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ALTIPLANATION TERRACES IN CZECHOSLOVAKIA AND THEIR ORIGIN

Kryoplanační terasy v Československu a jejich vznik. — Kryoplanační terasy byly v Československu popsány v posledních letech především z oblastí se značnou výškovou členitostí (Šumava, Sudety, Žďárske vrchy, hornatiny Vnějších Karpat). Jsou to zřetelné terasy na svazích, které mají většinou sklon 3—11° a jsou navzájem oddělené příkřejšími, často svislými úseky. Dosahují délky až přes 2 km a šířky několika desítek až stovek metrů. Jsou zaříznuty do skalního podloží. V některých případech sečou vrstvy, v jiných probíhají rovnoběžně s vrstevními plochami. Jejich vznik souvisí s periglaciálními pochody v pleistocénu. Vyvíjely se rovnoběžným ustupováním příkřejších úseků (mrazových srubů) na svazích. Materiál oddělený z mrazových srubů byl dále dopravován soliflukcí a splachem po povrchu teras, které byly těmito pochody dále modelovány. Protnutím kryoplanačních teras na protilehlých svazích byly místy rozrušeny zbytky terciérních zarovnaných povrchů a vznikly zarovnané povrchy vrcholů a rozvodních hřbetů kvarterního stáří.

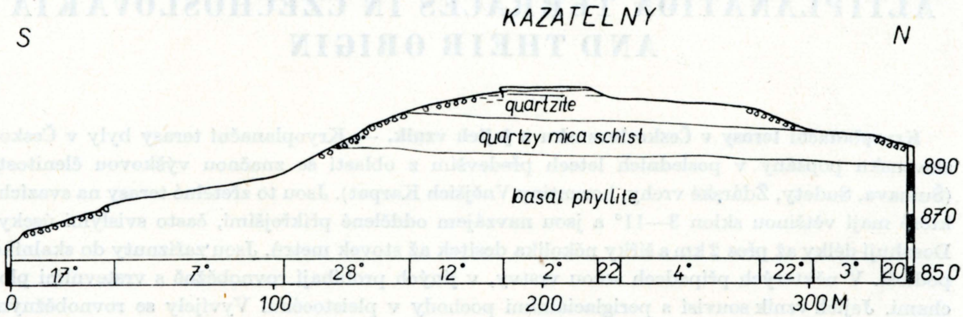
Introduction

Altiplanation terraces were recognized at first by H. M. Eakin (1916) in Central Alaska (Yukon-Koyukuk Region). H. M. Eakin termed them and described them as flat areas several square rods to hundreds of acres in extent, fronted by scarps a few feet to hundreds of feet in height (1916, pp. 77—78). The research workers of the Geographical Institute of the Czechoslovak Academy of Sciences (V. Panoš 1960, 1961, O. Stehlík 1960, T. Czudek—J. Demek 1961, T. Czudek—J. Demek—O. Stehlík 1961) were the first, who found the altiplanation terraces in the Czechoslovak landscape. This paper gives a summary of the results acquired in the Bohemian Highland and in the Flysh Zone of the Carpathians.

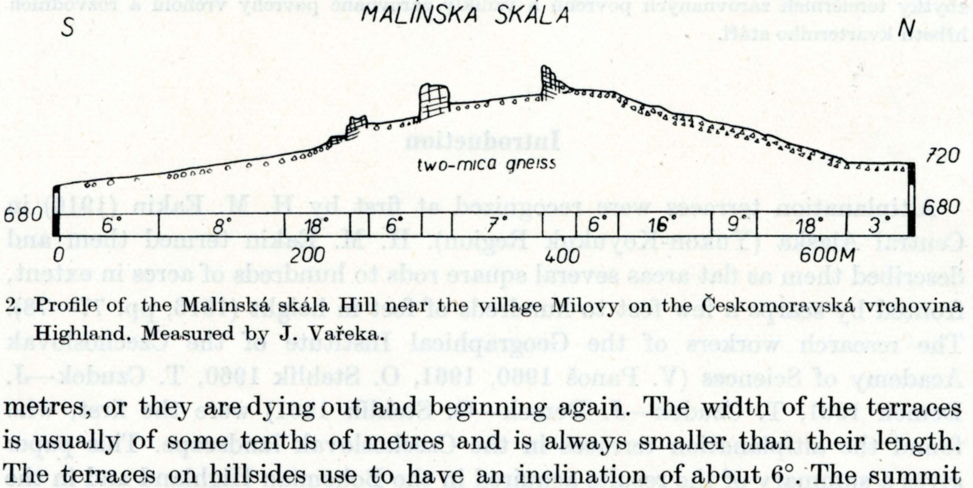
Characteristic of altiplanation terraces in Czechoslovakia

