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L A N D F O R M E V O L U T I O N I N M O U N T A I N A R E A S

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PLANATION SURFACES OF THE SOUTHERN PART OF WESTERN MECSEK

Abstract. Until today still, only a few works (Szabó 1931, 1957; Vadász 1935; Prinz 1936; Lovász 1970; Schweitzer et al. 2005) have dealt with the geomorphologic evolution of the mountain. As a result, there are many debated and unanswered questions on this topic. We applied high-resolution geomorphological mapping and a GIS survey in the southern foreland of Western Mecsek. Several well-defined planation (erosion) surfaces of different location and age were detected, which were classified into four surface groups. For the age determination of the surface groups lying at different altitudes, further investigation is needed. Based on the dip angle values of the individual surface groups and the slope of the southern and northern parts of the mountain we concluded that Jakab Hill behaves as a detached block, and its mass is definitely tilting towards SSW. Similar tilting movements can be observed in case of the Misina–Tubes Range, but it is of a smaller scale. Our results indicate the existence of a fault line between the Jakab Hill and the Misina–Tubes Range.

Keywords: planation surfaces, geomorphological mapping, GIS, Western Mecsek, Hungary

INTRODUCTION

The Mecsek Mountains rise above their surroundings as an inselberg of the Transdanubian Hills with a summit altitude of 500–600 m a.s.l. The Mecsek is surrounded by the Zselic Hills, the Völgység, the Szekszárd Hills, the Geresd Hills and the Pécs Basin (Fig. 1). From geologic and geomorphologic viewpoint the mountain may be divided into an Eastern and a Western part. A fault line between Komló and Hosszúhetény separates the parts of the mountain range.

The Western Mecsek has an anticlinal structure. It is built up of terrigenous Upper Permian and Lower Triassic conglomerate and sandstone, forming the Jakab Hill, and mainly Mesozoic limestone of marine origin, forming the Misina–Tubes Range (Fig. 2).

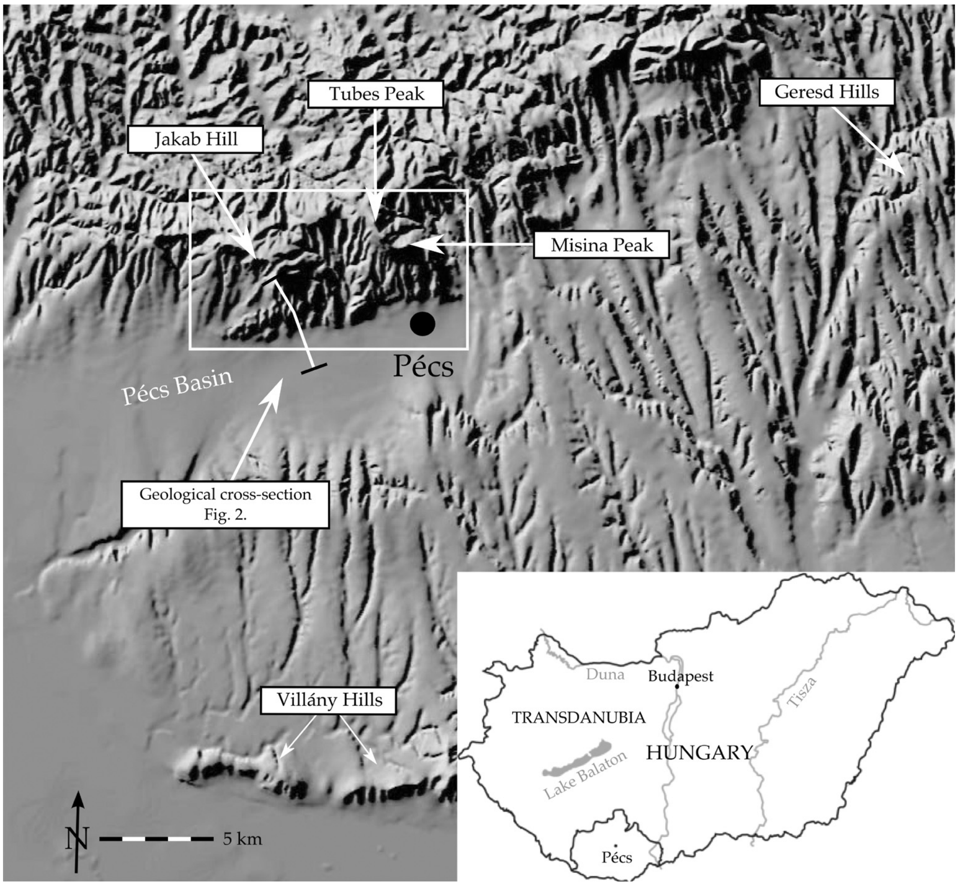


Fig. 1. Location of the investigated area.
Source: http://lazarus.elte.hu/hun/maps/shading/mecsek.jpg

According to the geological and geomorphologic studies of the late 19th and early 20th century, the Mecsek Mountains were surrounded by the Middle Miocene Sea (Böckh 1876; Vadász 1935). The latter geomorphologic studies only provided details about the area of maximum transgression height, which was 300 m a.s.l. (Lovász 1970; Lovász and Wein 1974). Based on the recent geological investigations (Hámor 2001; Fig. 3), only the Eastern Mecsek completely rose above while the Western Mecsek was submerged during the Middle Miocene (Badenian).

