MRAKOTIN GRANITE OF THE HORNI DVORCE QUARRY - PROPERTIES, UTILIZATION, RESEARCH

MRÁKOTÍNSKÁ ŽULA KAMENOLOMU HORNÍ DVORCE - VLASTNOSTI, VYUŽITÍ, VÝZKUM

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Abstract

In this paper, the authors inform readers about the operation of the Horni Dvorce Quarry exploiting the Mrakotin-type granite. The paper further summarizes the properties and utilization of the mined raw material. The reader is also familiarized with the parameters of research being currently in progress in this quarry. This is the research on mechanical properties of granites of Mrakotin type using various types of explosives to produce products of coarse and fine stone production.

Abstrakt

V tomto příspěvku autoři seznamují čtenáře s provozem kamenolomu Horní Dvorce, který těží žulu mrákotínského typu. Článek dále shrnuje vlastnosti a využití těžené suroviny. Čtenář je též seznámen s parametry výzkumu, který na tomto kamenolomu v současné době probíhá. Jedná se o výzkum mechanických vlastností žul mrákotínského typu při použití různých druhů trhavin k produkci výrobků hrubé a ušlechtilé kamenické výroby.

Key words: Mrakotin granite, Horni Dvorce quarry, mechanical properties, properties, utilization, research.

1 INTRODUCTION

The Horni Dvorce Quarry being operated by the firm Lom Horni Dvorce, s.r.o., has been situated since 1993 [7] in the northwestern part of the cadastral territory of the village of Horni Dvorce in the South Bohemian Region, the former District of Hradec Kralove. The quarry site is located approximately 400 m northwest of the village of Horni Dvorce at the top of the Kalec Hill (see Figure 1) with a spot elevation of 663.7 m a s.l. The main rock type is fine- to medium-grained binary granite of Mrakotin type. The rock is located under the cover, which is represented by sandy clay loam, loamy sands and loamy stone debris. The granite is mined in a block manner, solely for the purpose of coarse and fine stone production using natural rock block separation.

Fig. 1: Kalec Hill

2 GEOLOGICAL STRUCTURE OF THE DEPOSIT AND ITS NEAR SURROUNDINGS

Spatially and genetically the Horni Dvorce deposit is part of the large massif of granitoid rocks, which is called a central pluton. The deposit is located at the western edge of this pluton and is composed by a binary granite, which is predominantly medium- to coarse-grained. The texture of the rock is omnidirectional, the structure is porphyritic. In the surroundings of the Horni Dvorce village the grain size of rock dramatically changes, gets strikingly reduced, and phenocryst disappear. There are two basic facies here - grey-brown to yellowish granite and grey granite with a bluish tint. Yellowish to brownish discolouration is caused due to hypergenous factors. This facies towards the deep fade and change to a grey granite with a bluish tint unaffected by hypergenous agents. Both facies are fine- to medium-grained.

At the deposit there are both so called major tectonic elements and minor tectonic elements. The minor tectonic elements are represented by three, sometimes four crack systems. These include classic cracks of Q - L - S type that are not completely normal to each other in the case of the Horni Dvorce locality.

Spatial orientation of cracks [9]:
- 1st system 100-140° / 80-90° to antithetic 220-240°
- 2nd system 110-120° / 40-70°
- 3rd system 130-140° / 25-35°

Note: This is the orientation of dip lines of areas.

The frequency of occurrence of surface discontinuity of the first two systems is highly variable and at relatively small distances. This frequency varies from 0.5 to 4.0 m. In some parts of the quarry, we can see a significant increase in occurrence of one-direction cracks - the so-called crushed belt. The rock in these belts is virtually unusable for any type of stone production. Discontinuity surfaces of the third and possibly fourth scheme are indistinct and their incidence is substantially lower than the occurrence of the first two systems.

The elements of so-called „major tectonics“ are represented by classical tectonic disturbances. In the quarry area or in its vicinity, there is no major fault line of regional significance. The most important tectonic fault line is situated west of the existing quarry in its immediate vicinity. This fault is of overlaying significance and its direction is in general NNE - SSW.

3 HYDROGEOLOGICAL CONDITIONS OF THE SITE

Hydrology of the Horni Dvorce deposit [8] is very simple. When conducting mining operations any underground veins have not yet been affected. Surface waters originating from precipitation virtually totally infiltrate into the soil. Only during extreme rainfall at the bottom of the quarry a relatively small body of water occurs temporarily. Therefore, the mine waters are pumped out only rarely.

Intersticially permeable rocks of soil mantle of the Moldanubian Pluton together with the disturbed surface of crystalline rocks create a zone, where shallow underground waters are formed. The filtration coefficient in these rocks varies in the order of 10^{-6} ms^{-1}.

Groundwater rests conformally with the terrain and moves in the direction of the steep-curve down the hillsides to the foots. In order to determine the direction of groundwater flow at the top of the Kalec Hill, and thus the area of theoretical threat to activities in the quarry, situated in the cadastral area of Horni Dvorce, the firm GEOtest Brno a.s. performed an analysis to enable to divide the terrain in the vicinity of the quarry into sub-basins. Thus the area was defined, where the ground waters can theoretically be threatened by the quarry activities. According to the expertise by Geotest Brno a.s., the only area that can be thus endangered is the space between the quarry and the western edge of the Horni Dvorce village. There are two water sources (wells), both used to supply the Horni Dvorce village with drinking water.

4 PRESENT LEVEL OF DEPOSIT RESERVES (2009)

Tab. 1 shows the current volumes of reserves at the deposit.

Tab. 1 Current level of economically recoverable and economically unrecoverable deposit reserves

Reserves economic, total	**197,737 m³**
- reserves economic free	**97 544 m³**
- reserves economic bounded	100,193 m³
- temporarily bounded	100,193 m³
- permanently bounded	0 m³
Reserves sub-economic, total	87,946 m³
- reserves sub-economic free	54,546 m³
- reserves sub-economic bounded	33,400 m³
- temporarily bounded	0 m³
- permanently bounded	33,400 m³

Tab. 2 Current level of free and bounded deposit reserves in total

Reserves free, total	**152,090 m³**
Reserves bounded, total	133,593 m³
- temporarily bounded reserves	100,193 m³
- permanently bounded reserves	33,400 m³

5 INTENDED FURTHER SURVEY OF THE DEPOSIT AND ITS LIFETIME

Reserve openness is sufficient for exploitation. Currently no prospecting, detailed or geological survey is envisaged at the deposit. Only so-called exploration survey will be carried out and according its results the progress of face will be modified. The deposit lifetime under current conditions is estimated at around 20 years, i.e. until the year 2029.

