ACTA MONTANA IRSM AS CR (1995)
Series A, No.8(97), 17–27

GRANITE LANDFORMS IN THE PODYJÍ NATIONAL PARK, SOUTH MORAVIA

ANTONÍN IVAN and KAREL KIRCHNER

Institute of Geonics, Branch Brno, Academy of Sciences of the Czech Republic
Drobného 28, P.O. Box 29, 613 00 Brno, Czech Republic

ABSTRACT. In the eastern part of Podyjí National Park many granite landforms occur, (inselbergs, tors, corestones, blockfields and different microforms). They are found only on the eastern marginal slope of the Bohemian Massif and in the canyon of the Dyje River, whereas on the regional planation surface of the etchplain type with thick rests of kaoline weathering crust, the rock forms are scarce. On the marginal slope the forms were probably initiated during the Paleogene or Lower Miocene, and were buried under marine sediments. On the other hand, the canyon of the Dyje is younger, superimposed from the cover of Miocene marine sediments, and granite forms are younger and of a different type.

KEY WORDS: Podyjí National Park, Geomorphology, Granite landforms

1. INTRODUCTION

The eastern part of Podyjí National Park (PNP) in the southeastern part of the Bohemian Massif is composed of biotite granite and granodiorite (Dyje granite) with numerous different meso– and microforms. The main relief features of the Park, the rests of widespread planation surface, the marginal slope of the Bohemian Massif facing the topographic depression of the Carpathian Foredeep and the canyon of the Dyje, achieving a maximum depth of 235 m have been discussed by both authors in their recent papers [Ivan and Kirchner 1994a,b]. This article restricts itself to the treatment of those minor granite landforms which characterize the PNP landscape. The most attractive feature of the PNP, is the fissure–ice cave near the town of Vranov nad Dyjí. It is in the Bíteš orthogneiss and at present is subject of complex research not only by geomorphologists, but also other specialists [Zvelebil et al. 1993]. Most meso– and microforms, however, occur on granitoid rocks of the Dyje Massif, both on the marginal slope of the Bohemian Massif and in the Dyje Canyon. Contrary to this, the regional plation surface on granite is rather monotonous and featureless.

The Cadomian biotite granite and granodiorite of the Dyje Massif, dated about 550 m.y. [Scharbert and Batík 1980] is part of a complex Variscan structure known as Dyje Dome. Some authors suppose that the Dyje Massif and Brno Massif (in the surroundings of Brno) were originally one intrusive pluton, later divided by

the left–strike slip fault (the Boskovice–Diedendorf fault) with an amplitude of about 80 km [Jaroš and Mísař 1965]. During the Variscan orogeny the Dyje Massif, together with some metamorphic rocks, including the Bíteš orthogneiss (in the western part of PNP) became its core. In the course of intensive nappe tectonism the Dyje Massif was an autochtonne block, overthrusted by Moravian and Moldanubian nappes [Jaroš 1992; Schulmann et al. 1994]. The Dyje granite and the Bíteš orthogneiss were strongly influenced by tectonic shattering, mylonitization and retrograde metamorphism. These processes were important during post–Variscan subaerial denudation, especially in deep chemical weathering. Thus, it is possible that in addition to the tropical climate, the rests of thick kaoline weathering crust, in some places more than 100 m thick, preserved on the flat regional planation surface are in relation to the retrograde metamorphism, schistosity and mylonitization.

Many granite forms are present both on the eastern marginal slope of the Bohemian Massif and in the Dyje Canyon. They differ substantially in their forms, origin and age. For example, one of the most striking forms in PNP are the large blockfields which occur only in the canyon. The inselbergs, on the other hand, are only on the marginal slope of the Bohemian Massif and in its foreland (Fig. 1).

With the exception of some low exfoliatin domes (ruwares) and rudimentary tors situated close to the upper edge of the Dyje Canyon or above the eastern marginal slope of the Bohemian Massif, no distinct forms such as typical tors or inselbergs are present on the regional planation surface of the etchplain type.

2. The Eastern Marginal slope of the Bohemian Massif

The marginal slope of the Bohemian Massif trending SW is part of a flexure–like structure composed of basement rocks of the Bohemian Massif. The flexure, some tens of km wide is complicated by many mostly antithetic faults with total amplitude of several thousand metres. The marginal slope of the Bohemian Massif is only the uppermost part of this flexure–like structure which is buried below both Miocene and eastwrd, also Mesozoic sediments. The sediments rest unconformably on ancient planation surface. The thickness of the Miocene sediments in front of the marginal slope is up to 150 m [Čtyroký 1991] there. The marginal slope of the Bohemian Massif faces the Carpathian Foredeep. It is probable that the entire marginal slope was originally covered by Miocene sediments and only after regression in the Upper Miocene it was resurrected by subaerial denudation.