Due to the economic interest of the local uranium and black coal mining, as well as the possible location of the high-activity radioactive waste disposal the Mecsek Mountains were thoroughly studied over the past. Only a few investigations discusses to the orographic evolution and geomorphologic surfaces of Western Mecsek.

The theory of planation surface development has been studied since the 1920s (Penck 1924). The relationship between planation surfaces and climate is the ba-

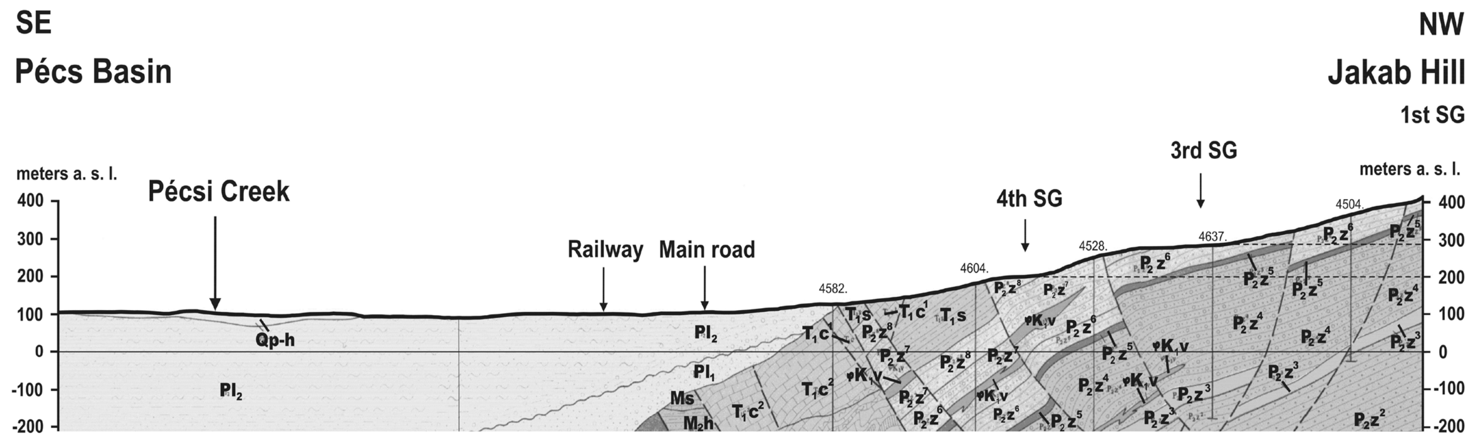


Fig. 2. Geological profile of the Jakab Hill (after J. S z a b ó 1966/1968), 1st SG — 1st surface group, 3rd SG — 3rd surface group, 4th SG — 4th surface group, P_2z^2 — grey sandstone, P_2z^4 — conglomerate under the red sandstone, P_2z^5 — Great Conglomerate, P_2z^6 — gravelly red sandstone, P_2z^7 — dull red sandstone, P_2z^8 — red sandstone (New Red Sandstone) and aleurolite (Lower Triassic), T_1s — Triassic red and green sandstone, schistic argillite, T_1c^1 — Triassic grey dolomitic marlstone with interbedded anhydrock and gyps, T_1c^2 — Triassic darkgrey bituminous marly limestone, K_1v — alkaline diabase (sills in the Werfenian formations), Ms — Middle Miocene yellow oolitic porous limestone, M_2h — Cobble, argillite, argillic sandstone, Middle Miocene formations, Pl_2 — Upper Pannonian cobble, sand and argillic sand, Pl_1 — coarse-grained sand, gravel, intercalated brown coal, Qp-h — Pleistocene loess and Holocene mud and argillite

