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RECENT FORMATION OF DEBRIS IN THE BÜKK MOUNTAINS, HUNGARY

In the periglacial climate of the Pleistocene very intensive surface evolution took place in the territory of Hungary. In the formation of features a very important role was played by the local differences in relief and the climatic changes during the Pleistocene. In our Central Mountains a predominant part is occupied by the varied periglacial assemblage of forms and debris. In consequence of the degradation processes of reduced intensity the periglacial forms have been preserved to our days in a nearly unchanged state. A number of Hungarian experts have reported on the outer appearance of the Pleistocene features (Pécsi 1964, 1968; Székely 1969, 1973, 1977, 1983; Pinczés 1974, 1977, 1985; Csorba 1982b). In the opinion of Székely (1969, 1973, 1983), Pinczés (1985), Csorba (1982a, b) and Demek (1969) the exposure of the slope is only an influencing but not determining factor in the evolution of the individual periglacial forms.

In choosing the topic for the study, therefore, I endeavoured to examine areas of identical exposure, but characterized of various types of rock and geological structure. My objective was, on the one hand, to verify the primary determining roles of the type of rock, geological structure and relief conditions, on the other hand, to compare the talus cones formed during the Pleistocene and Holocene periods.

GENERAL DESCRIPTION OF THE AREA UNDER STUDY

The area under study (Fig. 1) includes the slope of eastern exposure of the Fénykõ Hill, in the Hór valley, in the southern part of the Bükk Mts. The 700 m long reach of the valley is closed in the north by the Oszla basin, which is covered with dark-grey Jurassic shale series (Bérczi-Makk and Pelikán 1982). The shale series is articulated, in places, by sandstone, flinty limestone or flint settlements. Rising over the alluvium of the Hór valley in the south is the Upper Triassic limestone of Illés-parlag (393.6 m a.s.l.) and Kút-hegy (378.7 m a.s.l.), in the west is Kút-völgy cut into Jurassic shale, and in the east the

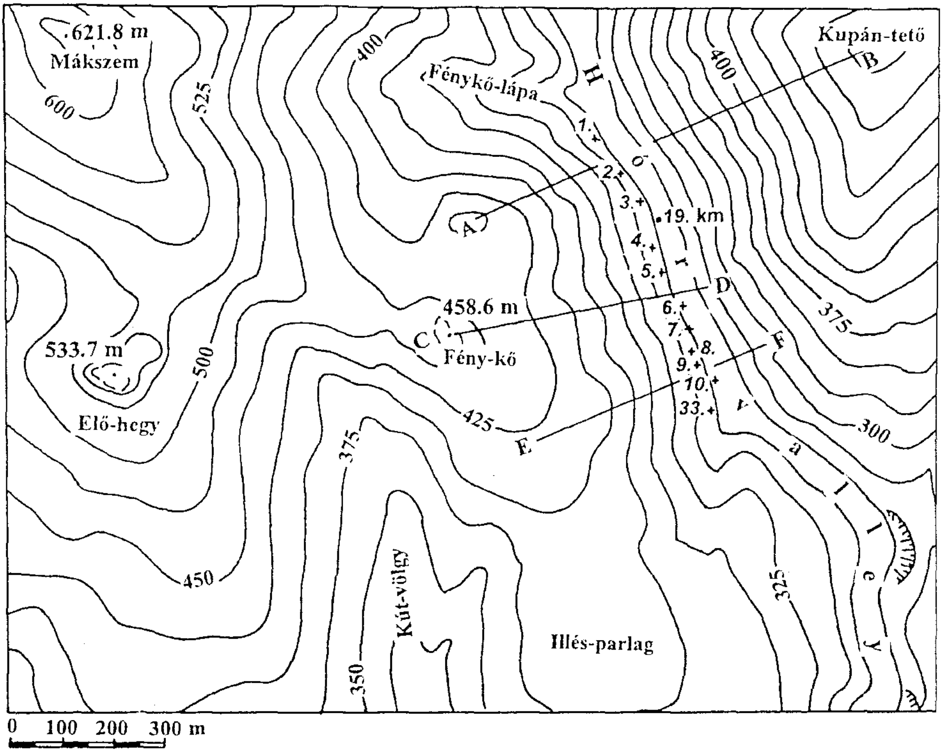

Fig. 1. Topographic position of the area under study in the Southern part of the Bükk Mountains (1–10 and 33 talus cones)

Ryc. 1. Szkic topograficzny badanego obszaru w południowej części Gór Bukowych (lokalizacja badanych stożków gruzowych 1–10 i 33)

area is bordered by the Triassic, Upper-Ladinian flinty, grey limestone mass of Kis-Piliske (534.6 m a.s.l.). The 458–443 m a.s.l. high plateau of Fénykõ, which is lowering towards Bükkalja, is articulated by erosional and derasional valleys, frost riven cliffs, steps. Very characteristic are frost-riven cliff segments retreating into the baserock, accompanied by talus cones.