6 MINING TECHNOLOGY

Development operations are performed directly before conducting mining works themselves [10]. It is basically about creating open surfaces of the rock massif, in order to realize the extraction of the raw material for the needs of classical course stone production. The disintegration is performed using explosives with slipping effect [2], in particular a black blasting powder. Creation of open areas, i.e., the development works for exploitation, is at the deposit executed through „shooting through the road" using high explosives. During performing the exploitation works the tectonic structure of the rock mass is used to a maximum extent, so that the artificial creation of additional degrees of freedom is minimal.

The mining is carried out in three benches not exceeding 10 meters by heights (see Figure 2).

Fig. 2: Mining area of the quarry

Within each bench, based on the tectonic structure of the rock mass, sub-blocks are defined, which are gradually quarried from the top down [1] according to the natural block jointing. The advance of benches and progress in mining works is in general from south to north. However, this general direction is not in individual cases strictly followed, because the detailed progress direction is limited to the local tectonic structure of the rock mass.

The actual mining activities are conducted primarily through small-scale blasting operations [4] using explosives with slipping effect. Vesuvit TN is especially used by using electric initiation with an electric exploder.

7 CURRENT PRODUCT RANGE AND ITS APPLICATION

The current product range [11] is composed of products of course stone production. The raw material is granite of Mrakotin type in grey, yellowish and yellow-brown (blended) colours. The production program is divided into several groups. This is essentially a road construction program, course stone products used for engineering-type buildings, coarse stone products used for other constructions and extraction of granite blocks for further processing.

7.1 Road Construction Program

Road construction program involves the production of cobblestones of types and size, as follows:

- cobblestone large 15/17 cm (Fig. 3, 5)
- cobblestone small 8/10 cm (Fig. 3, 4, 5)
- cobblestone mosaic 4/6 cm (Fig. 3)
- cobblestone atypical (Fig. 6)

Figs. 3, 4, 5, 6: Samples of road construction program

Other products of road construction program are road rough kerbs KS 3, used to strengthen verges of roads and platforms. The range of products finds its application in particular for reconstructions, paving of squares and other public areas, construction of roads.

In addition to the road building program also cube cuttings are in the offer of the firm. This is more or less the waste generated during the splitting the paving, however after all it is possible to create from these cuttings an area with lower requirements for its maximum load. This is usually the entrance to gardens and garages of houses, and even with a very impressive effect. Examples of such surfaces can be the paving of the entry premises of the Zoological Garden in Jihlava (see Fig. 7).

Fig. 7: Entry premises of the Zoological Garden in Jihlava

7.2 Course stone products used for engineering-type constructions

This part of the range of products of the Lom Horní Dvorce, s.r.o. company involves mainly rough stone plinth, rough stone unsorted, rough stone sorted (used as a blackstone course), rough stone riprap (ranging in size from several centimetres up to 200 kg and more), rough stone for cyclopean masonry (has an irregular shape and a straight-fracture face in a shape of quadrangle to hexagon), granite steppers (see Figures 8, 9, 10, 11).

In addition to these types of quarry stone for the construction of engineering-type kerb stones, large cobble, snecked rubble etc. are delivered. Their size is usually atypical, depending on the customer's wish.

These products are utilized as materials for reinforcement of embankments and dikes, as the plinth walls, retaining walls and cladding of the slopes, for the ground slopes stabilization (ditches, gutters), as lining material for water, railway and road constructions, etc.




Figs. 8, 9, 10, 11: Examples of course stone products used for engineering-type constructions

7.3 Course stone products used for other constructions

In particular, these are massive building components and elements of garden architecture, such as stairs, thresholds, granite garden steppers (even large dimensions), snecked rubble, measuring signs, etc. (see Figs. 12, 13, 14).




Figs. 12, 13, 14, 15: Examples of course stone products used for other constructions, granite blocks

7.4 Granite blocks for further processing

Granite blocks (see Figure 15) are quarried, as for size, depending on possibilities of loading and transport equipment of the quarry. The size of such stone blocks is also significantly limited by the sub-tectonic structure of massif. The cubic capacity of granite blocks is usually in the range of 1.8 to 2.8 m^3. The blocks are sorted by colour (yellow, blue, blended) and sold to customers from a number of companies that process them into products of fine stone production, such as paving slabs with face side cut, picked, sprung, ground or polished, hewn stone veneers of various shapes for exteriors and interiors of buildings, as well as fountains, gargoyles, flower pots, benches, decorative and utility articles and souvenirs, monuments, frames, plates, etc.

Fig. 16: Area for processing the raw material and loading the products

8 SPECIFICATION OF THE RESEARCH ON MECHANICAL PROPERTIES OF MRAKOTIN-TYPE GRANITES

In the Horni Dvorce quarry a research on the mechanical properties of Mrakotin-type granites takes place when using different types of explosives to produce products of coarse and fine stone production [5], performed by the first author within his dissertation thesis and the internal grant of VSB-TU Ostrava.

8.1 Used explosives and types of blasting charge designs

The study used mainly the explosives with slipping effect [3] - black blasting powders, specifically Vesuvit TN, Vesuvit THH and Black powder from delaboration, then for comparison with the explosive with fragmentation effect, represented by Perunit 28E, as well as the disintegration of the rock only by means of spring wedges without the use of any explosives. The blasting charge design was chosen as divided, or undivided, the undivided one with approximately 50% overestimation and with 100% overestimation of blasting charge to measure the impact of experience and the best estimate of the quantity of explosives by the shootfirer.

