ACTA UNIVERSITATIS CAROLINAE
2000 GEOGRAPHICA, XXXV, SUPPLEMENTUM, PAG. 239–245

Frost-riven cliffs and cryoplanation terraces in the Hostýnské vrchy Hills (east Moravia, Czech Republic)

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ABSTRACT

This article is about the typical Pleistocene landforms of the Hostýnské vrchy Hills (the Outer Western Carphatians) – frost-riven cliffs and cryoplanation terraces. These frost-riven cliffs are one of the relicts of the periglacial landforms which were originated in the cold phases of the Pleistocene. Besides frost-riven cliffs there are many other fossil periglacial landforms (block streams, cryopediment etc.) in this area. The frost-riven cliffs and cryoplanation terraces in the Hostýnské vrchy Hills are compared with the same landforms from other parts of the Czech Republic.

Key words: frost-riven cliffs, cryoplanation terraces, Pleistocene, Hostýnské vrchy Hills

1. Introduction

The Hostýnské vrchy Hills (291 km^2) are situated in the west part of the Outer Western (Flysh) Carpathians in Moravia (Czech republic). The area of the Hostýnské vrchy Hills (Photo 1) is situated on the western bank of the Vsetínská Bečva river among these following towns: Holešov, Valašské Meziříčí and Vsetín (Figure 1). The bedrock is composed of flysh sandstone, conglomerate, shale and claystone. Deep V-shaped valleys with sheer slopes (over 25°) are the typical phenomenon of this relief. The highest peak of this highland is Mt. Kelčský Javorník (865 m a.s.l.). Even the highest part of the Hostýnské vrchy Hills constitutes a mountainous area. It means the difference between the highest point and the lowest point is over 300 metres per 4x4 km. The surface of the Hostýnské vrchy Hills was formed by Pleistocene periglacial conditions, the same as the surrounding parts of the Outher Western Carpathians and other parts of the Central Europe.

This paper presents the general characteristics of the important periglacial forms in the Hostýnské vrchy Hills. They are frost-riven cliffs and cryoplanation terraces. Besides these frost-riven cliffs there are also other significant fossil periglacial landforms, for example cryopediment, solifluction streams, block fields and involution of sack–like types. I found an involution of sack–like type (Photo 2) in the foot of the Hostýnské vrchy

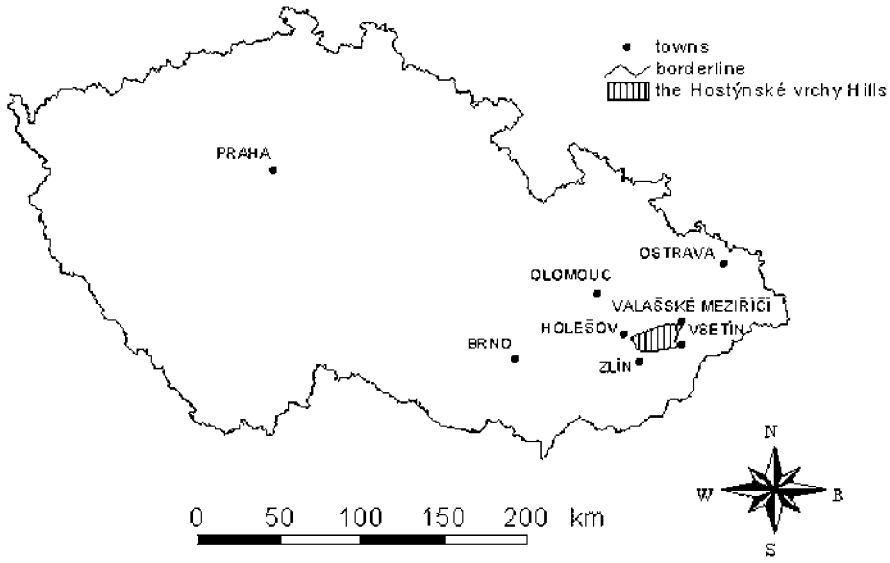

Figure 1: The situation of the studying area.

Hills near town of Holešov and it is of Würmian age. This involution supports an attendance of permafrost in this area in the Pleistocene (Würm).