Altiplanation terraces occur in Czechoslovakia most often in regions with a high relief, in which long hillsides and narrow watershed-ridges are prevailing (Šumava Mts., Sudety Mts., some parts of the Českomoravská vrchovina

Highland, sandstone mountain ranges of the Flysh Zone of the Carpathians, etc.). Slopes are often expressively stepped in these areas and tors are found on the summits of ridges. Gently sloping treads of 3—11° inclination and moderately steep to vertical risers alternate on the stepped hillsides (profiles No. 1, 2, 3). The flatter, gently sloping treads have the shape of terraces. The terraces pass on hillsides either coherently on a distance of some hundreds of



1. Profile of the Kazatelny Ridge near the village Rejvíz in the Hrubý Jeseník Mts. Measured by J. Demek, geological structure according to J. Skácel.



2. Profile of the Malínská skála Hill near the village Milovy on the Českomoravská vrchovina Highland. Measured by J. Vařeka.

metres, or they are dying out and beginning again. The width of the terraces is usually of some tenths of metres and is always smaller than their length. The terraces on hillsides use to have an inclination of about 6°. The summit terraces have smaller declivities (1—3°). Besides the inclination in the direction of the total angle of slope, the terraces are often inclined even in their longitudinal direction. The terraces occur individually on hillsides or some steps of terraces are developed at another time (profiles No. 1,3, 6).

The steeper inclined slope parts, which are backed by the individual terraces, have a different appearance. Less expressive are the steps covered by soil and vegetation, whose declivity varies about 16—24°. Steeper scarps veneered by angular talus blocks are projecting more expressively. In some cases these steps are formed by large angular blocks weighing many tons (profile No. 2).

The steps formed by rock walls are most expressive. The rock walls consisting of solid rock use to have angular forms. The height of the walls varies from 2,5 m (profile No. 1) to 20—25 m. Most often they are 5—10 m in height. At the foot of the rock walls talus are found consisting of angular rock fragments having often a considerable size. The angle of talus reaches in some places 39° (profile No. 5) and is drawing near to the angle of repose for its component

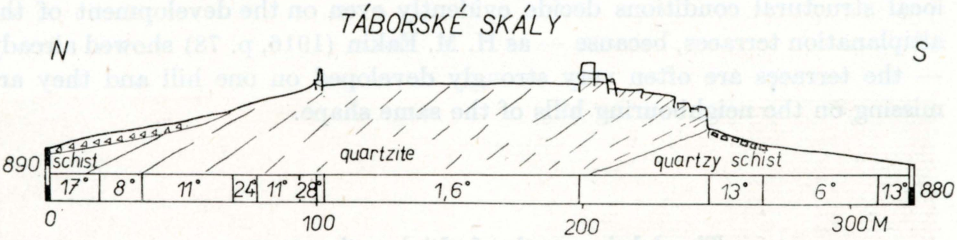
1. Frost-riven cliff in two-mica granite on the hill Tisá skála near the town Golčův Jeníkov in Českomoravská vrchovina Highland. At the foot of the frost-riven cliff the talus composed by angular rock fragments can be found. Photo J. Demek.

