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A METHOD TO REDUCE THE IMPACT OF TECHNICAL SEISMICITY GENERATED BY BLASTING ON NATURAL OBJECTS (CASE STUDY OF THE GOMBASEK QUARRY)

METÓDA NA ZNÍŽENIE VPLYVU TECHNICKEJ SEIZMICITY GENEROVANEJ ODSTRELMI NA PRÍRODNÉ OBJEKTY (PRÍPADOVÁ ŠTÚDIA Z LOMU GOMBASEK)

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Abstract

Vibration is one of the basic problems in quarries because its effects can cause critical damage to the environment near the quarry. For this reason, it is necessary to constantly deal with the evaluation of the effects of blastings and the optimization of technical parameters of blastings. The article presents the results of experimental research aimed at optimizing blasting work in the quarry Gombasek. Using the law of attenuation of seismic waves, the maximum mass charge weight explosives per timing stage was calculated in the quarry Gombasek so that blasting works did not cause negative effects on the cave Gombasecká and the chasm Diviačia. The results of the research presented in the article and the optimization of the technical parameters of the blasting works will make it possible to repeat the shots in the quarry Gombasek without negative effects on nearby natural phenomena and the entire surrounding area.

Abstrakt

Vibrácie sú jedným zo základných problémov v lomoch, pretože ich účinky môžu spôsobiť kritické škody na životnom prostredí v blízkosti lomu. Z tohto dôvodu je potrebné neustále sa zaoberať vyhodnocovaním účinkov odstrelov a optimalizáciou technických parametrov odstrelov. Článok prezentuje výsledky experimentálneho výskumu zameraného na optimalizáciu trhacích prác v lome Gombasek. Podľa zákona útlmu seizmických vĺn bola v lome Gombasek vypočítaná maximálna hmotnosť nálože výbušnín na časový stupeň tak, aby trhacie práce nespôsobili negatívne vplyvy na Gombaseckú jaskyňu a Diviačiu priepasť. Výsledky výskumu prezentované v článku a optimalizácia technických parametrov trhacích prác umožnia zopakovať odstrely v lome Gombasek bez negatívnych vplyvov na blízke prírodné javy a celé okolie.

Keywords

Blasting works in quarries, natural objects, attenuation law of seismic waves, seismic safety

Kľučové slová

Trhacie práce v lomoch, prírodné objekty, zákon útlmu seizmických vĺn, seizmická bezpečnosť

1. Introduction

Extraction of mineral resources is one of the main activities of the world economy, which participates in building the material and technical development of society. During this activity, interventions in the environment occur, which may be irreversible. Environmental protection laws, together with geological and mining laws, therefore impose an obligation on the mining plant to protect its surroundings from the negative effects of mining activity. Experts (mining companies) all over the world are also dealing with the issue of environmental safety of blasting. It is about establishing methodologies and technical procedures that will take into account the impact of the blasting effect on natural phenomena. There are no parameters set for the assessment of blasting work for environmental safety. Criteria for assessing the safety of natural objects from technical seismicity generated by blasting are absent from the technical standards (Abbaspour et al., 2018; Végsöová et al., 2019; Konček et al., 2021).

Identification of negative effects and determination of seismic safety is currently an actual problem. It is necessary to find an optimal evaluation methodology and blasting technology that will ensure the non-violation of natural phenomena (Dojčár and Pandula, 1998; Zhang and Goh, 2016).

Research into the seismic effects of blasting shows that it is necessary to monitor these factors in particular work (Dojčár and Pandula, 1998; Viskup et al., 2011; Pandula and Jelšovská, 2008; Kondela and Pandula, 2010; Kondela and Pandula, 2012; Pandula et al., 2012; Kaláb et al. al., 2013; Brixová et al., 2018; Feher et al., 2020; Konček et al., 2020; Konček et al., 2021):

- recognition and characterization of natural objects around the quarry,
- permissible peak particle velocities (PPV) for natural objects,
- blasting technology and frequency of blasting in quarry.

The article presents the results of the research that was carried out in the Gombasek limestone quarry and its surroundings. The goal was to determine the law of attenuation of seismic waves from blasting works to nature-protected objects, the cave Gombasecká and the chasm Diviačia. Based on experimentally measured propagation speeds and frequencies of seismic waves in situ in the rock environment of limestone karst, the seismic effects of blasting (vibrations) were reduced by optimizing blasting parameters. Based on the law of attenuation of seismic waves, the maximum permissible load was determined, which will not cause damage to the surrounding natural objects in the vicinity of the Gombasek limestone quarry during blasting operations. (Pandula and Kondela, 2021).

