local and regional economy; as factor with direct influence on the jobs of the adjacent territories; and as topographic unit with very active dynamics during the last 50 years, because of the brutal anthropogenic influence.



Fig. 3: The Mateiaș Mausoleum. A. Frontal view of the monument; B. Fissures and cracks caused by mining affecting the mausoleum basement (photos by L. Tîrlă, 2007 and G. Manea, 2014)

The aim of the study is to highlight the time-scale spatial extent of the Mateiaș quarry on the basis of the existent cartographic materials and orthorectified aerial photographs, and to estimate the local perception on landscape changes. The objectives of our approach are the following: showing, based on graphic and cartographic documents, the morphometric and morphographic changes that have occurred during the last 40 years; evaluating the perception of the population and local authorities on the viability of this economic activity. The results are meant to contribute to future studies in case of rehabilitation planning.

Research methodology

Data type. Two differently originated datasets were used within the study: mapping-based data revealing the change of spatial extent of the limestone quarry in Mount Mateiaș in 1979 to 2012, and the results of semi-structured interviews. Mapping-based data consisted in contour lines vectorized from the 1979 topographic map and polygon features representing

the quarry area in 1979, 2005, 2009 and 2012. A .hgt-type file (SRTM3) was used to create the DEM as a basis for topography analysis in 2000.

Materials: 1979 topographic map of scale at 1:25,000 (courtesy of DTM, (MTD) - Military Topographic Division); 2005 and 2009 orthophotographs with resolution of 0.5 m (courtesy of ANCPI (NACREA) – National Agency for Cadaster and Real Estate Advertising); 2012 satellite imagery (courtesy of Digital Globe); suggestive photographs of environment degradation.

Methods. Basic methodology involved field surveys, digital mapping and processing, and interviewing. The changes in spatial extent and topography of the limestone quarry were surveyed and analyzed by digital mapping and calculations. The next steps were followed: 1. Digital mapping by GIS techniques, using ArcMap™; 2. DEM generating in Global Mapper™; 3. Raster processing and creating graph profiles in ArcMap.

Resolution of the SRTM-based DEM in 2000 is about 65x93 m (Fig. 4A), too low comparing to that of

the DEM created after interpolating the elevation values of the contour lines digitized on the 1979 topographic map, which is 5x5 m (Fig. 4C). To reduce the difference, we generated in Global Mapper contour lines of equal interval (10 m), used to create a DEM with the same resolution (5x5 m) as the 1979 DEM.

The result is shown in Figure 4B, with noticeable differences in terrain smoothing. Though, the initial low-resolution grid could not be improved well-enough to reach the same accuracy as the 1979 grid, which had some consequences on the data precision in the 3D terrain model and profile.

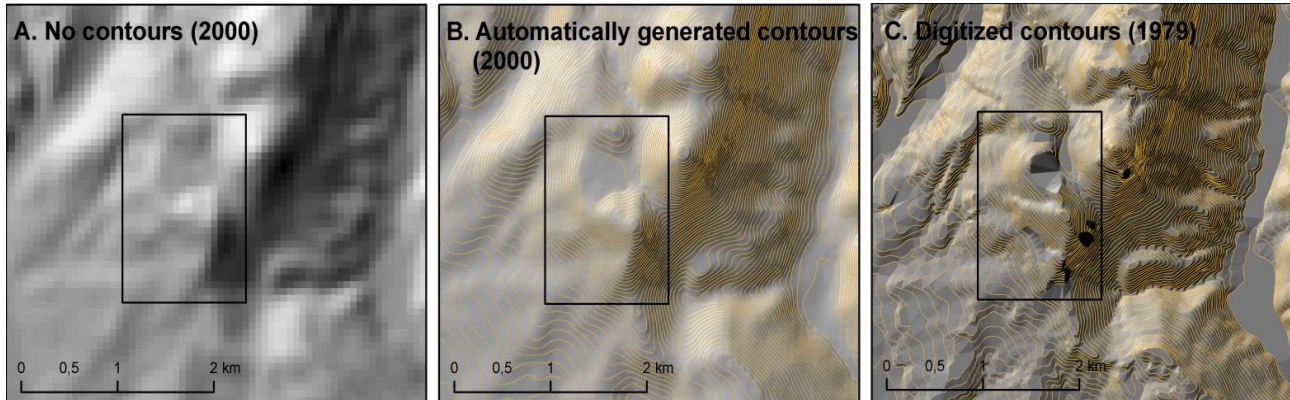


Fig. 4: Elevation data accuracy. A. 2000 topography, illustrated by a SRTM-based DEM (low resolution, unprocessed); B. 2000 topography, after processing the SRTM-based DEM (5x5 m resolution); C. 1979 topography, illustrated by a DEM obtained after digitizing and interpolating contours (5x5 m resolution)