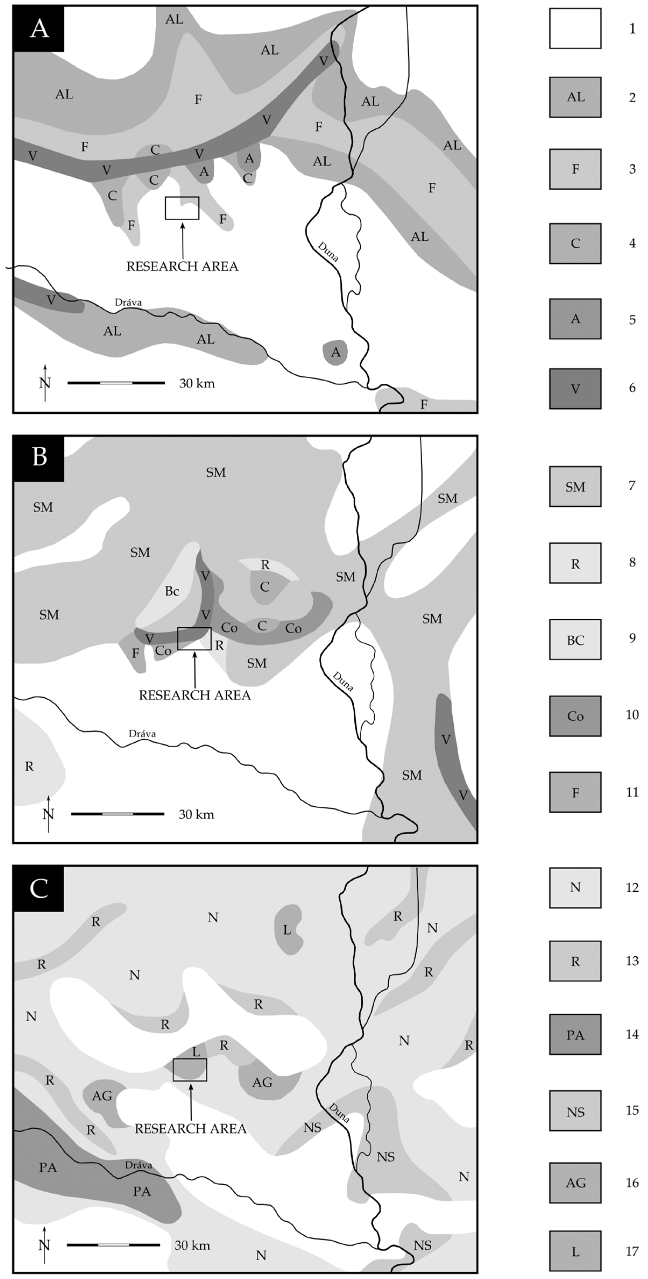


Fig. 3. Miocene facies map of Mecsek and surroundings. A — Lower Miocene, B — Middle Miocene, C — Upper Miocene; 1 — terrain, 2 — alluvial plain, 3 — fluvial sediments, 4 — limnic coal, 5 — andesite, 6 — extrusive acidic vulcanite, 7 — sedimentary basin (molasse, grauwacke), 8 — reef, 9 — Badenian clay, 10 — estuary (Congeria sp.), 11 — fluvial sediments, 12 — neritic sediments, 13 — reef, 14 — pelagic sediments, 15 — littoral sand, 16 — Lower Pannonian abrasion gravels, 17 — lagoonal sediments (evaporites) (after Hámor 1995)

sis for a major philosophic approach in geomorphology knows as climatic geomorphology, which was most forcefully championed by European scientist. A few studies interpreted the origin of planation surfaces as the result of tropical etch-planation (Büdel 1948, 1982; Bulla 1947, 1958), while others interpret them as a result of pedimentation (Birot 1951; Dresch 1957; Mensching 1958; Tricart 1950).

Our purpose was to review former studies and to combine and re-interpret the geologic, geomorphologic researches regarding the development history and Neogene surface features of Western Mecsek. Beyond preparing a geomorphologic sketch map we also defined the relationship among the various identified planation surfaces of the Mecsek Mountains. Besides revealing new horizons, our goal was to correct the delimitation and altitude of the planation surfaces previously identified by classic geomorphologic methods, as well as to demonstrate the vertical movements of the examined part of Mecsek. In the course of the more than 150 years research history of Mecsek Mountains, the national and international stratigraphic chart has changed several times[1]. According to the Hungarian Stratigraphic Committee (Császár 2002; Table 1), the Middle-Paratethys regional timescale was used in our work.

METHODS

The spatial setting and altitudinal relations of the erosion horizons of the southern part of Mecsek were mapped, as well as the dip angle values referring to young structural movements of the different parts of the mountain. A geomorphologic sketch of the examined area was made for the classic geomorphological analysis. Topographic maps in 1:10,000 scales were used, because these could demonstrate even the smaller planation surfaces. The sketch was corrected during multiple field survey.

We compared the extent and area of planation surfaces discussed in the former studies (Pécsi 1970; Prinz 1936; Szabó 1931, 1957) to those of identified by us.

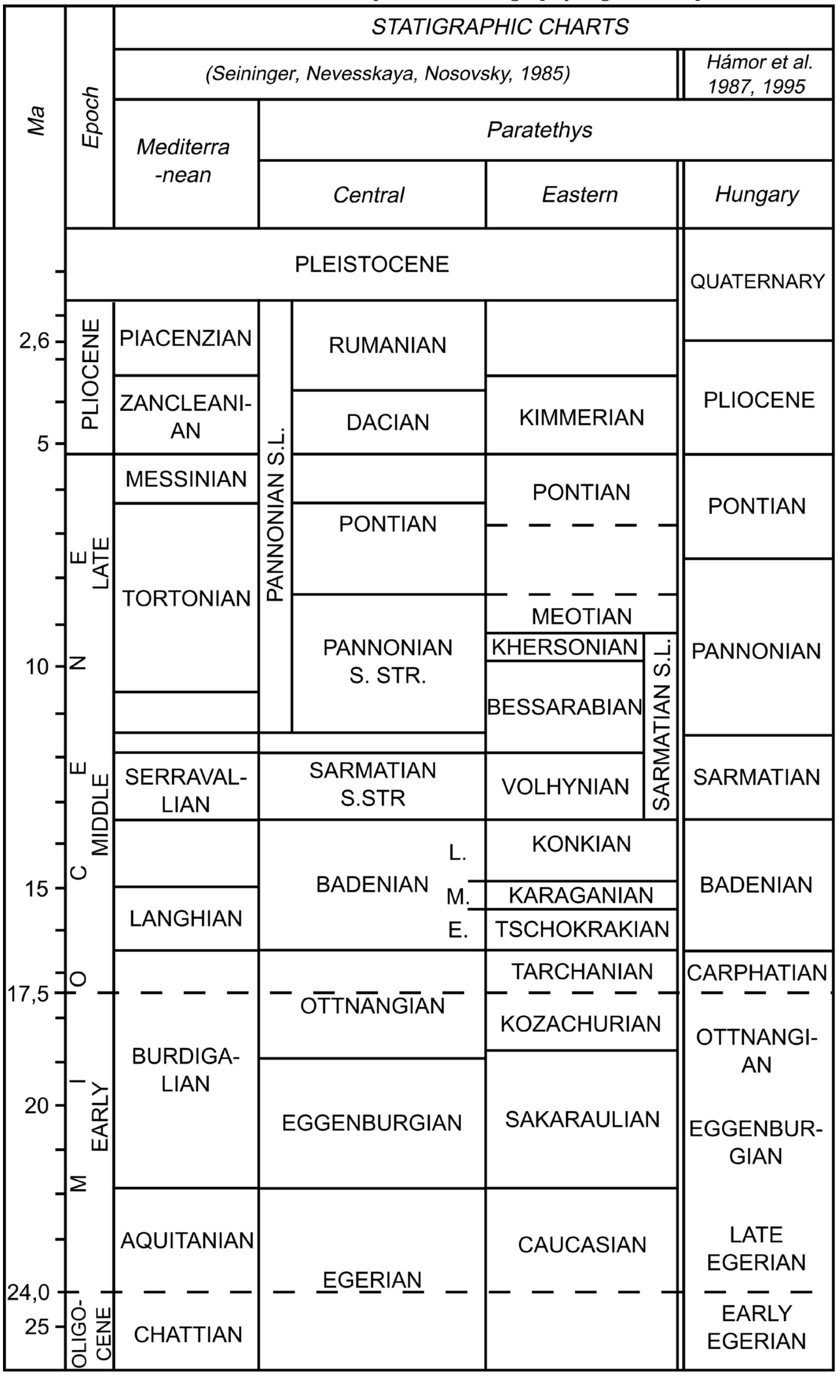
The basis of the GIS analysis was a 1:50,000 scale digital terrain model of the area, which was processed by version 6.1 of the GRASS geographic information system software, with a theoretical resolution of 10 meters.

