International Scientific Conference 20 UNITECH 26

INTERNATIONAL SCIENTIFIC CONFERENCE
19-21 November 2026
GABROVO

ENVIRONMENTAL IMPACT OF DIMENSION LIMESTONE QUARRYING IN THE KARST FORE-BALKAN REGION OF NORTHERN BULGARIA: A COMPONENT-BASED ASSESSMENT FOR THE LUKOVIT AREA

Dragomir Vassilev*, Dobromira Yaneva

Technical University of Gabrovo, 4 Hadji Dimitar Str., 5300 Gabrovo, Bulgaria
**Corresponding author: dvasilev@tugab.bg*

Abstract
The paper analyses how a typical open-pit quarry for dimension limestone would affect the environment of the Lukovit area in the karst Fore-Balkan of Northern Bulgaria, a region of karstified Maastrichtian limestones, karst springs used for drinking water, the Vit river canyons and the Natura 2000 site Studenets (BG0000240). A reference project with a maximum output of 150 000 m³ per year over 35 years, combining diamond-wire block extraction with crushing of the reject rock, is assessed component by component using baseline data and modelling results from an environmental impact assessment carried out in the region. Air quality, karst groundwater, biodiversity and protected areas, soils and landscape, noise and vibration, waste and human health are evaluated by extent, duration and reversibility. The quarry would emit about 44 t of PM_{10} per year, but exceedances of the 24-hour limit value remain within about 1 km of the pit, and noise at the nearest dwellings stays below 35 dB(A). The permanent change of relief, the temporary loss of about 14 ha of soil and the occupational exposure of workers are the main unavoidable impacts. The most sensitive regional receptor is the karst aquifer, so blasting design, fuel handling and the vertical distance to the water table determine whether such a project is acceptable.

Keywords: dimension stone, limestone quarry, karst, environmental impact assessment, PM_{10}, Natura 2000, Fore-Balkan.

INTRODUCTION

Limestone is the most widely quarried carbonate rock and is extracted both as crushed aggregate and as dimension stone for cladding and paving. Quarrying in karst is one of the most damaging human activities for this type of terrain: it removes the epikarst and soil, can destroy caves and increases the vulnerability of karst aquifers, in which contaminants move quickly through fractures and conduits with little attenuation [1], [2]. Quarries also emit fugitive dust from blasting, haulage, crushing and screening [3], and they leave permanent landforms that require reclamation [2].

Dimension-stone quarries have a specific problem: only a small part of the extracted rock is suitable for commercial blocks, and the rest has traditionally been dumped. Processing this reject rock into aggregates is now seen as a key step towards a circular use of stone resources [4], [5].

The Fore-Balkan around Lukovit (Lovech District) combines a high potential for limestone extraction with sensitive receptors: karst springs supplying villages, the canyons of the Vit river and its tributaries, protected caves with bat colonies and an extensive Natura 2000 site. The aim of this paper is to assess, in general terms, how a typical dimension limestone quarry would affect each environmental component in this region and which local conditions determine the significance of the impacts. The analysis uses the baseline data and

This is an open access article licensed under Creative Commons Attribution 4.0 International
Print ISSN: 1313-230X, Online ISSN: 3033-1404

modelling results of an environmental impact assessment (EIA) carried out in the region in 2015 [6].

REGION AND REFERENCE PROJECT

A. Regional setting

The area belongs to the Fore-Balkan climatic region, with mean January temperatures of about −1.5 to −1.8 °C, mean July temperatures of 20–23 °C and annual precipitation of 641–941 mm. Westerly and north-westerly winds prevail; winds are light (84.7 % of hours at 0.5–1.8 m/s) and stable conditions occur in nearly half of the hours, mainly at night (Fig. 1).

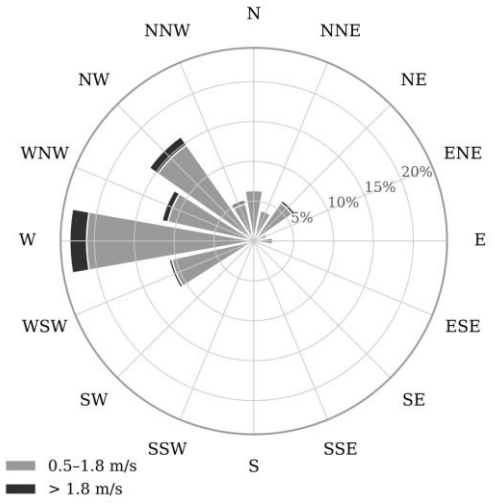


Fig. 1. *Wind rose for 2014, Dermantsi meteorological station (Lukovit area).*

The relief is hilly and plateau-like (160–305 m) and is cut by the canyon-like valleys of the Vit river. The bedrock consists of Maastrichtian limestones, intensely karstified along the valleys. They host the groundwater body "Karst waters in the Fore-Balkan" (BG1G0000K2s037), which is in good quantitative and chemical status. It is recharged by infiltration in the open karst and drained by the Vit and its tributaries through springs of 5–160 L/s [6]. Many villages depend on small captured karst springs (up to about 12 L/s) without formally established protection zones.