8.2 Blasting operations, sampling and sub-sampling

The blasting operations were carried out in the space of the quarry by a shootfirer, the rock block condition has been duly photographically documented before (see Figure 17) and after blasting. Two samples (size approx. of 25 x 20 x 16 cm) from each oversized piece (block) were then collected by the quarryman and transported to the testing laboratory of the Research Centre of Rocks at the VSB-Technical University of Ostrava. One sample directly from the surface of break-off and the other at a distance of 20 cm from this surface. This enabled to monitor the effect of the explosive on the rock in relation to the distance from the blasting charge. In the testing laboratory of the Research Centre of Rocks (hereinafter referred to as ZLVCH) at the VSB-TU Ostrava six individual specimens were prepared from each sample. From them the strength and deformation properties of the rock were established.

The break-off areas of disintegrated blocks were oriented in parallel to the S-crack systems, and so the main axes of specimens in the shape of cylinders were oriented in parallel to the Q-crack system.

In total 15 blocks have been disintegrated, one block was disintegrated using spring wedges, the remaining 14 pieces by means of blasting operations. From the disintegrated block the quarryman took 30 samples.

Fig. 17: Blocks of rock are ready to be disintegrated

8.3 Tests of mechanical properties of rock

Mechanical properties of rocks can be determined in three loading modes, in particular dynamically, quasi-statically, on a long-term basis.

Within the research of the mechanical properties of the Mrakotin-type granites, in relation to the used types of explosives and blasting charge designs, the most frequent method of laboratory measurements has been used, thus the method of quasi-static loading of the sample. In the test laboratory of the Research Centre of Rocks of the VSB-TU Ostrava the strength and deformation properties of rock samples were tested on a testing device of type MTS 816 Rock Test System.

8.4 Strength and deformation properties of rock

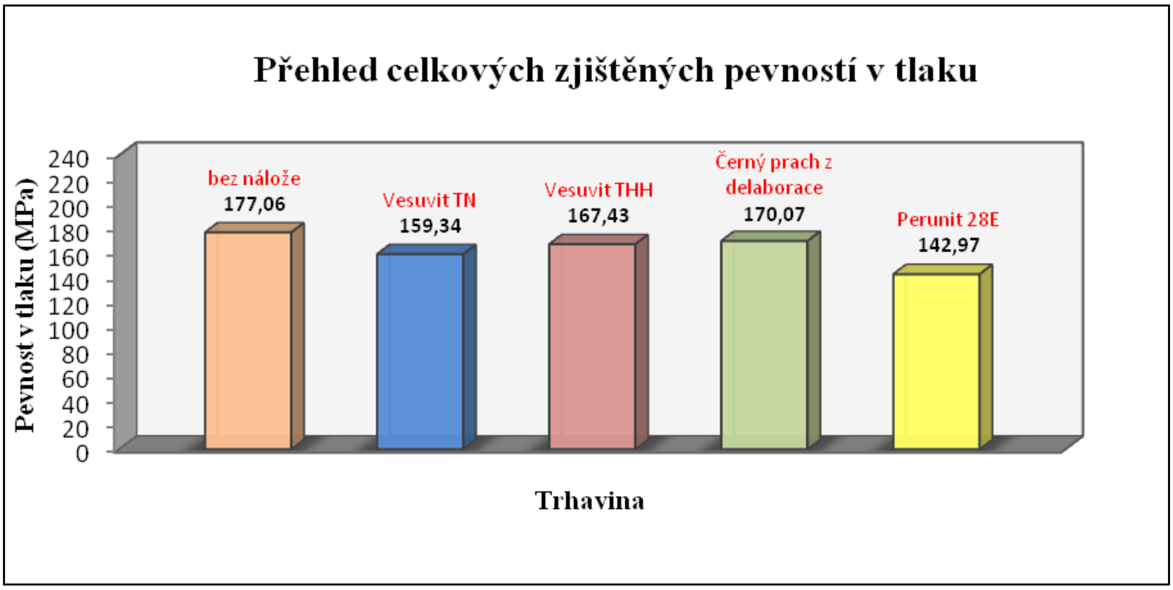
For the purposes of the research on strength properties of the Mrakotin granites the samples were tested to determine the compressive strength by the simple (uniaxial) compression test on regular test specimens with a pressure plough.

This characteristic of rocks is determined mainly when under compressive stress. We determine the rock deformation in transverse and longitudinal directions. In the case of the research on mechanical properties of the Mrakotin-type granites the rock deformation properties were detected by monitoring the deformation of the rock to breaking point. For the selected samples a deformation modulus was determined.

9 RESULTS OF THE IMPLEMENTED RESEARCH, ANALYSIS OF THE OBTAINED VALUES

The data obtained was converted also into a graphic form for an easy access to an overview of the research results. Based on the graphic design of the resulting research values, I have come to the following conclusions.

The graph below (Graph 1) shows the overview of the total detected compressive strengths for disintegrating the blocks without a blasting charge (spring wedges), using black blasting powders (Vesuvit TN, THH, CPD) and high explosive Perunit 28E.