material. In other cases we do not find any rock fragments at the foot of the rock cliffs and the foot is sharp, even then, when the extensive denudation of the rock cliff is evident of its whole appearance. The foots of such walls use to be moderately undermined and the walls are usually overhanging. In some cases the material accumulated in the shape of a not high rampart can be found below the overhanging wall in a certain distance of its foot. The length of the rock cliff is different. The longiest rock cliffs were described up to this time in the Hrubý Jeseník Mts. (R. Netopil 1956, pp. 95), where they are to 2 km long and in the Moravskoslezské Beskydy Mts. (length round 1,5 km). But steeper back slopes are found on these benches most often, on which vertical rock cliffs with sections formed by angular talus blocks and even with soil mantled and vegetated steps alternate (for instance the 480 m long and on average 25 m high step on the mountain ridge Táborské skály in the Hrubý Jeseník Mts.). It should be noted, that the marginal scarps of the higher terraces on stepped slopes are generally as steep as the scarps of the lower terraces. The benches are developed on hillsides facing all cardinal points and in various altitudes (in the described area from 200 to 1,400 m above the sea level).

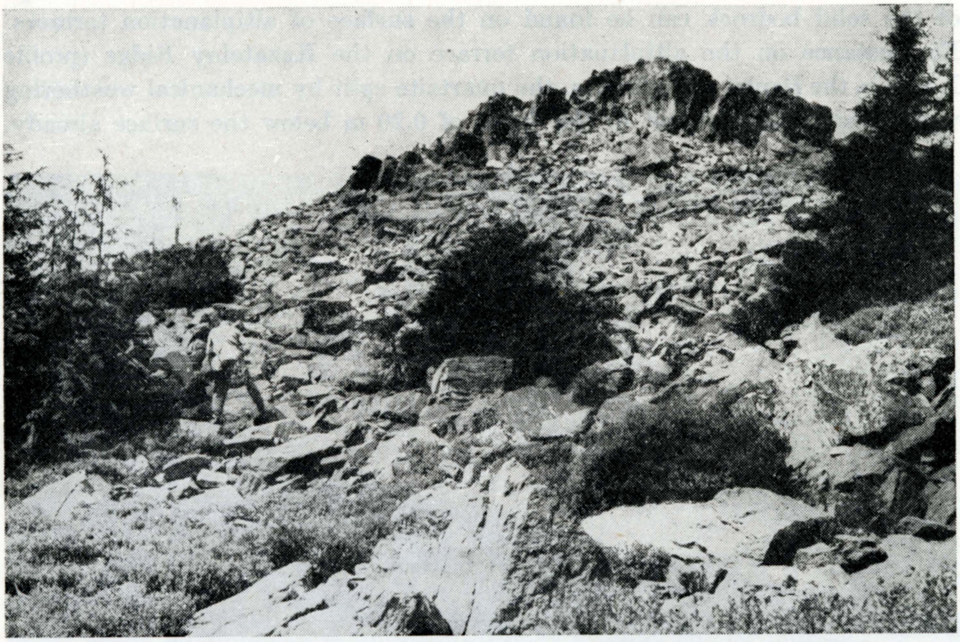
2. Frost-riven cliff in gneiss in the valley of the right tributary of Rokytná-River near the village Horní Kounice in the Českomoravská vrchovina Highland. At the foot of the frost-riven cliff the block- stream can be found. Photo O. Bárta.

Structural relations

It is obvious from the evidence furnished by various exposures that the terraces are cut in solid rock. They are developed in all sorts of rocks, but they are found in some ones more often, in others less often. The altiplanation terraces occur seldom in coarse grained intrusive igneous rocks, especially in granites or syenites. They are developed most often on slopes consisting of quartzite, phyllite and sandstone. They can be found especially on places, where rocks more or less resistant to the macrogelivation alternate. In the Hrubý Jeseník Mts. they are for instance often developed in places, where quartzite with mica schist and phyllite alternate (profiles No. 1, 3).



3. Profile of the Táborské skály Ridge near the town Zlaté Hory in the Hrubý Jeseník Mts. Measured by J. Vařeka and J. Demek, geological structure according to J. Skácel.