2. Cryoplanation terraces and frost-riven cliffs

Cryoplanation terraces are dependent on periglacial climate-morphogenetic areas with characteristic climatic conditions and their origin is connected with periglacial (cryogenic) processes such as frost weathering, solifluction and nivation in the cold phases of the Pleistocene. Frost weathering is based on freeze-haw cycles, let us say, volume changes of water during freezing. Freezing water (ice) increases its volume by 9% and damages surrounding rocks. The pressure of ice can amount to 2100 kg/cm^2 (–22° C), even a tenth of this pressure can damage any rock (Klimaszewski 1978).

Most of the frost-riven cliffs in the Hostýnské vrchy Hills have only narrow ledges from 3 to 10 metres (Mt. Obřany 704 m a.s.l., Mt. Skalný 709 m a.s.l.) and some of them have no ledges or terrace flats. The feet of these frost-riven cliffs are covered with angular rock fragments – the products of weathering of various grain-size. The mean size of these boulders being 40–150 cm. There are often block streams (e.g. Mt. Obřany 704 m a.s.l.), which are sometimes buried and covered by a 20–60 cm thick soil layer, with solitary stones on the surface. But there are also mature cryoplanation terraces (from 10 to 25 metres wide) which sometimes develop cryoplanation summit flats with tors[1], for

[1] Tor – asummit type of a frost-riven cliff with a wide cryoplanation terrace which has an inclination of less 5°.

example Mt. Sochová 741 m a.s.l. (Photo 3), Mt. Čerňava 843 m a.s.l., Mt. Jehelník 838 m a.s.l., and spot height 832 m a.s.l. (Photo 4) which is situated about 200 metres SW from the top of Mt. Kelčský Javorník. The gradient of these terrace flats decreases from 7°–12° in the other less mature cryoplanation terraces to 3° in the cryoplanation summit flats. Numerous measurements have shown that in well developed (mature) cryoplanation terraces the inclination often fluctuates from 3° to 7°. These terrace flats are slightly convex from the top to the edges and they are 20–40 metres wide. In general, the size of cryoplanation terraces depends much on the gradient of the slopes. On gentler slopes, the terraces are bigger than on the steeper slopes. Elsewhere we can find between cryoplanation terraces vertical rock walls (frost-riven cliffs) reaching a height of 2 to 20 metres. The number of cryoplanation terraces on slopes is different (from 1 to 6 levels of cryoplanation terraces). In some places, only isolated terraces are developed on slopes (e.g. spot height 832 m a.s.l. SW from Mt. Kelčský Javorník), while elsewhere whole groups of terraces are found (for example Mt. Obřany 704 m a.s.l. with three cryoplanation terrace levels and north part of Mt. Javorník 803 m a.s.l. with six cryoplanation terace levels).

Cryoplanation terraces and their frost-riven cliffs in the Hostýnské vrchy Hills are developed at altitudes from 435 m a.s.l. to over 840 m a.s.l.. Most frost-riven cliffs are situated over 650 m a.s.l. and cryoplanation summit flats with tors are developed over 700 m a.s.l.. Cryoplanation terraces and their frost-riven cliffs are more common and more distinct at higher elevations. In the Czech Republic, cryoplanation terraces are developed in many localities. They developed in the Pleistocene at altitudes from 300 metres to over 1500 metres (Demek 1984, Czudek 1997). These terraces and their frost-riven cliffs in the Hostýnské vrchy Hills are most fully and distinctly developed on resistant rock – sandstone and conglomerate and these terraces absent on "soft" non resistant bedrock (shale, claystone). About 90% of frost-riven cliffs have one of E, NE, N, NW, W expositions but there are also frost-riven cliffs which are oriented to SW, S, SE. The morphostructure (e.g. the direction and gradients of layers, the gradients and frequency of cracks etc.) of this area significantly influences the development of these frost–riven cliffs and their cryoplanation terraces. The distribution of frost-riven cliffs tends to indicate that their occurrence is much more closely related to bedrock type than to their geographic exposition and elevation. Therefore, these frost-riven cliffs have been preserved in this region since the Pleistocene Period as fossil landforms and they are now a disharmonic form to the present-day humid climate. These frost-riven cliffs were and are remodelled by contemporary weathering processes. In some cases, sink holes, pseudolapiés, draining chanels, rock cavities, honeycombs and other microforms developed which were produced by recent (Holocene) weathering. But now in some places in north Moravia (the highest parts of Králický Sněžník Mts. and Hrubý Jeseník Mts.), the periglacial development of frost-riven cliffs continues. There, the cold climate periglacial climatic conditions and periglacial processes (e.g. frost weathering, frost splitting, nivation) are similar. But the speed and intensity of these processes is lower.