FACTORS INFLUENCING THE EVOLUTION OF THE TALUS CONES

STRUCTURAL BUILD-UP AND PETROLOGICAL CHARACTERIZATION OF THE AREA

The flinty, grey limestone building up the area under study is of compact texture, grey colour, finely layered (Balogh 1964) and it settled between the soft decaying shale and the more compact, resistent Berva limestone (Fig. 2). The structural section made of the lower part of Kispiliske's slope with western exposure (Fig. 2) clearly shows the settlement conditions of the individual rock

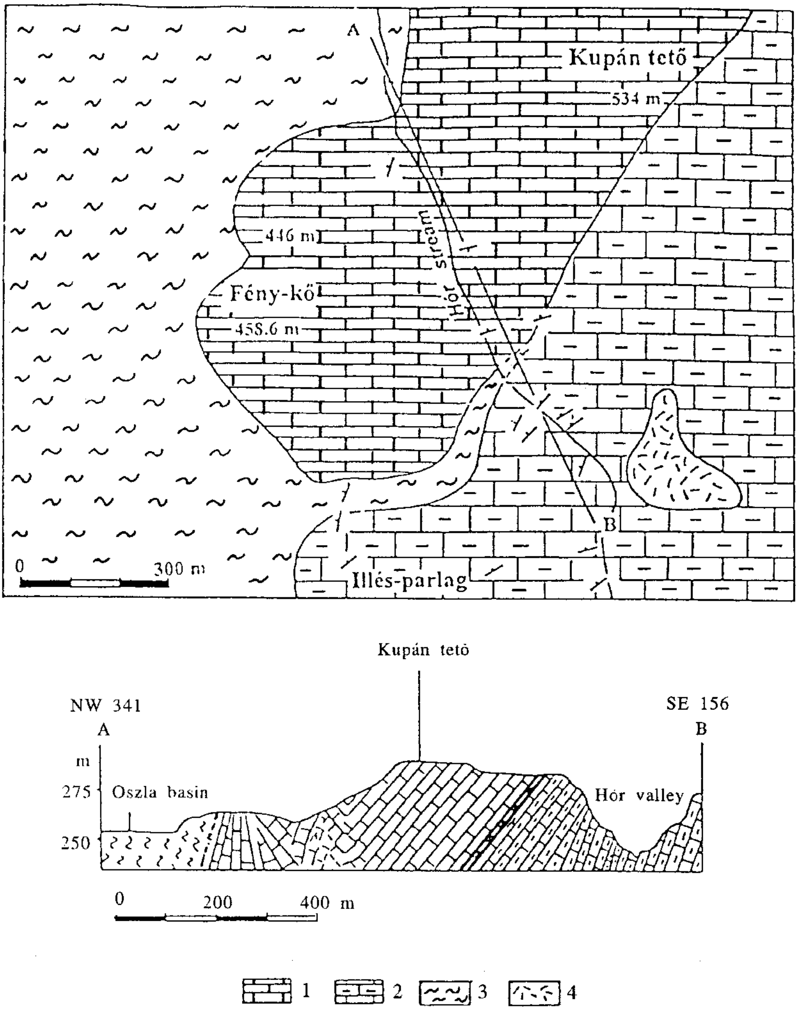

Fig. 2. Geological map of the area under study (modified version of Balogh's geological map, 1964) and geological structural section between the Oszla basin and Illés-parlag.
1 — Flinty grey limestone, M. Triassic, 2 — Berva limestone, U. Triassic, 3 — Dark grey slate series, Jurassic, 4 — Rhyolite tuff, Miocene

Ryc. 2. Mapa geologiczna badanego obszaru (wersja mapy wg Balogh 1964) oraz przekrój geologiczny pomiędzy Kotliną Oszla i Illés-parlag.
1 — szare wapienie z krzemieniami, środkowotriasowe, 2 — wapienie górnotriasowe, 3 — ciemnoszare serie łupkowe, jurajskie, 4 — tufy riolitowe, mioceńskie

masses. The angle of tilt of the flinty, grey limestone layers concordantly settled on the older Berva limestone is 35–40°. The tilt direction of the bedding planes is NW 290–345°. The bassets of the limestone layers settled in parallel outcrop to the surface, get completely denuded, thus yielding a very good basis for the erosional-derasional surface evolution processes and frost attack. Between the two masses of limestone, thin shale and radiolarite bands wedged in, which extend to the southern part of the area under study. Due to the smaller resistance of the shale, lower saddles (Fénykő) and erosional-derasional valleys (Ficsodor-lápa) evolved on it. At the 19th kilometre-stone, on both sides of the Hór valley there are chaotic dips, which show creased-anticlinal-synclinal-folding structure. Towards north the flinty, grey limestone layers are replaced by shale with NW tilt, forming a widening basin (Oszla basin). The limestone layers got arranged in tilted position, in other places in fractured, creased folds. The limestone is intensely fractured, its texture is permeated by a great number of microcracks. To the later power effects — exceeding the capacity of elastic deformation — the compact limestone masses could not respond in any other way but the displacement of the rock layers. The thick web of the cracks in the limestone gave way to outward forces. Water infiltrating the cracks dissolved the limestone surface and produced a whole series of karstic features during the interglacials, whereas in the colder glacial periods of regelation the cracking impact of frost was the predominant surface evolving factor.

