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THE GEOMORFOLOGY OF PRAGUE

Geomorfologie Prahy. — Území Prahy se rozkládá v oblasti Pražské plošiny, charakterizované převážně erozně denudačním reliéfem. Základním geomorfologickým tvarem je plošinný reliéf, který lze považovat za parovinný povrch třetihorního stáří. Ostatní povrchové tvary jsou výsledkem mladotřetihorní a kvartérní eroze a denudace, která v podloží křídy odkryla paleozoické a proterozoické horniny Barrandienu. Dnešní geomorfologický ráz území podstatně ovlivnila členitost původního předkřídového podloží. Ze zbytků mladotřetihorních limnických a fluviálních sedimentů se v reliéfu uplatňují jen zdibské písky a štěrky. Tok Vltavy provází 7 pleistocenních akumulací, v nichž autoři rozlišili akumulační a erozní povrchy. Významným prvkem reliéfu jsou akumulace spraší, uložené v několika pokryvech, které geneticky odpovídají jednotlivým pleistocenním terasám Vltavy.

The area of Prague — the capital of Czechoslovakia — is situated in the centre of the Bohemian basin, i.e. in the north-eastern part of the Berounka hills, and extends on either bank of the lower Vltava. Most characteristic is its peneplain relief (Prague Plateau) which is due to Tertiary and Quaternary denudation and erosion processes which took place along the southern margin of the sediments of the Bohemian Cretaceous Plateau. The relief exhibits intensively folded and faulted Palaeozoic rocks of the Barrandian synclinorium whose axis runs from south-west to north-east over the southern and south-eastern outskirts of Prague. The central historical part of the town originated in a comparatively small erosion basin (Prague Basin) around the mouths of two larger right-hand tributaries of the Vltava — the Botič and the Rokytka. The relief reaches its maximum height in the western part of the map (401 m), the lowest-situated place being the surface of the Vltava near the northern margin of the map (177 m).

The oldest Proterozoic rocks (shale, gray-wacke shales, lydite) crop out to the surface on comparatively small areas in the north-west and south-east. The largest part of the Prague area is composed of Ordovician shales and quartzites; in the south-west occur Silurian and Devonian shales, diabases and limestones (predominantly on the left bank of the Vltava). In the north and south-west Ordovician and Proterozoic rocks are overlaid by almost horizontal layers of Upper-Cretaceous sandstones and marls. At present their southern border is the result of a more recent (Tertiary and Quaternary) denudation so that

the relief — in the largest part of the Prague area — represents the exhumed substratum of Upper-Cretaceous sediments. From the more recent superficial deposits denudation fragments of Tertiary (most probably Miocene) gravels have been preserved on the left bank of the Vltava as well as sands and gravels of the lake type in the northern part of the map. They may be considered as Pliocene. From Quaternary sediments most important are gravel-sands of the Vltava terraces and loess occuring on larger areas west of the Vltava valley.