The lack of recent large-scale cartographic materials (of a scale at minimum 1:25,000) hampered estimating the removed limestone and considering the volumetric values. Under the circumstances, we used information resulted from digital mapping of the quarry area – vector data and related attributes.

The assessment of the perception of population and local authorities concerning the environmental issues triggered by the limestone working in Mount Mateiaș was based on the survey method (semi-structured interview sub-type) applied face-to-face in April 2013 and written recorded. All respondents have orally accepted to use their answers and demographic data for research purpose. The advantage of this survey sub-type is that the interviewed person is allowed to express himself freely, unconstrained by prepared, and rigid questions. The order of the questions can be permanently changed, driven by the discussion flow. The adequate questions may be addressed in favorable moments, with good results. The interview guide included only six questions, in order to maintain itself within the limits of acceptability. The questions considered the following aspects: Mount Mateiaș notoriety among residents in Valea Mare-Pravăț; its importance to community; the resident's opinion on limestone quarrying and how long he believes it would be active; the resident's opinion on beginning the mining works in Mateiaș Peak; the consequences in case of the complete disappearing of Mount Mateiaș. All data obtained during the research were coded in Nvivo v 10, thus, every question became a „node”. As the interview group comprised different people, they were coded as

nodes, too using the following symbols: F1, F2 ... Fn for females and M1, M2... Mn for males having demographic characteristic attributes added. Thus, Nvivo software allows to manipulate data and organize them to research topics in order to analyze a great amount of data (Mihalca, 2013), to find patterns generated by queries such as the tree map and cluster analysis diagram.

Results

Assessment of the morphometric and morphographic alteration of the mountain unit

The analysis and processing of cartographic materials reveals that during the interval 1979-2012 the area of the quarries in the Mateiaș perimeter continuously grew (Fig. 5 and Table 1). The Soviet map from 1970 at scale 1:50,000 shows no topographic change yet, unlike the map from 1979, where a small quarry 'bites' from the northern part of Mount Hula. The DEM in 2000 shows a complete removal of this northern peak and a decrease in altitude by 150 m. Different short time-scale orthophotographs (2005, 2009 and 2012) depict the evolution of quarrying works from north towards south. Visible mining terraces appear on Mount Hula in 2005 (Fig. 6); it was almost completely removed until 2012.

At the same time, the volume of the removed bedrock proportionally grew, causing a decrease in elevation by about 150 m (from 1100 m in Hulei Peak to 950 at peripherals). Consequently, the cone-shaped Mount Mateiaș (1239 m) is now totally

exposed, and remains the only topographic barrier against the northeasterly turbulent air drafts in the Bran-Rucăr-Dragoslavele tectonic corridor.

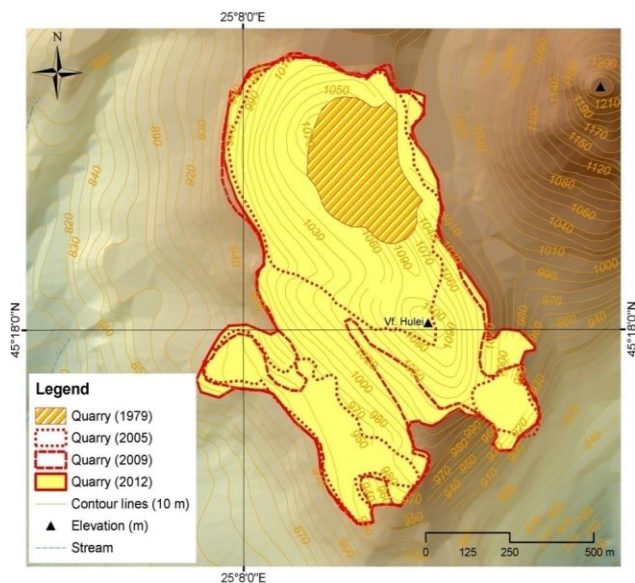


Fig. 5: Mount Mateiaș – Time-scale change of quarry extent

The quarrying site has generated a number of processes and phenomena that add to the negative impact on the environment, of which we can mention the following: massive deforestation, with