CHARACTERIZATION OF THE SLOPES

Owing to the difference in resitance of the above rocks, the tilt of 30–40° and the completely denuded condition of the bassets, the sides of Fénykő are bordered by complex slopes. The mean angle of slope varies between 2° and 10° near the plateaus and saddles, in the upper part of the slope between 21° and 29°. The lower part of the slope is characterized by steep, 38–45° parts. The individual slope sections are separated by smaller terraces. The cross-section figures made of the predominantly eastern (NE, E, SE) slope of Fénykő demonstrate the asymmetry of the valley.

CLIMATE

In the periglacial climate of the Pleistocene a number of frost-riven cliffs and talus cones evolved. The formation of the features was primarily determined by fracturing due to intensive freezing and regelation. The cracking action of ice filling up the cracks is negligible if there is no continuous replacement of water, which is ensured by the water of the capillaries interweaving the rocks (Taber 1943). A very important condition is that the temperature rises intermittently above freezing point, and further amounts of water get into the capillaries. The conditions for cryofracturing are optimal during a fluctuation in temperature between –10° and +10°C. The constantly growing ice crystals exert an extremely strong pressure in the cracks and destroy the structure of the rock (Pinczés 1984). Smaller and larger pieces of debris are separated both from the surface outcrops and from the bedrock. Today, the Southern Bükk is temperately cool, whereas its southern part is an area of moderately dry climate. Transgression in spring of the 10°C limit takes place between 15th–20th April. Transgression in autumn is likely round 10th October. On the last spring frost one can count between 20th–25th April, whereas the first autumn frost is between 7th and 10th October. The mean of the lowest winter minima is between –16 and –16.5°C. The number of frosty days is 120–130. The number of days with snow cover is 50–60, the mean maximum thickness of snow 30 cm. From these data it becomes clear that the climate assuring the development of the cryoplanational forms can be assigned to the transitional seasons in our times. On the other hand, there are only a few days or at most one or two weeks when the recent periglacial climatic conditions prevail. The period of spring-time warming (February–April) is very important since the temperature fluctuates, in this period of time, round freezing point. In consequence of the microclimatic conditions the snow spots remain at the feet of the outcropping rocks resulting in the further fracturing of the rock.

VEGETATION

In the Hór valley of V-shape cross section, due to higher vapour density and lower insolation, etc. the so-called inversion of the vegetation zone phenomenon (Jakucs 1962) is manifested. In the lower third of the valley the plant community of a higher vegetational zone appears: the beech forest. Owing to the overgrowth effect of the vegetation the further development of the forest-covered Pleistocene talus cones is limited in our times. The evolution of recent talus cones is rather restricted to the steeper slope segments in front of the frost-riven cliffs and the edges of the older talus cones, where the movement of the rock debris is not hindered by the vegetation.

MATERIAL TESTS

The evolutional conditions of talus cones originating in the degradation and recession of the frost-riven cliffs were studied in the laboratory. Our aim was to observe the water uptake of the rocks and the grain-size composition of the materials brought about by cryofracturing. From the data obtained we were able to conclude on the rate and quality of debris formation.

WATER SATURATION TESTS OF ROCK SAMPLES FROM THE SOUTHERN BÜKK AREA

From the area of the Southern Bükk 12 rock samples of various materials and ages were collected (Table 1). The pieces of rocks were placed into a vessel filled with water and kept there until the state of saturation was completed (1 month). As a result of the experiment the weight of flinty, grey limestone increased on average by 6.46%, in comparison with the 3.5% increase of Berva limestone and the 13% of shale. This way of water uptake by the rocks and the temporal diversities can be assigned to the quality and structure of the rocks as well as the density of microcracks. The rocks interwoven with cracks, especially shale, took up water continuously. Out of the limestones

Table 1 — Tabela 1

The water-saturation results of the building rocks of the area (in kg) (1–27 No of selected rock samples in the Southern Bükk area)

Wyniki badań nad nasiąkliwością skał budujących obszar badań (w kg)