The first step was to define the typical horizons. A horizon in geomorphology is a surface of a large extent, which may be easily identified, and where the average inclination is definitely lower than on the slopes situated below and above it. Based on the terrain model, a slope map of the area was made for searching these surfaces. Because the map in this way was too detailed, generalization was needed. The generalization was performed by an average convolution matrix sized 11×11 rasters. This way the local, greater and smaller inclination differences unessential

[1] http://www.statigraphy.org/cenoeu.pdf

Table 1

Neogene chronostratigraphic chart of Hungary. Source: G. Hámor et al. (1987); G. Hámor (2001) and http://www.stratigraphy.org/cenoeu.pdf



for the examination disappeared, and only the really important, tendentious grade relations were indicated on the map. Thus the map became simpler to selected the areas that are characterised by lower dip angle values than the average. This way we easily separated relatively steep slopes from close-to horizontal surfaces.

During the next step, 3D image of the terrain model was created, with 1 and 5 times over-heightened, and a previously made map was streched above it. This method provided us to inspect the relation of the surface horizons to each other, and to group them.

Based on the terrain model, profiles were made by the section preparation module of the GRASS 6.0.1 (*d.profile),* and the vertical situation and appearance of the planation surfaces were also demonstrated and photo-documented during field survey.

RESULTS

GEOMORPHOLOGICAL SURFACES AND MAPPING

According to the geomorphologic sketch (Fig. 4) resulting of classical geomorphologic mapping and the modern GIS survey we are able to distinguish four typical surface groups (Fig. 5). Each surface group has similar geomorphologic profile, their formation and age is probably the same.

The oldest planation surfaces *(first surface group)* form the summit region of the mountain (Misina 535 m, Tubes 611 m, Jakab Hill 592 m). They rise above their surroundings by 50–100 meters (Misina–Tubes) and 400–600 meters (Vörös Hill, Jakab Hill). They are separated from the lower surface groups by a definite steep slope (15–35°). Their age is probably Eocene, Oligocene (Lovász 1970).

Below the oldest surfaces, a newer surface group (*second*) can be found, the position of which is quite scattered. These surfaces mostly appear as narrow, thin ridges (Misina–Tubes Range) or flat, dissected residues (SW part of the Jakab Hill). Their elevation is above 400 meters regarding the Misina–Tubes Range, but it is far lower than the oldest planation surface. In many cases they reach the upper regions of the younger, lower planation surfaces. Determination of their age is not clear yet, but according to their position they are likely younger than the Eocene–Oligocene denudation horizons, and older than the presumably Middle or Upper Miocene surfaces that are located at lower elevation. The maximum height of this group of planation surfaces is at an elevation of 350–380 meters, while minimum height is 240–270 meters.

The belt-like, higher surface residue (*third surface group*) extending below the top surface were formerly explained as the abrasion platform of the Badenian Sea (Szabó 1931; Vadász 1935; Prinz 1936). In the 1960s, it was described as pediments without age determination (Pécsi 1963, 1964). Like before, Upper Pannonian abrasion platform was described by recent sedimentological investigation (Chikánné-Jedlovszky and Kókai 1983). This brings us to the con-

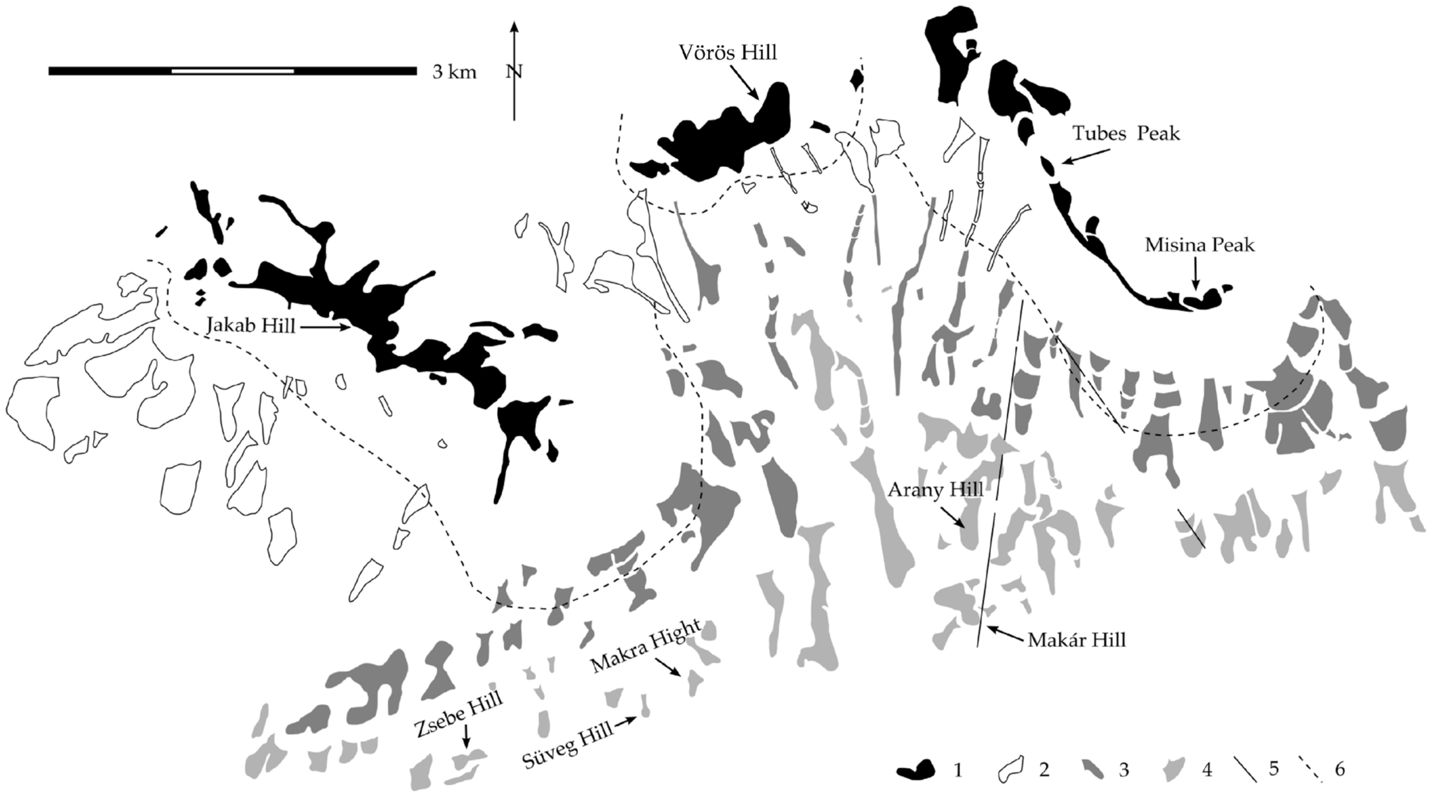


Fig. 4. Geomorphologic sketch about planation surfaces of the Western Mecsek. 1 — first surface group, 2 — second surface group, 3 — third surface group, 4 — fourth surface group, 5 — the location of Pannonian coastal terraces adapted from M. Chikánné-Jedlovszky and A. Kókai (1983), 6 — the location of the abrasion platform of the Badenian sea adapted from P. Z. Szabó (1931) (drawn by K. Lampért and I. P. Kovács)

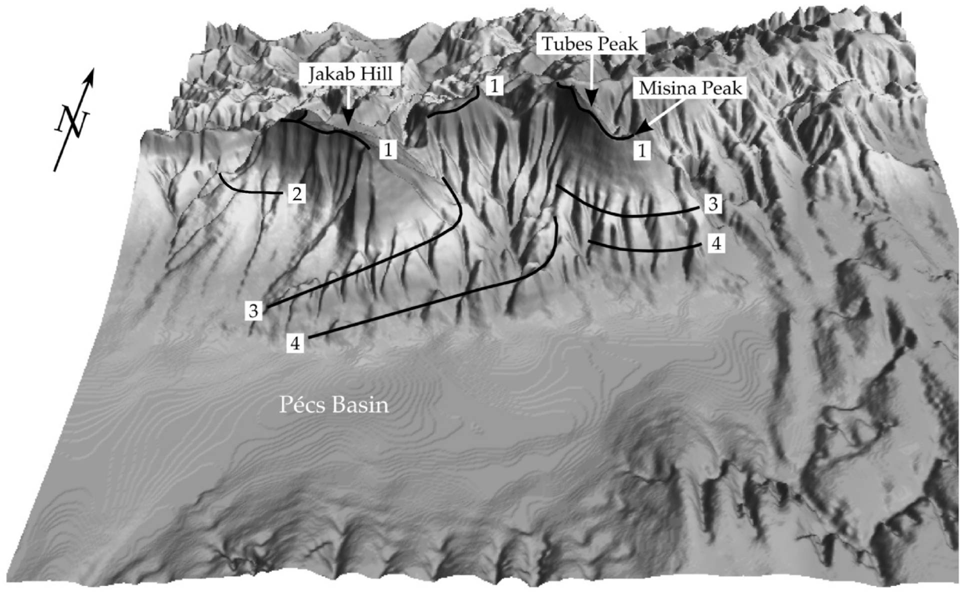


Fig. 5. 3D image of the Western Mecsek and Pécs Basin. 1 — first surface group, 2 — second surface group, 3 — third surface group, 4 — fourth surface group

clusion that at almost similar elevation, with low relative relief the residue of both transgressions may be demonstrated, however they can not be easily distinguished. One of the most important reasons for this is that abrasion activity of the Pannonian Sea affected and transformed the surfaces formed during the Badenian stage, and the young tectonic movement could have altered their positions, too. These surfaces are well separated from the planation surfaces of the other groups. Below the Misina–Tubes Range they tilt slightly, almost negligibly westwards. Their position is 280–300 and 400 m a.s.l.