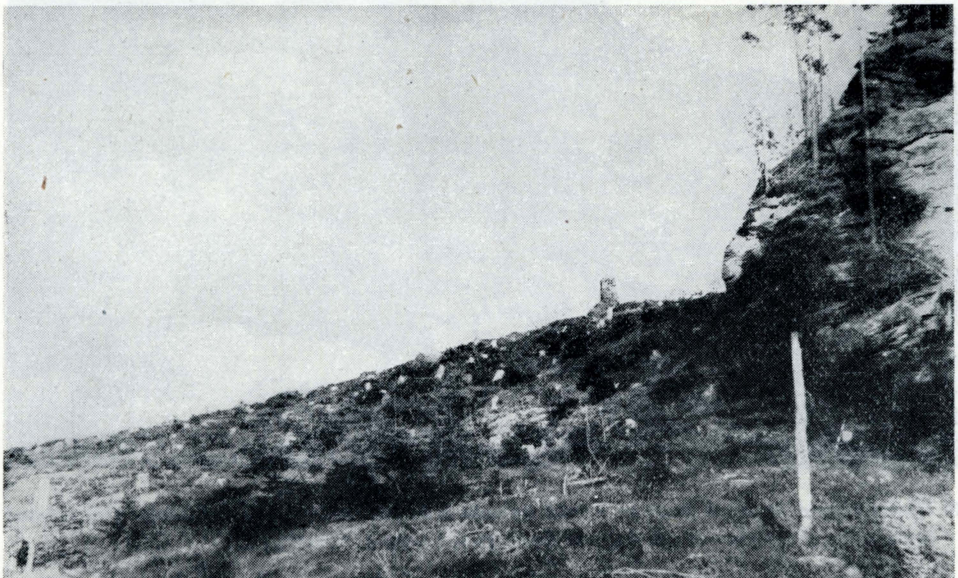


3. Castle koppie Ztracená skála in Hrubý Jeseník Mts. At the foot a considerable talus created by angular fragments of quartzite is developed. Photo J. Demek.

In some cases the surface of the altiplanation terraces is parallel with the inclination of the beds (profile No. 1). Especially in the horizontal differently resistant rocks of the Bohemian Plateau and in some areas of the Carpathian Flysh Zone (O. Stehlík 1960, p. 47) the origin of the altiplanation terraces is closely related to the origin of the structural terraces. At another time the terraces are cutting the folded or tilted beds evidently (profile No. 3). The most expressive rock walls are developed on the fronts of the strata or of the cleavage. The jointing of rocks and especially the vertical joints are of main importance for the origin of the free-face. The steeper sections can have even in the same rocks due to local conditions a different appearance. The local structural conditions decide evidently even on the development of the altiplanation terraces, because — as H. M. Eakin (1916, p. 78) showed already — the terraces are often very strongly developed on one hill and they are missing on the neighbouring hills of the same shape.

The debris mantle of altiplanation terraces

The debris mantle of altiplanation terraces is different. In some cases outcrops of the solid bedrock can be found on the surface of altiplanation terraces. For instance on the altiplanation terrace on the Kazatelny Ridge (profile No. 1) in the Hrubý Jeseník Mts. the quartzite split by mechanical weathering was found in the test pit in the depth of 0,20 m below the surface already.