Results of the water-saturation examination of the building rocks of the area (kg)											
Specimen rocks	Dec. 14.	Dec. 16.	Dec. 20.	Dec. 23.	Dec. 28.	Jan. 2	Jan. 5	Jan. 6.	Jan. 9.	Jan. 12	Jan. 13.
1. Bervai limestone, U. Triassic	0.49	0.49	0.5	0.5	0.5	0.5	0.5	0.51	0.51	0.51	0.51
2. Bervai limestone, U. Triassic	0.65	0.65	0.66	0.66	0.66	0.66	0.67	0.67	0.67	0.67	0.67
12. Flinty grey limestone, M. Triassic	0.425	0.425	0.425	0.43	0.43	0.43	0.44	0.44	0.44	0.44	0.44
13. Flinty grey limestone, M. Triassic	0.25	0.25	0.255	0.256	0.26	0.26	0.27	0.275	0.275	0.275	0.275
14. Flinty grey limestone, M. Triassic	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.355	0.355	0.36	0.36
15. Flinty grey limestone, M. Triassic	0.57	0.57	0.58	0.59	0.59	0.59	0.59	0.595	0.595	0.6	0.6
16. Dark grey slate, Jurassic	0.56	0.57	0.59	0.59	0.595	0.595	0.6	0.6	0.6	0.6	0.6
17. Dark grey slate Jurassic	0.21	0.21	0.23	0.24	0.24	0.24	0.25	0.25	0.25	0.25	0.25
22. Flinty grey limestone, M. Triassic	0.46	0.46	0.475	0.48	0.48	0.48	0.48	0.48	0.49	0.49	0.49
23. Flinty grey limestone, M. Triassic	0.4	0.4	0.405	0.405	0.405	0.405	0.41	0.42	0.42	0.42	0.42
26. Flinty grey limestone, M. Triassic	0.69	0.7	0.705	0.71	0.71	0.71	0.72	0.72	0.72	0.72	0.72
27. Flinty grey limestone, M. Triassic	0.175	0.175	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

flinty grey limestone is more fragmented, thus its microcracks are filled more slowly. At the same time, this type of limestone took up more water because of its looser structure and fragmented state.

FREEZING THE SATURATED ROCKS

In the second stage of the experiment the water-saturated rock samples were placed into the freezing chamber for 73 days. Two samples were selected from each type, one of the two was placed into a dry dish, the other was laid into water. For 22 days the day-time temperature was +10°C, the night temperature was –5°C. Then, for two weeks, the respective temperatures were +10°C and –20°C. For the rest of the period temperature was maintained at +10°C during the day and –10°C during the night. The experiment proved how great a role continuous water replacement plays in cryofracturing. Fracturing was more intense with the samples placed in water. In spite of this fact the rocks mostly remained in one piece, only smaller grains fell off their surfaces. Grains larger than 20 mm in diameter amounted to more than 84% of the material.

EXAMINATION OF THE MATERIAL OF TALUS CONES

On the slope of Fénykő with easterly exposure material from 11 talus cones was collected with the aim of grain-size determination (Fig. 1). The samples were collected from different heights of the cones. With the evaluation of the samples collected the aim was to perform more detailed analyses as to the degree of assortedness of the talus cone materials in downslope direction. The samples analised below served as a good basis for comparison concerning the fracturing tendency of the building rocks of the area and the differences of fossil and recent debris evolution.

1. The recent detrital material of talus cone No 10, which was collected at the northern end of Ficsodor-lápa, is constituted by shale and a smaller amount of radiolarite (Fig. 3). Proceeding in downslope direction the material of the talus cone gets intermittently coarser. There are finer fractions (59.9% coarser than the grit, 2.5% clay) in the medium sample, whereas at the bottom of the slope the coarser debris (75.1% coarser-than-grit fraction, 1.9% clay) was agglomerated.

2. At the talus cone No 10/a is the site where the surface outcroppings of the wedged-in shale and radiolarite stripes are found. The material of the debris is compound: limestone, shale and radiolarite are equally found in it. The material of the still developing talus cone is recent, still evolving material of periglacial origin, in which the proportion of the coarse fraction is very considerable. The material gets gradually coarser proceeding in downslope direction (the coarse fraction is from 64.01% to 84.3%), the secondary maximum detectable for small- and fine-grain sand is characteristic of all curves, at the same time the clay content is gradually decreasing from 4.6% to 1.6% (Fig. 4). This means

