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THE EFFECT OF QUATERNARY CRUSTAL MOVEMENTS ON GEOMORPHOLOGICAL EVOLUTION IN THE MIDDLE DANUBE BASIN

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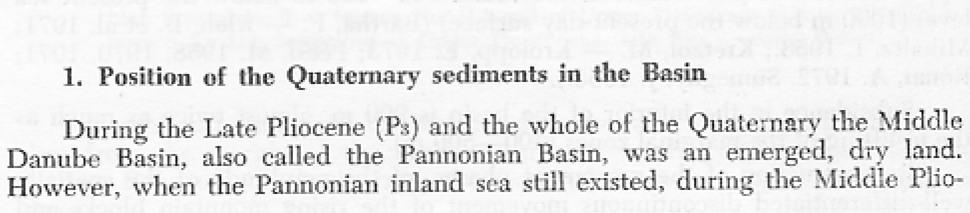
1. Position of the Quaternary sediments in the Basin

During the Late Pliocene (P_3) and the whole of the Quaternary the Middle Danube Basin, also called the Pannonian Basin, was an emerged, dry land. However, when the Pannonian inland sea still existed, during the Middle Plio-



Sl. 1. Položaj Panona u srednjedunavskom bazenu (M. Pécsi)
1 — Temeljno gorje kristalastog sastava; 2 — Temeljno gorje mezozojske starosti 3 — Fliš; 4 — Panon i mlađe taložine; 5 — Položaj panona u prostoru prigorja (— 360 m); 6 — Položaj panona u zavali (— 3000 m); Q — Kvartarne taložine; P — Taložine panona

Fig. 1. Diagram to show the position of the Pannonian sediments in the Middle Danube Basin (M. Pécsi)
1 — Crystalline bedrock; 2 — Mezozoic bedrock; 3 — flysch; 4 — Pannonian and younger sediments; 5 — 360 m — position of the Pannonian sediments in the foothill areas; 6 — (—) 3000 m — position of the Pannonian sediments in the basin; Q — Quaternary sediments; P — Pannonian sediments

cene (P_2) predominantly sands and clayey sands were deposited in shallow waters. From the spatial or orographic position of these Upper Pannonian sediments the maximum amplitude of the vertical movements that occured during the interval P_3—Q can be established with relatively great accuracy. It is 1300—1500 m.

— Along the marginal zones of the Pannonian Basin, bordering the Alps and the Carpathians, these sediments are situated at a maximum height of 400—600 m above sea level.

— While they are found at only 300—400 m above sea level around the Hungarian Central Mountains that traverse the Basin (Figure 1.).

— Upper Pannonian terraces of abrasion were also formed at a similar altitude.

— Yet in the interior of the Pannonian Basin — around Szeged — these Upper Pannonian (P_3) sediments are found 800—900 m below the present sea level (1000 m below the present-day surface) (Bartha, F. — Kleb, B. et al. 1971; Miháltz, I. 1953.; Kretzoi, M. — Krolopp, E. 1973; Pécsi, M. 1958, 1970, 1971; Rónai, A. 1972. Sümeghy, J. 1953.).

Subsidence in the interior of the basin is 900 m, almost twice as much as the uplifting of the marginal zones (400—500 m).

Reconstruction of the movement phases, of the amplitude of the spatially well-differentiated discontinuous movement of the rising mountain blocks and downwarping basin parts is based upon the study of the geological and geomorphological age and position of

— river terraces and sediments

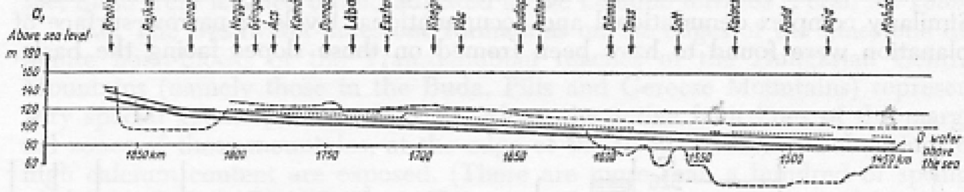
— the planation levels of the marginal surfaces of mountains or (foothill areas) and the rate of accumulation of local alluvial fans

— as well as the formation of freshwater limestone (travertin) horizons closely associated with the former.