The pseudokarst caves in the Čecher hill 461.5 m a.s.l. (Křížek 1999) and Mt. Smrdutá 750 m a.s.l. (Demek 1963) are very interesting landforms in the Hostýnské vrchy Hills. Both these caves are situated near the feet of their frost-riven cliffs and rock fracturing

Photo 1: The Hostýnské vrchy Hills. (Photo by M. Křížek)

Photo 2: The involution of sack-like type (Würm) in the foot of the Hostýnské vrchy Hills near the town of Holešov. (Photo by M. Křížek)

Photo 3: The summit frost-riven cliff (tor) in Mt. Sochová 741 m a.s.l. (Photo by M. Křížek)

Photo 4: The frost-riven cliff (832 m a.s.l.) near the top of Mt. Kelčský Javorník. (Photo by M. Křížek)

influenced the origin and development of these caves. But similar caves are typical for the whole Moravian Carpathians, the very well known and biggest pseudokarst caves in the Czech Republic are in the Moravskoslezské Beskydy Mts.

3. Conclusion

In the Hostýnské vrchy Hills there are the fossil frost-riven cliffs which originated during the several cold phases of the Pleistocene. Most of these frost-riven cliffs are in the stage of initial cryoplanation terracing (Demek 1969) when the terraces formed narrow ledges on the slopes (their width is small) 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. In other localities in the Czech Republic, the ages of frost-riven cliffs has been determined as from Riss to Würm. For example, Petrovy kameny (1446 m a.s.l.) in Hrubý Jeseník Mts. – Riss and Würm, Rolandova skála (900 m a.s.l.) in Hrubý Jeseník Mts. – Würm, Pasecká skála (819 m a.s.l.) in Žďárské vrchy Highland – Riss and Würm (Demek 1984). Even most of the permafrost soil wedges in Moravia are of Würmian pleniglacial age and these permafrost soil wedges are bigger than the older permafrost soil wedges (Czudek 1997). It corelates with the probably coldest Pleistocene period in Moravia. The mean annual temperature was about –8°C, in some years about –10 °C, even –12 °C, the lowest January and February temperatures in some years were from about –40 °C to –30 °C and the mean annual temperatures in these months were from about –30 °C to –25 °C (Czudek, Havlíček, Minaříková 1992). At this time, during 60,000 years, the Würmian (pleniglacial) periglacial geomorphologic cycle was culminating and these climate conditions were like today climate in Byrranga in Tajmyr (Siberia). There are recent frost-riven cliffs with cryoplanation terraces, permafrost and recent periglacial processes such as frost weathering, nivation, frost splitting and solifluction.

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MRAZOVÉ SRUBY A KRYOPLANAČNÍ TERASY V HOSTÝNSKÝCH VRŠÍCH (VÝCHODNÍ MORAVA, ČESKÁ REPUBLIKA)

Resumé

Hostýnské vrchy byly v chladných obdobích pleistocénu ovlivněny a formovány periglaciálními podmínkami, podobně jako sousední části karpatského oblouku. Mezi nejnápadnější rezidua těchto periglaciálních podmínek patří mrazové sruby a kryoplanační terasy. Dalším výrazným periglaciálním tvarem je vyvinutý kryopediment před částí čelního severního svahu Hostýnských vrchů. Na úpatí Hostýnských vrchů nedaleko Holešova se nacházejí zbytky kryoturbačních jevů – mrazové hrnce.

V práci jsou stručně charakterizovány mrazové sruby a plošiny kryoplanačních teras na území Hostýnských vrchů. Vznik a vývoj zdejších mrazových srubů a kryoplanačních teras je evidentně ovlivněn morfostrukturou, velký význam má směr a sklon vrstev a směr a četnost puklin. V Hostýnských vrších je výskyt mrazových srubů jednoznačně vázán na odolné pískovce a slepence. Rozmístění mrazových srubů ukazuje, že závislost na typu horniny je větší než na nadmořské výšce nebo expozici ke světovým stranám.

Mrazové sruby jsou pleistocénními tvary, které jsou přemodelovány jiným souborem zvětrávacích procesů, které odpovídají holocénním klimatickým podmínkám. Takto vznikaly a vznikají skalní mísy, pseudoškrapy, voštiny, skalní dutiny a další mikroformy.