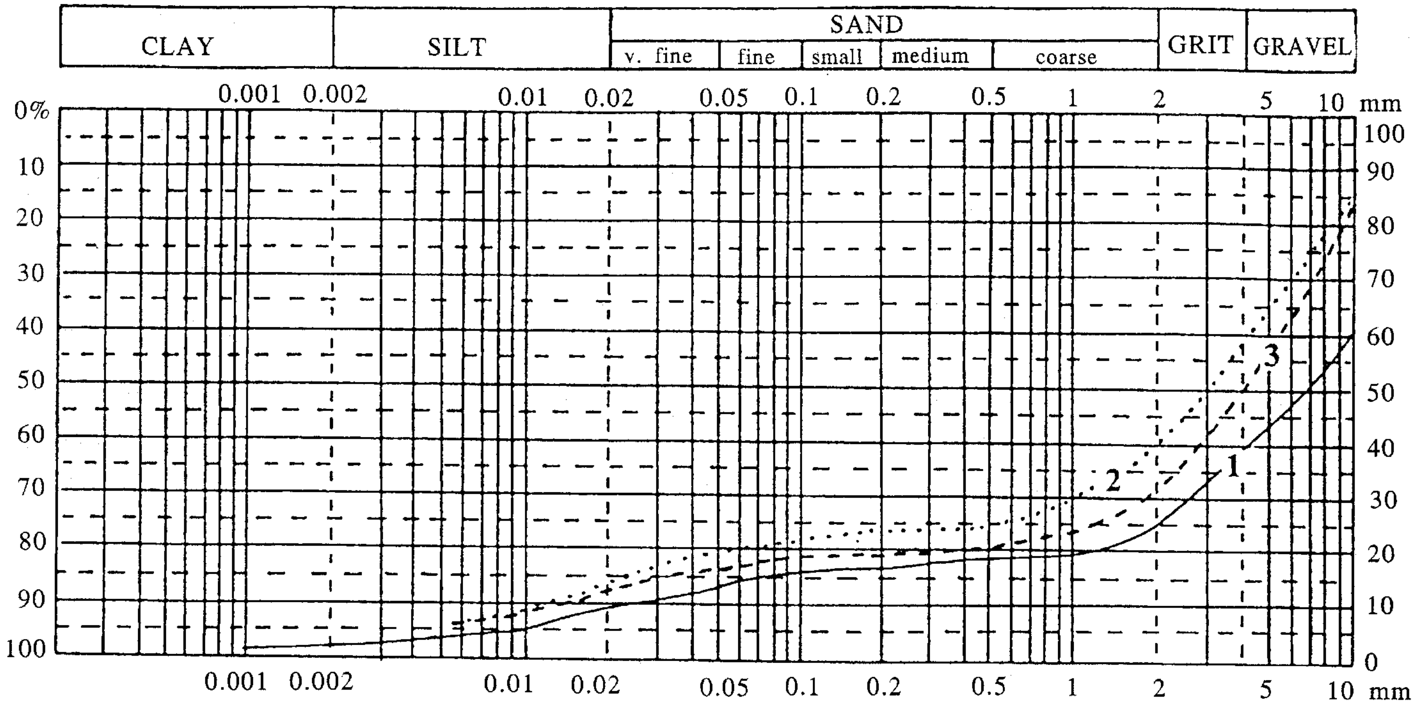

Fig. 3. Granulometric curves of the recent talus cone No 10 (shale and a smaller amount of radiolarite). 1 — 0–80 cm, 2 — 80–150 cm, 3 — 150–420 cm

Ryc. 3. Krzywe granulometryczne materiału pochodzącego ze współczesnego stożka gruzowego nr 10 (łupki i mniejsza ilość radiolarytów). 1 — 0–80 cm, 2 — 80–150 cm, 3 — 150–420 cm

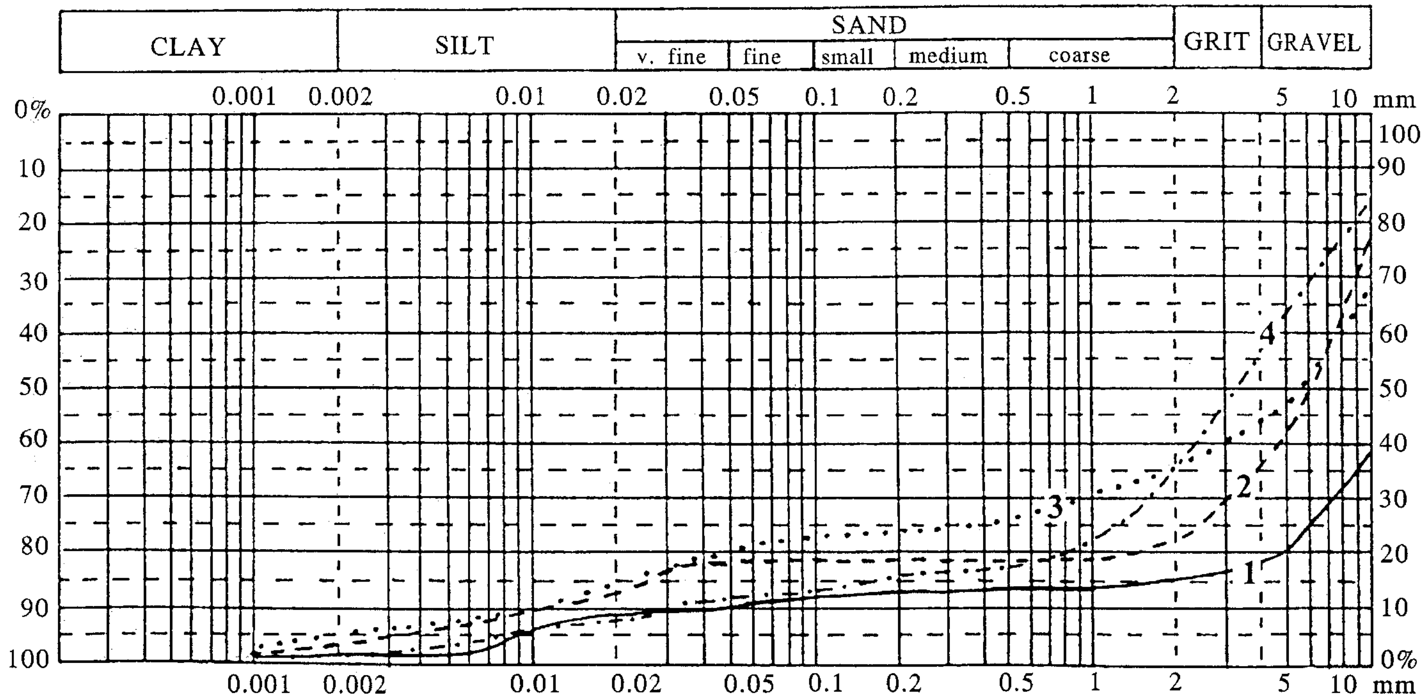

Fig. 4. Granulometric curves of the recent talus cone No 10/a (limestone, shale and radiolarite) and sample No 33 (fragmented shale). 1 — 180–350 cm, 2 — 350–570 cm, 3 — 570–800 cm, 4 — sample No 33