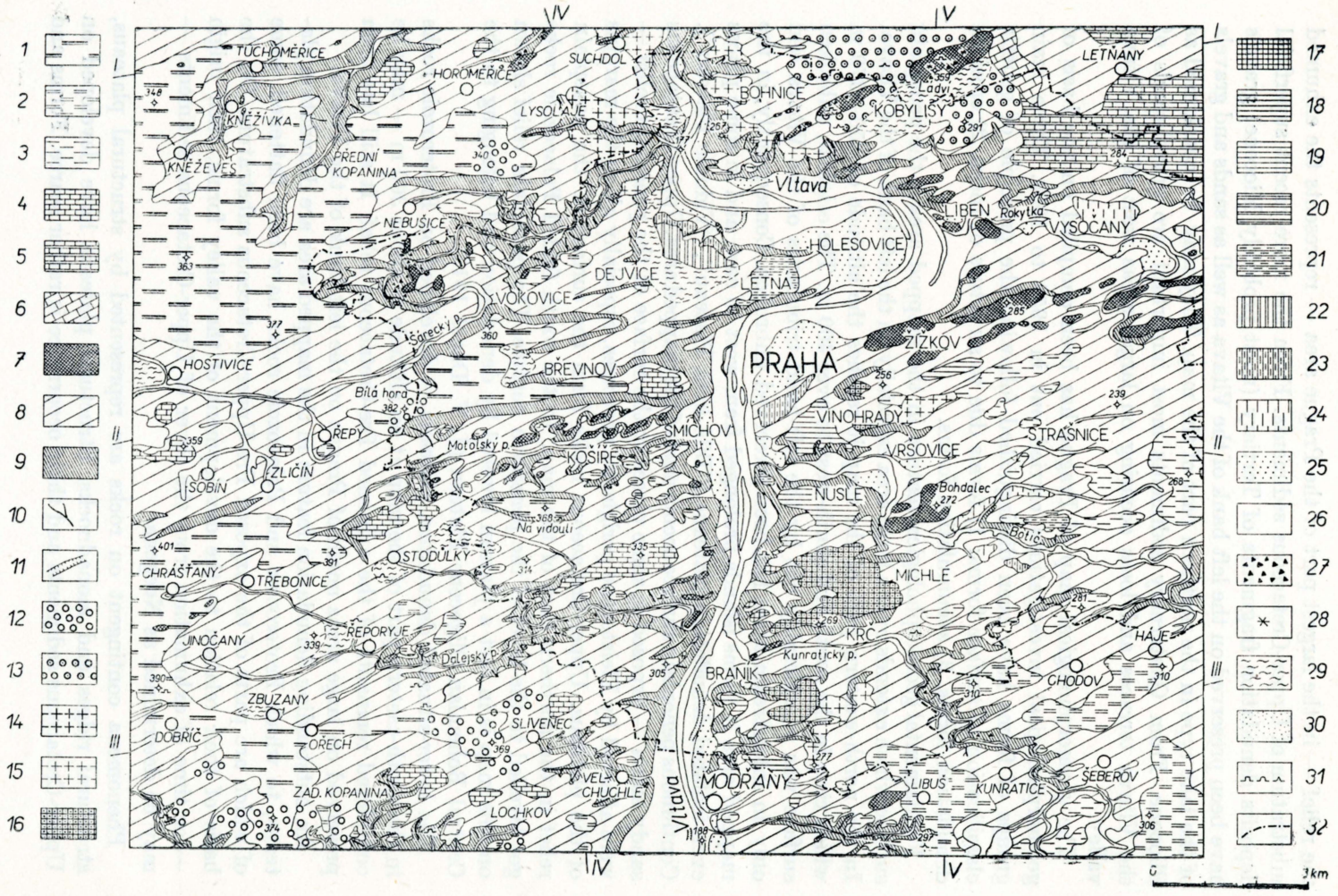
The geomorphological map of Prague has been compiled on the basis of geomorphological investigations carried out in 1958 to 1959. Three main groups of forms have been distinguished following the principle of genetic classification of surface forms: 1) forms due to structure of rocks, 2) erosion-denudation forms, 3) accumulation forms.

Fundamental geomorphological feature in the mapped area is the peneplain surface which extends over a large area especially on the left bank of the Vltava. In the north-western part of the map it reaches the altitude of 350—370 m which rises in the south and south-west to over 400 m. The original, unbroken surface was considerably cut by the left-hand tributaries of the Vltava and only in interstream areas has been preserved unbroken. Consequently, in the mapped area it forms islands prolonged from west to east, and in some places even isolated denudation plateaus ("Bílá hora Plateau", "Vidoule Plateau"). Continuous peneplain surface occurs west of the mapped area. Upper-Creataceous sandy marls — exposed in some places at the surface of the peneplain relief — were affected by Pleistocene periglacial processes, especially along the margins of the plateaus. Upper-Cretaceous rocks form the surface of the peneplain relief in the northern part of the map. In the south folded Palaeozoic rocks got levelled to the level of the peneplain surface. The peneplain relief shown on this map is in fact a plateau lowered by denudation and belonging to the Central Bohemian Oligocene Plateau (J. V. Daneš 1913).

The lower-situated denudation plateaus — developed on Proterozoic rocks in the south-eastern part of the map at an altitude of about 300 m — may be considered remnants of the exhumed Pre-Cretaceous relief. It still has been preserved on large areas north of Prague on the left bank of the Vltava.