direct impact on the intensification of mass wasting processes (collapses, torrential erosion etc.), pollution with settling dust (at present diminished due to the refurbishment of the Holcim Enterprise), and the degradation of the Mateiaș mausoleum (fissures, infiltrations) and the nearby buildings, because of the limestone exploitation blasts. One important step towards the rehabilitation planning has already been made by the mining company by planting a protective shelterwood of Scots pine (*Pinus sylvestris*) on the southern slope of Mount Mateiaș, under the Hulei Peak. This pine forest is meant to protect the European and national road (E577/DN73), and there with the Mateiaș Mausoleum against the direct negative effects of the quarrying works (Fig. 6).

The dramatic change of topography in 1979 to 2012 is also illustrated by the 3D models and topographic profile in Figure 7.

Table 1: Evolution of the quarry area

No.	Year	Area (hectares)
1	1979	9.54
2	2005	46.09
3	2009	65.70
4	2012	72.63

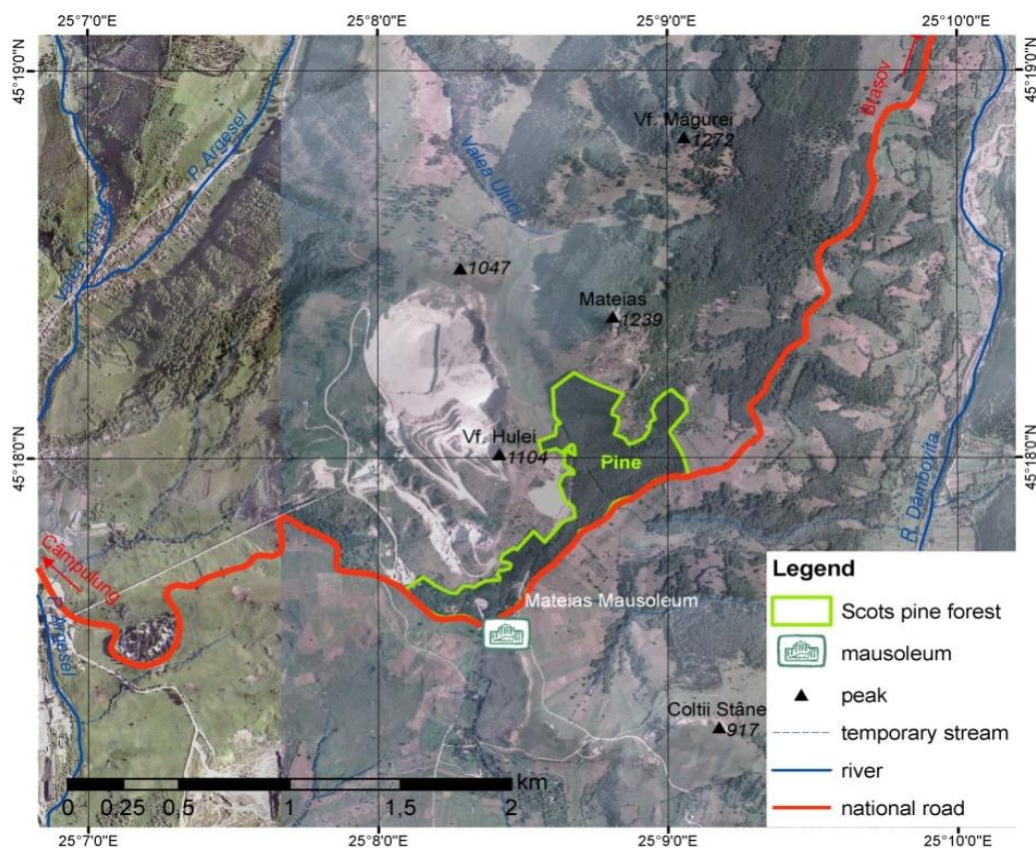


Fig. 6: Mateiaș quarry in 2005 (Source: orthophotograph, courtesy of ANCPI, 2005)