Ryc. 4. Krzywe granulometryczne materiału pochodzącego ze współczesnego stożka gruzowego nr 10/a (wapienie, łupki, radiolaryty) i próby nr 33 (pokruszone łupki). 1 — 180–350 cm, 2 — 350–570 cm, 3 — 570–800 cm, 4 — próba nr 33

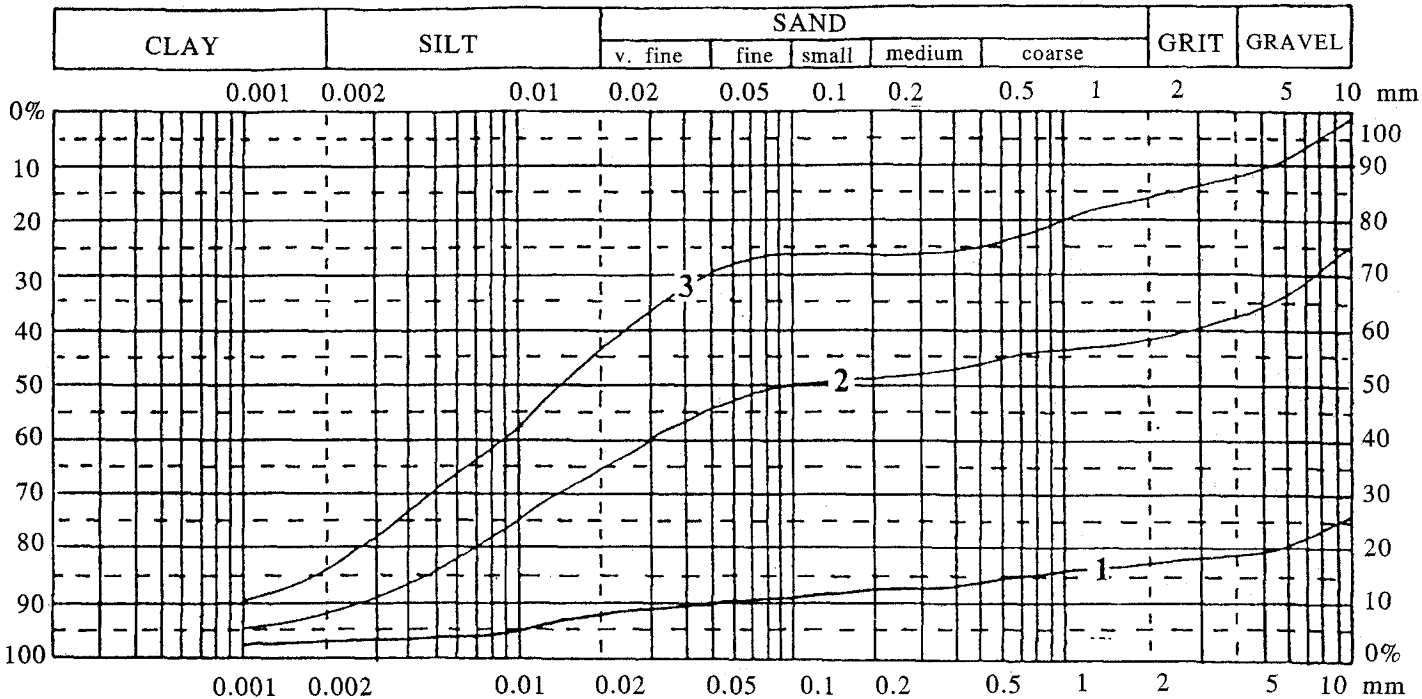

Fig. 5. Granulometric curves of the recent talus cone No 2 (flinty grey limestone). 1 — 470–730 cm, 2 — 1320–1860 cm, 3 — 1860–2020 cm

Ryc. 5. Krzywe granulometryczne materiału pochodzącego ze współczesnego stożka gruzowego nr 2 (szare wapienie z krzemieniami). 1 — 470–730 cm, 2 — 1320–1860 cm, 3 — 1860–2020 cm