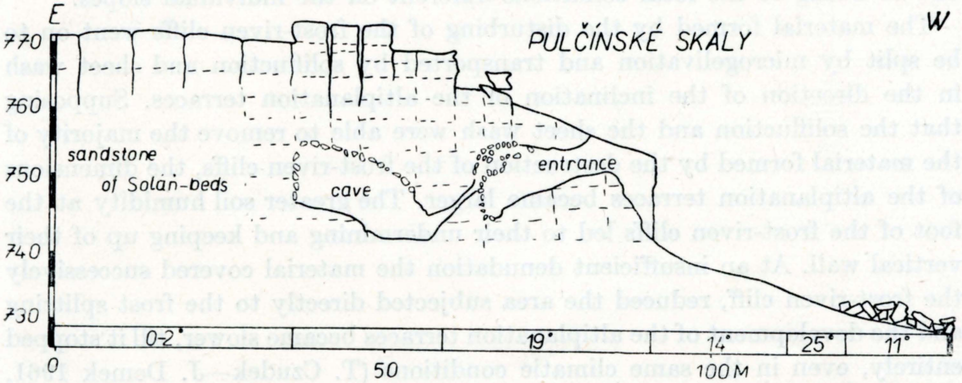


4. Altiplanation terraces on the summit of the Táborské skály-Ridge in Hrubý Jeseník Mts., which are separated by an expressive step. Photo J. Demek.

In contradistinction to it the terraces on the north slope of the Malínská skála Hill on the Českomoravská vrchovina Highland (profile No. 2) are covered by an at least 3 m thick layer of block waste. Other test pits showed the terraces to be covered by rock fragments mixed with sandy loam. Even in close vicinity of the cliff angular rock fragments were often lying loosely in the sandy loam. Some of them were situated diagonally up to vertically. There is no sign of stratification in this material. In some sandstones of the Bohemian Plateau and of Carpathians the non-stratified loose up to loamy sand created by the direct disintegration of sandstones forms the mantle of the terraces. In some cases the sorting of the material by frost (for instance in the Hrubý Jeseník Mts. — M. Prosová, 1954, pp. 8—11) can be observed on the terraces.

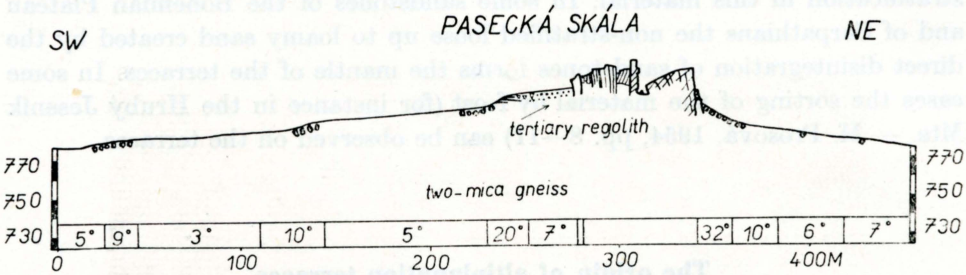
The origin of altiplanation terraces

The origin of the altiplanation terraces is connected with intensive periglacial processes passing on the territory of Czechoslovakia during the cold periods of Pleistocene. The intense frost weathering disturbed the massive rocks on slopes and summits to the depth of 10—40 m (profile No. 4). The frost weathering passed more quickly on places of the greater slope humidity or in the vicinity of undulations, in which the snow kept up longer. As soon



4. Profile of the Pulčínské skály Ridge near the village Pulčín in the Javorníky Mts. Measured by J. Vařeka.

as the weathering processes reached the solid bedrock, the initial terraces began to develop. The initial terraces were formed in places of the break of slope most often, where the solid bedrock was situated near the surface, or where its outcrops could be found. The steeper section formed by the cutting of the initial terrace into the slope, retreated parallelly and so the not large steps were enlarged into altiplanation terraces. The parallel back-wearing was caused by the separating of blocks due to the opening of the vertical joints. In favourable conditions the steeper section got the shape of a frost-riven cliff, i.e. of a vertical up to overhanging rock wall, which was intensively modelled by congelifraction. The frost-riven cliffs have owing to the separating of blocks not seldom a step-like shape in the upper part (profile No. 3). They



5. Profile of the Pasecká skála Hill near the village Kadov on the Českomoravská vrchovina Highland. Measured by J. Vařeka and J. Demek.

did not retreat with the same velocity in all their parts. The proofs of their back-wearing can be found in form of differently shaped tors in front of the frost-riven cliffs. The origin of the altiplanation terraces does not depend on the erosion basis. The terraces can develop in various heights and their number can be owing to the local conditions different on the individual slopes.