Rendzinas prevail, and land use is dominated by arable land and pastures (70.3 % of the municipality is agricultural land). The Natura 2000 site Studenets (BG0000240, about 27 900 ha) covers the karst canyons of the Vit, Kamenitsa and Chernelka rivers; it protects 19 habitat types, including caves (8310) and calcareous grasslands (6210), and 12 bat species. The cave Gorniya and Dolniya Parnik (3.5 km long) is a major wintering site for bats [6].

Rural background air quality is good (regional background station Vitinya: 16.5 µg/m³ PM_{10} in 2014), while the towns of Lovech and Pleven exceed the daily PM_{10} limit mainly because of solid-fuel heating. The population is ageing and shrinking; in 2014 the crude mortality rate in Lovech District was 19.1 ‰, about four points above the national average, and 26.2 ‰ in villages, with cardiovascular diseases as the leading cause of death [6].

B. Reference project

The reference quarry (Table 1) represents a medium-sized dimension-stone operation typical of the region. Blocks are cut with water-cooled diamond wire saws and split with detonating cord. Rock that cannot yield blocks is extracted by selective contour blasting and crushed and screened in a mobile plant into aggregates for concrete, asphalt and road bases. The site is assumed to lie about 1.5 km from the nearest village, about 0.6 km from the Natura 2000 boundary and 1.2–1.6 km from the nearest captured springs, which corresponds to the situation analysed in [6].

Table 1. *Main parameters of the reference quarry*

Parameter	Value
Area of reserves / pit	30.6 ha / 14.4 ha
Reserves (proven + probable)	12.6 million m³
Overburden (of which topsoil)	1.15 million m³ (0.09)
Maximum output	150 000 m³/yr (≈ 400 000 t)
Block yield	≈ 15 %
Rock crushed to aggregates	up to 340 000 t/yr
Operating period	35 years

Parameter	Value
Working regime	200 days × 8 h (09–16 h)
Blasting	≤ 24 blasts/yr, ≤ 1 575 kg each
Diesel fuel	≈ 300 t/yr
Water for dust suppression	≤ 20 m³ per shift

C. Methods

Each environmental component was assessed for the preparation, operation and closure phases. Fugitive emissions were estimated with US EPA AP-42 emission factors [7], [8] and their dispersion modelled with AERMOD [9] using hourly meteorological data for 2014, in three scenarios: overburden removal, operation, and cumulative impact with domestic heating and road traffic. Noise was calculated with geometric divergence from measured sound power levels of similar equipment, and blasting effects with the safe-distance criteria of the national blasting regulations. Results were compared with the limit values of Directive 2008/50/EC [10] and the national noise limits [11]. Significance was rated from the extent, duration, reversibility and sensitivity of the receptors.

RESULTS AND DISCUSSION

A. Air quality

The quarry would emit about 43.6 t of PM_{10} per year under conservative assumptions: 18.8 t from overburden removal, 19.2 t from mobile equipment and haulage and 5.6 t from the crushing plant with water spraying. Diesel engines would emit about 19 t of NOx per year. Without spraying, the PM_{10} emission of the crushing plant would double, and the unpaved access road has an emission factor about 190 times higher per vehicle-kilometre than the paved regional road.

Exceedances of the 24-hour PM_{10} limit value (50 µg/m³) are confined to the pit and its surroundings, with a maximum of 127 µg/m³ and 11–13 exceedance days per year in the cumulative scenario. In the nearest village the maximum daily concentration is 20–34 µg/m³, below the upper assessment threshold of 35 µg/m³, and in villages 3–4 km away it stays below 20 µg/m³ (Fig. 2). The quarry adds less than 0.5 µg/m³ to annual means. Hourly NOx exceeds 200 µg/m³ only around the pit. The impact is low because the quarry operates only in daytime, when unstable conditions favour dispersion, and because winds blow from the pit towards the nearest village in only about 5 % of hours.