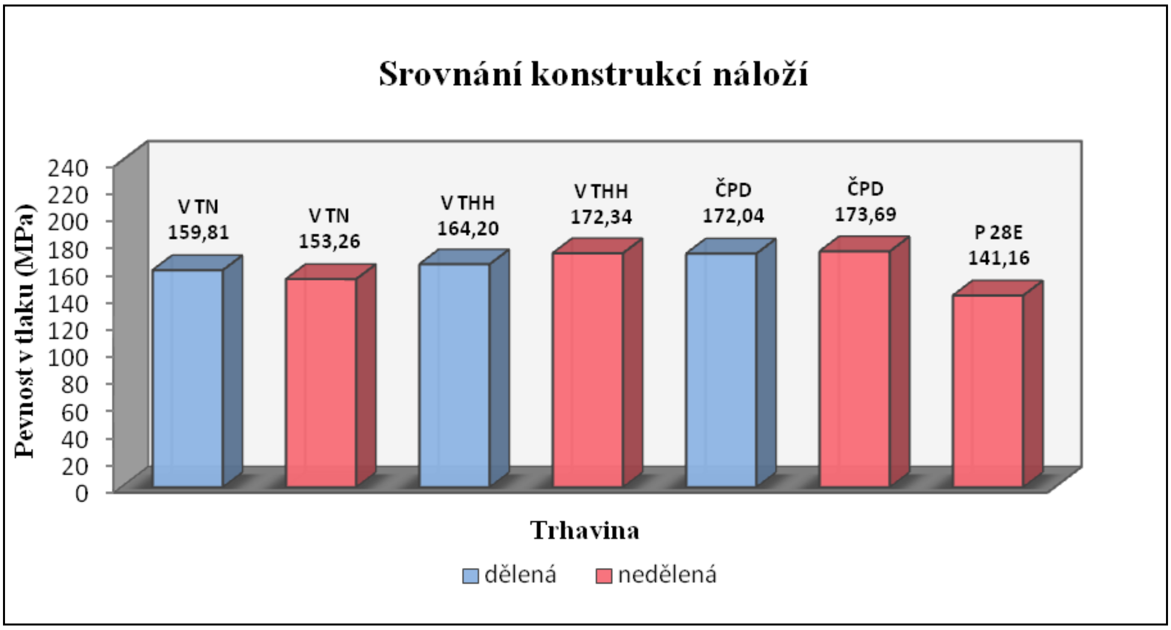
Graph 1: *Overview of the total proven compressive strengths.*

Compressive strength (Mpa), Explosive, Without blasting charge, Vesuvit TN, Vesuvit THH, Black powder from delaboration, Perunit 28E

The graph illustrates that the highest compressive strength was showed by the test pieces made of the samples of blocks disintegrated without any blasting charge (spring wedges). From this perspective, such a method of disintegration of excessive rock blocks appear to be ideal, but in fact, due to strenuous physical work and time demands of such an operation black blasting powders are used to disintegrate oversize blocks and also to chip the blocks from the rock mass. Among three types of black blasting powders used for the research, the highest average compressive strength was reached by the Black powder from delaboration. Compared with TN Vesuvit the average strength was even higher by more than 10 MPa. Resulting from the measurements and as expected Perunit 28E is extremely unsuitable for mining and secondary disintegration of excess blocks intended for processing into the products of coarse and fine stonework, by reason that the average strength of the test pieces of the rock disintegrated with Perunit 28E is more than 16 MPa lower than the average strength of the test pieces disintegrated with Vesuvit TN, which achieves the worst results of all the black blasting powders.

One of the partial goals of my dissertation was to compare the resulting strengths of test specimens taken from the samples after the blast by different charge designs, in particular charges divided and undivided. The divided blasting charges are in the Horni Dvorce Quarry used only under exceptional circumstances when high granite blocks are being disintegrated.

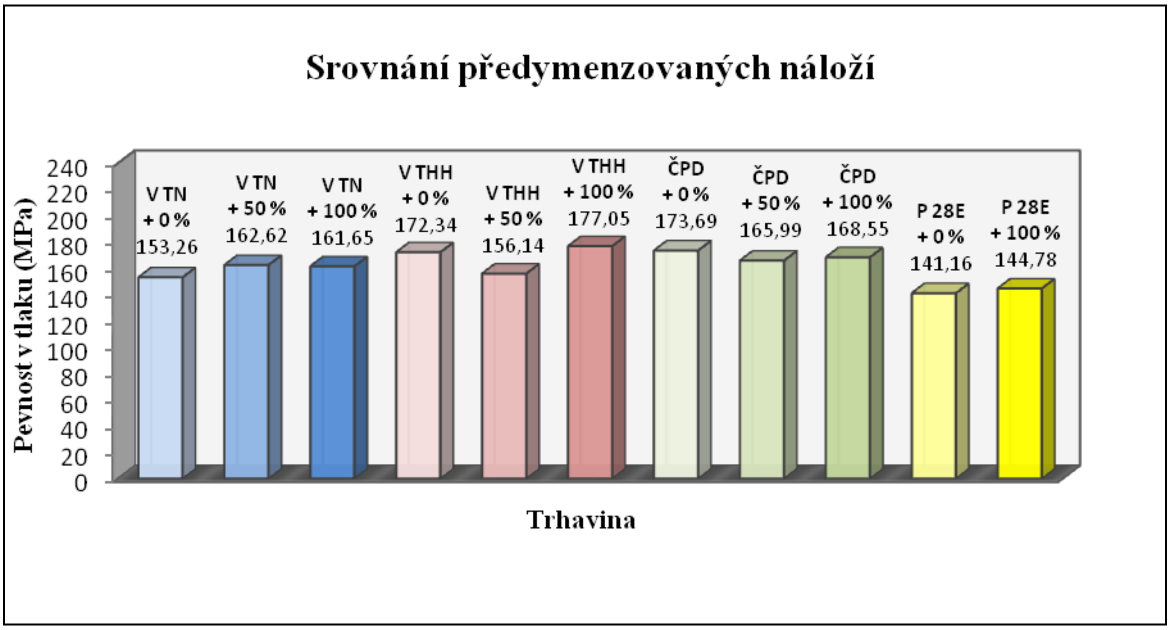
When using a divided charge, I chose the sampling point of the block purposely midway between individual blasting cartridges, in order to analyse the impact of the explosive cartridge on its immediate surroundings. The precondition to achieve higher compressive strengths for divided charges has turned out to be unjustified, because a higher average strength was achieved using a divided charge only for Vesuvit TN (Figure 2). The overall strength of black blasting powders for divided charges amounts to 165.35 MPa and 166.43 MPa for undivided charges. The difference is then only 1.08 MPa, but in favour of the undivided charge. The explanation can be found in the disintegration of larger blocks using divided charges than by means of undivided charges and thus also using approximately twice the mass of the total blasting charges than undivided ones. I still believe that the introduction of the mass utilization of divided blasting charges, the weights of which correspond to the weights of undivided charges, should have on the discussed site no significant effect both in terms of strength properties of the disintegrated rock, and time losses incurred due to a more complex way of preparation of the blast, and also from economic reasons, because instead of one electric exploder two exploders should be applied for divided charges.