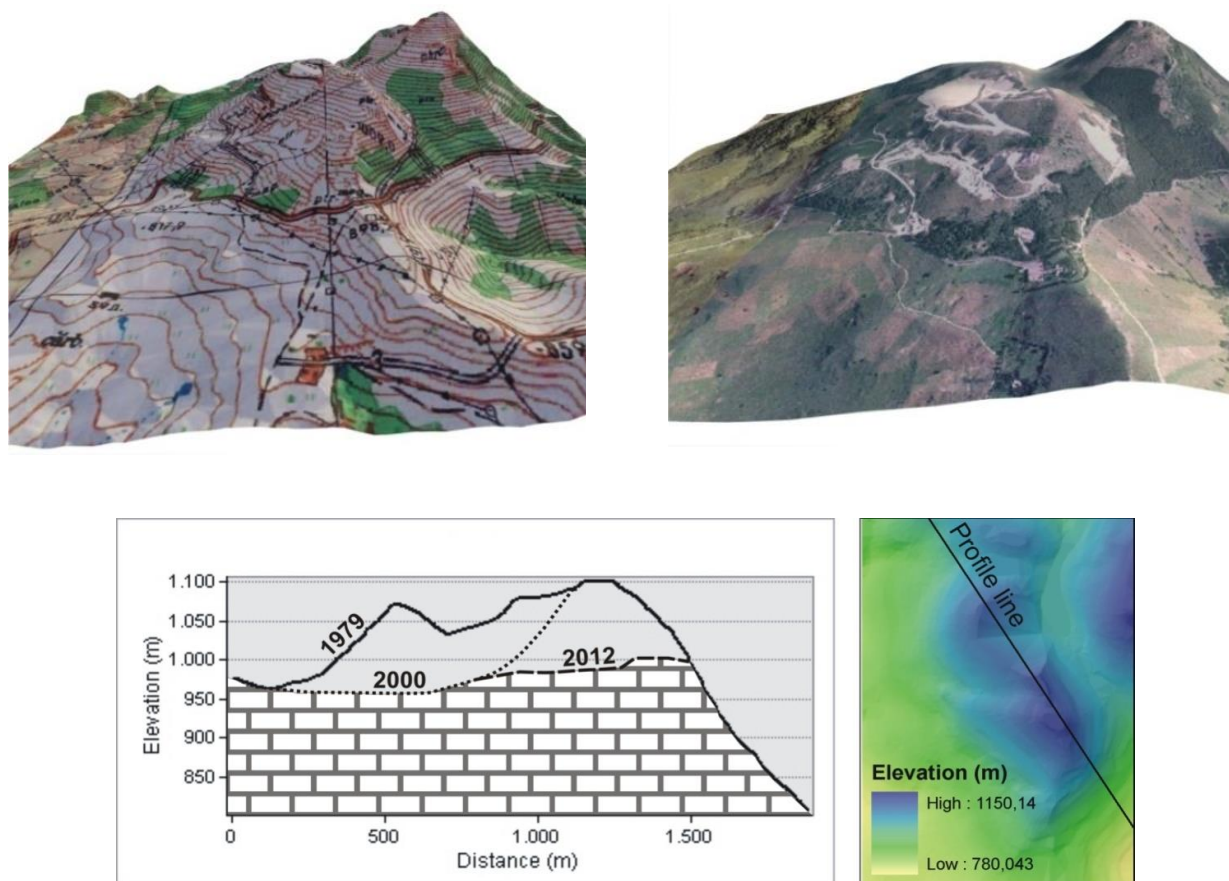


Fig. 7: Changes of the quarried area in 3D and topographic profile: A. 1979 topography, lateral view (northward); B. 2005 view (topographic map and orthophotograph draped on a 3D surface derived from a SRTM3 raster file). C. NW-SE profile of the Mount Mateiaș with topographic changes in 1979 to 2012

The perception of people and local authorities on the viability of the economic approach