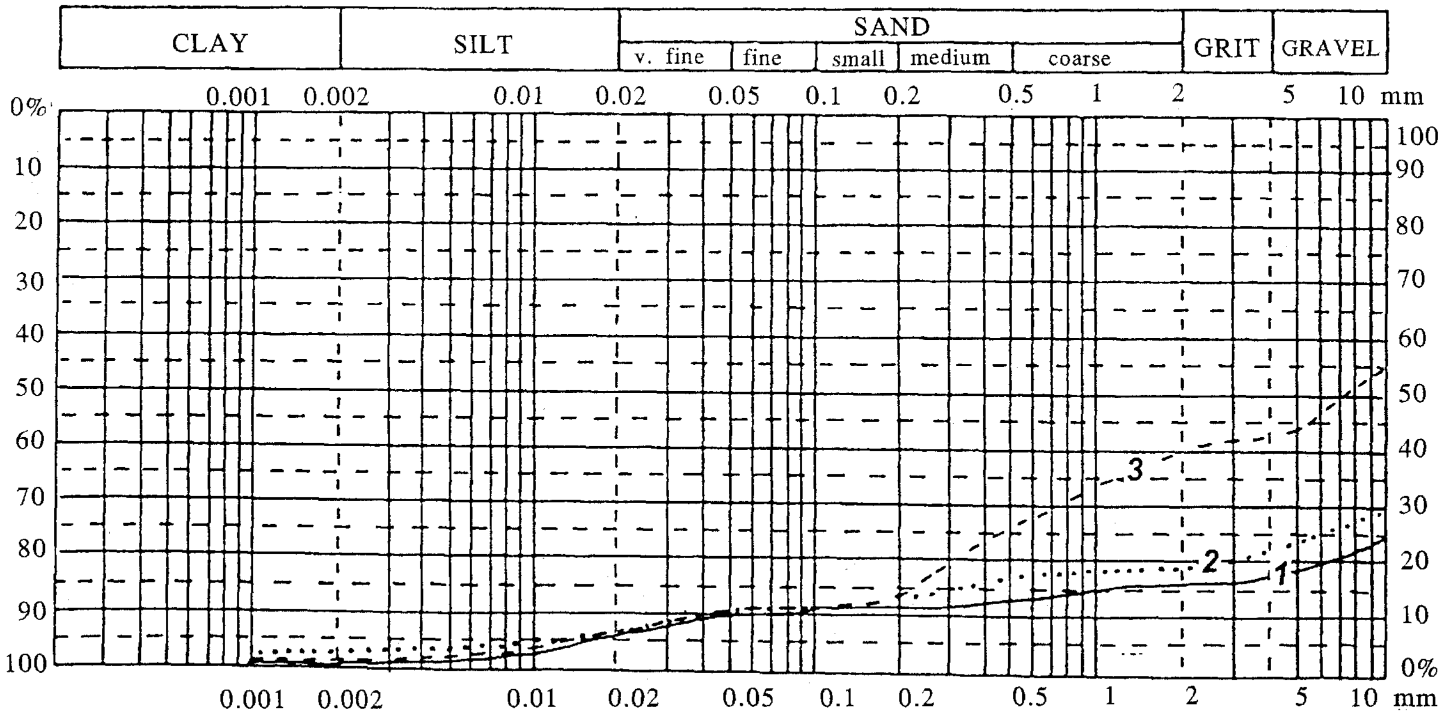

Fig. 6. Granulometric curves of the fossil talus cone No 5 (flinty grey limestone). 1 — 390–440 cm, 2 — 440–780 cm, 3 — 780–860 cm

Ryc. 6. Krzywe granulometryczne materiału pochodzącego z fosylnego stożka gruzowego nr 5 (szare wapienie z krzemieniami). 1 — 390–440 cm, 2 — 440–780 cm, 3 — 780–860 cm that mixed among the coarse rock debris transported downslope gelifluctionally were fine grains, too.

3. The material of the sample No 33 is fragmented shale. It is originated from the area of Ficsodor-lápa and this is a fossil one from the Pleistocene era. The grain-size composition of the building material of the fossil talus cone is finer than that of the recent debris. The greater proportion of e.g. shingle is striking (Fig. 4). The rock pieces are more rounded, showing less sharp edges.

4. The talus cone No 2 shows the evolution of a typical rock arch, which is a recent feature (stone stream) building up on the side of a fossil talus cone (Fig. 5). Its material is flinty grey limestone. The formation of recent limestone debris is less active than was in the Pleistocene era. The larger rock masses broken off the frost-riven cliff were transported gravitationally as far down as the bottom of the slope, however, at the bottom of the rock faces, due to the fracturing of the rock, finer sand was produced. This less coarse, fine material is accumulated locally on the mildly slanting slope, in front of the cliff, whereas receding from the cliff, it already takes part in gelisolifluctional reagglomeration as well. In our days, through the fracturing of the flinty grey limestone it is primarily material with larger diameter grains than grit, or sand fraction that is produced.

5. The talus cone No 5 also serves as a basis for comparison with the talus cone analysed above (Fig. 6) because its material is fossil, from the Pleistocene. The detrital limestone is the product of the fracturing of the receding rocks of a 4–5 m wide "cryoplanational amphitheatre". Today the debris is overgrown by vegetation, which protects it from denudation. The fossil limestone debris is highly assorted and contains hardly any clay (1.7–2.4%). Coarse and medium-grain sand (25.5%) accumulated on the upper, mildly slanting part of the slope. The amount of both the coarser sand (6.5–2.8%) and clay fractions (2.4–1.7%) decreases proceeding downslope. The surface of the pieces of fossil limestone debris is rounded off, there are no sharp edges, in contrast to recent debris.

