

GEOMORPHOLOGICAL INVENTORY OF ROCK LANDFORMS ON MT. KAMENEC IN THE NOVOHRADSKÉ HORY MTS. (THE CZECH REPUBLIC)

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Abstract: For the investigated area, located in the Novohradské hory Mts. (South Bohemia), cryogenic forms built by granite are characterized and are forming a unique relief in the Czech Republic. Study site Mt. Kamenec (1 072 m a.s.l.) is distinguished by high density of manifold cryogenic forms. Detailed geomorphological mapping with using GPS instrument was utilized for research and geomorphological inventory, the geomorphological map of the study locality was elaborated. Within cryogenic forms, basic destructive and accumulative forms were mapped - tors (9), frost cliffs (10), peak castle coppies, rock wall, block field, debris heap and small weathering forms (rock ledges, rock basins). Main destructive granite forms are conditioned by activities of cryogenic weathering and structural-tectonic character (jointing and foliation) of granite. One hundred sixty-six joint measurements were performed in the interested area. It was found, that prevailing orientations of joints are ENE-WSW and NW-SE, this found directions correspond to the main tectonic directions in the Bohemian Massif and at the same time determine the basic shaping of the destructive granite forms. The observed quantity, quality and representativeness of cryogenic forms led to the declaration of the site Mt. Kamenec as the geologically important site within the system of geologically important sites registered by the Czech Geological Survey. A proposal of declaration of the site Mt. Kamenec as a natural monument was also submitted to the Ministry of the Environment of the Czech Republic. The using of geomorphological inventory has led to new findings in landscape micro- and mezo- landforms at localities that have been prior to 1989 for obvious reasons inaccessible to any form of scientific research.

Key words: the Novohradské hory Mts., Mt. Kamenec, GPS mapping, geomorphological inventory, large protection

1. INTRODUCTION:

The region of the Novohradské hory Mts. represents a unique nature area, which was in the past minimally exposed to human intervention due to its position along the border with Austria. The Novohradské hory Mts. are situated in the south – west of Bohemia in the Šumava System within the Czech Republic. The study area is built by granite and retained a wide range of its indigenous ecosystems, often with preserved rare fauna and flora associations along with interesting landforms. Due to increased investors' interest in the recreational as well as industrial sphere within the

entire region of the Novohradské hory Mts. after 1989, a scientific research has commenced with the aim to propose this area to be declared a protected landscape area. The Czech government has rejected the proposal in 2005.

The area-wide land protection of the Novohradské hory Mts. therefore has a compromise solution. In 2003 the Council of the South-Bohemian region issued a regulation declaring the Novohradské hory Mts. a Natural Park in its entire area. This form of protection enables the Council to partially influence local planning processes in the area.

In scope of the program NATURA 2000 the government of the Czech Republic has declared the

Novohradské hory Mts. a Birds Area in addition to two localities of European significance: Žofínský prales – Pivonické skály and Horní Malše. Under Act no. 114/1992 Coll. localities with the rarest fauna and flora associations have been proclaimed local protected areas (e.g. NNR Žofínský prales, NNP Hojná Voda, NP Myslivna, NP Ulrichov etc). Surprising is the absence of any local protected areas under the Act with abiotic subject matter. Due to this fact the research of the Novohradské hory Mts. included a geomorphological inventory survey with the use of GPS mapping.

Some of the most spectacular scenery on Earth is supported by granite. Granite geomorphology is typically associated with inselbergs rising above vast savannah plains and with castellated tors which give a special flavour to treeless European uplands. But granite landscapes do not have one face, but many (Migoń, 2006).

In the Czech Republic there are very interesting granite areas with unique and spectacular landforms. The Jizerské hory Mts. belong between granite areas with the sufficient large protection of the landscape area. So the Giant Mountains and the Podyjí area belong between granite areas with the sufficient large protection of the national park. The sufficient large protection is missing in the Novohradské hory Mts. up to now in spite of that the Novohradské hory Mts. are the unique area with well – preserved, matchless, spectacular, granite landforms in the Czech Republic. The main reason of this situation is inaccessibility and the marginal

position of the area within of the position the Czech Republic in the middle Europe before 1989.