The sample of interviewed persons is made of 15 local people, 40% females and 60% males, aged between 25 and 67 years old (Table 2). The provided answers enlightened us about the attitude of the local authorities and the inhabitants of the Valea Marea-Pravăț commune with regard to the potential disappearance of Mount Mateiaș in the next 50 years. For all respondents, Mount Mateiaș is very well known, but only 40% of them recognize it as a landscape symbol of this area, while 60% appreciate its importance for building materials input and the jobs opportunities offered by the quarry and nearby Holcim Plant for local communities. Even they agree the necessity of jobs, 80% of respondents expressed worries about its disappearing in 50-100 years and pollution generated by specific works. Concerning the beginning of mining in Mateiaș Peak, 85% of respondents consider useful the banning of it, keeping the state of protection and conservation. Despite these divided answers, all respondents

recognized the ecological impact of the quarry, the depletion of local resources, the temporal economic benefits, and destruction of its tourist attractiveness. Only one person knew that there are possibilities to recovery the landscape suggesting both revegetation and leisure infrastructure development.

Table 2: Respondents' profiles

No.	Respondent	Age	Profession
1	F1	60	Accountant
2	F2	50	Professor
3	F3	35	Professor
4	F4	26	Sociologist
5	F5	51	Biochemist
6	F6	67	Pensioner
7	M1	25	Student
8	M2	25	Freelancer
9	M3	35	Engineer
10	M4	67	Pensioner
11	M5	31	Economist
12	M6	58	Professor
13	M7	55	Engineer
14	M8	30	Professor
15	M9	57	Counselor

Analyzing the NVivo outputs, The Word Frequency Query shows that much attention is given to the

economic values ('limestone', 'materials', 'source', 'constructions') then those about the environment ('pollution', 'climate', 'disappear' etc.) (Fig. 9). The cluster analysis diagram reveals similarities of respondents' views that allow us to see that the authorities (M9) and the majority of people (F2, M4, M3, M7) form a cluster with rather similar views, while F6 and M8 put an accent on the economic importance toward the environment. There is also a third cluster, who thinks the environment is more important than economic benefits (Fig. 10). Thus, a contradiction

between some of the respondents' views could be noticed, due the fact they want both benefits: environmental quality and economic needs.

In sum, they particularly emphasized the economic and social importance of the exploitation (the only profitable industrial activity in the area), the historical and strategic importance of Mount Mateiaș, as well as the possible risks of the complete disappearance of the mountain, the loss of the forests and the diminishing of its local climatic role.



Fig. 8: Mount Mateiaș quarry: a. general view; b. anthropogenic-triggered landform inversion (photos by G. Manea, 2012)

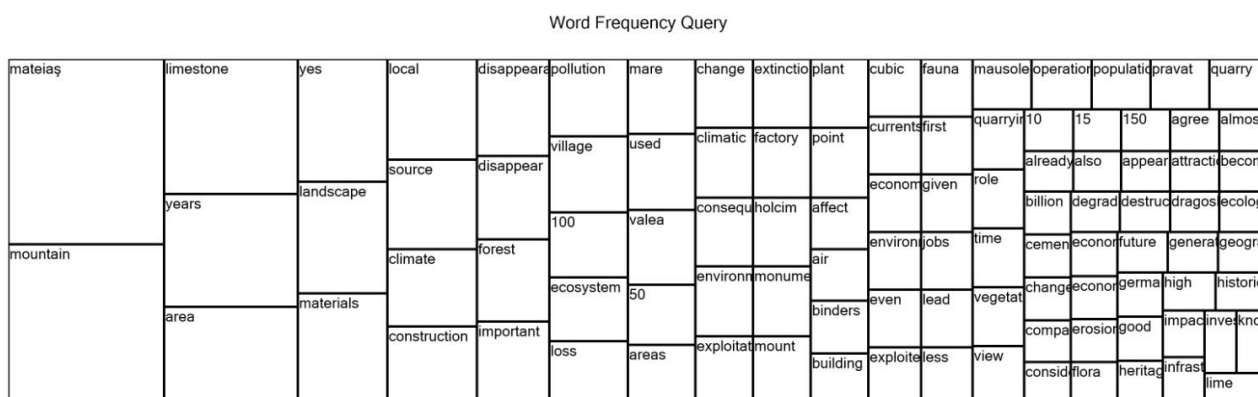


Fig. 9: Word Frequency Query Tree Map (extract from Nvivo v 10 output)