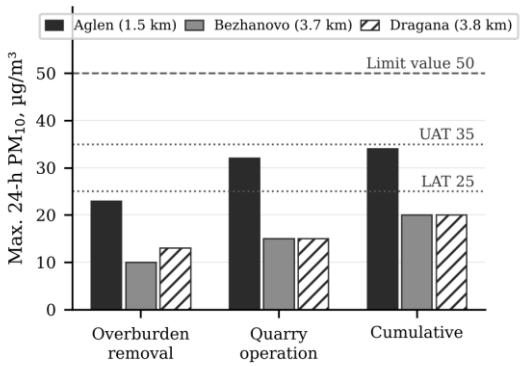


Fig. 2. *Maximum 24-hour PM_{10} concentrations modelled in the nearest villages (upper bounds of ranges) for the three scenarios.*

B. Surface water and karst groundwater

No process wastewater is discharged: rainwater from the pit is collected in a settling reservoir and reused for dust suppression, and sanitary needs are covered by chemical toilets. Because the water table lies at about 115–125 m a.s.l., some 60 m below the final quarry floor (265 m), no dewatering is needed and the quantity of groundwater is not affected.

The karst nevertheless makes groundwater the most sensitive component in this region. Fuel or oil spilled on the pit floor can reach the aquifer through open fractures without filtration [1], and blasting can open new fractures and change the recharge paths of nearby springs. The design safe distances are 300 m for ground vibration, 500 m for air blast and 257 m for flyrock. These are well within the distance of 1.2–1.6 km to the captured springs, but the real vibration attenuation in karstified rock

should be verified by trial blasts with seismic monitoring. Fuelling on sealed surfaces with spill kits and a ban on storing fuel in the pit are essential.

C. Biodiversity and protected areas

In this part of the Fore-Balkan, the land outside the canyons has long been converted to arable land, pasture and coppice. The vegetation at the reference site is secondary and ruderalised, with no habitats or species of conservation concern, and it will be lost on about 14 ha. The site offers no habitat for the European ground squirrel or the Romanian hamster listed for Studenets.

Impacts on the Natura 2000 site are therefore indirect: dust deposition on adjacent grasslands, noise and human presence. At a distance of about 0.6 km they are not expected to be significant. For cave-dwelling bats, the critical factor is the distance of blasting from caves used as roosts, which in the region must be checked case by case. Progressive reclamation and the end of grazing on restored areas can increase local biodiversity.

D. Soils, land and landscape

The rendzina soil will be removed from the pit area of about 14.4 ha, at an average rate of about 0.4 ha per year. The 91 670 m³ of topsoil is stored separately and reused for reclamation, so the loss of soil function is temporary. The change of relief is permanent: a pit with benches replaces agricultural and forest land and is visible from the nearest village for 35 years. Technical and biological reclamation, preferably following the landform replication approach developed for limestone quarries [2], can integrate it into the karst landscape.

E. Noise and vibration

Individual machines emit 85–90 dB(A) and the total sound power of the site is 115–120 dB(A). At the nearest dwellings, 1.5 km away, the calculated level is about 35 dB(A), and below 32 dB(A) at 3–4 km, well below the residential daytime limit of 55 dB(A) [11]. Traffic is the more important issue: the regional road already produces about 71 dB(A) in the villages, and up to 48 truck trips a day would add to noise, vibration and road damage. A haul route that bypasses the villages is therefore a key condition for this type of project.

F. Waste

With a block yield of only about 15 %, a dimension-stone quarry without crushing would turn about 85 % of the extracted rock into waste. Processing the reject rock into aggregates reduces the extractive waste to the overburden (1.06 million m³ of weathered limestone, inert waste code 01 01 02), which is stored on a temporary dump of 550 000 m³ and later used in reclamation. Dust collected by the bag filters of the drill rigs, up to about 4 t per year, is the only other process waste. This is in line with the circular-economy approach to dimension stone [4], [5].

G. Human health

Because the modelled concentrations and noise levels in the villages remain below the limit values and assessment thresholds, no measurable effect on the health of the population is expected, even for an ageing population with a high burden of cardiovascular disease. The main health issue is occupational: workers are exposed to dust, to noise above the upper exposure action value of 85 dB(A) [12] and to whole-body vibration in trucks, bulldozers and loaders [13]. The free crystalline silica content of the dust should be measured, and workers need cabs with filtered air, hearing protection and regular health surveillance.

H. Overall significance

Table 2 summarises the assessment. With the planned measures, all impacts outside the site are rated as insignificant or low. Within the site, the permanent change of relief and the temporary loss of soil are unavoidable. Cumulative effects arise with domestic heating in winter, other quarries and the cement plant in the region, and future traffic on the Hemus motorway, but the quarry's

share is small because it operates in daytime and in the warm season.