2. STUDY AREA

The studied area encompasses a geomorphological unit of the Novohradské hory Mts. namely the peak ridge of Mt. Kamenec locality (1072 m). According to the geomorphological classification of the Czech Republic the unit Novohradské hory Mts. is a part of the Šumava System (Balatka & Kalvoda, 2006; Demek, et al., 2006), while much wider part of this unit is located in Austria, where it reaches Danube under the name ‘Waldviertel’. The altitude of the Novohradské hory Mts. exceeds 1 000 m and its highest peak is Viehberg (1111 m) in Austria. The highest point on the Czech side is the aforementioned Mt. Kamenec (1072 m), located in the southern part of geomorphological subunit the Pohořská hornatina Mts. (Fig. 1).

3. AIM OF STUDY

The aim of this study was to undertake a geomorphological inventory of granite landscape rock forms at the selected locality and in case of confirmed presence of qualitatively as well as quantitatively significant rock forms to propose a form of protection under the nature protection system of the Czech Republic.

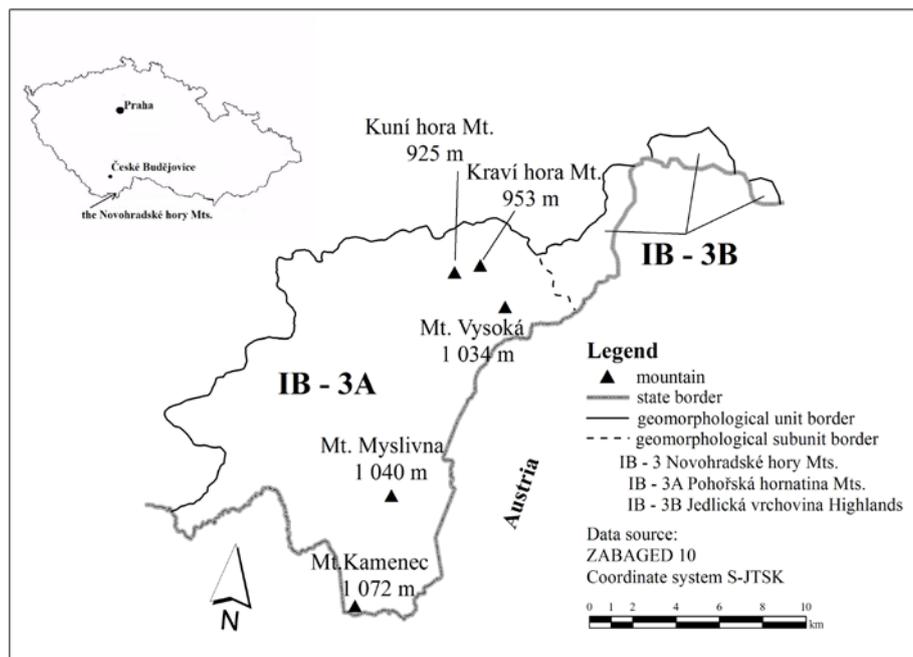


Figure 1. Location of Novohradské hory Mts. within the scope of the Czech Republic and its basic geomorphological regionalisation (Balatka & Kalvoda, 2006; with modifications)

4. METHODS

To resolve the issue of distribution and protection of granite landscape rock forms at Mt. Kamenec in the Novohradské hory Mts. results of earlier works have been used (Rypl, 2005; Rypl & Kadubec, 2007, Vítek, 1995).

These were accompanied by methods of detailed geomorphological mapping (Demek et al., 1972, Smith, et al., 2011), GPS mapping (Condorachi, 2011, Smith et al., 2011, Voženílek et al., 2001) and geomorphological inventory used e.g. in works of Kirchner & Roštínský (2007), Kirchner & Kubalíková (2011), Kirchner & Kubalíková (2013).

The geomorphological inventory survey of selected localities consisted of description of bedrock and landscape macroforms as well as microforms in respect to their nature- and landscape significance and protection. Human influence with its negative impact on the abiotic sector of nature has also been considered. Results of the geomorphological inventory are applicable in the area of basic knowledge regarding rare or significant landforms and also in the application area where landscape management arrangements are being proposed in order to protect these landforms, or to remove or diminish any negative impact of human activity in the area of interest (Kirchner & Roštínský, 2007).