The marginal slope probably originated already in the Upper Paleogene, in connection with orogenetic movements in the Eastern Alps and Western Carpathians. Denudation of the marginal slope took place not only in the subaerial environment, but modelation by shore processes was also probable. The marginal slope and its complicated relief was submersed during several marine transgressions and their deposits; sands, gravels and clays are found in differing positions [Čtyroký 1991; Steininger and Roetzel 1991]. In the area of PNP the marginal slope of the Bohemian Massif is relatively uniform and rectilinear, yet in other parts great fault embayements existed which were filled with estuarine deposits. The evolution of the slope, in comparison with the Dyje Canyon, was therefore long–lasting and

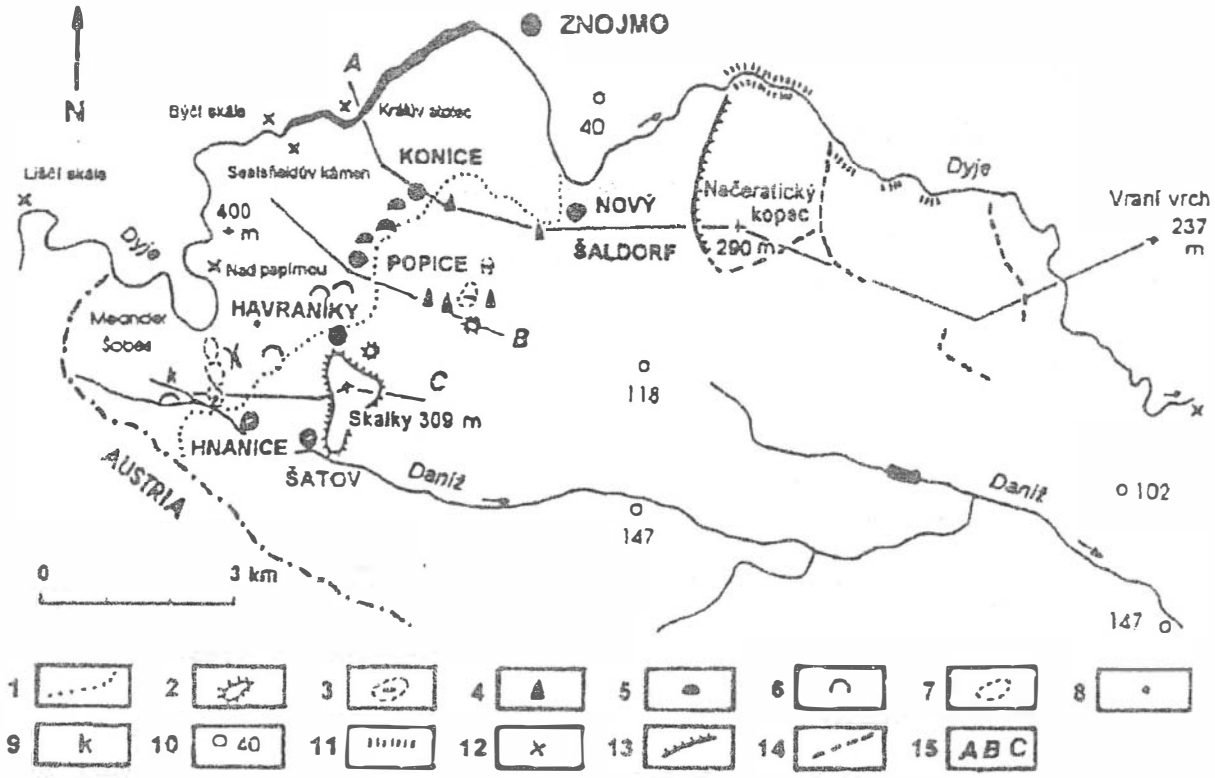

FIG. 1. Schematic map of main granite forms in the eastern part of the Podyjí National Park

1 – foot of the marginal slope of the Bohemian Massif; 2 – distinct inselbergs surrounded by Miocene and Quaternary sediments; 3 – flat surface of granite, at the same level as younger sediments; 4 – sharp granite protrudings above Miocene and Quaternary sediments; 5 – low exfoliation domes; 6 – exfoliation; 7 – less distinct inselbergs; 8 – summit tors with corestones and weathering pits; 9 – outcrops of kaolinized granite (growan); 10 – boreholes, (figure indicates thickness of Miocene and Quaternary sediments) ; 11 – steep slopes of the Dyje river in the gap through to the Krhovice horst; 12 – most important groups of granite valleyside tors in the Dyje canyon; 13 – distinct fault scarp of the Krhovice horst; 14 – other morphologically distinct faults; 15 – geomorphological profiles.

much more complicated.