Graph 2: *Comparison of blasting charge designs.*

Compressive strength (Mpa), Explosive, divided undivided, Vesuvit TN, Vesuvit THH, Black powder from delaboration, Perunit 28E

Another of the partial objectives of my dissertation was to analyse the impact of the blasting charge overestimation by the shootfirer for the rock being mined. I have included the comparison into the research work at the request of the company's owners, for workers from the quarrymen, processing the quarried blocks into the products of course stonework, often complain about the quality and difficult workability of the raw material and attribute this to a false choice of the blasting charge weight by the shootfirer. That's why I made blasts using black blasting powders with a minimum weight of blasting cartridge and with approximately 50% and 100% overestimation of the weight of the explosive cartridge, and for Perunit 28E with a minimum weight of the cartridge and 100% overestimation (Graph 3).



Graph 3: *Comparison of overestimated blasting charges.*

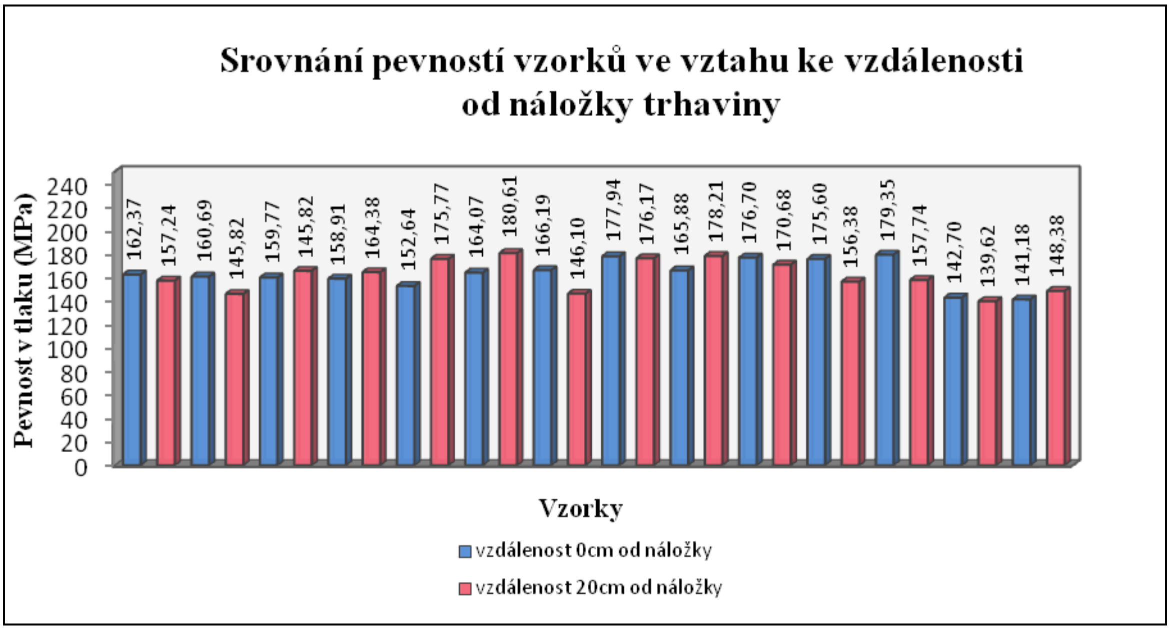
Compressive strength (Mpa), Explosive, Vesuvit TN, Vesuvit THH, Black powder from delaboration, Perunit 28E

The comparison of average values for each explosive and over-values is depicted in a graph (Graph 3). This comparison may indicate that for the black blasting powders and Perunit 28E in neither case 100% of the cartridge overestimation has the lowest average strength, while for the Perunit 28E and Vesuvit THH this is even the highest value. The values of different overestimations are for individual explosives at a similar level, only for Vesuvit THH the value significantly decreases even at overestimation of 50%. Thereof and also as assumed it can be deduced that bigger, even a double quantity of explosive has no significant effect on the strength properties of the mined raw material. Concerns of quarrymen thus reveals to be odd and in my opinion it then rests more in the natural quality of the extracted raw material, dependent on its imposition within the entire massif.

The following comparison is devoted to the comparison of strengths of samples in relation to the distance from the explosive cartridge. After the blast the rock near the blasting charge of a circular radius, in the blast hole also of a circular radius, is strongly compressed and crushed. In the vicinity of the blast hole a relatively short crushing zone occurs, or a zone of tangential cracks with a radius of two to five times the radius of the explosive cartridge. Following by a zone of radial cracks and an elastic deformation zone, behind which in the distance of approximately two hundred times the cartridge radius a stress wave will smoothly go over to an acoustic wave seismic.

While conducting the research work, I planned to verify the existence of crushed zones, so I took from each disintegrated block a sample directly close to the explosive cartridge and the other about 20 cm from the explosive cartridge. For the cartridge diameter of 32 mm the crushed zone radius range should be 64-160 mm, which means that most of the test specimens taken from the sample coming directly from the explosive cartridge was hit by the zone of tangential cracks only from a small part, especially when using weak explosives with deflagrating effect (black blasting powders).