The survey consisted of three phases:

- 1st phase – preparatory works
- 2nd phase – fieldwork
- 3rd phase – final works and evaluation of results

In the first phase the source materials related to geological and geomorphological conditions of the area have been evaluated. Up-to-date publication on geological characteristics of the Novohradské hory Mts. has been used (Pavlíček, 2004) accompanied by geological maps of 1:50 000 scale freely accessible at www.geology.cz. Information about rock forms geomorphology was based on older specialized publications (Demek, 1964) as well as newer ones (Rypl, 2005; Rypl & Kadubec, 2007; Vítek, 1995).

The second phase of the inventory survey was based on field research at Mt. Kamenec locality. For mapping of wider surroundings a topographical map of scale - 1:25 000 was used, specifically a map list No. 33–311 Pohoří na Šumavě. The fieldwork was based on detailed geomorphological mapping method with emphasised mapping of structure-denudational and accumulation rock forms described by Bezvodová et al., (1985), Demek et al., (1972),

Smith et al., (2011). Simple measuring devices (telemeter HD 150, measuring tape) were used to describe the rock forms and their properties. For measurements of bedrock structures a geological compass was used. Important part of the field research comprised of photodocumentation. In addition, a detailed GPS mapping using Garmin GPS V Deluxe was undertaken based on Condorachi (2011), Smith et al., (2011), Voženílek et al., (2001).

The third and final phase of the inventory consisted of field data evaluation with emphasis placed on relief rock forms. All field data contain information about localization, basic geological description, description of the main landforms, structures, impact of anthropogenic activity and a proposal of protection. The text is accompanied by a photographic documentation. The rock forms of destructional as well as accumulative character were classified terminologically and genetically according to the common geomorphological practice (Demek, 1972; Demek, 1987; French, 2007; Goudie ed., 2004; Rubín et al., 1986; Summerfield, 1991; Thomas & Goudie, 2000). The geomorphological map was accompanied by a legend after Létal (1998) which was complemented by key signs missing in the original (e.g. a sign form for castle coppie). Both, the geomorphological map and the legend were processed electronically for ArcGIS 9.1 under the ArcView license.

There are specific and unique relief in the Novohradské hory Mts. with many significant localities (eg. the Kraví hora Mt., Mt. Myslivna, Mt. Vysoká) namely with regard to the specific, geological building areas. Mt. Kamenec was selected as typical illustration locality that contains the whole various complex of landforms on the granite.

5. GEOMORPHOLOGICAL CHARACTERISTICS OF THE MT. KAMENEC LOCALITY (1 072 M)

Mt. Kamenec locality is used in this paper to illustrate the elaboration process and the level of detail described at each point.

5.1. Location

Mt. Kamenec is located 3 km south-westerly from Pohoří na Šumavě, within a cadastral territory of the same name. Mt. Kamenec is the highest point of Czech part of the Pohořská hornatina subunit (of the Novohradské hory Mts.) and is positioned along state border with Austria in the southernmost tip of geomorphological district the Žofínská hornatina

Mts. This district is a part of geomorphological subunit Pohořská hornatina Mts., unit Novohradské hory Mts. (Demek, et al., 2006; Balatka & Kalvoda, 2006) (Fig. 1). The main European Elbe-Danube watershed runs across the summit of the Mt. Kamenec. The inflow of Austrian river Flambach springs at its southern and south-western slopes in Austria. The remaining slopes pertain to the Elbe catchment area. Eastern to northern slopes are drained by spring inflows of the Pohořský potok creek, western slopes by inflows of the river Malše. Vegetation cover of Mt. Kamenec is represented mainly by spruce monoculture

5.2 Geology

Geology of the Pohořská hornatina Mts. (of the Novohradské hory Mts.) is rather dull. Late variscan migmatites of the Central Moldanubian Pluton prevail (represented by several types: Weinsberg granite, Freistadt granodiorite, Mrákotín granite). These are partially overlaid by cordieritic gneisses to nebulitic migmatites representing remnants of the Pluton's mantle. Mt. Kamenec locality itself is formed by the Weinsberg type granite (Pavlíček, 2004).

5.3. Characteristics of the main landforms

The summit of Mt. Kamenec is formed by a cryoplanation plateau elongated in the NE-SW direction, where the cryogenic relief of the southern part of the study area is present most. Demek et al. (2006) describes two apexes of Mt. Kamenec - the north-eastern one with altitude of 1072 m and the south-western one with altitude of 1058 m. However, both apexes are only 150 m apart, with no saddle or any distinctive depression dividing them and their altitude difference is given purely by a height variance of rock mezoforms located on the platform. Slopes surrounding the plane are of erosion-denudational character with an inclination of 5-10°. At the south-western end the ridge transforms into short erosion-denudational slope of 2-5° incline, which changes along the state border to a slope of 0-2° incline.

The cryoplanation plateau is developed in two altitude levels copying the direction of the peak ridge. In its upper level the plane is 150 m long a 70 m wide and contains a group of 6 tors (of which only 4 are marked in the map for clarity reasons). The tors are 15 m high, with smaller tors of 5 m width and length clearly distinguishable from the larger ones with width and length ranging between 10 to 30 m. GPS measurement has confirmed that the tors are

aligned in a row and are separated by frost-riven cliffs 2 to 10 m wide. We therefore postulate that formerly a single large castle coppies existed in this place prior to being remodelled to its present shape.

The cryoplanation plateau at lower altitude surrounds the upper platform. Its total length is approximately 300 m a width up to 80 m. The north-western and the opposite south-western rim of the cryoplanation plateau is demarcated by frost-riven cliffs. The north-western rim contains 2 cliffs 8 m long and 4 m high (respectively 20x8 m). Another cliff of 13 m length and 5 m height is located along the northern edge of the cryoplanation plateau. Frost-riven cliff in the north of the southeaster rim has dimensions 18x5 m and beneath it is partially developed a short block stream. On the described cryoplanation plateau is also located a castle coppie and a tor. The castle coppie is situated at the south-western end of the platform, its length is 60 m, width 15 m and height 15 m at maximum. In scope of this coppie is developed a fissure-type rock gate 3 m high and 2 m wide at most, which formed by release and movement of individual blocks of rock. By contrast, the tor occurs at the north-eastern end of the platform and reaches height of 10 m. Due to alignment of this tor and the aforementioned castle coppie with tors on the cryoplanation plateau it is presumed that these two landforms were also part of single massive unit. This massive unit underwent progressive erosion during colder periods of pleistocene and gained its present appearance.

Landforms located on slopes of the northern part of the summit are also remarkable. On the eastern slope, approximately 10 altitude metres below the north-eastern end of the cryoplanation plateau rest two frost-riven cliffs of size 20x8 m (respectively 10x5 m). A tor has developed on slope roughly 20 m below the larger cliff. Its maximum size is 6 m and a talus pile (28x17 m) runs out from it. Further down the slope beneath these landforms extends a block field. Away from these forms of relief, towards the southeaster to southern slope is located another frost-riven cliff 10 m long and 5 m high. Within a distance of 80 m a high tor is developed on a slope, underneath which has formed a frost-riven cliff (8x4 m). To the SW from the cryoplanation plateau exist several smaller frost-riven cliffs with dimensions: 5-15 m length, 3-5 m width. Close to an erosion-denudational slope with inclination of 0-2° has developed a frost-riven cliff of 6x3 m in size. Cryogenic relief mezoforms of the entire locality are accompanied by numerous ledges and several weathering pits of 20-30 cm in diameter. Disposition of landforms on Mt. Kamenec is depicted in figure 2.

5.4. Description of rock relief structures

166 measurements of fissure system were undertaken on Mt. Kamenec (Table 1a and 1b) and a rose diagram was constructed (Fig. 3). The measurements indicate almost radial fissure system. The most dominant is ENE – WSW direction (with prevailing direction 60°) which is accompanied by

an almost perpendicular direction NW – SE (with prevailing direction 140°). The course directions of these massive and morphologically distinctive fissures, some of which participate at segmentation of cryogenic mezofoms into individual blocks, were established as a primary fissure system. Secondary system is represented by an assemblage of fissures with direction 30°, respectively 100°.