Although weathering and denudation were the principal relief–forming processes, the slope is tectonic in its origin and later also some faulting occured. That the flexure–like structure found in PNP is complicated by fault tectonics is also evident in the present relief [Karásek 1985]. Some large elevations in front of slope are classified as horsts (Fig. 2, profile A). Cross profiles of these blocks are mostly assymetric and the rests of planation surface on their top parts are also tilted towards the E to a deeper part of the Carpathian Foredeep. The greatest block,

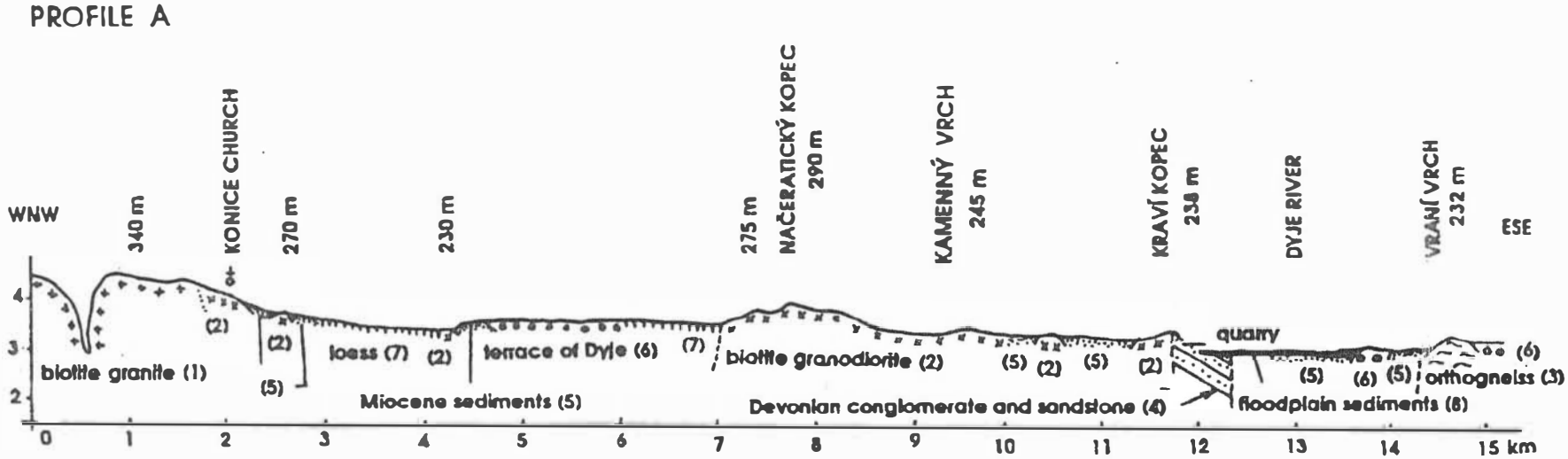

FIG. 2. Profiles across the eastern marginal slope of the Bohemian Massif near the villages of Popice (B) and Šatov (C)

the Krhovice horst, is cut by a tranversal valley of the Dyje river. Together with a general SW trend of marginal slope, in last phase of faulting the N–S direction was important. This is apparent both in the Krhovice horst and in the canyon of Dyje.

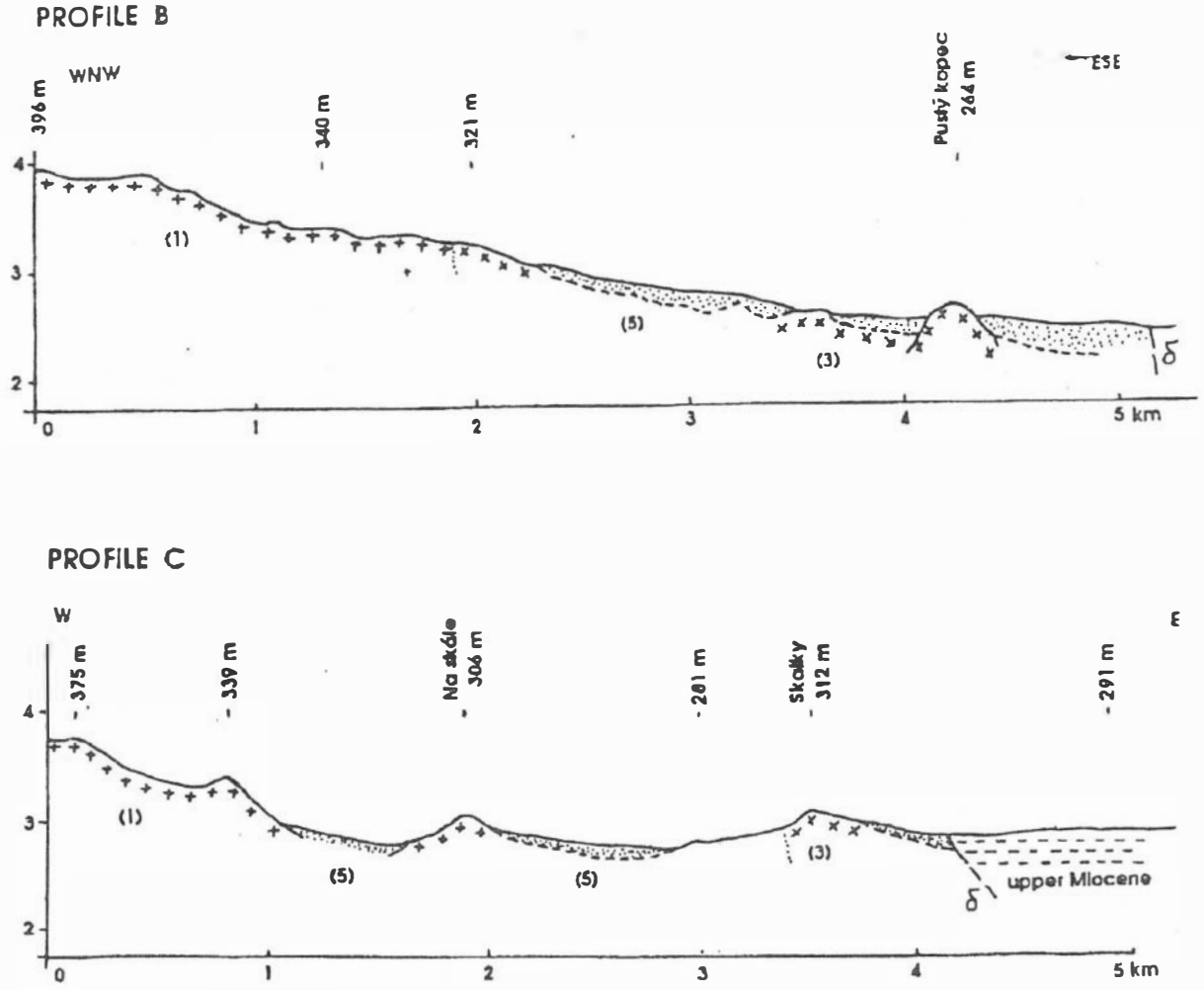

FIG. 3. Profiles across the eastern marginal slope of the Bohemian Massif near the villages of Popice (B) and Šatov (C)

The marginal slope in PNP is very gentle, only some tens of metres high and up to 2 km wide (Fig. 3, profiles B and C). The profile of the slope is mostly smooth, with some granite protrusions. In depressions between protrusions the rests of the Lower Miocene sands and gravels (with perfectly rounded pebbles) are preserved both in upper and lower parts of this gentle slope. At the village of the Konice, gravel pavement composed of monomict quartz with well rounded fine–grained pebbles occurs above upper edge of the slope at an altitude of about 360 m. West of Hnanice, polymict coarse gravel with well rounded boulders lies on the weathered granite. On the other hand, in the abandoned sand–pit west of Hnanice, at appoximately same altitude, below a thin loess cover, sandy weathered granite (with a perceptible clay content) passes gradually into only weakly altered rock, but no corestones are visible. Of course, this deep sandy weathering is probably younger, perhaps Upper Miocene.

The most distinct features of the slope and its adjacent foreland are mostly small isolated hills, protruding from the smooth profile of the slope or the flat piedmont surface consisting of Miocene sediments (Fig. 2, profile A, Fig. 3, profiles B and C). Although their development was really very complex, we classify these forms mostly as low exfoliation domes (ruwares) or inselbergs. Most of them have been strongly damaged by the activity of man, both by granite quarrying and agriculture. Although the rock surfaces (pavements, sheeting slabs) and blocks are many, microforms and typical corestones are scarce. The typical tors, rounded boulders and some weather pits, occur only on upper edge of the slope, near the villages of Havraníky and Hnanice. Here, the boulders are subangular or partly rounded, however, the surround ing rock is only weakly weathered. It is probable, that shore processes were important in the modellation of these inselbergs. They destroyed most of both subaerial microforms and weathering products. Well rounded pebbles also occur, but no traces of abrasion

The structure and profile of the slope are also complicated. South of Znojmo, the main part of the slope is composed of Miocene and Quaternary sediments and only the low (some 2–4 m high) mostly sharp–topped residual hills were exhumed in middle and lowest part of the slope (Fig. 2, profile A). Between the villages of Konice and Popice the uppermost part of slope is characterized by low rounded hills (at an altitude of 313–328 m) which are separated from the highland by shallow saddles.

The hills between the villages Popice and Hnanice, as well as between Šatov and Havraníky, trend generally N, diagonal to SW direction of marginal slope and schistosity of rocks. Neverheless, the schistosity and jointing are important factors in controlling details of the forms. On the top of Na skále hill (306 m), tors, up to 2 m high with two embryonic weather pits occur. The tors consist of densely jointed biotite granite, with subvertical joints 55 – 75°, projecting above only weakly weathered granite.

Between the villages of Nový Šaldorf and Šatov, the low and flat granite elevations on the slope protrude above the Miocene sediments from the foot to the upper edge of the slope. Some of them are flat and inconspicuous. The only exceptions are the oval inselberg Pustý kopec (264 m, relative height 15 m, Fig. 2, profile B) and a similar hill in the village of Havraníky. Between Popice and Havraníky, the middle part of the slope consists of a gently inclined smooth rock surface and exfoliation slabs. Granular disintegration and seems to be an important process at present.

Very complicated
villages of Havraníky, Šatov and Hnanice. Between Havraníky and Šatov the residual ridge, about 2 km long, and up to 20 m high (Skalky 312 m), presents a more advanced stage of separating of elevation from the highland massif. Its foot is not as distinct as Pustý kopec one, and slopes are more gentle.

3. THE DYJE CANYON

The granite and granodiorite section of the canyon is almost 20 km long and in it two subsections of different direction, morphology and river slope, are apparent. In the upper, west subsection trending SE, the canyon is deeper (about 160 m), with

incised meanders, the lower gradient and a relatively well developed floodplain. In the downstream east subsection, from the great incised meander, Šobes, to end of the canyon at Znojmo, the canyon trends NE, suparallel with the east marginal slope of the Bohemian Massif. Its depth is only around 120 m. Its course is not so complicated, however the profile of the valley slopes as well as, the river slope are steeper and the floodplain is almost absent. In addition valleyside tors and blockfields are more frequent.

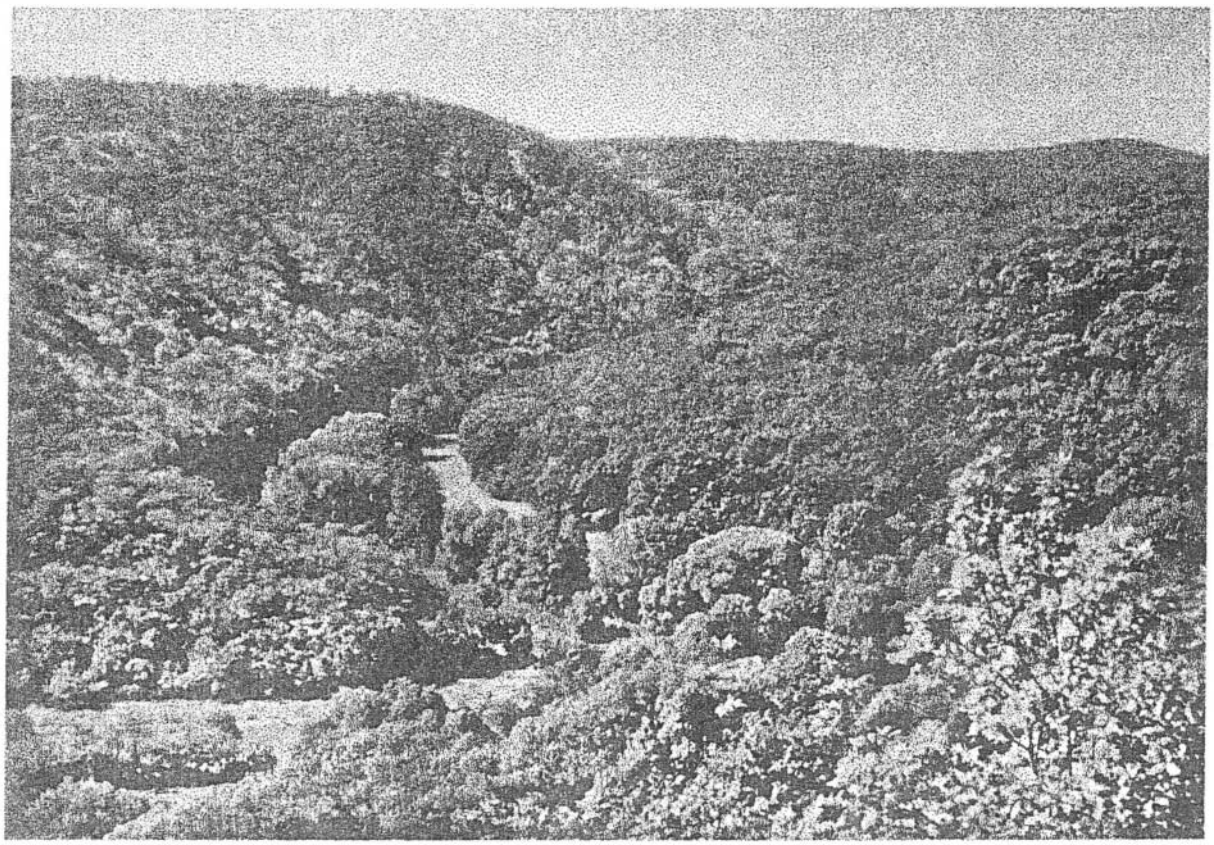

PHOTO 1. Dyje river canyon in the eastern part of Podyjí National Park at the incised Šobes meander (Photo: K. Kirchner).

Although on regional planation surface very thick rests of kaoline weathering crust are known [Neužil and Kužvart 1972; Neužil, Kužvart and Šeba 1980; Holzer and Wieden 1969] relatively close to the rim of the Dyje Canyon, the role of the spatial weathering pattern for course of the canyon is not clear. Owing to the great depth of the canyon, its bottom is everywhere below the basal surface of weathering. The Dyje flows on the regional slope, but the details of its course and especially the course of its tributaries depend partly on the geological structure, mainly on joints and other weakness features.

The granite landforms in the Dyje Canyon are much younger than both the inselbergs and the tors of marginal slope areas of the Bohemian Massif. The Dyje Canyon is thougt to be superimposed from the cover of Lower Miocene (Ottnangian 17,5 – 19 m.y.) brackish sediments (sands and gravels) [Batík 1993]. In the Upper Miocene, in part of the Carpathian Foredeep adjacent to marginal slope of the

Bohemian Massif, marine sediments were deposited. It is probable, that the cutting of the Dyje Canyon started only in the Pliocene. It is also probable, that the present valley pattern differs from the pattern developed after regression in the Upper Miocene. The abrupt change in the direction of the Dyje from the SE to the NE near the incised meander Šobes and residual gravel in saddle (above 40 m above of the canyon bottom) suggest possible changes in the valley's pattern even in the pre-Quaternary period.

In the valley pattern of the Dyje Massif, the influence of the spatial weathering pattern characterized by alternation of short narrow valley sections and small riverine basins, which is evident in topography of some Variscan plutons (e.g. in Žulovská pahorkatina Hilly land and Slavkovský les Mts., [Ivan 1982; 1983]) is not apparent. Most of the tributaries of the Dyje are trending SE, roughly parallel with the canyon, and only in the short lowest course turn to the S or SW towards the Dyje (the most typical being the Granický potok brook). Strict structure control in the drainage pattern (SW direction), can be observed mainly in the less resistant phyllites.

In the canyon of the Dyje river and its tributary valleys, the granite tors are very numerous (perhaps several hundred). They are mostly of the valleyside type according to present classification, e.g. [Ehlen 1991]. There are also several summit tors, situated on the lowered planation surface at the upper rim of the canyon. The are only 1 – 4 m high. The rounded boulders and corestones suggest their two-stage origin. Schistosity and subvertical jointts were very important in their formation.

On the other hand, the valleyside tors occur mainly on steep slopes or canyon walls and are up to some ten metres high. They occur everywhere, both in the lower and upper parts of the slopes. The most dense pattern of tors is found on the outer concave slopes of incised meanders and at the mouths of tributary valleys, where spur type of tors are common.

The most impressive tor forms are found in the vicinities of Liščí skála – Hájka. Králův stolec (King's Table), Sealsfieldův kámen (Sealsfield's stone) and Nad Papírnou (Fig. 1). In valleyside tor development, the vertical joints were very important, but the top parts of the tors are often determined by horizontal joints. Their influence is apparent on those cases where tors occur at several levels, as e.g. Liščí skála (Fox rock). The possible role played by deepening of the canyon during several stages in formation of the both step-shaped of valley slope and the distribution of tors has not been excluded, making further research necessary. The valleyside tors are one-stage forms, in which the processes of physical weathering and gravitational loosening were most important. This is evidenced by huge accumulations of angular debris and block which form numerous taluses, block streams and blockfields. The largest blockfields are under vertical rock walls, both some tens of metres wide and high. At some sites, mainly in subsection between the Šobes meander and the end of the canyon at Znojmo, the blockfields extend from the upper rim of the canyon to its bottom. At Nad papírnou we also found well-rounded river gravels in the material of the blockfields. The uppemost tors at the edge of the valley slope could also be affected by younger (pre-Quaternary ?) chemical weathering, as is shown by granular disintegration of granite and microforms of alveolare weathering of ta-

foni type. The tafoni at Liščí skála developed in the weakly weathered schistosed biotite granite, is up to 150 cm deep, complicated by "rock window" about 0,5 m wide and 0,25 m high. It is the tor, situated directly below the upper rim of the canyon. Exfoliation was also an important process and the sheets are mostly some tens of cm thick.

The steep concave meander slope at Liščí skála is dissected into several narrow ridges or ribs. The ridges are composed of step-like arranged tors, some of them 15 – 20 m high. In their formation, joints in the direction of NNE (200 – 220°) were most important. The tors of ridges are separated by subvertical cross joints trending to ENE (95 - 120°), the trend of schistosity planes is SSW.

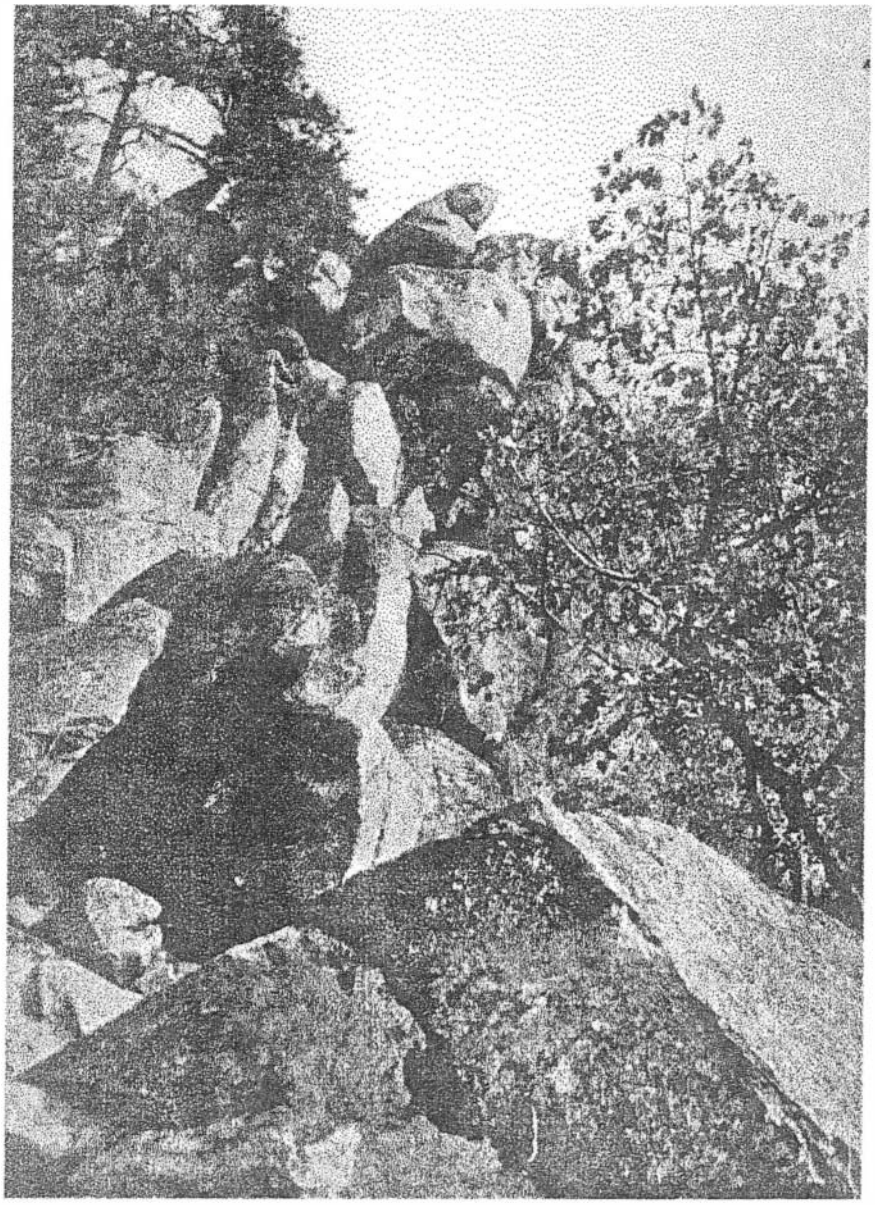

PHOTO 2. Granite forms on the southern slope of the Králův stolec (King's table) (Photo: K. Kirchner).

Similar forms have been found at Králův stolec, where the pseudolapiés and perched block are most interesting. Here, the bulk of granite debris was used in the costruction of cultivation terraces, not only on slopes of about 15°, but also in very steep (up to 25 – 30°) tributary valleys and gullies. In the bottom of one such gully, 12 terrace steps were constructed, practicaly from the head to the foot of the Dyje Canyon. Some fields have an area of only a few m^2. In our opinion, the favourable microclimate (perhaps for vinyards) was a decisive factor in the construction of terraces.

4. Conclusion

In the Bohemian Massif granites and granodiorites are widespread. Study focused mainly on typical granite landforms, such as inselbergs, tors and different microforms (weather pits, pseudolapiés etc.) from the late Paleozoic (Variscan) granites, [e.g. Demek 1964]. The area of the older (Cadomian) granites is smaller and rocks are also mylonitised and cataclased (Brno and Dyje Massifs). They are less favourable to the development of typical granite topography. Plenty of granite forms in the area of the Dyje Massif (especially of tors) is surprising especially when compared to the Brno Massif. This can be explained by less intensive tectonic shattering and a deeper level of denudation. Owing to a very long post–Variscan, mostly acyclic denudation and planation, probably supplemented and completed by marine abrasion, the regional planation surface is very flat and almost featureless. On the marginal slope of the Bohemian Massif and in the Dyje Canyon, however, granite forms of different type and age are plentiful.

The reserch project was supported by the Czech Academy of Sciences internal grant No. 31 459 and a grant from the Ministry of Environment of the Czech Republic – No .774/93.

References

Batík P. (1993), *Geologische Karte des National Parks Thayathal. 1:25 000*, Praha.

Čtyroký P. (1991), *Členění a korelace eggenburgu a ottnangu v jižní části karpatské předhlubně na jižní Moravě*, Západné Karpaty, geológia, 15, Bratislava, pp. 67–109.

Demek J. (1964), *Slope development in granite areas of Bohemian Massif*, Czechoslovakia. Z. Geomorph. Suppl. **5**, Berlin–Stuttgart, 82–106.

Ehlen J. (1991), *Significant geomorphic and petrographic relations with joint spacing in the Dartmoor Granite, Southwest England*, Z. Geomorph. N. F. **35**, no. 4, Berlin–Stuttgart, 425–438.

Holzer H.F., Wieden P. (1969), *Kaolin deposits of Austria*, In: J. Vachtl (ed.): Kaolin deposits of the world. A – Europe, Prague, pp. 25–29.

Ivan A. (1982), *Některé morfostrukturní rysy reliéfu na granitoidech Českého masívu*, Geomorfologická konference, Univerzita Karlova, Praha, pp. 53–60.

Ivan A. (1983), *Geomorfologické poměry Žulovské pahorkatiny*, Zprávy GGÚ ČSAV **2O**, no. 4, Brno, 49–69.

Ivan A., Kirchner K. (1994a), *Geomorphology of the Podyjí National Park*, Moravian Geographical Reports **2**, no. 1, Brno, 2–25.

Ivan A., Kirchner K. (1994b), *Některé vztahy mezi reliéfem a geologickou stavbou v Národním parku Podyjí*, Geologické výzkumy na Moravě a ve Slezsku v roce 1994, 2, Brno, pp. 113–114.

Jaroš J. (1992), *The nappe structure in the Svratka dome*, Proc. Conf. Bohemian Massif, Prague, pp. 137–140.

Jaroš J., Mísař Z. (1965), *Problém hlubinného zlomu boskovické brázdy*, Sbor. geol. věd, G **12**, Prague, 131–147.

Karásek J. (1985), *Geomorfologická charakteristika reliéfu jižní části Znojemska*, Sborník ČGS 90, Prague, 177–189.

Kužvart M. (1966), *Geologické poměry moravskoslezských kaolinů*, Sbor. geol. věd, LG 6, Prague, 87–146.

Neužil J., Kužvart M. (1972), *Petrography of the kaolin deposit Hradiště near Znojmo*, Acta Univ. Carolinae, Geologica 3, Prague, 207–218.

Neužil J., Kužvart M., Šeba P. (1980), *Kaolinizace hornin dyjského masívu*, Sbor. geol. věd. Econ. geol. **21**, Prague, 7–46.

Scharbert S., Batík P. (1980), *The age of Thaya (Dyje) pluton*, Verh. Geol. Bundesanst **3**, Wien, 325–331.

Schulmann K. et al. (1994), *Contrasting styles of deformation during progressive nappe stacking at the southeastern margin of the Bohemian Massif (Thaya Dome)*, Journal of Structural Geology **16**, no. 3, 355–370.

Steininger F., Roetzel R. (1991), *Die tertiären Molassesedimente am Ostarand der Böhmischen Masse*, Exkursionen im Tertiär Österreichs, Eggenburg.

Zvelebil J., Košťák B., Novotný J., Zika P. (1993), *Loosening in the rock slope near the town of Vranov on Dyje*, 7th ICFL. Post conference guidebook, Prague, pp. 4–7.

TVARY NA ŽULÁCH V NÁRODNÍM PARKU PODDYJÍ, JIŽNÍ MORAVA

Antonín IVAN a Karel KIRCHNER

Východní část Národního parku Podyjí je tvořena biotitickými žulami a granodiority dyjského masívu, který je kadomského stáří. Dyjský masív je součástí komplexní variské struktury označované jako dyjská klenba. V žulových horninách jsou vyvinuty typické mezo– a mikrotvary, které jsou rozšířeny jak na okrajovém svahu Českého masívu, tak v kaňonu řeky Dyje. Na plošinách regionálního zarovnaného povrchu jsou tyto tvary vzácnější.

Na okrajovém svahu Českého masívu a v jeho předpolí se nachází výrazné nízké exfoliační klenby a ostrovní hory. Často jsou narušeny těžbou a zemědělstvím. Typické tors se zaoblenými balvany, na kterých se vytvořily skalní mísy a pseudoškrapy, se vyskytují mezi Havraníky a Hnanicemi. Puklinatost a břidličnatost žulových hornin predisponuje tvar a rozmístění drobných tvarů zvětrávání.

Na příkrých svazích kaňonu Dyje se vyskytuje velké množství žulových mrazových srubů, věží, hřebenů i balvanových akumulací (úpatní haldy, balvanové proudy, kamenná moře). Na vzniku tvarů se převážně podílelo mechanické zvětrávání, gravitační odsedání a exfoliace. Na lokalitě Liščí skála v nejvyšší části svahu byly nalezeny dutiny typu tafoni, na jejichž vzniku podílelo předkvartérní chemické zvětrávání. Na plošinách regionálního zarovnaného povrchu typu etchplén leží méně výrazné nízké exfoliační klenby a tors. Okolní plochý reliéf převyšují max. o 5–6 m. Charakteristický výskyt těchto tvarů je v oblasti západně Popic a jihovýchodně Mašovic.

Reliéf dyjského masívu se vyznačuje ve srovnání s rovněž kadomským brněnským granodioritovým masívem množstvím typických tvarů na žulách. Příčinou je pravděpodobně méně intenzivní tektonické porušení a hlubší úroveň denudace žulových hornin.