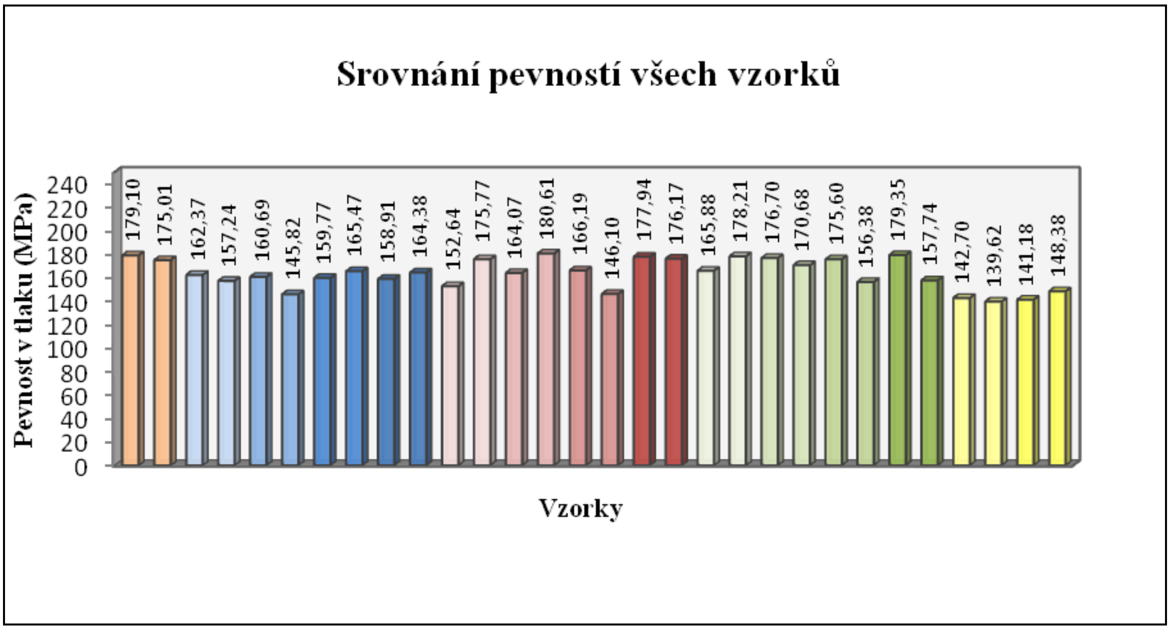
The comparison of the strengths of the samples in relation to the distance from the explosive cartridge shows (Graph 4) that the test specimens made of samples from the immediate vicinity of the explosive cartridge in case of the black powders have the average strength of 163.14 MPa and the specimens made from the samples being at the distance of 20 cm from the break-off surface, hence also the explosive cartridge, achieve an average strength lower than expected, in particular 161.61 MPa. Thus no impact of high explosive on the rock in the immediate vicinity of the blast hole has been proved.



Graph 4: *Comparison of the strengths of samples in relation to the distance from the explosive cartridge.*

Compressive strength (Mpa), Samples, distance of 0cm from cartridge, distance of 20cm from cartridge

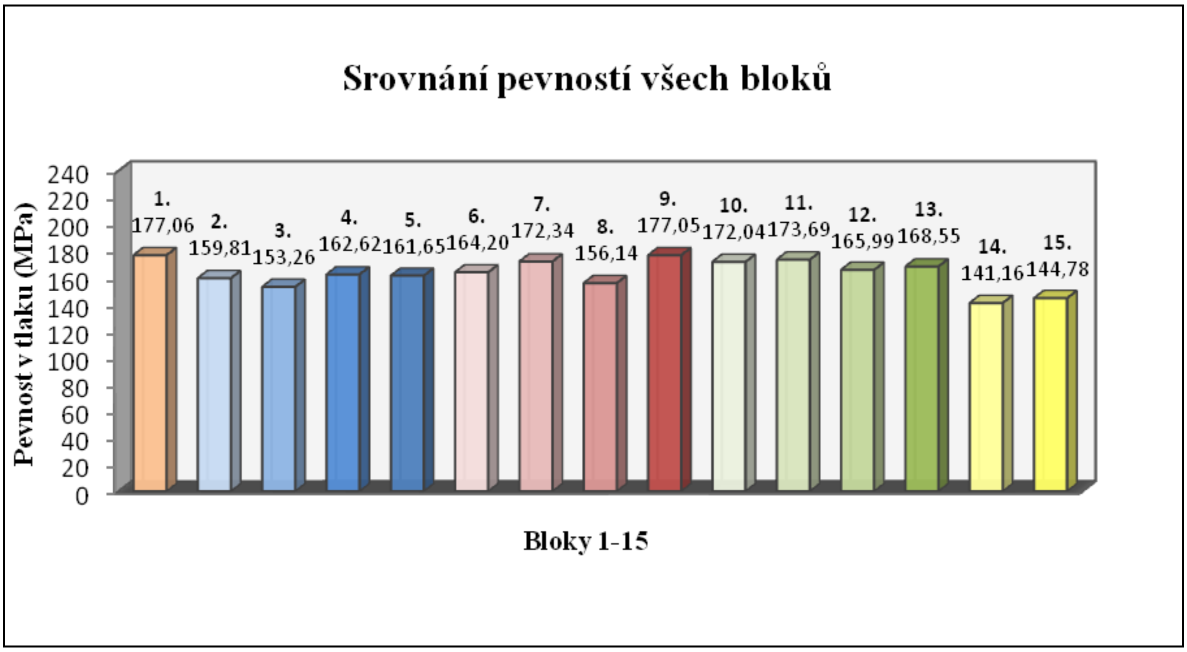
The following graph (Graph 5) shows the comparison of the individual average strengths of all thirty samples. Each column so represents the value created by the average of six test specimens. The highest strength shows the sample No. 14 of the block disintegrated by Vesuvit THH (180.61 MPa), the lowest then the sample No. 28 of the block disintegrated by Perunit 28E (139.62 MPa).



Graph 5: *Comparison of strengths for all samples.*

Compressive strength (Mpa), Samples

The comparison of strengths of all fifteen disintegrated blocks is showed in the graph below (Graph 6). Each column so represents the value created by the average of two test specimens, thus twelve test specimens. The highest strength shows the block No. 1 disintegrated by spring wedges (177.06 MPa), the lowest then the block No. 14 disintegrated by Perunit 28E (141.16 MPa).

