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Neotectonic Map

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Introduction

The Neotectonic Map presents those tectonic elements which where active and are still active in the most recent period of the geological evolution. This period lasts from the Late Pliocene to the Holocene. Basically these tectonic elements and recent tectonic processes determine the relief characters of the larger units of the landscape [Ádám & Marosi 1975, Franyó (ed.) 1971, Hreπko & Mederly 1988, Kovác & Baráth 1995, Kõrössy 1963, Pécsi 1959, Rónai 1977, Sümeghy 1942, Szádeczky-Kardoss 1938].

To mark the structures still active today and the recent history of the Earth we took into consideration four factors. In the area of filling up basins of subsiding character the faults were identified mainly on the basis of sudden changes in the thickness of the Quaternary sediments. The identification of neotectonic structural elements was facilitated by the changes in fluvial terraces and in the linear morphological elements of the terrain in the slowly uplifting and eroded areas. For both types of areas the data available in connection with earthquakes experienced so far as well as direct evidences of neotectonic processes have also been taken into account.

The map displays the final setting produced by neotectonic activity and the dynamics of the vertical movements of individual blocks of a block-structure. It represents an applied synthesis of older, but mostly latest data obtained by the regional research and 1:25 000 and 1:50 000 scale geological mapping of the territory of Slovakia (Baòack˝ & Sabol 1973, Harèár & Priechodská 1988, Harèár *et al.* 1988, Ivanicka *et al.* 1988, Konecn˝ *et al.* 1978, Konecn˝ *et al.* 1983, Kopeck˝ 1973, Marcák *et al.* 1976, Mazur & Lukòis 1978, Pospiπil *et al.* 1992, Pospiπil *et al.* 1978, Vanko & Kvitkovic 1980, Vaπkovsk˝ *et al.* 1982, Vaπkovsk˝ & Halouzka 1976. The data from the Neotectonic Map of Slovakia (scale 1: 500 000) were taken into account as well (Maglay *et al.* 1999, Maglay *et al.* in press).

The basic source of information was the critical revision of existing ideas about the tectonic and neotectonic evolution of the area. A second important source was the assessment of the records of drillholes and subsequently the differences in level of the basement. Results of the detailed systematic sedimentary-petrographic, lithofacial, micropalaeontological and palynological research of the Quaternary were also used.

We used the results of additional geophysical research that served as a basis for the construction of the Map of Genetic Types and Thickness of Quaternary sediments, scale 1:200 000.

The data gained during the last decades by the geodetic study of recent vertical movement tendencies were taken into account as well. Vanko (1988) published the newest isolates of vertical movements. These data were correlated with the values of the crust thickness (Horváth 1993) and the heat flow.

The results of the palaeostress analysis of tectonically disturbed Pliocene and Quaternary sediments were used as well. The results allowed us to study in detail the function and character of fault lines (Kvitkovic 1993, Kvitkovic & Plancár 1975, Kvitkovic & Plancár 1977, Kvitkovic & Vanko 1990, Labák & Moczo 1996, Maglay *et al.* 1993). The results of palaeostress analysis were correlated with the geophysical measurements.

Aerial photographs and satellite imagery in combination with seismologic data which served for the estimation of the recent stress fields were used for the detailed assessment of the differentiation, rate and stage of the sinking or uplift of individual tectonic blocks [Bada 1999, Balla 1993, Hreπko & Mederly 1988, Janáèek 1971, Joó 1992, Scharek (ed.) 1990, 1991a, 1991b]

The identification of the youngest tectonic movements within the shown individual structures has provided an integrated image of movements and of the changes during the geochronolologic units. The effects of these movements on geomorphologic activity (intensity of erosion, accumulation) and subsequently on the evaluation of the genesis of the present stage and prediction of further evolution of the structures were assessed as well.