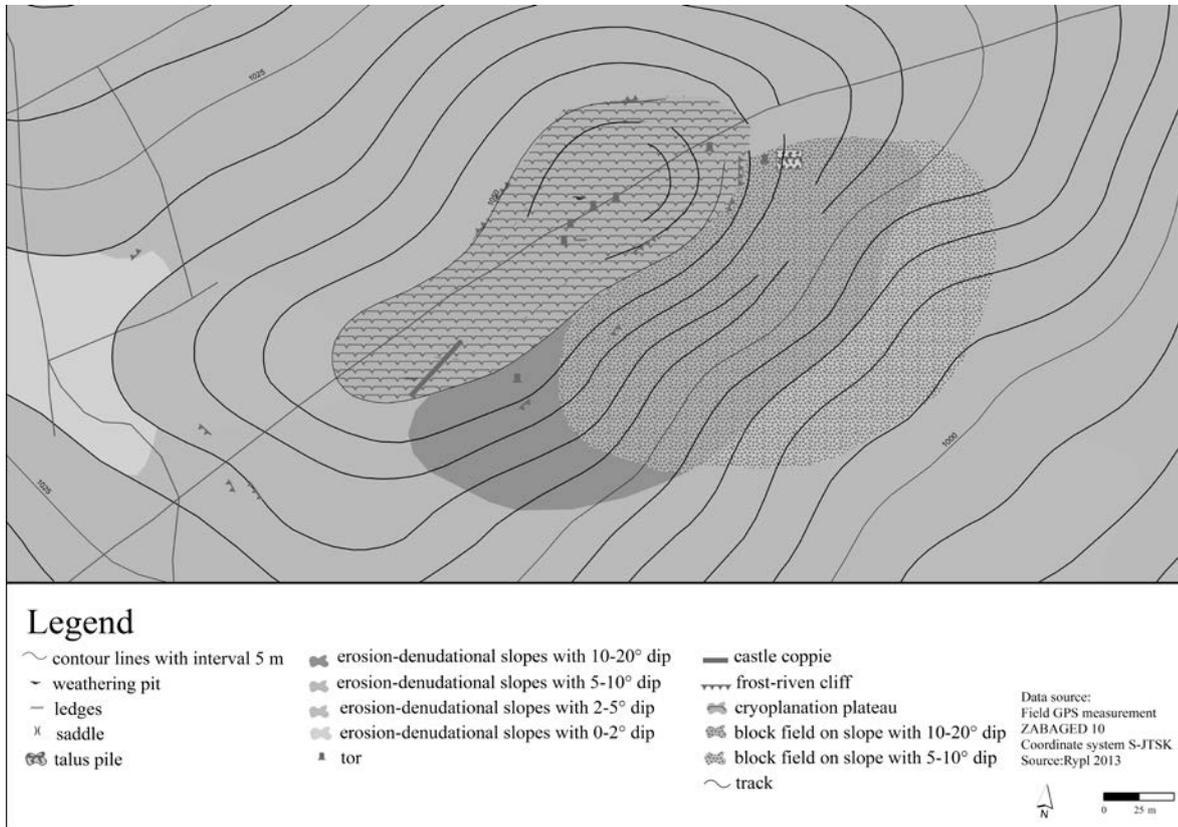


Figure 2. The geomorphological map of Mt. Kamenec (Rypl, 2013)