At the southern margin of the anticline of Kővágószőlős (the south-western slope of the Jakab Hill), below the *third surface group*, surface residue of an altitude of 170–180 meters can be found. On the west they are bordered by the *third surface group*, while to the east they gradually separated from those. They can be observed as lower hills definitely separated and emerged from their surroundings (e.g. Zsebe Hill 117 m, Süveg Hill 168.9 m, Makra Height 182.1 m). On the Zsebe Hill sediments and abrasion pebbles referring to the abrasion activity of the Pannonian Sea are found (Kleb 1973).

These surfaces may also be observed regarding the Misina-Tubes Range, thus forming the *fourth surface group*. Here their position is much more uniform; their elevation varies between 240 and 200–210 meters. According to P. Z. Szabó (1931), E. Vadász (1935) and Gy. Prinz (1936), the lower situated *fourth surface group* is the abrasion level of the Pannonian Sea. These surfaces are pediment-remnants (Pécsi 1963; Pécsi et al. 1988; Schweitzer 1997).

It needs to be noted, however that the planation surfaces were significantly altered over the Pleistocene periglacial periods when younger and smaller extent surfaces were formed (Pécsi 1961; Pinczés 1977; Székely 1977). On one hand this makes the categorization of the surfaces more complicated, but on the other hand it provides further, more detailed insight to the geomorphic development of the area. Because of the tectonic movements of mountains the Pleistocene sediments evolved in periglacial climate were eroded and can be hardly detected in the studied area.

GEOMORPHOLOGICAL SURFACES AND GEOINFORMATICS

After stretching the geomorphologic map on the 3D image of the terrain model it was visible that two horizons on the southern flank of the Jakab Hill can be differentiated. By the side of the Misina–Tubes, a higher and a less emphasized lower horizon can be identified. There is a third less distinct planation surface can be recognise in the Eastern Mecsek, south of the Hármas Hill. These three surfaces have different dip angles: Jakab Hill has the highest, Misina–Tubes has a medium and the Hármas Hill has the lowest (almost horizontal) dip angle. L. Koch (1988) presumes three main and several less important geomorphologic surfaces due to the periodical uplift of Mecsek. According to his observations, and that was also justified by our investigation, the equal ascent of the surface residues extending from Kővágószőlős to the Makár Hill demonstrates a tilted uplift even till nowadays. It was found that the Western Mecsek shows periodical uplift even today and the tilted uplift of tectonically bordered blocks has variant degree.

Regarding the Jakab Hill the *third surface group* surrounds the mountain in 90 degrees: it starts from east and stretches along the entire southern side. Its highest part is the eastern: its elevation is between 320–330 meters here, while the lowest, western part is located at the elevation of 190–200 meters. The distance between these two end points is almost 5.5 km, consequently the dip angle is about 1.5 degrees.

The *fourth surface group* surrounds the mountain similarly to the *third surface group,* but its eastern part is separated from the western by a low valley. Here, too, the eastern part is higher, maximum 270–290 meters, and the western is the lowest: its lowest elevation is 140–150 meters. The entire length of the arch is almost 5.5 km, so the dip angle is also about 1.5 degrees (Fig. 6).

The dip angle of the *third surface group* in front of the Misina–Tubes Range is very small: its eastern part is about 330–340 meters, while its western end is between 310–320 meters. Since the distance between these two end points is almost 2.5 km, the dip angle is only approx. 0.5 degrees. The lower surface (*fourth surface group*) also dips a bit towards west: in the east its elevation is about 240 meters, in the west it's between 210–220 m a.s.l., consequently its dip angle is about 0.5 degrees.

In the vicinity of the Hármas Hill surfaces are uneasy to identify. The area is much dissected, thus broad horizontal surfaces are rare with the exception of surface residues at the elevation of 330 to 350 meters.

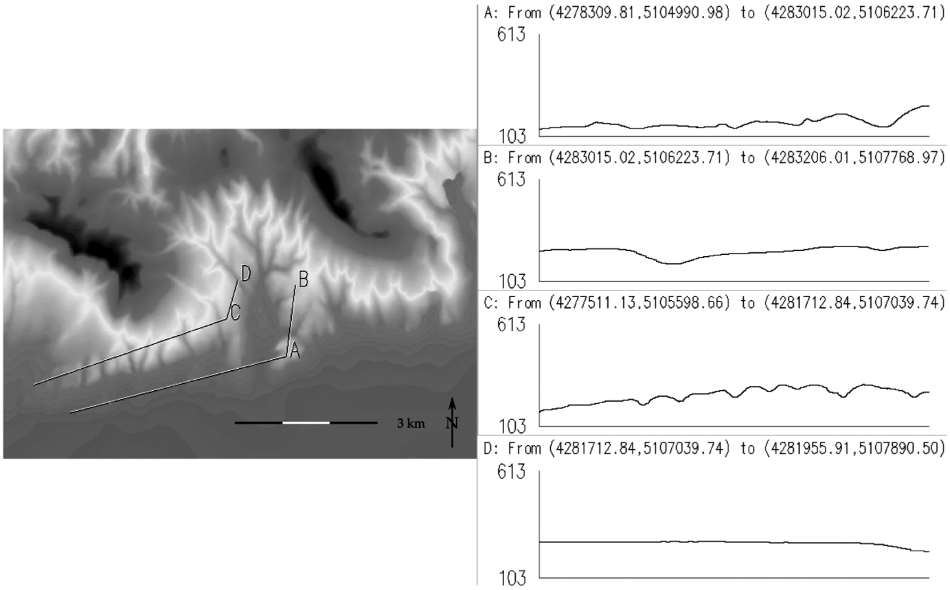


Fig. 6. Profiles of the third (C, D) and fourth (A, B) surface groups in the southern foreland of Jakab Hill. (UTM coordinates, the central meridian is 21°) (edited by T. Bugya)

It is remarkable on the map representing dip angels that, except the surroundings of the Hármas Hill, the western or southern side of each higher group is steeper than the northern side. This is especially visible at the Jakab Hill, because here dip angles are always above 20 degrees (in places over 30 degrees), while on the northern side slopes are generally below 20 degrees (Fig. 7 A, B). The dip angels of the southern side of Misina–Tubes are around 20 degrees, at the steeper parts it reaches 25 degrees, and even the gentlest slopes have dip angles over 16 degrees. The northern side of this range has a slope between in 15–18 degrees, though at some places it reaches 21 degrees (Fig. 7 C, D). Regarding the Hármas Hill we cannot find difference between the northern and southern sides. Consequently, the southern side of the Jakab Hill is generally 8–10 degrees steeper than the northern side, however at the Misina–Tubes this value only 3–4 degrees, and on Hármas Hill no difference was found.

The masses of Jakab Hill and Misina–Tubes Range is tilted to the SSW, straight toward the basin formed in front of the western and middle part of Mecsek Mountains. This tilt is best demonstrated on the mass of the Jakab Hill. It may be well shown that the mass of Jakab Hill is separated along a distinct fault line from the Misina–Tubes Range (Fig. 8). Today, the Éger Creek flows along this fault line. The surfaces to the west are remarkably deeper than the surfaces to the east, and that the southern side of Jakab Hill is significantly steeper than the northern side.

The Arany Hill and Makár Hill in south of the Misina–Tubes Range, lies to the south of the fault line originated from the valley of the Éger Creek (Lehmann

1995). Formerly they belonged to the horizon surface system of the Jakab Hill. This range is the eastern continuation of the lower horizon of the Jakab Hill, which has — similarly to the upper horizon — a north-south strike.

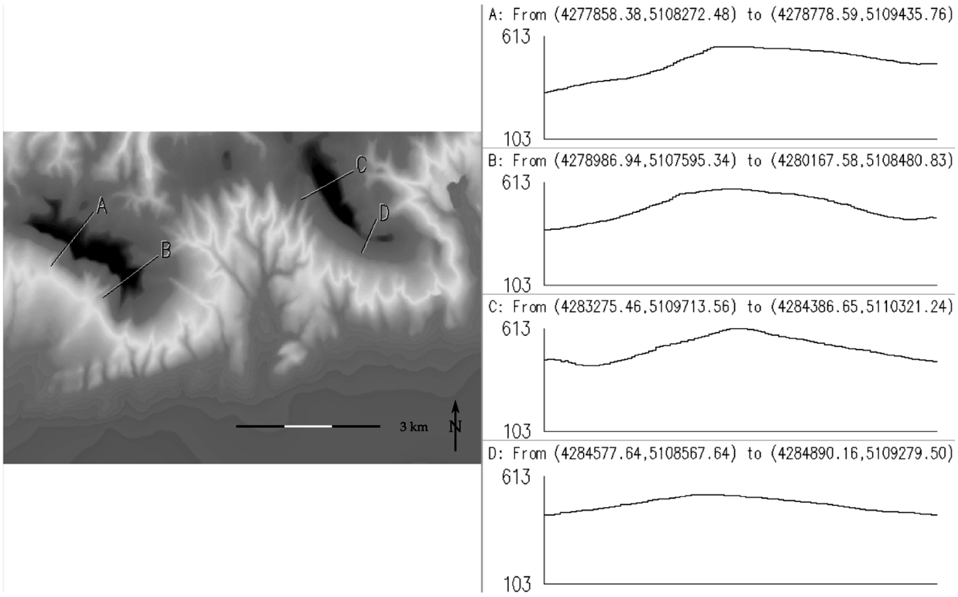


Fig. 7. Cross-sections of the Jakab Hill (A, B) and Misina–Tubes Range (C, D). (UTM coordinates, the central meridian is 21°) (edited by T. Bugya)