Main factors in the research of neotectonic processes

Sudden changes in the thickness of Quaternary sediments

The thickness of Quaternary sediments in this area varies widely: in the most markedly subsiding middle part of the Kisalföld it exceeds 600 m (Scharek (ed.) 1990, 1991a, 1991b), while in the East, around the area of Gerecse, Pilis, Visegrád and Börzsöny Mountains the Quaternary sediment cover is totally missing in many places. However, the Quaternary thickness of several hundred metres indicates only a relatively slow subsidence of about 0.1–0.3 mm/year. The relatively small extension and the mosaic-like pattern of areas exempt from Quaternary formations indicate a similar emergence rate. All in all it can be stated that under the climatic conditions characteristic of this area in the Pliocene, the accumulation and the denudation could more or less keep pace with these relatively slow processes. Neither a deeper sedimentary basin nor more prominent high mountains could come into being. Instead in the subsiding area a compensated basin of plain surface was formed whereas in the uplifting areas —depending on the capability of rocks to resist weathering— hills or low mountains developed.

As shown by boreholes drilled in the Kisalföld (Little Hungarian Plain) [Scharek (ed.) 1990, 1991a, 1991b] the rate of subsidence was relatively constant. The thickness of sediments deposited in different periods of the Pleistocene is proportionate with the duration of the individual periods. Accordingly the basin is filled up mostly by Lower Pleistocene sediments and the thickness of Middle and Upper Pleistocene sediments does not exceed 50–100 m. The thickness of the Holocene deposits in the middle of the basin, which was filled up very rapidly, is 10–14 m.

As indicated by the sudden change in the thickness of Quaternary sediments it is possible to separate a relatively deep part of the basin NE to the Rajka–Abda Line and within that an exceptionally quickly subsiding area at Bezenye and to NE of the line between Dunakiliti–Gyõrújfalu. In these parts the thickness of Quaternary sediments reaches 600 m. SW of the Rajka–Abda Line, between Mosonmagyaróvár and Ikrény there is a ridge which compared to its surroundings shows less intensive subsidence. There, the thickness of Quaternary sediments does not exceed 100–200 m. The part of the basin extending from the ridge to the SW has a rather varied block-structure. The thickness of the Quaternary sediments varies between 100 and 350 m. The individual blocks are bordered by faults of mainly NW–SE strike, and by structures of NE–SE strike in a slightly curving arc which form acute angles. Of the former, the ridge between Jánossomorja and Rábapordány as well as the more intensively subsiding graben south-west of it along Hanságfalva and Pásztori are worth mentioning. Of the latter the most important is a down-faultbock at the centre of the Lébénymiklós–Rábatamási–Beled Line which continues in the valley of the River Rába towards S–SW.

The thickness of the Quaternary sediments is not an exact indicator of the boundaries of the basin on the SE. The Pannonian sediments forming the Parndorf Plateau show a slow and gradual subsidence under the Quaternary sediments, moreover the valleys of bordering hills can be seen buried under Quaternary sediments to about a depth of 30–40 metres. The unusual NW orientation of the ranges of the Pannonhalma Hills also indicates a gradual subsidence.

Moving towards the interior of the Kisalföld the sediments grow thicker only slowly and the basin deepens suddenly only after reaching a sediment thickness of 40 m. Therefore it is at this place that the faults bordering the Quaternary basin of the Kisalföld may be supposed to be. The NW fault is relatively straight, but the structure along Egyed–Enese–Ikrény–Kolozsnéma shows a marked curve towards East. Considering the thickness of the Quaternary sediments it seems that the faults of NW–SE strike prevailing in the Kisalföld Basin also divide the border faults into longer and shorter sections. As the individual section shows a transform fault it can be supposed that the dip of the border faults is 60 to 70°.

The sudden change in the thickness of the Quaternary sediment makes the detection of neotectonic structures possible mainly in the area of the basin, but in some cases they can be detected also in the uplifting parts. Thus, for instance in the Gerecse SW to Szomód–Tarján Line, the occurrence of loess of small thickness is only sporadic whereas NE of it loess is more extensively found, and in many places its thickness reaches 25–30 m. In the Pilis Mts West of the structure with N–S strike a Quaternary loess–blownsand sediment sheet can be rather extensively found, while to the East in the block of Nagy-Szoplák and Nagy-Kopasz Hill the older rocks suddenly appear on the surface in large areas. Also in the Börzsöny Mts there are few Quaternary sediments to be found but on the NW rim of the mountains, NW of Szalka–ˇahy loessy and fluviatile sediments make sudden appearance.

The level changes of fluvial terraces

In the Quaternary the main force shaping the relief was the River Danube (Szádeczky-Kardoss 1938) with its coarse-grained load coming from the Alps. Keeping pace with the subsidence, it filled up the Danube Basin and in the emerging parts ensured drainage towards the Great Hungarian Plain by gradual cutting-in. The filling up and the cutting-in were not continuous. Owing to the extremes of the Pleistocene climate the load-balance of the Danube underwent changes several times, and sometimes the load deposition was preponderant also in the incutting section. This occurred mostly when the temperature rose suddenly and considerably after a cooler and drier cold period. The further deepening and incutting of the Danube, the remnants of the accumulation valley fill of earlier periods have been elevated in relation to the valley floor and survive as terrace-levels.

Along the valley between Gyõr and Budapest are known at present an older Pliocene (Ruscinian) terrace level as well as several younger — Lower Pleistocene, Middle Pleistocene (Mindel$_{1\text{-}2}$ interstadial), and two Upper Pleistocene (Riss–Würm interglacial, and Würm$_{2–3}$ interstadial) terraces. The older, Pliocene level can not be considered a genuine terrace, because this gravel was deposited still in the filling-up period of the area, and its pebbles were weathered out only in the course of the later incutting of the Danube. Their presence is not limited to the present Danube Valley as they dip everywhere towards the interior of the basins, and dive under the younger deposits.

The intensity of the uplift of this area is well marked by the terrace levels, for the faster the uplift the higher the given terrace is. The difference between the levels of the Middle–Pleistocene terrace having been formed about 730 000 years ago and the rocks underlying the Holocene Danube-deposits, indicates a yearly uplift of 0.05–0.25 mm. Examining the elevations of younger terraces in different valley-sections we can conclude that the uplift was uniform in time and thus the difference in the level of the bedrock is always proportionate to the duration of the uplift.

On the basis of sudden level changes of the terraces, it would be easy to detect the active faults of vertical components and crossing the Danube Valley. Such, however, occur only sporadically. Of these the border faults formed in the Kisalföld Quaternary basin can be mentioned where terrace sediments of inverse stratigraphic position suddenly follow the normal stratigraphic sequence of the basin sediments. In addition to that using the level change of the older Late Pleistocene terrace we can detect a minor active fault along the valley of the Kalocsa Brook between Dunabogdány and Tahi. On the other hand no significant recent vertical dislocation can be seen along the faults of Bõnyrétalap, Nagyigmánd and Tata.

The fact that the changes in the elevation of the terraces occur stepwise and instead of shifts along faults they extend to larger areas indicates tectonic processes of tilting character. The rock underlying the Middle Pleistocene terrace for instance rises gradually from 135 metres to 155 metres above Baltic-sea-level from Gyõrszabadhegy to Mócsa. At Lábatlan the underlying rock is between 180–185 m above Baltic-sea-level. At Csömör the base of the Pleistocene terrace appears at 155–160 m above Baltic-sea-level, and moving down gradually to 140–145 m above Baltic-sea-level at Kõbánya, and 130 m above Baltic-sea-level north of Gyál. The underlying rocks run similarly on the Buda side, 170 m above Baltic-sea-level at Üröm and Budakalász, 150 m above Baltic-sea-level at Óbuda and 130 m above Baltic-sea-level at Budafok.

The tectonic process of tilting character has interesting consequences. At Gyõrszabadhegy the Lower Pleistocene terrace is situated under a Middle Pleistocene terrace, with the base at 130 m above Baltic-sea-level. In the area of Bábolna the two terraces are to be found at the same height with a base of 150 m above Baltic-sea-level. At Tata, however, the Lower Pleistocene terrace is situated well above the Middle Pleistocene level with a base of 185 m above Baltic-sea-level.

The changes in terrace levels indicate that in the Quaternary it was the Esztergom–Visegrád section of the Danube Valley that was uplifting most intensively. Terrace levels older than Late Pleistocene gradually rise in this direction and come up to the surface.

Linear morphological elements

In the uplifting hilly and mountainous parts of the area remarkably straight brook valleys and mountain margins occur in fairly great numbers which can occasionally be followed for several scores of kilometres. They strike mainly NW–SE, but rarely there are other directions as well. They are characteristic mostly of the Pannonian formations on which the valleys have developed mainly along faults which are weak zones.

The neotectonic significance of these linear morphological elements is proved also by earthquakes that occurred along them. But only some of these valleys and mountain rims were active during the Quaternary. Often we have to do only with selective denudation, weathering out of rocks of different resistance, which had got close to each other due to the tectonism of earlier geological periods. Exposition due to weathering is most common in the case of Mesozoic carbonate rocks as well as Badenian volcanites. Typical of these is, for instance, the faults bordering the uplifted block of Mt Naszály. In other cases, however, selective denudation and the recent activation of the earlier fault can be seen combined *e.g.* in the case of the structure which can be followed to Szalka–ˇahy and borders the Börzsöny Mts on the NW.

The character of tectonic structures determined on the basis of morphological elements is usually difficult to recognise. In some cases it is almost sure that considerable vertical dislocation occurred along these structures. Such faults border *e.g.* the uplifted blocks of the Pannonhalma Hills which in fact continue to the SE, the ridge in the basement of the Kisalföld Quaternary basin between Mosonmagyaróvár and Ikrény. The considerable differences in the height of structures along Nyergesújfalu–Telki and Esztergom–Rákospalota also suggest considerable vertical dislocation.

In other cases, *e.g.* along valleys between Gyõr and Tata any vertical dislocation is practically excluded because the terrace levels are unchanged. At the same time the significant deepenings at Gönyû, Ács, Dunaalmás, Nyergesújfalu and Esztergom in the rocks underlying the Holocene sediments of the Danube, and the characteristic northward sinking of the Danube bed suggest that along valleys striking NW–SE the displacement is mostly left-handed. A very significant sinistral displacement is demonstrated in the Buda Hills by the direction of Ördögárok.

The straight line of the valley of the Ikva and the Kardos Rivulet as well as the innumerable linear morphological elements of the Gerecse and Pilis Mts have been formed along a fault zone which is still active today. However, the tectonic character of these structures is not sufficiently known.

Earthquakes

Earthquakes are directly indicating the tectonic processes occurring at the present times and the main tension centres. In the map the sites and intensities of the known earthquakes are shown. As more exact observation data are available only from recent decades, the sign in many cases does not mark the epicentre but only the settlement where the greatest damage was observed.

From seismic point of view the area is relatively calm. Earthquakes higher than 6 on the Modified Mercally Intensity Scale (MMIS) occur only rarely (Szeidovitz 1987, Vanko 1988). It is especially remarkable that the fastest subsiding part of the Danube Basin including the graben along Lébénymiklós–Rábatamási–Beled are seismically “deaf”. The faults along the margin of the basin seem to be relatively active: in the West at Sopronkövesd and Fertõszentmiklós earthquakes of intensity 6 in the East several quakes of 4–5 have been observed at the junction of the marginal fault and the fault set rectangular to it. Similar activity characterises the structures to be found in Bõnyrétalap and Nagyigmánd which also strike NW–SW. Earthquakes of intensity 4–5 occurred along the line of Süttõ–Mogyorósbánya–Dorog in the northern part of the Gerecse Mts.

The central part of the Pilis Mountains is relatively less active, but in the area of Óbuda, Budakalász, Csobánka several quakes of intensity 4–5 have been observed. A seismically highly active structure of the region is the Diósjenõ Line along which there have been quakes of intensity 5.5–6.5. Also mobile although somewhat less active is the fault to be found at the NW rim of the Börzsöny Mts between Szalka and Ipolyság.

In this area the strongest earthquake, of intensity 8.5 on the MMIS has been observed near Komárom. According to the terrace levels, no neotectonic structure can be marked at Komárom. The source of tension is probably the marginal fault bordering on the South the eastern bay of the Basin, which is situated in Slovakia. SZEIDOVITZ (1987) has found correlation between the earthquakes of Komárom, Mór and Berhida. As no such structure has been identified in the morphology and in the stratification of the Quaternary sediments, in the neotectonic map this zone is presented as a seismoactive line of N–S direction. A tectonic element of similar direction and character is common to earthquakes as Vác, Óbuda and Dunaharaszti, the latter being of intensity 6 to 8.

Principles and displaying concept of the map elements

The principles and the displaying concept of the map elements are clear from the legend of the map. The map shows the lines of neotectonic dislocations and territorial units — neotectonic structures, delineated by these lines. These units are divided into a system of megastructures, structures and microstructures.

Colour in the map shows the dynamics of the area — relative uplift or subsidence of the blocks. The intensity of the colour displays the intensity of the uplift or subsidence without any quantification. Green spots represent basinal subsidence evolution, while the intensity of colour expresses the relative intensity of this tendency. Similar principle is used for areas with non-basinal evolution (yellow spots). Mountainous evolution and positive block structures are expressed in brown colour. Bilingual names are used for faults crossing the borders of two countries.

The main criterion of the determination of the basin was the change in the thickness of Quaternary sediments. It concerns mainly of Gabèíkovo Depression (depression of the Podunajská nízina Lowland) and partly also of Zohor–Marchegg Depression (depression of the Vienna Basin).

Criteria like: positions of terraces, amplitudes of uplift among the individual periods of the Pleistocene, the undercut of riverbeds (atectonic processes such as aeolian processes, slope processes were not taken into account) were used in marginal parts of basins.

Proluvial sedimentation, evolution of alluvial fans was important criteria for the determination of movements along the boundaries of block structures.

The regional geomorphologic zoning was used for the delimitation of the individual macrostructures. The microstructural classification is based on the relative morphological position (altitude) of the individual structures.

The results of the measurements of recent vertical movements by the nivellation net and special nivellation net were used. According the latest measurements, the western parts of the DANREG region (mostly Vienna Basin and Danube Basin) show subsidence, while for other part of the region stable situation or gentle uplift is characteristic (VANKO 1988).

As concerns the seismic activity the DANREG area belongs to the active areas, which are subdivided into several zones (HRAπNA 1997). A specific seismotectonic zone is the surroundings of Komárno/Komárom town, oriented N–S, a direction rather unusual in Hungary (SZEIDOVITZ 1987). Earthquakes within this zone reach intensities up to 6–9° MSK. The most intensive ones (up to 6° and more) are in the vicinity of Komárno/Komárom town, where fault systems of different directions are crossing. The seismic activity in this zone is obviously connected with important movements part between the uplifting and subsiding parts of the Podunajská panva Basin, or at the contact of the Carpathian and Pannonian blocks.

Regional overview

Vienna Basin

The Vienna Basin reaches the territory of DANREG only with its NE part. Its substantial part is the Zohor–Marchegg partial Depression, which is a component of the vast Zohor–Plavecká Depression. It extends along the western margin of the Malé Karpaty Mts and continues to Austria. It is a part of the larger and neotectonically transversally divided Podunajská panva Basin in Austrian territory. The Vienna Basin is bounded by the Láb–Lakπárska elevation on its NW margin. The eastern margin of the basin is the Malé Karpaty Mts. The depression is not a uniform tectonic unit. It is divided into several segments by transverse faults.

The Zohor–Marchegg partial Depression, which continues from the Pernek partial Depression, has a contact with the Lasse Depression in Austria. Proluvial sediments in its NE part fill this depression. The SW part is filled by fluvial sands and gravels of the Morava River. The overall subsidence in this depression is 100–110 m (MAGLAY *et al.* 1999a, 1999b).

The youngest depression of the Vienna Basin of the DANREG region is the Stupava–Lamac Depression. Its age is Würm–Holocene. The proluvial sediments are mostly gravelly, loamy and sandy. There are young seismoactive faults along the Malé Karpaty Mts.

The horst structure — Malé Karpaty Mts together with the Hainburg hills in Austria is the boundary between Vienna and Podunajská níΩina basins. This structure is bordered by seismoactive NW–SE faults.

Danube Basin

Kisalföld (Little Hungarian Plain)

During the Pliocene and the Quaternary in the structural conditions of the area differ from the characteristic features of the preceding Pannonian period [FRANYÓ (ed.) 1971, RÓNAI 1977, SCHAREK (ed.) 1990, 1991a, 1991b, SZÁDECZKY-KARDOSS 1938]. The most important change is that the subsidence characteristic of a considerably larger area in the earlier period became confined gradually to the eastern part, which is the area of the present Kisalföld. The intensity of the subsidence was not going on at a rate of 0.1–0.3 mm/year. The subsidence was uniform in time but different by areas. The Quaternary basin was divided into differently subsiding blocks along faults of NW–SE and NNE–SSW strikes. The main tectonic elements of the basement continue in the uplifting border areas: the down-faulted part between Rajka–Abda towards NE in Dévény-kapu, the ridge between Mosonmagyaróvár–Ikrény towards the SE in the deep graben, in the Lébénymiklós–Rábatamási–Beled Line towards SSW in the Rába Valley.

The Danube, the subsidence being compensated all along, more or less gradually filled up the slowly subsiding basin. No deeper drainage basin developed. The whole basin is filled by coarse load. The shallow marshy-wet areas of today (Fertõ, Hanság, Gutai Marsh) are not centres of subsidence, but they are partial areas of the subsiding basin compensated at the present by sediment accumulation.

The subsidence of the area east of Gyõr was stopped in the Early Pleistocene and gradually turned into slow uplift. In the uplifting area due to the variable climate of the Pleistocene the Danube, which received load in an extremely unpredictable way, cut in to different extents and formed a terraced valley. In the earlier subsiding basin first the Pliocene and then the Pannonian sediments started to be eroded and the older formations gradually appeared on the surface. The structures consisting of highly resistant Mesozoic carbonate rocks and Badenian volcanites were weathered out.

The uplifting occurred more or less evenly in time, but in different rates in space. Dislocations by tilting are most characteristic of the area between Esztergom and Visegrád towards the basins the rate of uplifting gradually decreases.

Podunajská niΩina

The complicated hierarchy of territorial neotectonic units in the Podunajská níΩina Lowland can be subdivided into two groups (Halouzka *et al.* 1994).

The first group comprises the relatively negative units of the Gabèíkovo (central) Depression, called as Podunajská rovina Plain.

The second one is an ensemble of relatively positive units with neotectonically active blocks, known as Podunajská pahorkatina Upland (Trnavská, Nitrianska, ≥itavská, Hronská a Ipel'ská).

This basic neotectonic division of the Podunajská níΩina Lowland reflects the neotectogenesis of the area. The neotectonic structures and their movements directly indicate the sedimentary geological evolution. It implies the geomorphologic erosion-accumulation processes and thus the evolution of the relief.

The neotectonic heart of the Podunajská panva Basin is the Gabèíkovo (central) Depression. It is bounded by marginal seismoactive faults, which are landmarks along the Malé Karpaty Mts. Trnavská pahorkatina Upland and to some extent also the Nitrianska pahorkatina Upland have similar boundaries. The marginal fault there is the Salibsk″ fault that is connected with the Dolnovázsky fault and this runs up to the seismoactive junction near Komárno.

The eastern and south-eastern margin of the depression is marked by the Dolnovázsky (Kolárovsk″) fault. The eastern KliΩskej Nemej fault continues near KliΩská Nemá–Gönyû across the state boundary Slovakia–Hungary. These faults separate extra- and intra-depression neotectonic trenches and structures. Faults within the active depression are generated and are identified as faults of basinal type. They were generated during the flexuring of the basin. This flexure is a result of balancing of the tension generated during primary flexuring. Especially in clastic, coarse and weak sediments like sands and gravels, these faults are less expressive and the dip is usually gentler. This is typical for the central depression. Sometimes one can observe isolated faults that do not create structures.

Outstanding vaults of trenches occur in marginal part of the basin, mainly on the Salibsk″ and Malodunajsk″ faults. This confirm the dynamics of the evolution of the depression, which is characterised by progressive pulling in of marginal parts of the basin along the mentioned lines. These result in expansion and rejuvenation of the basin. One can observe a progressively younger (seismic) activity up to recent times.

The centre line of the basin coincides with the present course of the Danube River. The Slovak part of the central depression passes continuously to the Little Hungarian Plain (Kisalföld), which is about its symmetrical counterpart.

The neotectonic Gabèíkovo (central) Depression is filled by sandy and sandy-gravelly strata (fluviolimnic and fluvial) in 2–3 sedimentary sequences. The overall thickness is up to 500 m. The subsidence of the basin continues up to present day, but without the inside differentiation of blocks, which remain in the periphery of the basin.

There are transitional structures along the Gabèíkovo (central) Depression — western Bratislava band and the eastern, lower Komárno marginal block. The greatest number of younger Pleistocene and Holocene up to recent active neotectonic faults is situated just there. It is in these two structures, but mainly in the Komárno marginal block that the strongest and most frequent earthquakes have been observed.

The Danube uplands are in relation to the units of Danube Lowland a system of relatively positive tectonic blocks. These blocks have different rates of uplift, which results in a complex system of uplifted and sunken structures in the marginal part of along the Gabèíkovo (central) Depression. Structures with prevalence of positive tectonics have Quaternary fluvial deposits. These appear mostly in form of a succession of terraces. Morphologically they appear as uplands. Structures with oscillating, but generally with positive tectonics are of plateau character. Fluvial deposits are deposited in morphological terrace succession. The lowest relative uplift of structures is recorded in places of bottom accumulations of lowland segments of the present rivers Váh, Nitra, ≥itava and Hron. In this respect, the most noteworthy are the deposits of the ancient valley of ≥itava River with the occurrence of Lower Pleistocene sands and fine gravels with Lower Pleistocene mammal fossils.

The partial blocks of individual marginal uplands, which are the offsets of the Podunjaská panva Basin, have many common features, but differ in details in their specific evolution and structure.

The block of neotectonic structures of the Trnavská pahorkatina Upland joins to the DANREG region by its southern part only. It is expressively bordered by tectonic lines. A marked seismoactive band of tectonic lines of NE–SW direction separates the upland from the horst structure of the Malé Karpaty Mts. The N–S Váh fault separates the upland from the positive structure of PovaΩsk˝ Inovec Mts and from the Nitrianska pahorkatina Upland. The southern and south-eastern part between Bernolákovo a Sládkovicovo is divided from the Gabèíkovo (central) Depression by an important tectonic fault with the difference in the thickness of sediments which exceeds 30 m.

There is a system of sunken and uplifted blocks in the southern part of the Trnavská pahorkatina Upland. Westward from the higher blocks (˘alaperskej hory Mts) and the Malé Karpaty Mts between Èierna voda River, Pezinok and Modra towns originated a system of small isolated depressions or blocks which are filled by proluvial sediments and peat. East of that place occur two parallel transversally differentiated rows of the highest blocks. They are covered mostly by Neogene sediments. East of these blocks up to the flat of the lower Váh River occurs blocks of the medium tectonic uplift of the Trnavská tabula Plateau. It is characterised by underlying proluvial sediments of Malé Karpaty streams and fluvial terrace sediments (Middle Pleistocene) which are masked by a mighty cover of loess and fossil soils.

The river bottom of the lower part of the Váh River represents a separate, detailed differentiated structure with very slow uplift. These structures played an important role in the formation of the present relief.

The Nitrianska pahorkatina Upland reaches to the territory of DANREG by its SW part (so called ZáluΩská pahorkatina Upland). The marginal block of the Nitrianska pahorkatina Upland is bordered from all sides by tectonic faults. The differences in the thickness of sediments are lesser than those in the Trnavská pahorkatina Upland.

A high block, probably the prolongation PovaΩsk˝ Inovec Mts with Neogene sediments occurs in the western part, along the contact with the bottom of the lower Váh Valley. Farther East, in the vicinity of Komjatice village there is another higher block of wedge shape. The area between these two blocks is the component of the Hlohovec-Nitria system of high blocks. This system is separated from the Nitrianska tabula Plateau by a fault. The Nitrianska tabula Plateau is characterised by the massive occurrence of Váh River fluvial terrace sediments, partly also of River Nitra of the Middle and Upper Pleistocene age. The sediments of these two rivers differ slightly in elevation. The fluvial terrace accumulations are sandy gravels. Their age is variable. The gravels are covered by thick loess deposits and aeolian sand.

The Hronská pahorkatina Upland is a specific morphostructure, which differs from the Trnavská, Nitrianska, and partly also ≥itavská pahorkatina uplands. It extends in N–S direction up to the Hungarian escarpment from which is separated by the Danube River valley.

Together with the Ipel'ská pahorkatina Upland, the Hronská pahorkatina Upland structurally is the eastern edge of the Podunajská panva Basin. The valley of Hron River represents only the subsequent structure based on a system of N–S faults, at the boundary of older Miocene and younger Pliocene structures. As a whole, the Hronská pahorkatina Upland is a stable morphostructure, with morphological balance, without any great dip to the South. Its internal structure is differentiated in detail and considerably affected by fault tectonism. All water courses follow tectonic lines. Young tectonism has played an important role in the creation of the relief and geological structure.

The area is disturbed by two systems of faults. NNE–SSW and W–E faults prevail in the northern part, while faults of NW–SE, W–E and N–S orientation dominate in the southern part of the upland. The Hronská pahorkatina Upland is broken up into a system of blocks along these lines. The faults were identified mostly by morphostructural analysis. The activity and character of these lines was changing during the whole Quaternary. In most cases one can observe moderate subsidence, uplift and dipping of individual blocks. The movements reach the rate up to several tens of metres. The expressive palaeogeographical changes of the ≥itava River valley are in close connection with this neotectonic activity.

The high blocks of Chrbát and Belianske kopce Hills dominate in the neotectonic structural scheme of the southern part of the Hronská and Ipel'ská pahorkatina uplands. The occurrences of the pre-Quaternary basement are common. This basement separates the valley of the Danube River from the Transdanubian Range. The system of massive high blocks dominates the neotectonic structure of the central part of the upland. They belong to the watershed zone of Nitra, ≥itava and Hron rivers and sunken elongated intra-upland basinal structure of the River Hron with terraces and loess plains on its right bank. The system of higher blocks of the Ipel'ská kotlina Basin with the lower part of the terraced valley of the River Ipel'/Ipoly occurs in the east.

An extraordinary position have the Kováèovské kopce Hills (Burda). They are clearly neotectonically separated from higher blocks of Ipelská pahorkatina Upland. They are a component of the foreground of the stratovolcanic arc of the Börzsöny Mts.

Ipel'ská panva Basin

The Ipel'ská panva Basin together with the neovolcanics of the Krupinská planina Plateau makes up the easternmost part of the DANREG region. Neotectonically they are an inner, transitional zone between the typical basinal evolution and intramountainous basinal evolution. It is delimited mostly by erosion (denudation), hence it has a geological boundary. This boundary is expressive due to the higher resistivity of the Badenian volcano-sedimentary complexes in comparison to the soft Miocene sediments. It has, together with the second half of the area in the Hungarian territory, a character of intramountainous valley extended between Krupinská planina Plateau and the Cserhát and Börzsöny Mts.

The neotectonic structure and division of the area are based on the faults of NW–SE strike. It is separated from the area of lower Ipel'/Ipoly River by the highest blocks of the Bericensk″ potok Brook. They make up the breakthrough area of the ˇahanska brána Gate. Eastwards, the area is sinking into a symmetric-shaped graben. The deepest-situated block of the graben is bordered by the Kleniansky and Vinick″ faults. The graben is mostly filled by proluvial sediments of the older Middle Pleistocene and by fluvial sediments of Middle and Late Pleistocene and Holocene. The western rim of the graben is characterized by micro-deformations with partial vertical dislocations.

The eastern part is more sectionalised. There are high, asymmetric blocks (Príbelsko–Plachtinské kryhy blocks), which are separated from the vinická prepadlina graben by the higher block (Dolinka–Trebuπovce) and the sunken Opatovce block. The Príbelsko-plachtinské kryhy blocks are characterised by extensive fluvial and proluvial sediments of the Middle Pleistocene. The block ends by the cebovsk″ fault in the east.

The margin of the Krupinská planina Plateau with the radial orientation of water flows is a component of the central arc structure of the Javorie Mts.

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