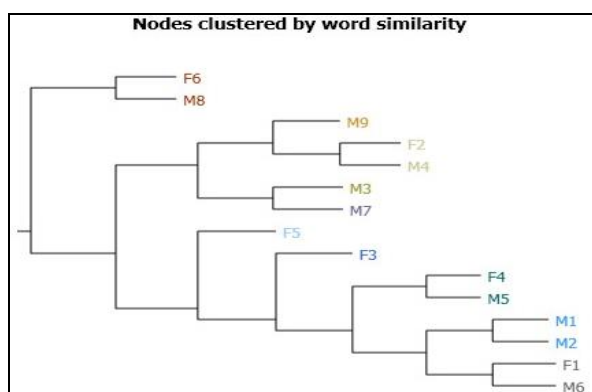


Fig. 10: Gender clustered by words similarity; M- male, F-female (extract from Nvivo 10 output)

Discussions

The present study does not claim to give solutions for solving the environmental issues derived from the discussed limestone quarry. The obtained preliminary results are relevant only by contributing on a database that could be used in further pre- and feasibility studies, required when implementing post-closure rehabilitation planning measures.

Although, according to the estimates, the quarry will close approximately in 50 years, the extent of the impact that Mount Mateiaș disappearance will have on the adjacent settlements should be anticipated at an early stage, so that to prepare

functional conversion scenarios for the rehabilitation of degraded lands.

From the input-data perspective, the study has some limitations: the area was digitized based on cartographic materials with unevenly distributed information, available only for certain years. The interval 1979-2005 is too large in comparison with 2005-2009 and 2009-2012, making it impossible to trace the evolution of the quarry at regular intervals.

The values of the quarry area in the input years were obtained by mapping techniques from the specified materials, so accuracy might not be as high as the technical data.

The results of the semi-structured interview are relevant, although the answers are not homogeneous, which emphasizes the different perception of the respondents with respect to limestone quarrying. The advantage of the interview in comparison with the questionnaire is that allows the operator to get a broader spectrum of information, opinions and comments, some of them really enlightening for the authors.

The analysis of the answers leads to the conclusion that, although aware of the quarry's aggression on the environment, the locals believe that immediate incomes obtained from limestone exploitation are much more important than the potential benefits they would have on medium and long term, if the quarry would close and economic reconversion of the area were implemented. This attitude reveals that for the local residents economic stability and immediate prosperity prevail over the environmental concerns, even if that means health risks and a worse quality of life.

The authors aim to achieve in perspective a thorough analysis of the civil society in the vicinity of the quarry, in order to identify people's opinion regarding the conservation of Mateiaș Peak (which so far escaped exploitation), as a symbol of the region and of the cultural-historical continuity of the human communities living around it.

The present study is intended to bridge the gap between the local authorities and the scientists, which can work together in the future for finding the best solutions in order to harmonize the economic interests with the necessity of protecting the environment.

Conclusion

The approximately 40 years of limestone exploitation have resulted in irreversible damage of Mount Mateiaș. The analysis and processing of cartographic materials reveals that during the interval 1979-2012 the area of the quarries in the Mateiaș perimeter continuously grew. The volume of the removed bedrock proportionally grew, causing a

decrease in elevation by about 150 m (from 1100 m in Hulei Peak to 950 at peripherals). The contract concluded with the Swiss company Holcim, is unlikely to be cancelled in the near future, which means that large areas will continue to be mutilated by excavation. On medium term, at the current rate of exploitation, the Mount Mateiaș landscape will face an increasing dynamics, being continuously crushed by the machinery that excavates the limestone. Practically, the mooned landscape will become dominant; the fragmentation of natural environment will worsen, while the impact on the housing quality will definitely be negative. On the other hand, the interview survey reveals that the prosperity of local communities depends on limestone exploitation and processing, while the interest for environment protection comes second. Under the circumstances, the compromise solution can only be a rehabilitation program, meant to improve the degraded lands according to the models provided by the countries with experience in this respect (Italy, UK, Germany etc.).

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Author contribution

The authors of the study had the following contributions: bibliographic documentation, field activities and paper drafting were done by Gabriela Manea, Iuliana Vijulie and Adrian Tișcovschi; the processing of the interviews in QSR Nvivo and the translation of the final paper were performed by Elena Matei and Octavian Cocos; computer mapping, data analysis and assistance with proofing were provided by Laura Tîrlă.

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