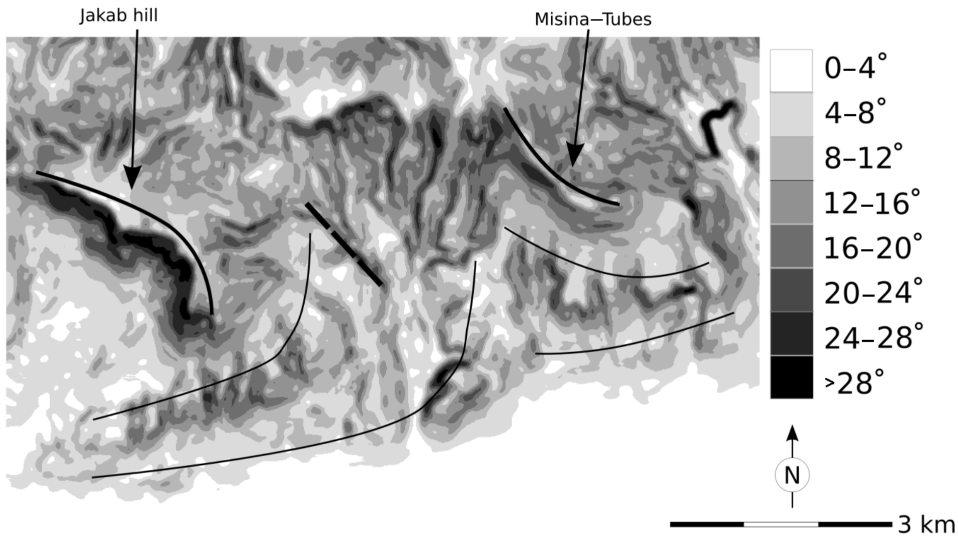


Fig. 8. Generalised slope map of the Western Mecsek. Pecked line — fault line, continuous lines — surface groups (edited by T. Bugya)

DISCUSSION AND CONCLUSIONS

The age of the individual surface groups has always been differently explained; even nowadays the development of the planation surfaces and their chronologic ranking is quite doubtful. On the score of our investigation the surfaces formed on the foreland of Mecsek could interpret as pediments or abrasion platforms reshaped by pedimentation. Recently these surfaces are denudated or dissected.

Four surface groups were set apart in this work. The *first surface group* is composed of Eocene–Oligocene summit, which direction is the NW–SE bearing of Misina–Tubes and Jakab Hill. This group of surface is interpreted as general erosion surface.

The genetics of the *second surface group* may be revealed correctly only by further detailed investigations. Their chronologic ranking regarding the Misina–Tubes Range is much easier as the same as regards to the surface residue in the southern foreland of the Jakab Hill. Here their altitude would place them into the *third surface group*, but we have to consider the tilting of the Jakab Hill — indicated by the other surface forms — which is also evidenced by the GIS survey. Accordingly they are likely much older formations than the third surface group, getting into lower position due to the tilting of the mountain.

The *third* and *fourth surface groups* in the southern foreland of Jakab Hill, decline from east to west, while in the line of Misina–Tubes Range, are almost horizontal. The two blocks are divided by a fault line originated from the valley of Éger Creek. The direction of tilt-axis is the bearing of Jakab Hill and Misina–Tubes Range. Based on the average inclination of the *fourth* and the *third surface group*, angle of 1.5°, SW-tilting of the Jakab Hill was measured. The result of the Misina–Tubes Range was 0.5°, while at the Eastern Mecsek tilting was not measured. The fourth surface group is interpreted as general erosion surface, and the age of origin is maximum 8 Ma (Schweitzer 1997), hence the tilting of the blocks (Jakab Hill, Misina–Tubes Range) should be younger, consequently this is neotectonics.

In our work we did not examine the Pécs Basin, the formation of which is presented by two, apparently opposite theories. Gy. Konrád (2004) and his colleagues suppose pull-apart sedimentary basins renewing in motion in the foreland of the mountain, that have already existed in the Miocene. On the other hand, F. Schweitzer et al. (2005) described a plain opening scissor-like between the pediment surface detaching from the mountain and the mountain itself. In our opinion the opposition of the geological and geomorphological evidence may be resolved by a third hypothesis which summarizes the previous two theories. At first, the incision of valleys was parallel to the inclination of the pediment surface forming after the creation and sedimentation of pull-apart basins and the emergence of the mountain. Presumably because of the submergence of the erosion base and periodical increase of precipitation, a smaller valley was formed in the Pleistocene, which was perpendicular to the previous valleys. This valley could develop as the result of the sheet erosion in the glacial periods and linear erosion in the interglacial periods, until it separated the pediment from the mountain. However, formation of the Pécs Basin remains an open question, requiring further, detailed research, all the more because the permanent disposal for high-activity radioactive waste of the nuclear power plant of Paks is planned to be built in the southern foreland of the Jakab Hill.

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STRESZCZENIE

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POWIERZCHNIE ZRÓWNANIA W POŁUDNIOWEJ CZĘŚCI GÓR ZACHODNI MECSEK

Badania ewolucji geomorfologicznej gór Mecsek były bardzo nieliczne. W dyskusjach geomorfologicznych postawiono szereg pytań, na które do dzisiaj nie ma jednoznacznej odpowiedzi. Dlatego autorzy tej pracy podjęli badania powierzchni zrównania na południowym przedpolu Zachodniego Mecseku przy zastosowaniu kartowania geomorfologicznego, stosując metody GIS. Wyróżniono kilka dobrze wykształconych powierzchni uważanych przez autorów za erozyjne i połączono je w cztery grupy w zależności od lokalizacji i wieku. Dla określenia wieku powierzchni położonych na różnych wysokościach niezbędne są dalsze badania. Na podstawie wartości kąta zapadania indywidualnych powierzchni i stoków południowej i północnej części gór wyprowadzono wniosek, że obszar określany jako Jakab Hill ma cechy odłączonego bloku i pochylonego w kierunku SSW. Podobne przemieszczenia stwierdzono na mniejszą skalę w przypadku pasma Misna–Tubes. Badania wskazują, że istnieje linia uskokowa pomiędzy tymi dwoma jednostkami geomorfologicznymi.