EVALUATION

On summing up the so far analysed field observations and the laboratory findings, we can establish the following:

1. On the eastwardly exposed slope of Fénykő at identical exposure, debris evolution is going on variedly even in our days. The shape and size of the talus cones are very varied. As for the outer appearance of the talus cones we can attribute a great role to the developmental stages of cryoplanational features. As we have seen, smaller rock arches and wider amphitheatre-like forms developed due to the receding bassets and the bedrock in standup formation. Characteristic in the more ragged northern limestone area with creased structure — where the preservation of limestone was less stable — are the wider, more mature forms, whereas through the recession of the southern bassets in

tilted position but parallel settlement, narrow, linear stone streams and talus cones developed.

2. Debris formation was primarily determined by the quality and settlement conditions of the rocks building up the area (shale, flinty, grey limestone). Nowadays, with the periodic alternation of frost and thaw in the transitional months — especially in February and April — the water getting into the cracks of limestone and shale freezes and destroys the structure of the rock. Because of the fluctuations in temperature the intermittently thawing soil layer supplies water replacement for the rocks rich in cracks. The degradation of the rocks along the layers of limestone outcrop in bassets of 30–40° NW is always more intensive than on the bedding planes. The degrading effect of frost can go deeper here along the bedding planes and the cracks. The stagnant snow spots at the bottom of the rock layers continue to degrade the limestone making the steeply outstanding 4–8 m high frost-riven cliffs more and more unstable.

3. The materials and sizes of the debris formed are different according to the rock types and forms assignable to various periods of time. After 73 days of freezing in the freezing chamber no larger piece of rock came off any rock type. Predominant after freezing was material with grain size larger than 10 mm in diameter. On comparing the older detrital materials, it was found that shale yielded finer factured products than limestone.

On the grounds of a comparison of Pleistocene, fossil and contemporary, recent detrital materials, we can establish that the material of older talus cones is really more assorted, since frost-induced fracturing had a longer time to act, and the edges of the fractured pieces of debris are more rounded. On the other hand, it is very interesting to find that the debris pieces of the older talus cones are, in spite of the enrichment of the coarse and medium-grain sand fraction, larger. The strongly tectonized limestone gradually outcropping from under the shale cover in the periglacial climate of the Pleistocene, could be built up of intensely fragmented blocks of highly unstable position. This unstable support was further weakened by cryofracturing, which widened the cracks between the larger rock masses. When the limestone layers supporting the larger rock pieces and floats were fractured, the latter, having lost their firm support were moved due to gravitation, and accumulated at the bottom of the slope. The debris (coarse and medium-grain sand, grit, gravel) remaining on the upper section of the slope, as shown by the analyses of the curves, were transported downslope through gelisolifluction and, in places, through the surface flushing effect of meltwater and rains. Thus, the debris formed in our days does not reach the amount of the material of the older talus cones. I think it probable that the areal denudation of enormous intensity during the Pleistocene disturbed, in newer and newer depths, the limestone mass intensely cracked in places. The process of facturing was, thus, much more intensive than it is today. The tendency towards equilibrium started as early as that time on the unstable parts of the slope, which is verified in our central mountain regions by the widespread presence of colluvia. Since in our days the conditions for cryofracturing are given only to a restricted extent and in certain periods of time, the fractured debris is of smaller size. Smaller or larger boulders and splinters come off the frost-riven cliffs, and the debris accumulated on the slope is fractured further on the spot. Thus, today characteristic is the enrichment of the sand fraction (coarse and medium-grain sand, small and fine-grain sand) mixed among the stone debris of larger size.

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STRESZCZENIE

A. Dobos

WSPÓŁCZESNE FORMOWANIE POKRYW GRUZOWYCH W GÓRACH BUKOWYCH (WĘGRY)

W górach węgierskich znaczne powierzchnie zajmują różne zespoły form i pokrywy pochodzenia peryglacjalnego. Formy te rozwinęły się wskutek działania degradacyjnych procesów peryglacjalnych, których intensywność w czasach współczesnych jest bardzo ograniczona. Są to ścianki mrozowe, stopnie krioplanacyjne, języki i stożki gruzowe. W przedstawionej pracy zamieszczono wyniki badań nad współczesnymi procesami mrozowymi na obszarach o identycznej ekspozycji, lecz różnej litologii i strukturze geologicznej w Górach Bukowych. Wykonano badania nasiąkliwości wodnej próbek skał oraz wykonano badania laboratoryjne w komorach zimna, poddając próby cyklom zamarzania i rozmarzania. Dla materiału pobranego z pokryw gruzowych określono rolę litologii, struktury geologicznej i warunków morfologicznych (charakter rzeźby). Dokonano porównania materiału pokryw gruzowych uformowanych w plejstocenie oraz w czasach współczesnych. Współczesne formy peryglacjalne są modelowane podczas „współczesnego okresu peryglacjalnego", który zdaniem autorki występuje w górach węgierskich od lutego do kwietnia.