Table 2. *Summary of impacts with mitigation measures*

Component	Main impact	Significance
Air	PM_{10} above limit only near the pit	Low, local
Groundwater	Spill and blasting risk in karst	Low*
Surface water	No discharges	None
Biodiversity	Loss of 14 ha of secondary vegetation	Low
Natura 2000	Indirect (dust, noise)	Insignificant
Soils	Topsoil removed, stored	Medium, temporary
Landscape	New pit, visible	Medium, permanent
Noise	≤ 35 dB(A) at dwellings	Insignificant
Traffic	Trucks, road damage	Low with bypass
Waste	Inert overburden	Low
Population health	Below thresholds	Insignificant
Workers	Dust, noise, vibration	Medium

** Conditional on blasting design and fuel management.*

I. Conditions for the region

The analysis shows that the impact of such projects in the Lukovit area depends less on the technology than on location. A quarry is likely to be acceptable if:

– the final floor stays well above the karst water table, so that no dewatering is needed;
– blasting is kept outside the safe distances from springs, water mains and caves, and verified by trial blasts;
– the site lies outside Natura 2000 sites, at a distance that keeps dust and noise from reaching protected habitats;
– the nearest dwellings are about 1 km away or more, and trucks can bypass villages;
– the reject rock is processed into aggregates and topsoil is kept for reclamation.

The study is based on a single reference site and one year of meteorological data, and background concentrations were not measured on site. Before operation starts, baseline monitoring of PM_{10}, spring discharge and spring water quality is recommended.

CONCLUSION

A dimension limestone quarry of about 150 000 m³ per year in the karst Fore-Balkan around Lukovit would have a local impact on the environment. Dust and noise exceed the limit values only on the site and in its immediate surroundings, and they stay below the assessment thresholds in villages 1.5 km or more away. The unavoidable impacts are the permanent change of relief, the temporary loss of soil and the occupational exposure of workers. The karst aquifer and its springs are the most sensitive receptors in the region, so the vertical distance to the water table, blasting design and fuel management decide whether such a project is acceptable. Processing the reject rock into aggregates turns most of the would-be waste into a product and should be a standard requirement for dimension-stone quarries in the region.

REFERENCE

[1] Parise, M., V. Pascali. Surface and subsurface environmental degradation in the karst of Apulia (southern Italy). Environmental Geology, Vol. 44, 2003, pp. 247–256.

[2] Gunn, J., D. Bailey. Limestone quarrying and quarry reclamation in Britain. Environmental Geology, Vol. 21, No. 3, 1993, pp. 167–172.

[3] Petavratzi, E., S. Kingman, I. Lowndes. Particulates from mining operations: A review of sources, effects and regulations. Minerals Engineering, Vol. 18, No. 12, 2005, pp. 1183–1199.

[4] Careddu, N. Dimension stones in the circular economy world. Resources Policy, Vol. 60, 2019, pp. 243–245.
[5] Strzałkowski, P. Characteristics of waste generated in dimension stone processing. Energies, Vol. 14, No. 21, 2021, 7232.
[6] Valchev, T. et al. Environmental impact assessment report for extraction of dimension limestones in the Aglen deposit, Lukovit Municipality, Lovech District. Sofia, 2015 (in Bulgarian).
[7] U.S. EPA. AP-42, Fifth Edition, Vol. I, Section 11.19.2: Crushed Stone Processing and Pulverized Mineral Processing. Research Triangle Park, NC, 2004.
[8] U.S. EPA. AP-42, Fifth Edition, Vol. I, Section 13.2.2: Unpaved Roads. Research Triangle Park, NC, 2006.
[9] Cimorelli, A. J., S. G. Perry, A. Venkatram, J. C. Weil, R. J. Paine, R. B. Wilson, R. F. Lee, W. D. Peters, R. W. Brode. AERMOD: A dispersion model for industrial source applications. Part I: General model formulation and boundary layer characterization. Journal of Applied Meteorology, Vol. 44, No. 5, 2005, pp. 682–693.
[10] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe. Official Journal of the European Union, L 152, 2008.
[11] Ordinance No. 6 of 26.06.2006 on environmental noise indicators. State Gazette No. 58, 2006 (in Bulgarian).
[12] Directive 2003/10/EC of the European Parliament and of the Council on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise).
[13] Directive 2002/44/EC of the European Parliament and of the Council on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration).