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The Quaternary sculpturing of sandstones in the Rusavská hornatina Mts.

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Abstract

This study presents an analysis of rock landforms and their development in the northwestern part of the Hostýnské vrchy Hills – the Rusavská hornatina Mts. The main part of this article focuses on periglacial and recent rock landforms, which are formed in the Pleistocene and also in the Holocene. The author takes notice of the relationship among rock landforms, geological and climate conditions in the Rusavská hornatina Mts. during the Quaternary.

Key words: periglacial processes, frost-riven cliffs, Pleistocene, Holocene, Rusavská hornatina Mts.

Introduction

The Rusavská hornatina Mts. are situated in the west part of the Outer Western (Flysh) Carpathians in Moravia (Czech Republic). The area of the Rusavská hornatina Mts. is situated between the Juhyně river and the Rusava river among these following towns: Bystřice pod Hostýnem, Rusava and Rajnochovice. The Rusavská hornatina Mts. are the highest part of the Hostýnské vrchy Hills and constitute a mountainous area. It means the difference between the highest point and the lowest point is over 300 meters per 4 x 4 km. The highest peak of these mountains is Mt. Kelčský Javorník (865 m a.s.l.) and the lowest point of this area is located on the bank of the Rusava river near Brusné (325 m a.s.l.). The northern part of the Rusavská hornatina Mts. is sharply surrounded by the steep northern slope, being formed by the Magura Nappe. On the foot of this northern slope there is pediment.

The bedrock is composed of flysh sandstones, conglomerates (polymict), shales and claystones. The convex parts of relief (elevations) are formed by more resistant rocks and depressed areas are formed by non-resistant rocks. In the northern and central higher part of the studied area the rock formations prevail in the rocks of the Rusava Member (Zlín Formation) with sandstone and conglomerate beds, in the rest of the Rusavská hornatina Mts. the Hostýn Member (Soláň Formation) with pelite and psamitt form elevations (the lithostratigraphy articulation by Stráník, 1995). Conglomerates are often built by sandstone boulders, limestone rounded pebbles

and sometimes clastogene crystalline schists. Sandstones have fawn, lime green and frequently glaucous colors. There are many granularity kinds of sandstones (from flag sandstones, gritstones to feldspathic sandstones).

The geological conditions (structural dependency) are the main factor influencing the rock formations occurrence in the Rusavská hornatina Mts. (see Křížek and Létal, 2000). This phenomenon is conditioned by the courses of ridges and faults (the main faults have SW-NE direction) which are influenced by the Magura Nappe.

The all outcrops (without man-made outcrops, e.g. quarries, road cuts etc.) in the Rusavská hornatina Mts. are from 425 m a.s.l. Most of them there are in the top of the elevations.

The outcrops of sandstones and conglomerates were formed by Pleistocene periglacial conditions, the same as the surrounding surface of the Rusavská hornatina Mts. and other parts of the Outer Western Carpathians and the rest of the Central Europe. Then these rocks have been remodeled by recent (Holocene) geomorphological processes.

The Pleistocene sculpturing

In the Rusavská hornatina Mts. there are the typical landforms, which originated during the several cold phases of the Pleistocene – the frost-riven cliffs (Photo 1) and tors. In this article the frost-riven cliff is defined as a steep rock wall which was originated by periglacial processes and which has still born traces of the action of these periglacial processes. Tor – I describe it as a summit type of a frost-riven cliff which

Photo 1 Frost-riven cliff with fissures and cracks in the Skalný locality (665 m a.s.l., NW). Photo by M. Křížek

was originated the same processes as a frost-riven cliff with a wider cryoplanation terrace which has a small inclination (often less 5°). The frost-riven cliffs and tors have been preserved in this region since the Pleistocene Period as fossil forms and they are now disharmonic forms to the present-day humid climate. Sometimes the same processes (such as frost weathering and other periglacial processes from the cold Pleistocene Period) can make during winter, but the speed and intensity of these processes is low.

In the Pleistocene the frost weathering was the most important process for the development of periglacial rock landforms in the Rusavská hornatina Mts.. Freezing water (exactly ice) increases its volume by 9% (French, 1976) and destroys surrounding rocks. During freeze-thawing cycles in the cold phases of the Pleistocene the fissures and cracks of rocks (frost-riven cliffs and tors) developed. These fissures and cracks are developed in the frost-riven cliffs in the Rusavská hornatina Mts., sometimes their wide is no fewer than 2 m and they are several meters long. But all of the frost-riven cliffs are remodeled by recent geomorphological processes (e.g. soil acids because they are covered by soil with the decomposition of plant materials).

In the Rusavská hornatina Mts. there are most of the frost-riven cliffs in the stage of initial cryoplanation terracing (look for the classification of cryoplanation terraces in Demek 1969), they have only narrow ledges from 3 to 10 meters (e.g. Mt. Obřany 704 m a.s.l., Mt. Skalný 709 m a.s.l.) and some of them have no ledges on the slopes which, with other traces, shows that most of the frost-riven cliffs are of Würmian age. That is why the mature cryoplanation terraces and cryoplanation summit flats are probably older than preceding initial cryoplanation terraces. The feet of these frost-riven cliffs are sometimes covered with angular rock fragments – the products of weathering of various grain-size. The mean size of these boulders being 40–150 cm. Sometimes these block accumulations form block fields on the slopes which lie bellow the frost-riven cliffs (e.g. east slope of Mt. Čerňava 843.6 m a.s.l., northwest slope of Mt. Sochová 740.6 m a.s.l.). But these products of the periglacial weathering are often buried and covered by a 20–60 cm thick soil layer, with solitary stones in the surface. Moreover local sandstones and conglomerates decay faster than igneous or metamorphic rocks (e.g. orthogneiss block field in Velký Blaník Hill 631.8 m a.s.l. in the Načeradecká vrchovina Hills, mica shist block fields in Mt. Růžová hora 1390 m a.s.l. in the Giants, nepheline trachyte block fields in Mt. Milešovka 837 m a.s.l. in the České středohoří Mts. etc.). There are also the frost-riven cliffs with mature cryoplanation terraces (from 10 to 25 meters wide), which sometimes develop tors with cryoplanation summit flats, for example Mt. Sochová (741 m a.s.l.), Mt. Čerňava (843 m a.s.l.), Mt. Jehelník (838 m a.s.l.), spot height 832 m a.s.l. which is situated about 200 meters SW from the top of Mt. Kelčský Javorník. The frost-riven cliffs and tors in the Rusavská hornatina Mts. are developed at altitudes from 435 m a.s.l. to over 840 m a.s.l.. Most of the frost-riven cliffs are situated over 650 m a.s.l. and tors with cryoplanation summit flats are developed over 700 m a.s.l. The most of these frost-riven cliffs are built by the Rusava Member (Zlín Formation) (over 85%) and the rest of the frost-riven cliffs is formed by the Hostýn Member (Soláň Formation). The position of the frost-riven cliffs in the Rusavská hornatina Mts. is influenced by the

specific geological structure and conditions of this area (see over). The frost-riven cliffs form two main belts which have the direction from SW to NE (see Fig. 1). The first belt extends from Mt. Hostýn (734.6 m a.s.l.), Mt. Javorník (803 m a.s.l.) to Mt. Kelčský Javorník (865 m a.s.l.) and the surroundings of Mt. Černá Bařina (653.3 m a.s.l.). The second belt extends from Mt. Grapy (538 m a.s.l.), Mt. Skalný (708.8 m a.s.l.) via Mt. Smrdutá (750 m a.s.l.) and Mt. Čerňava (843.6 m a.s.l.) to Mt. Sochová (740.6 m a.s.l.). These frost-riven cliffs in the Rusavská hornatina Mts. occur on the face of layers which have an inclination between 30° and 50°. In case that the inclination of layers is appropriate there are multiple levels of the frost-riven cliffs on the slopes which are separated by cryoplanation terraces (e.g. in Mt. Obřany there are four levels of frost-riven cliffs, their height is from 10 to 16 m and their cryoplanation terraces are from 10 to 30 m wide). Multiple by geomorphological survey levels of frost-riven cliffs was located on the eastern slope of Mt. Smrdutá, on the eastern, western and northern slope of Mt. Sochová, on the northern and southwestern slope of Mt. Skalný, on the slopes of Mt. Čerňava and on the northern slopes of Mt. Javorník and Mt. Kelčský Javorník.

The more frequent height of the frost-riven cliffs in the Rusavská hornatina Mts. oscillates from 3 to 15 m and the most of them are situated on the northern slopes. If the layers have congruous inclinations the frost-riven cliffs have developed rock shelters (abri). The one of them are situated in the Čerňava (E) locality. These rock

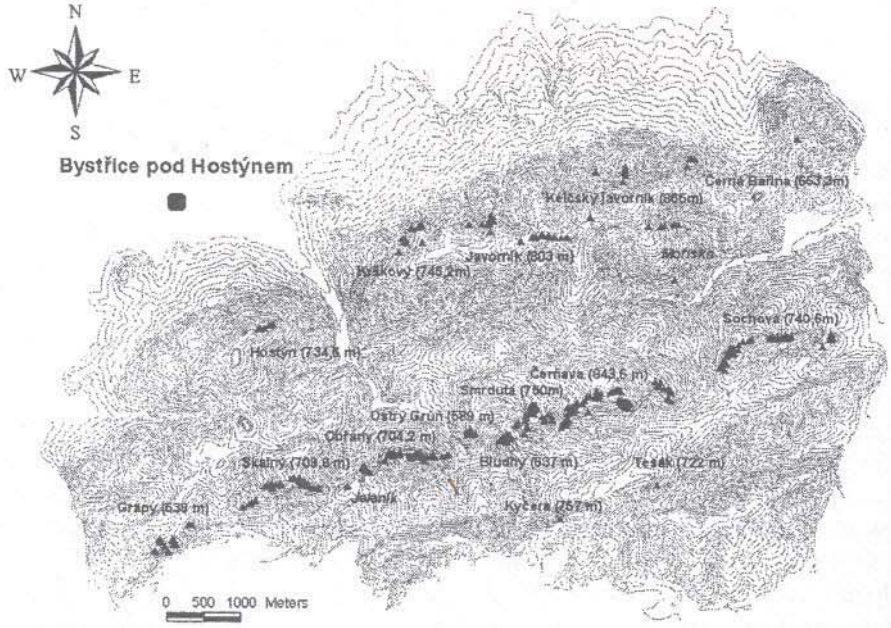

Fig. 1 Frost-riven cliffs (▲) in the Rusavská hornatina Mts.. This figure includes destroyed and undestroyed (by man) frost-riven cliffs. (data – Marek Křížek, Digital Elevation Model (DEM) – Aleš Létal, Marek Křížek)

shelters are 50 and 60 meters long, from 3 to 5 meters high and from 2 to 5 meters pendent. But these rock shelters have been intensively remodeled by recent geomorphological processes (slope movement, local sandstones are not too resistant and other geological conditions are specific). That is why these rock shelters are not typical factor of local rock shelters in the Rusavská hornatina Mts. which were developed on the feet of frost-riven cliffs. Therefore, these typical rock shelters are several meters long and high and from 0.5 to 2 meters pendent.

The water (ice) weathering was (in the Pleistocene) and is the most important process for the development of pseudokarst landforms (exactly caves). There are two pseudokarst caves in the Rusavská hornatina Mts. (Křížek 1999 and Demek 1964). Both caves (in Čecher Hill and Mt. Smrdutá) are typical fissure pseudokarst caves, which are common landforms in the Outer Western Carpathians in Moravia. These caves are situated near the feet of their frost-riven cliffs (Photo 2) and rock fracturing influenced the origin and development of these caves. Their length is about 14 m (the cave in Čecher Hill) and 55.9 m (the cave in Mt. Smrdutá). These pseudokarst caves have a poor decoration. In the cave in Čecher Hill there is a thin sinter crust, which has arose during the Holocene. A sinter crust arises from dissolved limestones which are included in conglomerates or by leaching of calcareous cement from conglomerates and sandstones.

The Holocene sculpturing

After the end of the last cold period of the Pleistocene every frost-riven cliff has been remodeled by the Holocene geomorphological processes (natural and anthropo-

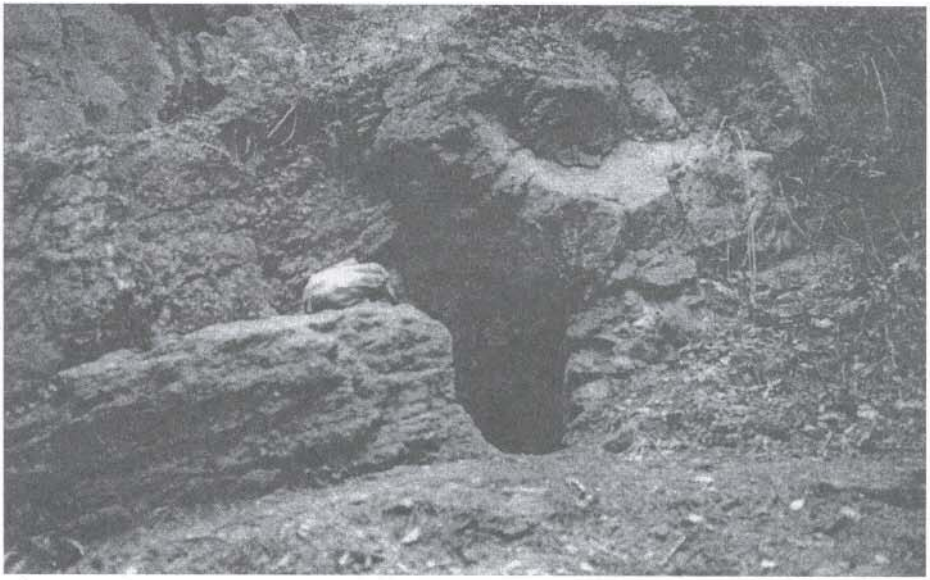

Photo 2 The pseudokarst cave entrance in Čecher Hill (461.5 m a.s.l.). The cave ceiling is limited by a sandstone bedding surface of the Rusava Member (Zlín Formation). Photo by M. Křížek

genic geomorphological processes). In the end of the Pleistocene and in the beginning of the Holocene the humid climate was on the increase and that is why the importance of chemical weathering was growing. Water was and is very important factor for chemical weathering and for remodeled of old landforms, formation and development of new landforms. Chemical weathering has started to remodel and round off angular periglacial landforms (e.g. angular blocks and rocks). And new landforms have originated by the "new" Holocene geomorphological processes in these rocks. In many frost-riven cliffs there are developed rock pits (potholes, waterpockets), outflow groove, pseudolapiés, rock cavities, ledges, honeycombs (Photo 3) and other microforms which are formed by recent weathering.

The very marked Holocene microforms are rock pits (Photo 4). During the geomorphological investigation it was found eight localities with rock pits (Table 1) and these rock pits are active landforms and they have always developed in the Holocene. These microforms are situated in the central part of the Rusavská hornatina Mts. and they have developed in horizontal and slightly inclined surfaces of rocks (on the frost-riven cliffs and other outcrops or somewhere on boulders) of the Rusava Member (Zlín Formation, exactly, only in their sandstones). In the locality – Smrdutá (ESE) there are nine rock pits which occurred on very small area (5 x 5 m) and these rock pits are very well developed and they were filled and partly covered by soil with

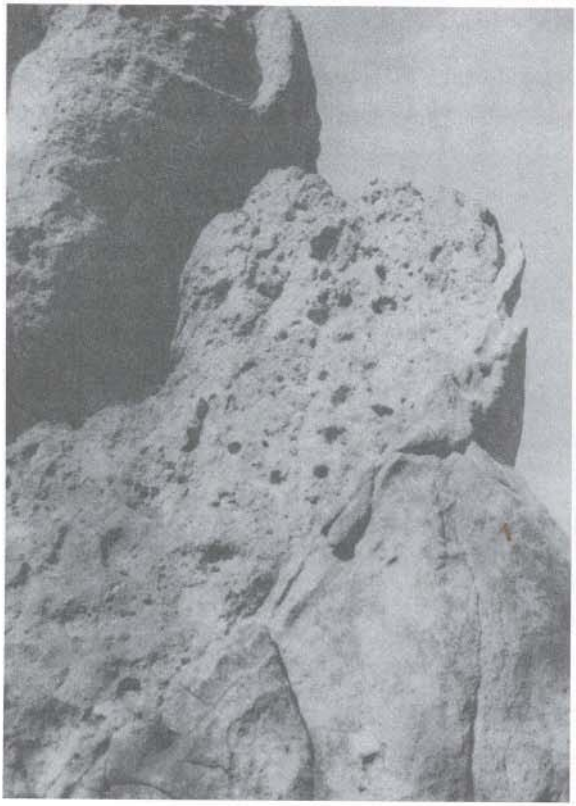

Photo 3 Honeycombs on sandstones (Rusava Member) in Mt. Skalný (708.8 m a.s.l.). Photo by M. Křížek

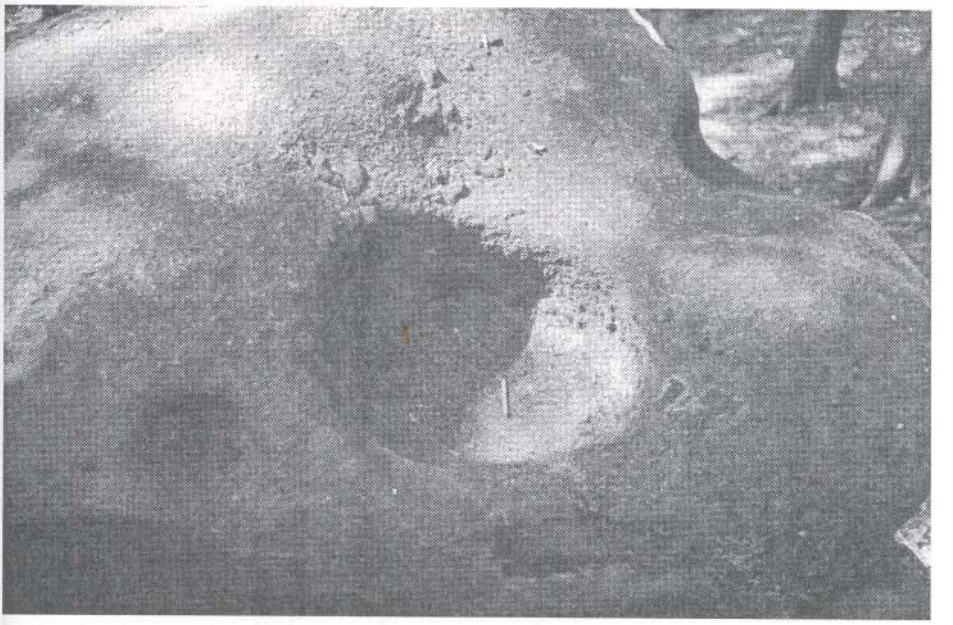

Photo 4 The very well developed rock pit (63 x 70 cm, 37 cm, Rusava Member) in the Čerňava SSW (765 m a.s.l.). Photo by M. Křížek

the decomposition of plant materials. In the some localities (for ex-ample: the Obřany and Čerňava (SSW) localities) there are any amounts of new young "proto rock pits". Unique land-form is a "duple" rock pit (100 x 140 cm, Čerňava (E)) which was formed by the mutual coupling of two neighbouring rock pits. A very interesting microform is situated in Mt. Bludný, one rock pit developed inside the other rock pit. Only four rock pits (35 x 5 1cm – Obřany, 55 x 61 cm – Bludný, 48 x 55 cm and 55 x 62 cm – Smrdutá (ESE)) have developed outflow grooves. In the Rusavská hornatina Mts. a lot of rock pits were destroyed by man (quarrying sandstones), for example a fragment (only 2/3 of original rock pit) of a rock pit (its diameter is 65 cm) in Mt. Čerňava. Thus, it shows that the number of rock pits was originally more than today number.

The rock cavities are formed in every types of sandstones and also conglomerates in the Rusavská hornatina Mts.. Their sizes are mostly from several centimeters to 1 meter. The biggest rock cavities are situated in Mt. Bludný (its height is 1.4 m and its depth is 2.5 m) and Mt. Smrdutá (its size is 0.5 x 1.6 m and its depth is 0.5 m). These rock cavities are predisposed by falled clasts or they are situated in the interface of sandstone and conglomerate layers. Some of these rock cavities are tafoni because conglomerates and sandstones (brownstones – ferruginous sandstones, calcareous sandstones, siliceous sandstones) are cemented by limonite, calcareous or silica and they have enduring surfaces. These microforms are developed in many localities of outcrops in the Rusavská Hornatina Mts. (e.g. they are very well developed around Mt. Obřany, Mt. Grapy, Mt. Smrdutá and Mt. Čerňava).

Table 1 Rock pits and their features

Locality	*Altitude (m a.s.l.)*	*Sense of direction*	*Size of pothole (cm)*	*Depth of pothole (cm)*
Bludný	535	SW	32x33*	17
			42x44	34
			55x61*	19
Čerňava (E)	800	E	20x22	31
			20x36*	19
			24x40*	30
			45x55*	20
			45x60*	34
			70x75	25
			duple pothole	
			100x140	22
(SSW)	765 – 795	SSW	22x30	17
			42x43*	19
			45x50	26
			45x60	25
			50x54*	37
			55x57	10
			63x70	37
			65 /diameter/*	43
Čerňava (summit)	825	NNE	25x28	16
			33x44*	22
			37x64	23
Kyčera S	645	S	20x21	8
Obřany	615 - 690	N - E	10x11	7
			12x13*	32
			19x25	13
			29x30	25
			30x35*	20
			35x51	28
			90 /diameter/*	50
			140 /diameter/*	70
Smrdutá ESE	715	ESE	23x28*	25
			25x27*	18
			30x40*	27
			32x36	22
			35x40	28
			40x60*	25
			48x55	32
			53x60	40
			55x62	35
Smrdutá SW	675	SW	20x30*	12
			35x35	15
spot height 733 m a.s.l. eastward from Čerňava	710	NE	9x12	8
			12x12	14
			13x13	13
			15x18	10
			17x17	13
			19x42	15

* These rock pits are asymmetric and were often destroyed by man (quarrying) or natural geomorphological processes have remodeled some of them.

Pseudolapiés and honeycombs are developed only in sandstones but their extension isn't often such as sandstones in the "Český ráj" (this sandstones include more kinds of cement /calcareous, ferruginous etc./) because sandstones of the Rusavská hornatina Mts. are more resistant and also the relief (with its forms) of the "Český ráj" is older. These microforms are very well developed around Mt. Skalný and Mt. Obřany.

Ledges are typical landforms for majority of remodeled frost-riven cliffs in the Rusavská hornatina Mts. These microforms are predisposed by bedding of sandstones. A thickness of ledges is from several centimeters to 0.5 meter. In this way rock plates are predetermined by bedding planes in the Rusavská hornatina Mts.. The largest rock plates are situated in Grapy Hill (their sizes are 20 x 40 m and 25 x 40 m, their inclinations are 40° and 35°), in the south slope of Mt. Čerňava (their sizes are 8 x 12 m, 12 x 17 m, 13 x 15 m, 14 x 15 m, 14 x16 m, their inclinations are from 30° to 45°). Sandstones were quarried in both localities.

Some outcrops were uncovered by sliding in the Holocene. There are several large sliding areas in the Rusavská hornatina Mts.. The first, this is landslide along cylindrical surface, is situated on the east slope of Hlavná Hill (its length is 390 m, its width is 270 m). In the scar (535 m a.s.l.) there are several rocks. The width of these biggest rocks is 12 and 25 m and their height is 3 and 6 m. The second area (with uncovered outcrops by sliding) is situated on the east slope of Mt. Hostýn (its length is 540 m, its width is 180 m) and the northwest slope of Mt. Krškový. There are a lot of outcrops around this scar. Their width is 4–22 m and their height is 3–13 m. On the east slope over the scar there is developed a gaping tension fissure which is 27 m long and 10 m wide. Besides it this genetic type of these outerops is situated also near Mt. Čerňavo and Mt. Sochová. These all areas were severalfold formed by landslides in the Holocene. The typical feature of these outcrops is a poor decoration (by microforms).

During the Human Era these landforms (frost-riven cliffs, potholes, rock cavities, pseudolapiés, honeycombs, ledges etc.) were destroyed by man, because sandstone was quarried and used for building purposes from the Celtic Era (oppidum in the top of Mt. Hostýn). In the Middle Ages there were built castles (Obřany, Zubříč, Šaumburk). In the 19th and the 20th century there were built roads, houses and other buildings (e.g. the evangelic church in Rusava) and that is why there were founded quarries and quarried sandstones. But gritstones and conglomerates were not quarried so much as sandstones. Today there is only one working quarry on the western slope of Mt. Hostýn near Bystřice pod Hostýnem.

Conclusion

The landforms, which are formed by rocks, have been originated in the Quaternary. Frost-riven cliffs are the most of outcrops . These landforms originated in the cold eras of the Pleistocene and recently in our temperate humid zone they are found as disharmonic rock formations not corresponding to existing humid climate. A lot of these frost-riven cliffs have narrow ledges on the slopes (their width is small, the initial stage of cryoplanation terracing) which, with other traces, it shows that most of the frost-riven cliffs are of Würmian age. Tors are probably older. The

morphostructure (e.g. the directions and gradients of layers, the gradients and frequency of cracks etc.) significantly influences the development of the frost-riven cliffs, cryoplanation terraces, rock plates and also their rock microforms (e.g. ledges, rock cavities). In the Pleistocene the frost weathering was the most important process for the development of periglacial rock landforms (frost-riven cliffs, tors, frost clefts, block streams, angular blocks) in the Rusavská hornatina Mts.. Today these frost-riven cliffs are not active (in a sense of periglacial processes; thus, we can say about "passive" frost-riven cliffs) but their characteristic features are still obvious. During the Holocene the blocks of rocks have moved along fissures and cracks. In this area it was surveyed several proofs of these movements along fissures and cracks. For example in the Jeleník locality the maximum movement of blocks of rocks is 40 cm.

The frost-riven cliffs have been remodeled by recent geomorphological processes. On these frost-riven cliffs there are a lot of microforms (e.g. rock pits, outflow grooves, rock cavities, pseudolapiés and honeycombs, ledges) which originated in the Holocene. Thus, in the Holocene most of outcrops (frost-riven cliffs) have already existed and they have been "only" remodeled by the Holocene geomorphological processes that have formed microforms on these outcrops (frost-riven cliffs). These microforms are still developing and they are in the different stage of development. More of rock microforms are developed in gritstones and conglomerates than sand flags. It shows different geomorphological resistances of these rocks. That is why most of rock cavities and rock shelters occur between more resistant layers (sandstones) and less resistant layers (conglomerates). On the other hand, sandstones (exactly, sandstone rock walls) were often destroyed by quarrying. But some outcrops were not influenced or originated by frost weathering and they were uncovered by sliding in the Holocene. I can say that rockslides and other landslides formed some rock landforms (e.g. rock plates, rock uncovered by sliding).

Water was and is very important factor for chemical weathering, which has remodeled and rounded off angular periglacial landforms. A sinter crust in local pseudokarst caves has formed also by an activity of water. The water (ice) weathering was (in the Pleistocene) and is the most important process for the spreading of rock fissures and cracks therefore for the development of frost-riven cliffs and also pseudokarst caves.

In addition a lot of frost-riven cliffs and their microforms were damaged by anthropogenic activities (quarrying). Even many of them were completely destroyed by man. Therefore, it shows that the number of the undestroyed (by man) frost-riven cliffs and their Holocene microforms was more than today number (inclusive of quarried and destroyed frost-riven cliffs).

References

CZUDEK, T. (1997): Reliéf Moravy a Slezska v kvartéru. Sursum, Tišnov, 213 p.

CZUDEK, T., DEMEK, J., STEHLÍK, O. (1961): Formy zvětrávání a odnosu pískovců v Hostýnských vrších a Chřibech. Časopis pro mineralogii a geologii, Nakl. ČSAV, Vol. 6, No. 3, Praha, pp. 262–269.

DEMEK, J. (1963): Jeskyně ve flyšových pískovcích moravskoslezských Karpat. Československý kras, ČSAV, Praha, pp. 127–130.

DEMEK, J. (1964): Zpráva o výzkumu vývoje svahů Moravských Karpat v pleistocénu. Zprávy GÚ ČSAV, GÚ ČSAV, No. 6, Opava, pp. 1–3.
DEMEK, J. (1969): Cryoplanation terraces, their geomorphological distribution, genesis and development. Rozpravy ČSAV, Academia, Praha, 80 p.
DEMEK, J. (1984): Fossil periglacial phenomena in Czechoslovakia and their paleoclimatic evaluation. Scripta facultatis scientiarum naturalium, Universitatis Purkynianae
Brunensis, Univerzita J. E. Purkyně, Vol. 14, No. 7, Brno, pp. 343–348.
FRENCH, H. M. (1976): The periglacial environment. Lorgman, London and New York, 308 p.
KŘÍŽEK, M. (1999): Povrchové a podpovrchové jevy na Čecheru v Hostýnských vrších.
Geografie – Sborník České geografické společnosti, Academia, Vol. 104, No. 3, Praha, pp. 201–208.
KŘÍŽEK, M., LÉTAL, A. (2000): GIS assist in the frost-riven cliff investigation. Acta Univ. Palacki. Olomuc. Fac. Rec. Nat., Geographica, Univerzita Palackého, 36, Olomouc, pp. 41–45.
WAGNER, J. (1984): Vývoj a morfologie pseudokrasových forem vnějšího flyšového pásma Západních Karpat. Československý kras, Academia, Praha, pp. 75–81.
Základní geologická mapa ČSSR list 25–143 Bystřice pod Hostýnem, 1:25 000, ÚÚG, 1986, Praha.
Základní geologická mapa ČSSR list 25–321 Fryšták, 1:25 000, ÚÚG, 1986, Praha.

KVARTÉRNÍ MODELACE PÍSKOVCŮ V RUSAVSKÉ HORNATINĚ

Résumé

Skalní tvary, se kterými se lze setkat v Rusavské hornatině, vznikly během kvartéru. Většinu skalních tvarů lze označit jako mrazové sruby (ať již poškozené nebo nepoškozené lidskou činností), které vznikly během chladných období pleistocénu. Tyto tvary jsou disharmonické vzhledem k současným klimatickým podmínkám a geomorfologickým procesům, které na ně působí. Tedy zdejší mrazové sruby lze označit jako pasivní mrazové sruby ve smyslu periglaciálních procesů. Mnoho mrazových srubů má vyvinutou kryoplanační lištu či kryoplanační plošinu. Z těchto a dalších vlastností lze soudit, že většina mrazových srubů je würmského stáří. Tory, které se nacházejí ve vrcholových oblastech jsou, vzhledem k pokročilejšímu stádiu kryoplanace, starší. Na rozmístění a vývoji mrazových srubů, ale i kryoplanačních teras, skalních ploten a na nich vzniklých skalních mikroforem, se odrazil vliv morfostruktury (sklon, orientace vrstev, typ horniny a také směr a intenzita rozpukání). I když mrazové sruby jsou přemodelovávány holocénními geomorfologickými procesy, lze u nich najít základní charakteristické rysy mrazových srubů (kryoplanační lišty či terasy, balvanové akumulace, zbytky po mrazových puklinách a trhlinách).

V pleistocénu byla role vody (v podobě ledu) při vývoji mrazových srubů, resp. jejich trhlin nezastupitelná. Podobně se podílela na vývoji puklin zdejších puklinových pseudokrasových jeskyní.

Během holocénu docházelo podél puklin k pohybům jednotlivých bloků skal. K nejvýraznějším patří pohyby skalních bloků na Jeleníku, kde se dochovaly stopy až po 40 centimetrových pohybech skalních bloků.

V holocénu vznikla na již existujících pasivních mrazových srubech celá škála mikroforem (např. skalní mísy, odtokové žlábky, skalní dutiny, skalní lišty a místy dokonce pseudoškrapy a voštiny). Tyto mikroformy se stále vyvíjejí a lze je pozorovat v různých stadiích vývoje i v rámci jedné lokality. Výskyt, resp. četnost těchto skalních mikroforem je do určité míry podmíněn charakterem horniny. Častěji se tyto mikroformy nacházejí v méně odolných pískovcích (převážně hrubozrných pískovcích) nebo slepencích. Např. skalní výklenky a převisy jsou nejlépe vyvinuté v místech přechodů méně odolných slepenců a odolnějších pískovců. Na druhou stranu, jistá nerovnovážnost v množství těchto skalních mikroforem lze přisoudit těžbě odolnějších pískovců ke stavebním účelům. Touto těžbou byla různou měrou postižena velká část pískovcových mrazových srubů. Takže například zdejší skalní plotny (resp. skalní výchozy, na kterých se tyto skalní plotny nacházejí) jsou natolik pozměněné, že u nich nelze rekonstruovat původní tvar.

Je zřejmé, že voda byla a je nejdůležitějším faktorem pro chemické zvětrávání, které získalo na významu v období holocénu a které přemodelovalo a „zakulacovalo" ostré periglaciální tvary mrazových srubů, balvanů kamenných moří atd. Také sintrová kůra pseudokrasové jeskyně na Čecheru je důkazem chemického působení vody.

Je zřejmé, že počet mrazových srubů (pozměněných i nepozměněných lidskou činností) a jejich holocenních mikroforem byl větší než je tomu v současnosti. Dokonce mnohé mrazové sruby byly úplně odtěženy.