2. Valley terraces, planation levels in the piedmont zones and travertine horizons

2.1. Research into the geological and geomorphological problems of the Quaternary conducted in the past decades by Bulla, B. 1941; Cis, P. M. 1962; Fink. J. 1965; Kéz, A. 1957; Láng, S. 1949; Pécsi, M. 1959; Savu, A. — Mac J. — Tudoran P. 1973; Sifrer, M. Vaskovsky, I. 1974) revealed that 5 to 7 Quaternary terraces (marked t_I—tVII) can be found along the rivers that flow from the surrounding Alps and Carpathians into the Pannonian Basin. Rivers flowing from the Eastern Alps into the Pannonian Basin such as the Raab and Mur (Rába and Mura) may have as many as 8 terraces in some places. There are also 6 to 8 terraces along the Danube as it flows through the Pannonian Basin especially in places where it breaks through some mountain barrier such as through the Carpathians in the Porta Hungarica or through the Hungarian Central Mountains at the Visegrád gorge (Pécsi, M. 1959, 1971) or as it finds its way through the Iron Gate pass in the Southern Carpathians (Cotet, P. 1973; Posea, G. et al. 1974). The oldest terraces widely vary in height above the flood plain levêl, and they may be at a relative height of 100 to 250 m.

There are significant differences in relative height between the first and second terraces above the flood plain level (Figure 2).



Sl. 2. Položaj nižih (mlađih) terasa Dunava na području Mađarske (M. Pécsi 1959)
1 — Krivulja »0« točke Dunava na području Mađarske; 2 — Visina terase br. I, tj. nivo višeg dijela naplavne ravni; 3 — Gornjo virmska terasa — br. II a; 4 — Terasa II b, početak gornjeg Pleistocena (kasni ris — rani virm)

Fig. 2. Position of Danube lower terraces in the Hungarian section (M. Pécsi) 1959
1 — Curve of the 0 point of the Danube; 2 — level of terrace No. I, i. e. of the high floodplain; 3 — terrace No. II a end of Upper Pleistocene (Upper Würm); 4 — terrace No II b beginning of Upper Pleistocene (late Riss — early Würm)

Height and number of the terraces decrease, as a rule, in height and number from the margin of the basin towards its interior. Rivers with terraced valleys flow into the basin from the marginal areas forming terraced alluvial fans.

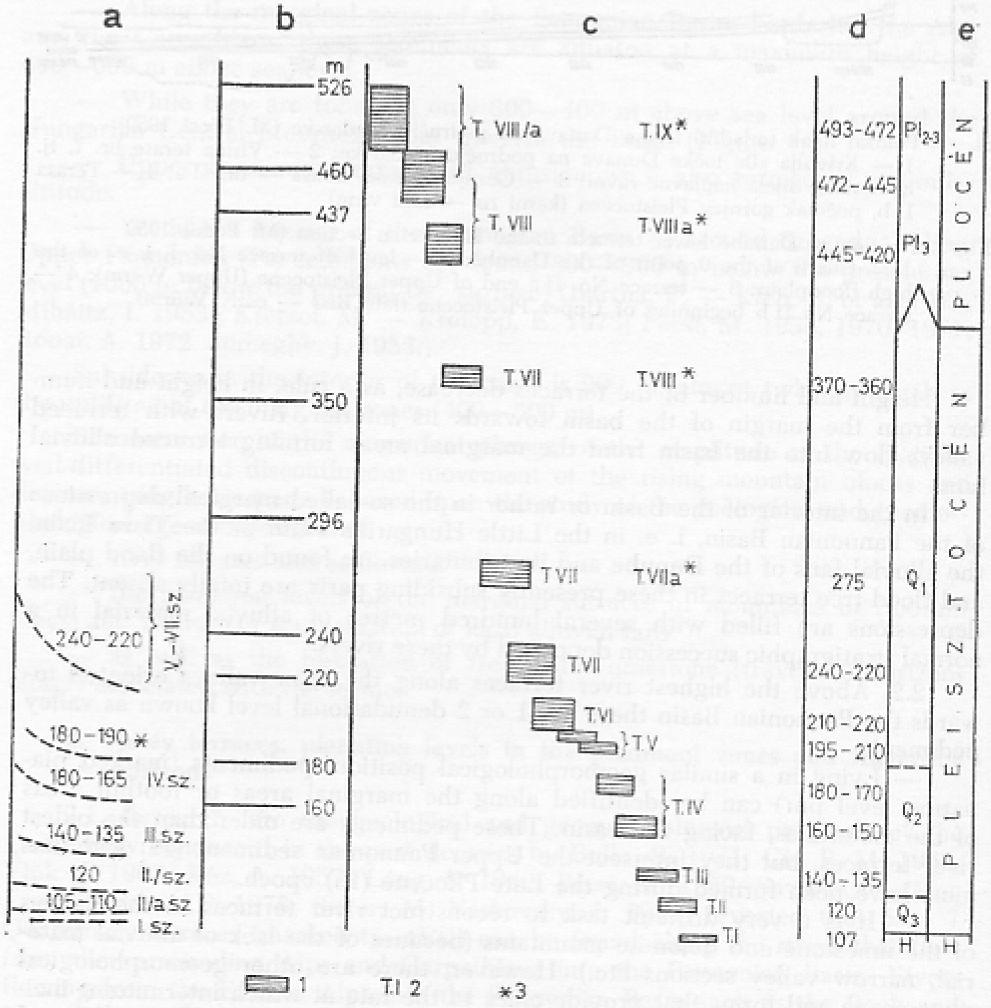
In the interior of the Basin or rather in the so-called marginal depressions of the Pannonian Basin, i. e. in the Little Hungarian Plain or the Tisza Plain, the alluvial fans of the Danube and its tributaries are found on the flood plain, and flood-free terraces in these presently subsiding parts are totally absent. The depressions are filled with several hundred metres of alluvial material in a normal stratigraphic succession deposited by these rivers.

2.2. Above the highest river terraces along the river valleys oriented towards the Pannonian Basin there are 1 or 2 denudational level known as **valley pediments.**

— Lying in a similar geomorphological position, **pediments** (marked planation level pm_1) can be identified along the marginal areas or foothill areas of the mountains, facing the basin. These pediments are older than the oldest river terraces, but they intersect the Upper Pannonian sediment (P_2) and thus must have been formed during the Late Pliocene (P_3) epoch.

— It is a very difficult task to reconstruct river terraces in the valleys of the limestone and dolomite mountains (because of the lack of alluvial material, narrow valley sections etc.). However, there are other geomorphological phenomena and forms that provide clues to the rate at which intermittent incision is characteristic of the river, or about the stages in the development of the river valley. Series of dry caves occur at 4—5 different levels on the valley sides of the limestone mountains. These series of **spring cave** horizons represent each the local base level of erosion at the time of their formation are found on the borderline of the valley floor of that time.

— In wider valley sections of some rivers terrace-like alluvial formations are situated one above the other, the materials they are made of were deposited as local debris cones or alluvial fans of tributaries and do not consist of the alluvial material of the main river. In some cases rock-pediment-like narrow planation levels were formed along the valley sides of the limestone and dolomite mountains. We have been able to prove that these latter **complex erosional-accumulational levels** indicate stages in the development of the main valley. Similarly complex denudational and accumulational levels or narrow surface of planation were found to have been fromed on those slopes facing the basin,



Sl. 3. Travertinski horizonti u Budimskom gorju i faze njihova razvoja (prema Gy. Scheuer i F. Schweitzer, 1974)
a — Dunavske terase u Peštanskoj nizini (M. Pésci 1959); b — Ravni uravnjavanja u budimskom gorju (M. Pésci); c — Glavni travertinski horizonti (Gy. Scheuer i F. Schweitzer, 1973); d — Nadmorska visina travertinskih horizonata; e — Kronološka skala dunavskih terasa I—VII

Fig. 3. Freshwater limestone horizons in the Buda Mountains and phases of their development (after Gy. Scheuer and F. Schweitzer, 1974)
a — Danube terraces of the Pest Plain (Pécsi M. 1959); b — planation surfaces in the Buda Mts. (Pécsi M.) c — main travertine horizons (Gy. Scheuer F. Schweitzer (1973); d — height of travertine horizons above sea level; c — chronological scale I—VII number of terraces

of block mountains made of carbonate rocks. In the hills around Buda for example, these were levelled of and adjusted to the Danube terraces (Pécsi, M. 1959).

2.3. The freshwater-limestone formations on the edges of the limestone dolomite horst-blocks of the Transdanubian reaches of the Hungarian Central Mountains (namely those in the Buda, Pilis and Gerecse Mountains) represent very special geomorphological levels. Along the active fault lines of the marginal zones of these mountains, at the edge of the flood-plains thermal springs of high calcium content are exposed. (There are more than a hundred of springs of this kind in Budapest today). Travertine development occurs under natural conditions in such freshwater spring-lakes. Since these freshwater limestone formations developed in several instances (at the margin of the Gerecse Mts.) directly on top of the Danube terraces, it is highly probable that those travertine formations without an underlying terrace bed were also formed at the then existing base level of erosion. The number of freshwater travertine terraces above the velley bottoms are 8 or 9 and are marked TI—IX (Figure 3.). (Schever Gy — Schweitzer, F. 1970., 1974).

If these freshwater limestone formations are underlain by formations other than alluvial sediments, then they rest in most of the cases on complex erosional accumulational levels.

Depending on their local morphological and tectonic position these travertine horizons vary in thickness from 3 to 30 meters. Due to other circumstances than those mentioned above, the number of travertine horizons usually appears to be greater than that of the river terraces in the area. It seems necessary that those horizons lying at approximately the same level should be grouped together, however their exact morphological classification is not possible at the moment since no satisfactory methodological approach has been developed yet.

The oldest freshwater limestone horizons either overline the Upper Pannonian sandy sediments at a relative height of 300—360 m (Szabadság-Szécsényi hills in the Buda Mts) or they were formed on top of the Late Pliocene pediments, at a relative height of 200—250 m (marked TIX—TVIII).

Freshwater limestone horizons also developed on river terraces at a relative height of 150 to 180 metres. (These are marked TVII—TVI). These were classified as Quaternary formations (Figure 4) of the pre-Günz part of Pleistocene time. (Formed before the Brunhes-Matuyama period).

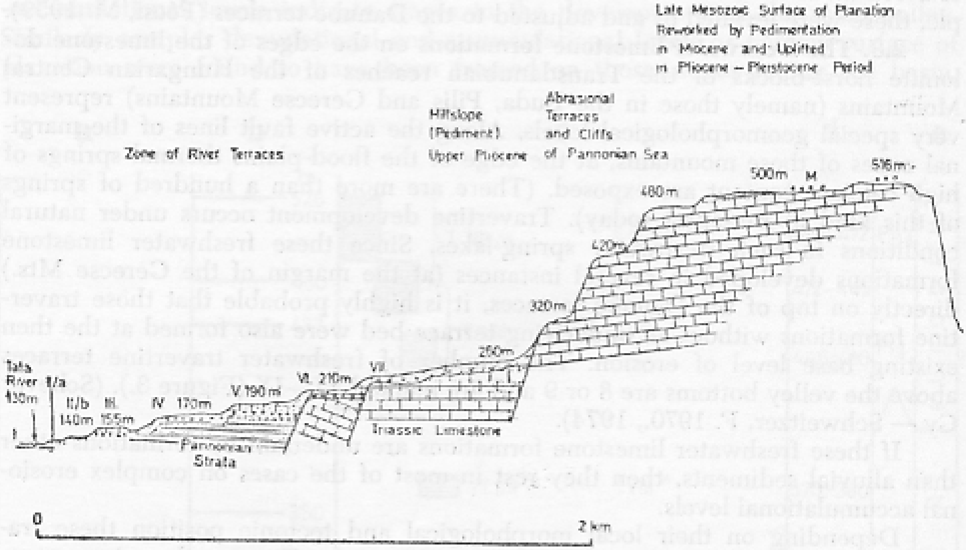
The freshwater limestone formations overlying flood-free terraces V—II. or other levels that can be correlated with these (TV—TII) developed in a rapid succession of 4 stages of development during the Günz-Würm periods and are at present at a 10—20—30 and 50 m relative height.

3. The effect of local and regional crustal movements and climatic changes on the development of the landfoms of the Quaternary.

Are the terrace systems of the Danube and its tributary valleys identical systems, can they be correlated?

The sequence of river terraces and freshwater limestone covers lying above each other in the valley sections along the fault lines in the marginal areas of the mountains, serve, in our opinion as a proof of repeated irregular rhythmic tectonic movements.

Gravels, sandy, loessy sediments and fossil forest soils are interbedded with those freshwater limestone formations that rest on the higher terraces and are 20—30 m thick (Figure 5.). According to our theory on travertine formation,



Sl. 4. Poprečni profil doline rijeke Tata kod Vértesszöllös-a (M. Pécsi 1973)
I—VII. brojevi riječnih terasa; I. — naplavna ravan; II/a — prva neplavna terasa; II/b — druga neplavna terasa; III. — riška terasa; IV. — Mindelska terasa; V. — Ginćka terasa; VI—VII. Preginške terase; M. — Terestrički šljunci miocene starosti

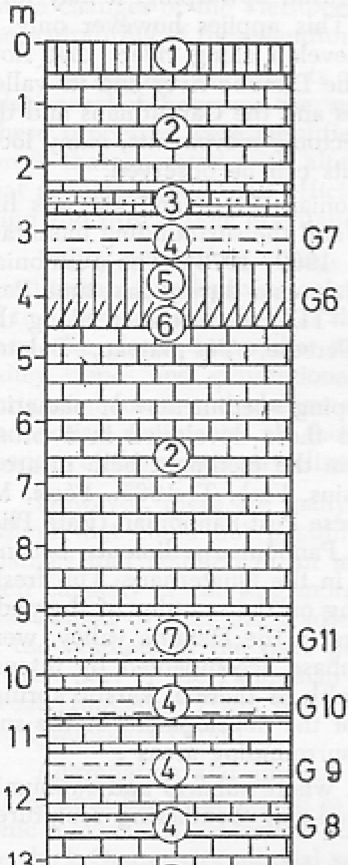
Fig. 4. The geomorphological crossprofile of Tata river valley at Vértesszöllős
I—VII. number of river terraces: I. — recent flood-plain; II/a — first flood-free terrace (Würm); II/b — second flood-free terrace (R/W); III. — Riss I. terrace; IV. — Mindel terrace; V. — Günz terrace; VI—VII. Pregqnz terraces; M — Miocene terrestrial gravels

this 30 m sequence of horizontally bedded formations was only possible if the uplift of the valley bottom temporarily slowed down and underwent phases of oscillation, uplift and subsidence alternatively, during the time of the accumulation of travertines.

Those mountain blocks at the margin of the Basin as well as in the Hungarian Central Mountains that traverse the Basin must have been rising very unsteadily and this is evident from the general and relative height differences of river terraces and of the terrace deformations that exist. Furthermore, the convergence of the alluvial fan terraces of the rivers flowing into the Basin are very diversified, and the frequent changes of the direction of flow in the Quaternary Period are a direct consenquence of the differential rate of subsidence of the partial basins or smaller depressions within the Basin.

The rate of subsidence during the Quaternary Period in the Pannonian Basin and in the partial basins was dissimilar both in space and time as well as in terms of regularity of movement. This is further underlined by the fact that the alluvial fan and river valley of the Basin cannot be treated as identical.

A group of research scientists were convinced that the formation of the terrace systems of the Danube and its tributaries was directly dependent on the climatic changes that occured during the Quaternary Period (Bulla, B. 1941, 1956; Kéz, A. 1937; Láng S. 1949). According to their views the regional development of similar terrace systems in river valleys and the formation of terraces of the same height could only be explained unequivocally by climatic factors that operate on a regional scale. In the earlier stages of research into the development of river terraces, they did not take into account the smaller regional differences that exist in the terrace systems of the Danube and its tributaries.



Sl. 5. Slijed travertinskih naslaga u profilu V-te terase Dunava na SZ dijelu gorja Gerecse (prema Gy. Scheuer i F. Schweitzer)
G_7—G_{11} = Naslage s suprotnom magnetizacijom starije od Brunhes-Matuyama granice (0,69 miliona godina). Utvrđeno paleomagnetskim analizama (prema M. A. Pevzner)

Fig. 5. Profile of the travertine sequences deposited on the terrace No V of the Danube (NW-Gerecse Mountains). (After Sy. Scheuer — F. Schweitzer)
G_7—G_{11} = strata with reversed magnetization older than the Brunhes-Matuyama boundary (0.69 million years) established by paleomagnetic analysis (after M. A. Pevzner).

They presumed that number and height of terraces were the same in the terrace systems of both the Danube and its tributaries. Research findings revealed that there are significant local and regional differences in the terrace systems of the rivers of the Pannonian Basin. (Fig 6, Pécsi M. 1971, Savv, Al et al. 1973. pp. 172—173; Vaskovsky, J. 1974; Winkler — Hermader, A) 1957; Zamoriji P. K. 1961.

Our observations in this field of research seem to disprove the extremist attitude adopted by those who are convinced of the tectonic theory of terrace formation, namely that each phase of subsidence in the basin is followed by a similar phase of terrace formation in the river valleys in the mountain belt, or of the alternative theory that a sudden (or more lasting) uplift of a mountain results in the formation of a specific terrace. In this latter case for example a whole system of terraces may be formed i. e. the formation of several karstic valleys and terraced valley sections is possible. If the river in an uplifting mountain or valley is able to maintain a state of equilibrium and the riverbed develops under these conditions during the time of crustal upwarping, it may form terraced valleys with a succession of terraces. This applies however only to short tivers of valley sections, and it cannot develop along rivers that flow across several partial basins as is the case with the Danube river and its valley system. In the ring of mountain frame of the Alps and the Carpathians and the Dinarids beside the general trend vergency of tectonic movements, many local and dissimilar movements of mobile tectonic units can be observed.

3.1. The slow recession of the Upper Pannonian (P_2) inland sea was linked with a gentle epeirogenetic rise of the Basin and the surrounding mountain belt (East-Caucasian tectonic phase (Gy. Wein, 1969, 1973). The Pannonian sea gradually turned into landlocked freshwater lake and during that time Pannonian freshwater limestone sheets (marked TX—TIX) were formed along the margins of a some mountains (Buda Mts, Gerecse, Tés-plateau, Balaton Highland).

In the next stage the formation of gently sloping »pediments« or planation surfaces (pn_1 pn_2 levels) became prominent and these developed in a broad belt along the marginal zones of the mountains in the piedmont belt, in areas facing the Pannonian Basin or one of its subbasins. Fink, T. 1965., Pécsi, M. 1959, 1970., Winkler — Hermaden, A. 1957.) These Post-Pannonian (Late Pliocene, P_3) denudational levels, which intersect the Pannonian sediments, became the initial levels of terraced valley development in the Quaternary. The freshwater limestone sheets (TVIII—TVI levels) resting on the margins of the pediments that lie at a relative height of 200—230 m in the Danube valley, were formed as a result of the Wallachian tectonic phase accompanied by intense thermal spring activites. Hence the resulting wealth of thermal karstic springs Late Pliocene teconic movements were crucial for the development of the surface landforms in the Pannonian Basin and the surrounding areas .

— The Basin became an emerged dry land, where subarid and subhumid processes (such as deflation, areal denudation, red-clay weathering sculptured the landforms;

— in the surrounding ring of mountains around the Basin in a broad belt: planation surfaces developed as a result of pediplanation, these sediments were joined by enormous alluvial fans towards the interior of the Basin.

During this period there were 2 tectonic phases of movement none of which resulted in a significant differences in the relief of the Late Pliocene.

The basic characteristics of the long process sof landform development in the Late Pliocene were still reminiscent of the morphogenesis of the Neogene, which could be summarized as planational landforming.

3.2. During the Quaternary Period (about 2 milion years) the overall sculptural pattern of the relief became totally different, and land was modelled so that valley and terrace forms became predominant. The new sculptural elements (valleys, terraces, glacial and periglacial forms and phenomena were superimposed onto each other. As a result of fast cyclic development they were either superimposed or cut into former landforms in rapid successions. Thus the rather monotonous Late Neogene planational-accumulational landforms were greatly dissected during the Quaternary.

The dynamic and revolutionary change of su:face forms developed partly as a result of repeated cyclic phases of tectonic movements which could be differentiated both in time and space and had differing effects, and partly by the cyclic changes of the Pleistocene climate that also played a determining role in the sculpturing of these landforms.

The tectonic movements of the Quaternary increased the angle of slope the relative relief between the subsiding basins and the rising mountain frame. These processes were amplified repeatedly and selectively by the exogeneous forces that operated with alternating intensity depending on climatic changes that predetermined their efficiency as erosional agents (running water, glaciers, wind and frost action, gravitational movement, etc.).

Valley incision on a large scale and the formation of 100—300 m deep incized terraced valleys was only possible in the mountains and hilly areas because of the predominant effect of the Quaternary tectionic movements. On the other hand, the glacial forms that developed on the high mountain ridges and steep valley slopes and gravitational forms and derasional, gravitational and other periglacial forms and phenomena on terraces, and the accumulation of deluvial and eolian sediments, all these processes and forms, were due to the cyclic changes of the quaternary climate.

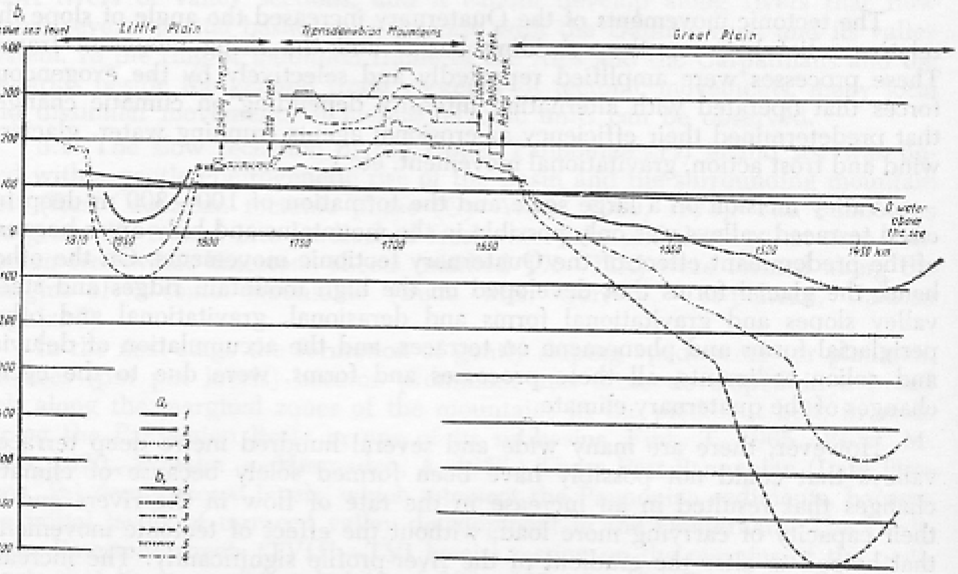
However, there are many wide and several hundred metre deep terraced valleys that could not possibly have been formed solely because of climatic changes that resulted in an increase in the rate of flow in the rivers and in their capacity of carrying more load, without the effect of tectonic movements that helped to alter the gradient of the river-profile significantly. The increase in the gradient of the river profile was due the differential subsidence in the greater part of the Pannonian Basin, including the Little Hungarian Plain, the Great Hungarian Plain, the Dráva-Sáva trough etc. during the greater part of the Quaternary Period.

Aggradation and alluvial fan formation characterized the subsiding basins under both the drier glacial as well as the wetter interglacial periods. Thus tectonic movements controlled both the accumulation of the several hundred metre thick Quaternary alluvial sequences as well as the formation of **valley pediments** in the surrounding belt of mountains and hills.

Valley incision in the interglacial periods and accumulation in the glacial period due climatic changes, would not have been a sufficient cause for the development of several hundred metre deep terraced valleys. The increase in the angle of slope between the may terraced deep valleys and the deeply in--filled aggraded basin are due to the combined effect of tectonic movements and climatic changes. These two forces, in the majority of cases especially in the mountaneaus valley section, mutually reinforced the effect produced by each. These forces facilitated the aggradation of valleys characteristic of glacial periods and valley incision in the interglacials. This latter phenomenon is due to the fact that those parts of the valley system of the Danube and its tributaries that were freed from the overburden of the ice would rise more rapidly for a period of time.

4. Phases of movement in the Quaternary Period

Changes both in time and place due to tectonic movements in the Pannonian Basin during the Quaternary Period were reconstructed on the basis of evidence provided by a comparison to the presentday gradient of the river profile of the Danube (Figure 6).



Sl. 6. Položaj viših (starijih) terasa Dunava na području Mađarske (M. Pésci 1959)
1 — krivulja nulte točke Dunava na području Mađarske; 2 — srednje Pleistocena terasa — br. III (Ris); 3 — terasa br. IV (Mindel); 4 — terasa br. V, Donji Pleistocen (Ginc); 5 — terasa br. VI, početak Pleistocena; 6 — terasa br. VII, kraj Pliocena. Položaj naplavnih taložina sinhrono s razvojem terasa ispod nulte točke Dunava u na području Malog i Velikog Alfelda šematski je prikazan

Fig. 6. Position of Danube higher terraces in the Hungarian section (M. Pésci 1959)
1 — curve of the 0 point of the Danube; 2 — Terrace No. III. Middle Pleistocene (Riss); 3 — terrace No. IV. earlier Pleistocene (Mindel); 4 — terrace No. V. Lower Pleistocene (Günz); 5 — terrace No. VI. beginning of Pleistocene; 6 — terrace No. VII end of Pliocene. The position of the alluvium deposited synchronously with the formation of the terraces below the 0 point of the Danube in the Little and Great Plains in schematically represented

By evaluating the geomorphological position of the terraces and freshwater limestone horizons, the Quaternary phases of movement can be differentiated at a much higher degree of accuracy than it is the case with the Late Pliocene ones, recorded by the deformation of pediment surfaces and of the oldest freshwater limestone horizons.

In the mountains, the Late Pliocene pediment (planation level pII) is situated on the average at about 200—300 meters relative height. The highest terraces (tVII) of the terraced valley sections are to be found 50—80 m lower, at 150—200 m relative height. Similar differences are observable between the freshwater limestone horizons resting upon the pediment surface (TIX) and those overlying the highest terrace. (TVIII).

It is beyond doubt, that this difference between the pediment surface and terrace No. VII is due to an erosinoal deepening of the valley, which was caused by differential tectonic movements that started on the Plio-Pleistocene boundary. This movement can be identified as **the late Walachian phase.** One may count with a maximum vertical movement of 150—200 m, as indicated by the difference between the uplift of the mountains and basin depressions.

The terraces No VI and the respective freshwater limestone horizons were formed under the influence of the Earliest Pleistocene tectonic phase, 30—50 m lower that the former. This **Pre-Günz tectonism** ended with small-amplitude oscillations. The presence of a 30 meter thick freshwater limestone cover interbedded with a few layers of sand, loess and fossil soils seem to support this hypothesis. Paleomagnetic analysis of the loesses and fossil soils interbedded in the travertine, was carried out. On the basis of this investigation it may be concluded that the travertine and interbedded layers were formed towards the beginning of the Matuyama epoch[1]. (Figure 4). After the formation of this enormous freshwater limestone mantle (TVI) terrace No VI together with its travertine overburden, broke up into two. This movement preceded the Early Günz formation of terraces No V, when there was yet another acceleration of the uplift of mountain block on one hand, and the subsidence of the basin or the other. The size of the subsidence surpassed even 50—100 meters here.

The next tectonic subphase of the Quaternary occured during the **Günz--Mindel interglacial** resulting in downwarping at the margin of the basin as well as the formation of terraces No V and of the freshwater limestone mantle resting upon them (TVI). At Vértesszőlős the absolute are of the freshwater limestone mantle overlying terrace No V of the Tata River is more than 350 thousand years as determined by the Th (U method Pécsi M. and Osmond J. K. 1973).

During **the tectonic phase comprising the end of the Mindel** glacial **as well as the Mindel-Riss interglacial,** the most important, and easily detectable movements of the Pleistocene were going on accompanied by intensive thermal spring activity. Subsidence of the basins (Little Hungarian Plain, central part of the Great Hungarian Plain and partial basins) attained 50—100 m. Deformation of the terraces No IV and of the alluvial fans surpassed 40—50 metres.

— The uplift of the marginal mountains (e. g. the Buda Mts) during the Late Pliocene — Earliest Pleistocene surpassed 120 m; another 100 m followed during the Early and Middle Pleistocene. At the same time the basins subsided 200—300 m.

The Upper Pleistocene terraces No III. II/b and II/a (Riss-Würm and Würm) sank below the surface at the margins of the basin and in the so-called marginal depressions of the Pannonian Basin (Győr-basin in the West, Upper Tisza basin in the Northeast and the Zagyva basin in the North, etc). Deposition of alluvium is in a normal stratigraphic succession E. Szádeczky-Kardoss 1938; M. Pécsi, 1958., 1970).

[1] The paleomagnetic investiations and analysis was done by M. A. Pevzner, a geophysicist.

In the valleys of the marginal part of the mountain these three terraces are overlain by freshwater limestone mantles of 190, 90, 60 thousand yours of absolute age, respectively (as determined by means of the Th (U method (M. Pécsi, 1973). Further terrace incisions after the deposition of travertines on the individual terraces occured during three shorter phases of Late Pleistocene movement (accompanied by uplift of mountains and subsidence of basins).

a) Late Riss

b) end of the Riss-Würm interglacial

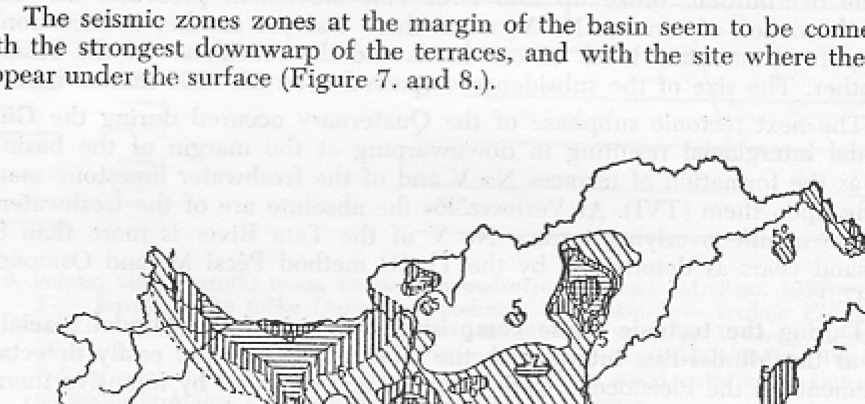
c) an Interwürm (W_1 W_2) phase.

As revealed by the deformation of terraces, uplift attained 20—30 m, subsidence in the partial basins 30—60 m.

In the Late Würm and in postglacial time renewed movements are testified to by the repeated sinking of troughs at the margin of the basins (Lake Balaton) as well as the accumulation of thick alluvial fans over the Pleistocene sediments.

These movements are still active in historical times up to the present day, manifested above all by earthquakes occuring along ancient tectonic lines (eg. the earthquakes of Kecskemét, Budapest and Komárom). Bendefy L.: 1972, Bistricsányi E. 1974).

The seismic zones zones at the margin of the basin seem to be connected with the strongest downwarp of the terraces, and with the site where they disappear under the surface (Figure 7. and 8.).



Sl. 7. Seizmička zonacija Madarske (E. Bisztricsányi, prema D. Csomor i Z. Kiss) 0_5—0_9 — stupnjevi intenziteta potresa prema Mercalli-Siebergovoj skali

Fig. 7. Seizmic zoning map of Hungary (E. Bisztricsányi, after D. Csomor and Z. Kiss) 0_5—0_9 — magnitude of earthguake intensity on the Mercalli-Sieberg Scale

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UTJECAJ KVARTARNIH TEKTONSKIH POKRETA NA GEOMORFOLOŠKI RAZVOJ U SREDNJEDUNAVSKOJ ZAVALI

Marton Pecsi

Ukupna vrijednost vertikalnih tektonskih pomaka u panonskom prostoru tokom Gornjeg Pliocena i Kvartaru iznosila je 1300—1500 m. Utvrđeno je to na temelju položaja marinskih sedimenata Srednje Pliocene starosti. Naime, isti se u rubnim dijelovima panonskog prostora prema Alpama i Karpatima nalaze na nadmorskoj visini od 400—600 m, a u njegovom središnjem dijelu na oko 800—900 m ispod današnje morske razine.

Utvrđeno je niz tektonskih faza. Prva je bila tzv. kasna Vlaška, koju slijedi Preginška. Naredna živost zemljine kore u panonskom prostoru fiksirana je za razdoblje Ginz-Mindelškog interglacijala. Tokom druge polovice Pleistocena utvrđene su tri tektonske faze i to krajem Risa, druga u Riško-Virskom interglacijalu i treća početkom Virma (V_1/V_2). Radijalni pokreti utvrđeni su osim toga, i tokom Holocena.

Rekonstrukcija i utvrđivanje pojedinih tektonskih faza temeljena je na položaju i geološkoj starosti

— riječnih terasa i sedimenata,

— nivoa zaravnjavanja (pedimenti), u rubnim dijelovima istraživanog prostora i vrijednostima akumulacija u okviru riječnih plavina, te

— razvoja travertina, vezanog za navedene vrste reljefa i sedimenata.