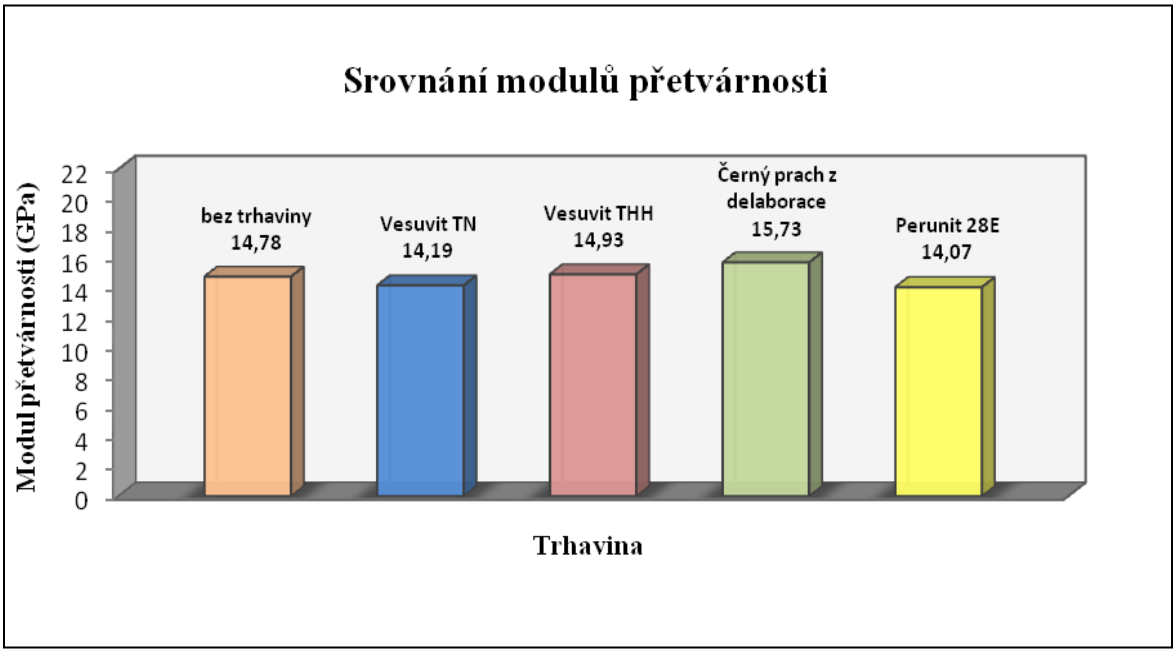


Graph 6: *Comparison of strengths of all blocks.*

Compressive strength (Mpa), Blocks 1-15

The comparison of the average values of deformation moduli is illustrated in the graph below (Graph 7). The deformation modulus is understood the ratio of the increase in stress and deformation in the line part burdening the deformation diagram branches.

The highest value of the deformation moduli were reached by the test specimens originating from the blocks disintegrated by the Black powder from delaboration, which means that for a certain value of longitudinal deformation the maximum compressive force had to be developed for testing specimens of the samples after blasts by this explosive. Their average value was 15.73 GPa.

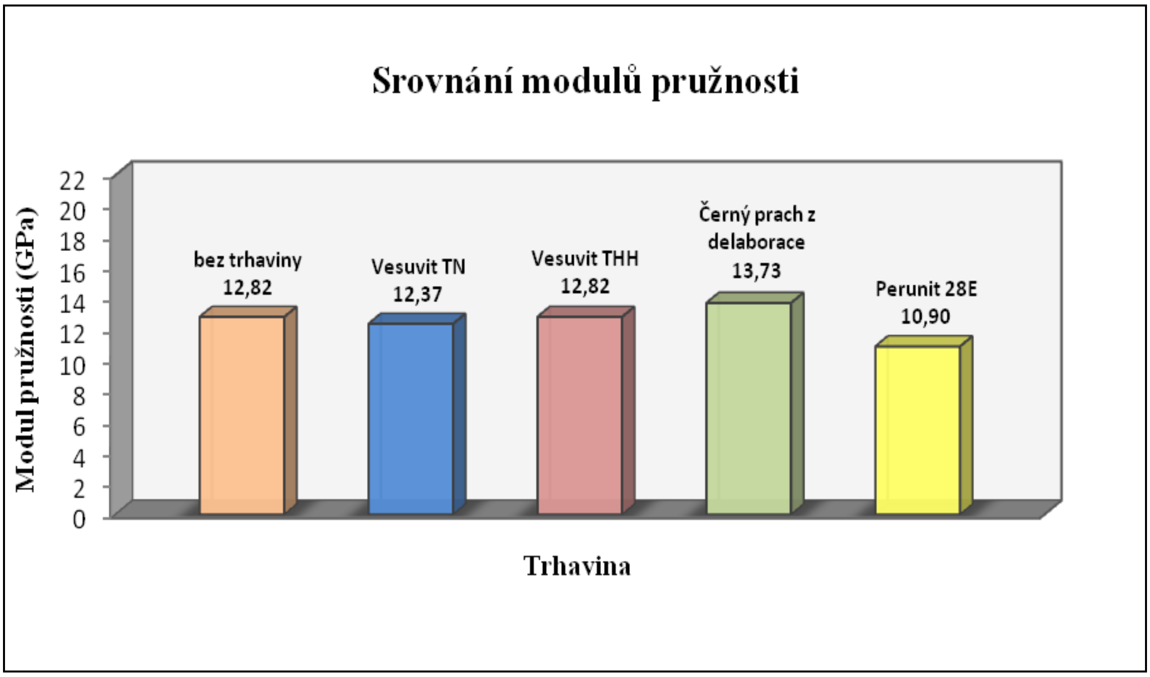


Graph 7: *Comparison of the moduli of deformation.*

Compressive strength (Mpa), Explosive,Without explosive, Vesuvit TN, Vesuvit THH, Black powder from delaboration, Perunit 28E

Comparison of the average values of elasticity moduli is illustrated in the graph No. 8 (Graph 8). The elasticity modulus is understood to be the ratio of the increase in stress and the deformation in the line part relieving the branches of the deformation diagram.