2. Geological structure of the rock environment around the quarry Gombasek

The limestone quarry Gombasek is located at the southern edge of the karst plain Plešivecka in southeastern Slovakia. (Fig. 1). The mining area of the Gombasek deposit is located from 230 to about 600 m above sea level. High-percentage Wetterstein limestone ($CaCO_3$ content from 96 to 99.9%) is mined and processed in the quarry Gombasek.

Limestones of the Wetterstein type are layered with a thickness of about 0.3 to 1.5 m, sometimes even massive. The transition of the slope of layering was found mostly in the direction northeast-southwest, with a slight slope of 10-20° (monoclinal) to the northwest. Tectonically broken strata surfaces are karstic in many places. Sediments formed in karst cavities (Quaternaries) are mainly formed from weathering, represented by clays (red to ochre), which are perforated by irregular fragments of limestone of the Wetterstein type (Fig. 2) (Sasvári et al., 2006).

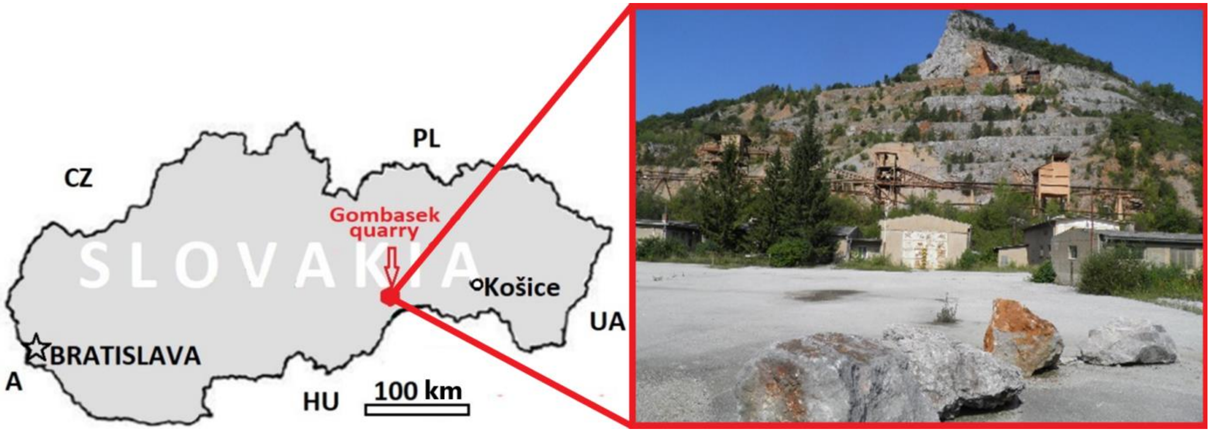
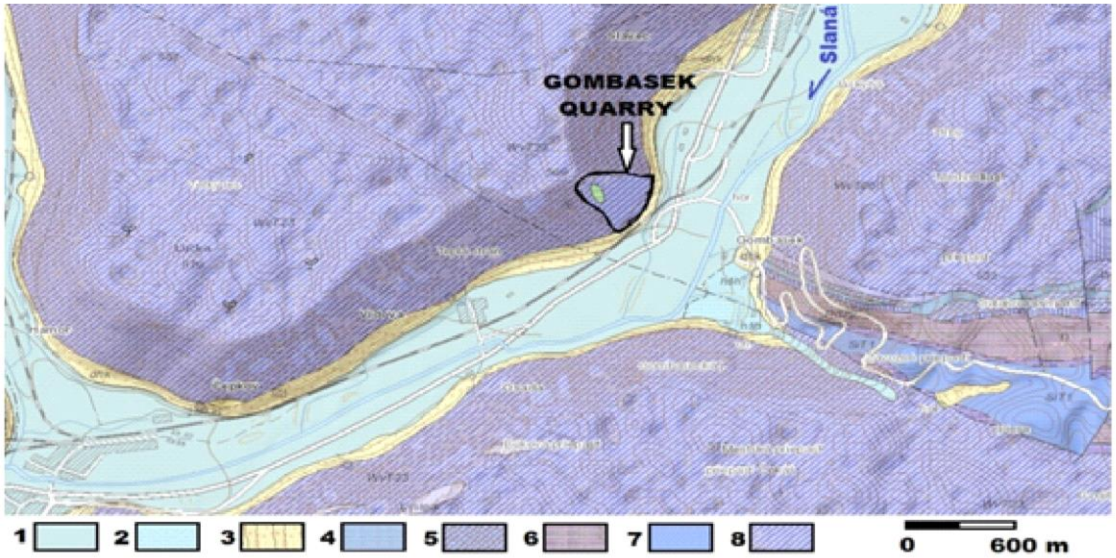