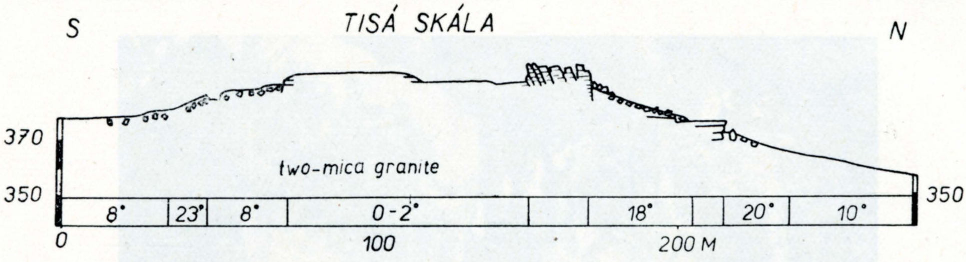
The material formed by the disturbing of the frost-riven cliffs went on to be split by microgelivation and transported by solifluction and sheet wash in the direction of the inclination of the altiplanation terraces. Supposing that the solifluction and the sheet wash were able to remove the majority of the material formed by the destruction of the frost-riven cliffs, the dimensions of the altiplanation terraces became larger. The greater soil humidity at the foot of the frost-riven cliffs led to their undermining and keeping up of their vertical wall. At an insufficient denudation the material covered successively the frost-riven cliff, reduced the area subjected directly to the frost splitting and the development of the altiplanation terraces became slower, till it stopped entirely, even in the same climatic conditions (T. Czudek—J. Demek 1961, pp. 58). In the climax of the cold periods of Pleistocene the frost splitting passed, while in the transition phases the material was sliding down the layer saturated with water between the melting active bed and the perma-frost. The melting snow moisted the material mowing even at very gentle inclinations (1—2°).

The parallel retreat of the frost-riven cliffs on the opposite slopes of one hill or ridge caused successively their crossing and the disintegration of the older topographic surface. It is necessary to explain in this way some flats on the summits of the ridges of an angle of 1—3°, above which angular tors are towering sharply. The tors and rocks have various forms and the degree of their disintegration is different. It is possible to compose a whole row of development from the extensive castle koppies over tors to the heaps of angular blocks, which are the last stage of the disintegration of these rock forms (T. Czudek—J. Demek 1961, pp. 58). The inclination of the flat summits is then further reduced by the frost weathering and by the solifluction. The forms considered as parts of the Tertiary peneplain are according to the new

5. Frost-riven cliff in flysh-sandstones in Pulčínské skály in Javorníky Mts. In the middle part of the photo the entrance in the considerable fissure cave can be found. Photo J. Demek.

investigations very young (of the Middle up to the Upper Pleistocene).

The investigations in the Bohemian Highland showed at the same time, that it is not possible to explain all flat summits on which castle-koppies and tors are rising, by the cryoplanation. The test pits on some of these summits at the foot of the castle koppies and tors reached the regolith of the hot-humid climate of Tertiary (profil No. 5). It can be assumed, these flat summits to be a part of the Paleogene surface of levelling of the Bohemian Highland, of



6. Profile of the Tisá skála Hill near the town Golčův Jeníkov on the Českomoravská vrchovina Highland. Measured by J. Vařeka.

which thick layers of regolith were stripped away especially by periglacial processes and the basal weathering surface was exhumed. The castle koppies and tors are then the more resistant parts, which were preserved in regolith and exhumated by their removal. The periglacial processes modelled then these forms created by the subsurface chemical weathering more or less after their exhumation. The initial rounded forms were preserved on tors consisting of rocks resistant to the macrogelivation (granite, syenite), while others got angular forms characteristic for the congelifraction. The differences in the resistance of rocks to the chemical weathering during the hot-humid climate of the Paleogene period caused the undulation of the basal surface of weathering and led then together with the irregular removal to the origin of steps on the flat summits, looking like the steps of altiplanation terraces. In some cases the periglacial processes led to a considerable reduction of castle koppies and to the origin of a narrow stripe of the altiplanation terrace bordering the tor.

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