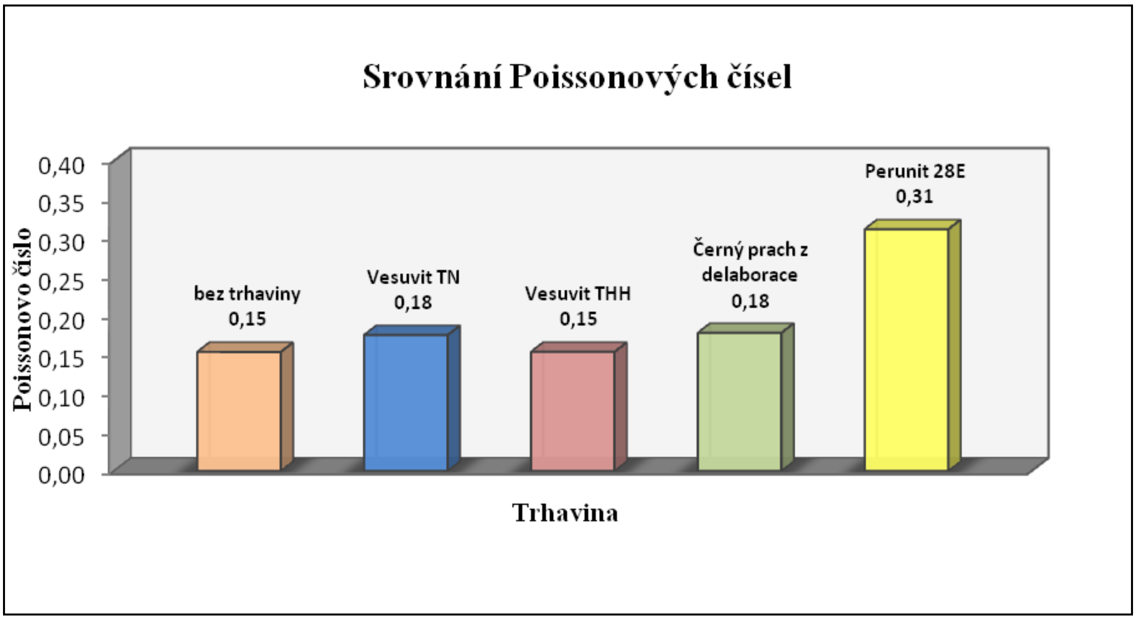
The highest values of the moduli of elasticity were reached again by the test specimens originating from the blocks disintegrated using the Black powder from delaboration. This shows that for a certain loss of compressive force these samples showed the lowest value of the reduction of longitudinal deformation. Their average value was 13.73 GPa.



Graph 8: *Comparison of the moduli of elasticity.*

Compressive strength (Mpa), Explosive, Withot explosive, Vesuvit TN, Vesuvit THH, Black powder from delaboration, Perunit 28E

Comparing the average values of Poisson's ratio (Graph 9), indicating the relationship between the longitudinal and transverse deformations, it can be determined which samples showed this highest ratio.



Graph 9: *Comparison of Poisson's ratio values.*

Compressive strength (Mpa), Explosive, Without explosive, Vesuvit TN, Vesuvit THH, Black powder from delaboration, Perunit 28E

Distinctly the highest ratio is showed by the test specimens of the samples taken after blasts using Perunit 28E, which may mean that these test specimens could contain a micro-crack system that caused the different ratio of longitudinal and transverse deformations. Their average value is very high and amounts to 0.31. It is also likely that these specimens have been affected by the above-mentioned crushed zone, to which corresponds also the overall compressive strength for Perunit 28E, the lowest from all explosives.

10 CONCLUSION

The main objective of this work, performing the research on mechanical properties of Mrakotin-type granites using various types of explosives to produce products of coarse and fine stone production, has been met. For the needs of the research on mechanical properties of the granites of Mrakotin type 15 blasts were carried out in the premises of the Horni Dvorce Quarry using various types of explosives and various blasting charge designs. Thirty samples were taken and from them then 180 sub-samples (test specimens) determined for testing on the test equipment. The output is a number of values and graphs, from which an ideal explosive for use in the described conditions, an ideal blasting charge design for quarrying Mrakotin-type granites for coarse and fine stone production were determined by comparing. The impact of a charge overestimation on the strength properties of the tested rock was analysed [6].

Sub-objectives of this work, namely: proposal of the most suitable explosive, blasting charge design and evaluation of the impact of the blasting charge overestimation by the shootfirer on the mechanical properties of the granite of Mrakotin type during mining blocks of rock and during secondary blasting works used to prepare the raw material for processing into products of coarse and fine stonework and finding an ideal ratio of explosive cartridge weight to the surface of fracture occurred by disintegrating the block, have been met.

According to the research results the ideal explosive for use is under given conditions the Black powder from delaboration. As an alternative we can designate Vesuvit THH. Vesuvit TN is less suitable and in the research used a representative of explosives with fragmentation effect, Perunit 28E, is as expected an extremely inappropriate explosive. The Black powder from delaboration can also be recommended from an economic point of view, as it is 8% cheaper than Vesuvit THH and 16% than Vesuvit TN. Using only the Black powder from delaboration could reduce the costs of explosives by 6%..

It is recommended to use henceforth the charge design undivided with a minimum possible weight of the cartridge, in particular for economic reasons, since any significant impact of neither the blasting charge design nor the weight of explosive cartridge was proved from the research results.

After calculating the ratio of the weight of explosive to the area of fracture of a disintegrated block for the undivided charge design with 0% overestimation of the cartridge of explosive and using black blasting powders, when the fireman made efforts to reach the lowest possible weight of cartridge needed to break the block, I have found the minimum value of this ratio as 32.09 gm -2 and the maximum value of 83.95 gm -2. Therefore, I propose an ideal ratio of the weight of cartridge to the area of fracture to be in the range of 0.30 to 0.50 gm -2. This value is important for the economical conducting blasting operations, but in practice it is very difficult to be sustained, since it depends on accurate estimation and experience of the shotfirer.

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RESUMÉ

Výstupy (výsledky zkoušek a hodnoty) byly získány provedením zkoušek na dílčích vzorcích mrákotínské žuly na zkušebním zařízení typu MTS 816 Rock test system ve zkušební laboratoři výzkumného centra hornin VŠB-TU Ostrava. Naměřené hodnoty byly následně vyhodnoceny a bylo zjištěno, že pro dané podmínky je nejvýhodnější trhavinou Černý prach z delaborace ať již z hlediska nejmenšího vlivu na horninu, tak i z hlediska ekonomického.

Konstrukci náloží lze na základě výzkumu doporučit k používání nadále jako nedělenou, ale s minimální možnou hmotností náložky, především z důvodů ekonomických, neboť výrazný vliv konstrukce nálože ani hmotnosti náložky trhaviny nebyl z výsledků výzkumu prokázán.