Fig. 1 Location and view of the quarry Gombasek



The legend
Quaternary:
1. fluvial sediments:
river floodplain - clayey, clayey-sandy, clayey,
stream floodplain - gravelly, gravelly-sandy,
2. proluvial sediments:
loamy-gravel,
3. deluvial sediments:
loamy-stony and stony sediments
Mesozoic:
4. Schreyeralm pinkish limestones,
5. Wetterstein limestones, lagoonal, reef,
6. Gutenstein dolomites,
7. Sinian layers: shale, marly limestones,
8. Reiflin and pseudo-Reiflin limestones

Fig. 2 Geological map of the vicinity of the quarry Gombasek (Mello et al., 1996)

2.1 Structural characteristics of etage VII C in the quarry Gombasek

Etage VII C, on which the blasting works are carried out, is segmented by general fault structures in two directions, namely the NW - SE and NE - SW directions. The most numerous are the fault structures in the NE - SW direction with moderate inclinations to the NW and SE. We registered both sinistral and dextral displacements on these structures. There are movement indicators that indicate declines or displacements on these fault structures. Less numerous are the NW-SE faults, showing primarily sinistral shifts, but also dips or slips on these fault structures.

Etage VII C is also broken by a cleavage system of decimeter-sized faults. The mentioned system represents secondary structures, which are the result of recent subsidence on a N - S fault structure with a moderate inclination to the west. The cleavage system is broken by a NE-SW fracture system, on which we registered dextral displacements. The fracture system is important from the point of view of stone mining, because it is almost vertical and almost parallel to the course of the etage. In this area, there are pronounced NW-SW strike-slip structures with an inclination to the NW, on which the rock massif was moved to form imbrication structures. These are penetrated by a V - Z fault system that has recently been opened with an infill of ochre, clays and aragonite mineralization. The openness of the fracture system is up to 1.5 m. The complexity of the structural construction of etage VII C and the degree of its violation is best described by the tectonogram (Fig. 3).

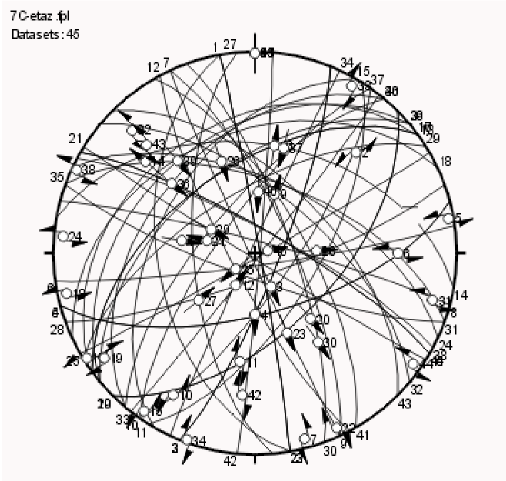


Fig. 3 Tectonogram showing all documented structures on the etage VII C

Fig. 4 Dripstone decoration of the cave Gombasecká and the entrance to Diviačia chasm (Gaál and Vlček, 2009), http://www.ssj.sk/Diviačia chasm)

2.2 Natural conditions of the cave Gombasecká and of the chasm Diviačia

The cave Gombasecká is a 1525 m long river spring cave. It is formed in the Middle Triassic light Wetter-stein limestones, dark gray Gutenstein limestones, light gray and dolomitic lime-stones along tectonic faults by the corrosion and erosion activity of the Black Stream. It is part of the Silicka-Gombasec underground hydrological system, which also includes the cave Silická ľadnica. It is known mainly for the occurrence of sinter quills - thin tubular stalactite formations. Within the caves of the Slovak and Aggtelek karsts, it is included in the world natural heritage (Fig. 4) (Bella, 2003).

The chasm Diviačia is one of the deepest chasm Slovakia. It is located in the eastern part of the plain Plešivska in the Slovak Karst (Fig. 4). It got its name after the discovery of a 3000 year old sintered skeleton of a wild boar (Sus scrofa). It has been a national natural monument since 1986 and is part of the Slovak Karst National Park. It belongs to the caves of the Slovak Karst, which were included in the UNESCO World Heritage List. It reaches a depth of 123 m and represents the deepest chasm of Plešivecka plain. The chasm Diviačia was formed along significant steep to vertical tectonic faults in the Mesozoic Middle Triassic light Wetterstein limestones of the nappe Silica. The chasm consists of a system of alternating corroded chimney and tumbled dome-like spaces, which are decorated with rich and varied sinter decoration (Herich, 2019).