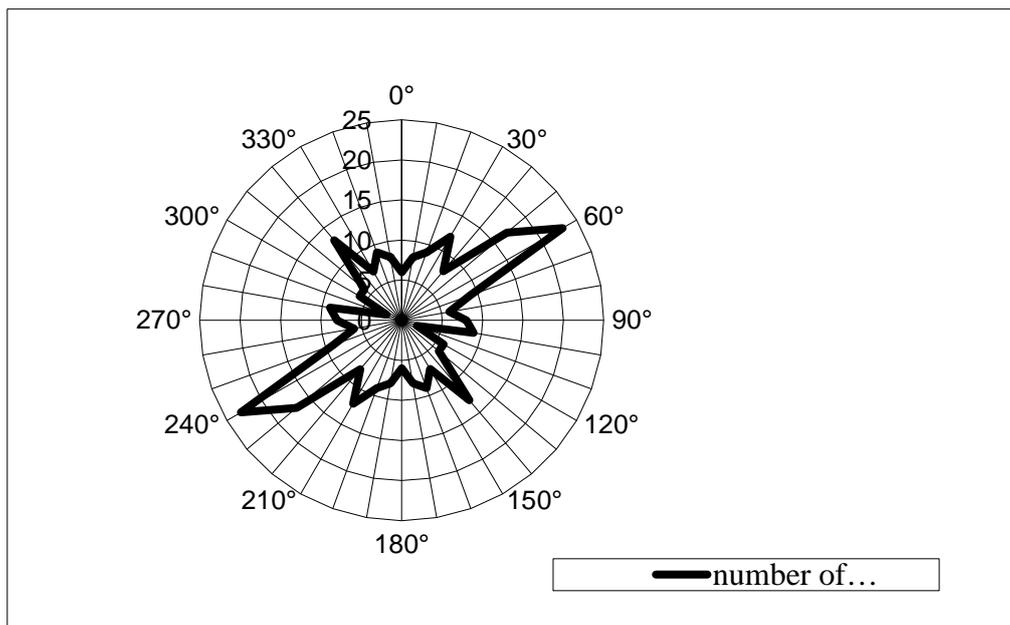


Figure 3. Rose diagram of fissure system of Mt. Kamenec (Rypl, 2013)

Table 1a: Number of measurements of fissure system with 0 – 90° interval at Mt. Kamenec

Direction	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
No. of measurements	6	8	9	12	8	17	23	9	6	8

Table 1b: Number of measurements of fissure system with 100 – 180° interval at Mt. Kamenec

Direction	100°	110°	120°	130°	140°	150°	160°	170°	180°
No. of measurements	9	2	6	6	13	7	9	8	6

Source: Rypl (2013)

5.5. Impact of Human activities

Owing to its position, the Mt. Kamenec is situated outside the main tourist area of the Pohorlská hornatina Mts. (of the Novohradské hory Mts.). Therefore no marked hiking trail runs in the vicinity of Mt. Kamenec however, there is significantly trampled path with extensive soil erosion. Along the northern base of Mt. Kamenec runs a compacted forest track that is accessible only by cars with access permit. Prior to 1989 this track was used mainly by border patrol, in present day it is attended by foresters. Remnants of stone walls that most likely formed estate markers are preserved in the western part of Mt. Kamenec locality.

5.6. Cryogenic landforms protection proposal

The Novohradské hory Mts. Nature Park was declared by the regional administration of Southern-Bohemian Region in České Budějovice in 2003. However, the legal status of NP does not provide a sufficient protection of the remarkable cryogenic landforms (tors and the peak castle coppies above all) occurring at the summit area of Mt. Kamenec. On this account, based on the research results (Rypl, 2010) in cooperation with the Czech Geological Survey Mt. Kamenec was in 2010 declared a Significant Geological Locality. A proposal for its legal protection in form of a Natural Monument has been submitted by the Czech geological Survey to the Czech Ministry of the Environment.

6. DISCUSSIONS AND CONCLUSIONS

The use of geomorphological inventory has led to new findings in landscape micro- and mezoforms at localities that have been prior to 1989 for obvious reasons inaccessible to any form of scientific research.

During the field mapping, a number of landforms designated in world literature as of cryogenic origin (Traczyk & Migoń, 2000) was identified in the area of Mt. Kamenec locality and the entire area of the Novohradské hory Mts. These primarily include frost-riven cliffs, tors, castle coppies,

block fields, cryoplanation platforms and terraces, occurrence of which is mainly linked to the Weinsberg type granite. According to Demek et al., (2010) these landforms could not have been developed without the presence of permafrost and represent therefore an indirect geomorphological evidence of permafrost existence in the study area. Traczyk & Migoń (2000) postulate, that the size of rock blocks within block fields developed on granites in the Giant Mountains often exceed 1 m in diameter.

The need for detailed geomorphological cognition of the most remarkable localities of the Novohradské hory Mts. arose with the issue of source material preparation for declaration of this area a Protected Landscape Area. The declaration of the Novohradské hory Mts. as a Protected Landscape Area was rejected by the Czech government in 2005, therefore the most remarkable localities were subjected to geomorphological inventory and GPS mapping with the objective of their thorough protection.

The most interesting localities, among which belongs Mt. Kamenec, are evaluated from the point of view of bedrock geology and the main landform features. Furthermore, structural elements are also described as is the impact of anthropogenic activity, and a landform protection proposal is suggested. In scope of the geomorphological inventory new findings were made in the area of research as well as application. Landforms in the summit area of Mt. Kamenec were newly described and on account of their significant qualitative and quantitative representation a proposal for declaration of a Natural Monument was made.

Mt. Kamenec is only the visual example of valuable relief on the granite in the followed area. Also other localities (eg. the Kraví hora Mt., Mt. Vysoká, Mt. Myslivna) are precious example of relief on the granite and therefore the large protection of the whole area is important.

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