3. Methodology and used vibrographs

The measuring standpoint were chosen so that it was possible to determine the law of attenuation of seismic waves in the quarry Gombasek and to assess the seismic effects on the cave Gombasecká and the chasm Diviačia. ABEM Vibraloc and UVS 1504 digital vibrographs from the Swedish company ABEM were used to measure and

Fig. 5 Position of measuring standpoint MS1 in Gombasek quarry ABEM Vibraloc Vibrograph at a distance of 18 m from the initiation borehole of the CO 575 bench blast (left) and a view of the limestone wall after the blast (right)

Fig. 6 Measuring standpoint MS2, location of vibrograph UVS 1504 on road bridge object in the vicinity of the quarry Gombasek at a distance of 755 m from the bench blast CO 574

Fig. 7 Position of the measuring standpoint MS3. The ABEM Vibraloc vibrographs were placed on a concrete base at the entrance to the cave Gombasecká and inside Gombasecká cave on the footpath for tourists. (Pandula and Kondela, 2021)

Fig. 8 Position of measuring standpoint MS2 in Gombasek quarry. Vibrograph ABEM Vibraloc at a distance of 834 m from bench blasting CO 575 in the direction on Diviačia chasm

graphically record the seismic effects of the blasting works at the mentioned measuring standpoints (Fig. 5, 6, 7, 8).

To determine the law of attenuation in the transmission environment between the source (bench blasting CO 575) and the receptor (Gombasecká cave, Diviačia chasm), the measuring station MS1 was located 18 m

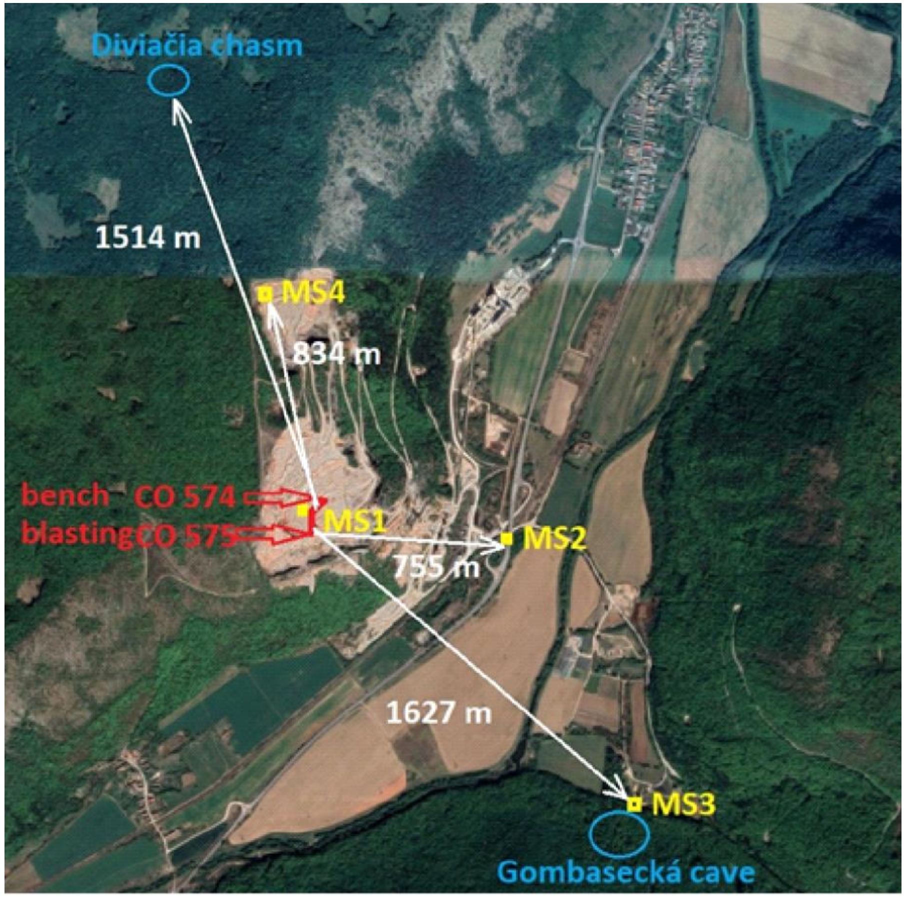


Fig. 9 Position and distances of the bench blasts CO 574 and CO 575 in Gombasek quarry in relation to the measuring standpoints (MS1, MS2, MS3, MS4) the cave Gombasecká and the chasm Diviačia

from the initiation borehole CO 575 in the quarry Gombasek (Fig. 5).

For a more precise determination of the law of attenuation of seismic waves in the direction of the Gombasecká cave, the measuring standpoint MS2 was located on the concrete foundation of the road bridge next to the quarry Gombasek quarry at a distance of 755 m from CO 574 (Fig. 6).

To assess the impact of seismic effects on the cave Gombasecká , the MS3 measuring standpoint was located on a concrete base at the entrance to Gombasecká cave and inside Gombasecká cave on the footpath for tourists (Fig. 7).

In order to assess the impact of seismic effects on Diviačia chasm, the measuring standpoint MS4 was located on the edge of the Gombasek quarry, in the direction of Diviačia chasm. The chasm Diviačia is not accessible (Fig. 8).

Three-component geophones from ABEM with a frequency range of 1 ÷ 1000 Hz and a sensitivity of 10 $mV/mm.s^{-1}$ were used for these measurements. The geophones were placed on a special pad with sharp steel spikes, which ensured continuous contact with a rock base (Fig. 5, 6, 7, 8).

4. Source of vibrations in technical seismicity research

The source of the seismic effects were the bench blasts CO 574 a CO 575 on the limestone deposit in Gombasek quarry. The bench blasts were located on etage 7 C, near the western edge of Gombasek quarry. The positions and distances of CO 574 and CO 575 in Gombasek quarry to the measuring standpoints MS1, MS2, MS3 and MS4 are in Tab. 1 and Fig. 9.

Bench blast CO 574 - 16 vertical boreholes with a diameter of 105 mm, a length of 23.5 m, a burden of 2.5 to 5.2 m and a spacing of 3.5 to 4.6 m were drilled during the bench blast CO 574. The total charge in these boreholes was 1657.5 kg of explosives, of which the maximum charge for one time stage was 142.25 kg. 31 heel boreholes were drilled with a total load of

Tab. 1 Data on the location of the blasting and the distance of the standpoints from the blastings in Gombasek quarry (Fig. 8)

Standpoint	Blast	Distance source - receptor		Comment
		sloping	horizontal	
MS1- quarry Gombasek	CO 575	29.6 m	18 m	quarry Gombasek
MS2- road bridge Gombasek, direction Gombasecká cave	CO 574		755 m	road bridge Gombasek
MS3- Gombasecká cave	CO 574		1627 m	
MS3- Gombasecká cave	CO 575		1672 m	
MS4- quarry Gombasek, direction Diviačia chasm	CO 575		834 m	quarry Gombasek

398 kg. The total blast charge was 2665 kg of explosives. The breakdown of the explosives used is in table no. 2. Non-electric ignition with millisecond timing delay of 25, 17 and 9 ms were used.

Bench blast CO 575 - 15 vertical borehols with a diameter of 105 mm, a length of 23 m, with a burden of 4.8 to 5.3 m and a spacing of 4.6 m were drilled during the bench blast CO 575. The total charge in these borehols was 2043 kg of explosives. The maximum charge for one borehole was 125.8 kg of explosives. Non-electric ignition and timing delay of 25 ms, 17 ms and 9 ms were used.

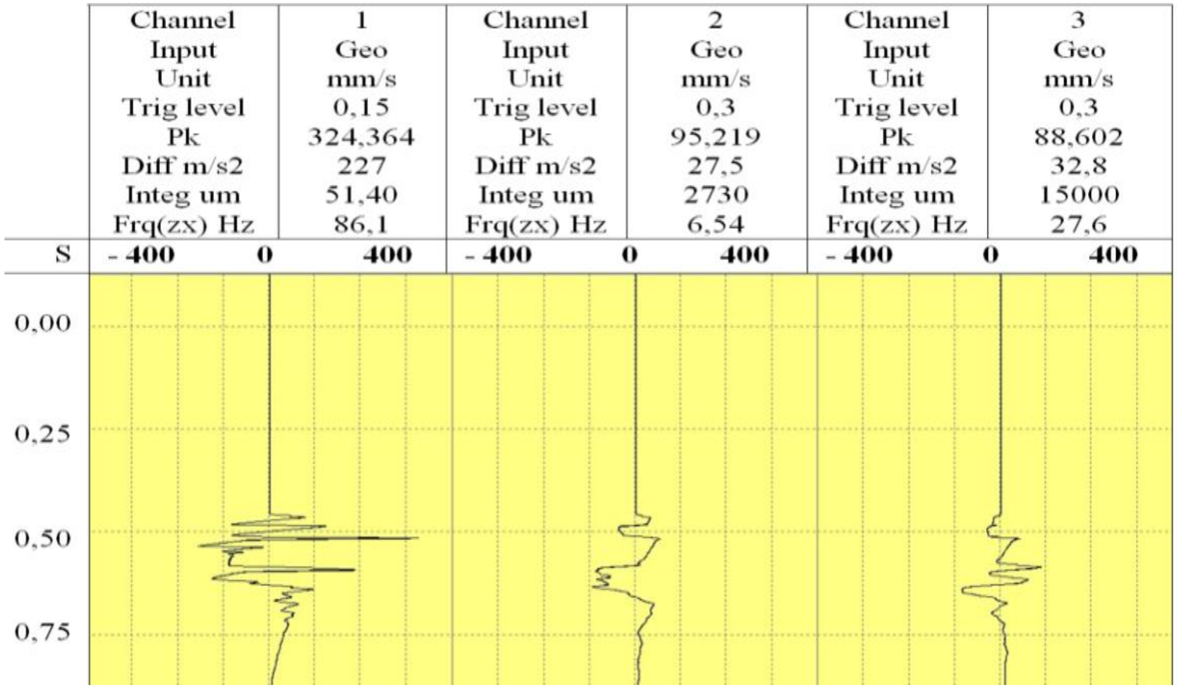


***Fig. 10** Graphical record of individual peak particle velocities (vert-z, rad-x, trans-y) at standpoint MS1 - Gombasek quarry at a distance of 18 m from initialization borehole CO 575 (Pandula and Kondela, 2021)*

5. Measured values and results

The measuring devices placed at the standpoints were calibrated before the measurement and their sensitivity was checked. At the measuring standpoints, graphic courses of individual components of seismic waves at bench blasts CO 574 and CO 575 were recorded. Graphic records are four seconds long.

The measuring vibrographs measured the components of the peak particle velocities on the channels (channel No. 1 - z component, channel No. 2 - x component, channel No. 3 - y component) and recorded the effects of seismic waves from bench blasts CO 574 and CO 575 in Gombasek quarry (Fig. 9).

The measured values at the individual measuring standpoints are shown in Tab. 2. At the measuring standpoint MS3, the peak particle velocities since the blasting were not measured, because the values of the peak particle velocities in Gombasecká cave were below the sensitivity level of the vibrograph ABEM Vibraloc of 0.3 mm.s^{-1}. For the measuring standpoint MS3 – Gombasecká cave, the values of the peak particle velocities components (v_x, v_y, v_z) were determined to be 0.3 mm.s^{-1}. The actual values of the peak particle velocities in Gombasecká cave were lower at CO 574 and CO 575 than the set sensitivity values of the ABEM Vibraloc vibrograph, stored in Gombasecká cave. Frequencies (f_x, f_y, f_z) could not be determined, therefore their values are not listed in Tab. 2 (Pandula and Kondela, 2021).

Tab. 2 Maximum values for peak particle velocities and frequencies at standpoints MS1, MS2, MS3 and MS4 at bench blasts CO 574 and CO 575

Standpoint	Distance [m]	v_x [mm. s^{-1}]	v_y [mm. s^{-1}]	v_z [mm. s^{-1}]	f_x [Hz]	f_y [Hz]	f_z [Hz]
MS1 – Gombasek quarry	29.6	324.4	88.6	75.9	6.54	27.6	86.1
MS2 –Gombasek bridge	755	0.75	0.65	0.5	2.9	0.9	2.3
MS3 – Gombasecká cave	1627	≤ 0.3	≤ 0.3	≤ 0.3	-	-	-
MS3 – Gombasecká cave	1672	≤ 0.3	≤ 0.3	≤ 0.3	-	-	-
MS4 – Gombasek quarry directoin Diviačia chasm	834	1.6	1.1	0.9	26.8	31.2	22

Legend: v_x - peak particle velocities of environmental particles (horizontal/longitudinal), v_y - peak particle velocities of environmental particles (horizontal/transverse), v_z - peak particle velocities of environmental particles (vertical), f_x - maximum frequency (horizontal/longitudinal), f_y - maximum frequency (horizontal/transverse), f_z - maximum frequency (vertical).

To process the peak measured values of the peak particle velocities in the Gombasek quarry, we used the following relations (Pandula and Kondela, 2010). The first relation is for calculating the value of the peak particle velocities:

$$v = \left(\frac{L}{Q^{0,5}}\right) = K\left[\frac{L}{Q^{0,5}}\right]^n, \qquad (1)$$

where v - is the peak particle velocities generated by blast, (mm.s^{-1}),
L/Q$^{0.5}$ - is the so-called reduced distance, (m.kg$^{-0.5}$),
L - is the shortest distance of the source of vibration from their receptor (m),
Q - is the mass of the charge of the one timing stage, (kg),
K - is a coefficient dependent on the blasting conditions, properties of the transmission environment, type of explosive charge, etc.,
n - is an indicator of the attenuation of seismic waves, (Pandula and Kondela, 2010).

The second relationship is used to calculate the maximum allowable mass of the charge for one timing stage depending on the distance for repeated bench blast in Gombasek quarry:

$$Q_{vmax} = L^2/L_R^2, \quad (2)$$

where L – distance (m),

L_R – reduced distance ($m.kg^{-0.5}$) (Pandula and Kondela, 2010),

$$L_R = L.Q^{-0.5}. \quad (3)$$

The third relationship is used to calculate reduced distance.

Tab. 3 Peak particle velocities for periodic blasting (Pandula and Kondela, 2010)

Object class T	**Permissible v_p peak particle velocities [$mm.s^{-1}$] for object quality – k**								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	46	27.6	16.5	10	6	3.7	2.2	1.3	-
2	75	46	27.6	16.5	10	6	3.7	2.2	1.3
3	120	75.6	46	27.6	16.5	10	6	3.7	2.2
4	198	120	75	46	27.6	16.5	10	6	3.7

Legend - T (classes of engineering work):

1. *particularly important works with a lifespan of over 10 years, (hydraulic tunnels, pits, main mining works, drainage and other water management works),*
2. *important works with a lifespan from 5 to 10 years, (buttresses, ditches, ceiling pillars, stable slopes of etages and piles, etc.),*
3. *works with a short lifespan from 1 to 5 years, (corridors, chambers, etc.),*
4. *works with a lifespan of up to one year, (excavations, slopes of working etages, etc.).*

There is no relevant technical standard for assessing the quality of natural objects. According to STN EN 1998-1/NA/Z1, the lowest value of the permissible peak particle velocities for objects $v_p < 3$ $mm.s^{-1}$ is established. In the case of assessing the seismic effects of blasting on the assessed objects (cave and chasm), it is not only an assessment of the physical condition of the cave, but mainly an assessment of the rock environment where the cave and chasm are located. If the rock environment of the cave Gombasecká and the chasm Diviačia were to be disturbed due to the seismic effects of blasting in Gombasek quarry, the underground hydrological system could be disturbed. The standard classifies particularly important works with a lifetime of more than 10 years T–1 as the lowest permissible peak particle velocities in the rock massif. For the stated reasons, Gombasecká cave and Diviačia chasm were classified according to the standard in the group of the lowest permitted peak particle velocities in the rock massif. The object quality parameter was set to the value k = 7 and the peak particle velocities to the value $v_p \leq 1.3$ mm.s^{-1}. According to the standard, this value represents the permissible value of the peak particle velocities in the rock mass (Pandula and Kondela, 2010; Pandula and Kondela, 2012; Kondela and Pandula, 2013).

The measured maximum values of the seismic effects generated by bench blasts CO 574 and CO 575, which were carried out in Gombasek quarry, are in Tab. 4. These values served as the basis for determining the law of attenuation seismic waves in Gombasek quarry and immediate surroundings area.

Based on the data from Tab. 4, the graphical dependence of the maximum components of the peak particle velocities on the reduced L_R distance for bench blasting in Gombasek quarry was constructed. The graph in Fig. 11 represents the seismic wave attenuation law for Gombasek quarry and immediate surroundings area, in which the value of Q was calculated according to relation 2.

From the law of attenuation of seismic waves, it is possible to determine the size of the charge explosives for a specific receptor at a known distance so that the maximum values of the individual components of the peak particle velocities do not exceed the permissible peak particle velocities.

The graph (Fig. 11) shows the values of peak particle velocities in Gombasek quarry (points on the

Tab. 4 Maximum values of peak particle velocities at bench blasts CO 574 and CO 575

L [m]	Q [kg]	$L_R = L.Q^{-0.5}$ [m.kg$^{-0.5}$]	v_x [mm.s^{-1}]	v_y [mm.s^{-1}]	v_z [mm.s^{-1}]
29.6	125.8	2.6	324.4	88.6	75.9
755	142.25	63.3	0.75	0.65	0.5
834	125.8	74.5	1.6	1.1	0.9
1627	142.25	136.4	0.3	0.3	0.3
1672	125.8	145.1	0.3	0.3	0.3

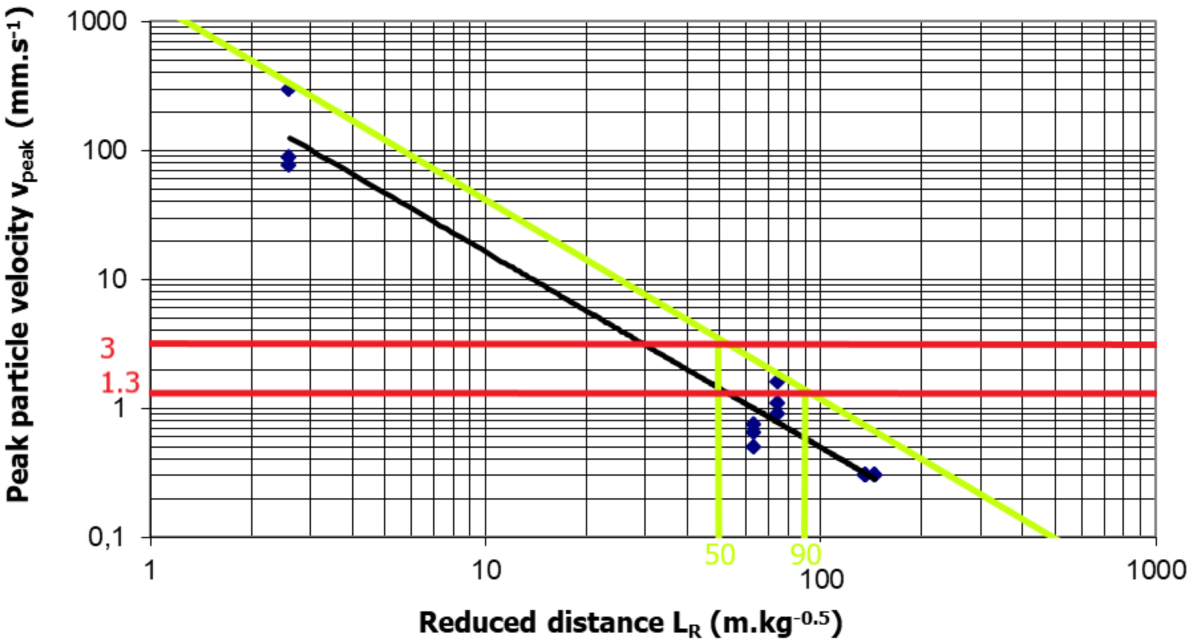


Fig. 11 Graphical depedence of the maximum values of the peak particle velocities on the reduced distance during CO 574 and CO 575 in the quarry Gombasek - the law of attenuation seismic waves

upper left part of the graph) and in the assessed Gombasecká cave and Diviačia chasm at CO 574 and CO 575 (points on the lower right part of the graph). The red line represents the limit of permitted peak particle velocities for the objects according to STN EN 1998-1/NA/Z1. The green line represents the limit of permitted peak particle velocities for Gombasecká cave and Diviačia chasm so, that no negative changes occur in the rock massif.

On the basis of the experimentally determined law of attenuation of seismic waves in Gombasek quarry, it is possible to determine the maximum permissible mass charge explosives for one timing stage depending on the distance for repeated bench blasting in Gombasek quarry. It follows from the graphical course of the law of attenuation of seismic waves for Gombasek quarry (Fig. 11) that the permissible peak particle velocities $v_p \leq 3$ mm.s^{-1} will not be exceeded at a reduced distance of $L_R = 50$ and the permissible peak particle velocities $v_p \leq 1.3$ mm.s^{-1} will not be exceeded at a reduced distance of $L_R = 90$. Using the reduced distance $L_R = 50$ and $L_R = 90$, the maximum allowable mass charge explosives per one timing stage was calculated depending on the distance in the Gombasek quarry, so that the blasting works does not generate negative effects on Gombasecká cave and Diviačia chasm, on the rock environment in which are situated (Tab. 5).

Tab. 5 Use of the maximum permissible charge for one timing stage depending on the distance for repeated bench blasts in Gombasek quarry

Distance source – receptor L [m]	**Reduced distance L_R [m.kg$^{-0.5}$]**		**Maximum permissible charge for one timing stage [kg]**	
500	50	90	100	31
750	50	90	225	60.5
1000	50	90	400	123.5
1100	50	90	484	149.5
1200	50	90	576	178
1300	50	90	676	208.5
1400	50	90	784	242
1500	50	90	900	278
1750	50	90	1225	378
2000	50	90	1600	498

Optimizing the technical parameters of the blasting works will make it possible to repeat bench blastings in Gombasek quarry without negative impacts on nearby natural phenomena and the entire surrounding area.

6. Conclusion

Based on the research on the seismic effects of blasting, which was carried out in the Gombasek quarry and the Gombasecká cave, it was found that the values of the seismic effects of bench blasts CO 574 and CO 575 (Tab. 2) were below the sensitivity level of the measuring devices of 0.3 $mm.s^{-1}$. Currently, the technical standard does not specify a limit of safe peak particle velocities for the assessment of the quality of natural objects. Gombasecká cave and Diviačia chasm are a protected natural formation created in a broken rock environment of carbonate rocks. The standard classifies particularly important works with a lifetime of more than 10 years T–1 as the lowest permissible peak particle velocities in the rock massif. In case of violation of natural phenomena, it is not possible to replace the damage in any way, or to reconstruct the natural formation. Due to the disturbance of the rock environment and the significance of the protection of the Gombasecká cave and Diviačia chasm, the maximum permissible peak particle velocities $v_p \leq 1.3$ $mm.s^{-1}$ was set. This is a peak particle velocities, that can also be induced by walking a large group of people around the cave.

After the analysis of the project of the technological procedure of the blasting works, a prediction model of the effects of safe vibrations was proposed depending on the distance of the Gombasecká cave and Diviačia chasm from the blasting. If the specified blastings parameters are observed in Gombasek quarry, there will be no damage to the natural formations in the vicinity of the quarry Gombasek. The mentioned model can be created for every mining operation, where the impact of vibrations from blastings on any protected natural phenomena is assumed and to protect them from the possibility of damage.

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