An outstanding denudation feature in the mapped area are denudation plateaus, to which Proterozoic and Palaeozoic rocks have been flattened, some of which are parts of the exposed Pre-Upper-Cretaceous substratum. On the basis of their relation to the development of the valley forms, their origin — or time of exhumation from the cover of Upper-Cretaceous sediments — may be determined as Neogene.

Phenomena contingent on rocks are represented by structural plateaus, structural ridges and monadnocks. Structural plateaus have developed on Upper-Cretaceous sediments and their occurrence is rather scarce. Forms and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PŘEDNÍ KOPANINA
LYSOLAJE
BOHNICE
KOBYLISY
Ládví
Vltava
NEBUŠICE
LIBEŇ
Rokytka
VYSOČANY
HOLEŠOVICE
DEJVICE
LETNÁ
VOKOVICE
Šárecký p.
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HOSTIVICE
BŘEVNOV
Bílá hora
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SMÍCHOV
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Bohdalec
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directions of structural ridges and monadnocks depend upon petrological and tectonic conditions. They occur in Proterozoic lydites, Ordovician quartzites, Silurian diabases, and Silurian and Devonian limestones. With the peneplain relief they are scarce. They occur mostly in strongly denudated areas and quite often in valleys (valley of the Motol brook). Most often they are geomorphologically quite unconspicuous. They occur mostly in zones of the Barrandian direction (south-west to north-east). In northern parts of Prague on lydite structural ridges, traces of the abrasion activity of the Upper-Cretaceous sea have been preserved in the form of surf deposits and abrasion plateaus (e.g. Ládví). In this case, old Pre-Cretaceous forms were exhumed by Tertiary and Quaternary denudation. In places, these structural ridges influenced the very geomorphological nature and development of the valleys of the Vltava tributaries (meanders of the Rokytka and Botič brooks). In the Pleistocene periglacial climate, monadnocks and structural ridges — especially those composed of lydite — were affected by intensive periglacial weathering. The result were exposed rocky masses, boulder streams and solifluction streams.

The valley of the Vltava in the mapped area is deeply cut and assymetric in profile. Its floor is comparatively narrow, widening out in the area of the Prague Basin where the river makes a large meander in Holešovice, lined with terraces. The valley runs almost directly from south to north. South of Prague the left bank is abrupt, without any terraces. It starts in an area situated higher than the oldest Quaternary terraces. On the other hand, large terraces of Old-Pleistocene age are developed south of Prague on the right bank of the Vltava. They fall down abruptly to the Vltava flood plain especially along the axis of the Barrandian syncline.

The geomorphological map of Praha.

1 — higher-situated level of denudation plateaus of Neogene age (lowered Central Bohemian Peneplain), 2 — lower-situated level of denudation plateaus of Neogene age, 3 — denudation plateaus of Pleistocene age, 4 — structural plateaus of Neogene age, 5 — structural plateaus of Pleistocene age, 6 — structural slopes, 7 — structural ridges, monadnocks, disturbed in places by Pleistocene frost weathering, 8 — backset slopes with "Dellen", 9 — abrupt slopes, 10 — erosion furrows, ravines, 11 — abandoned river beds, 12 — fragments of gravel and sand covers of Neogene age, 13 — plateau of Pliocene sands and gravels (Zdiby stage); Pleistocene terraces: 14 — terrace Ia (Lysolaje terrace of Q. Záruba), 15 — terrace Ib (Suchdol terrace), 16 — terrace IIa (Pankrác terrace), 17 — terrace IIb (Pankrác terrace), 18 — terrace IIIa (Kralupy terrace), 19 — terrace IIIb (Vinohrady terrace), 20 — terrace IVa (Letná terrace), 21 — terrace IVb (Letná terrace), 22 — terrace Va (Dejvice terrace), 23 — terrace Vb (Charles Square terrace), 24 — terrace VI (Veltrusy terrace), 25 — terrace VII (Maniny terrace), 26 — surface of valley plain; 27 — rubble and boulder streams, 28 — fragments of surf accumulations of Upper-Cretaceous age, 29 — slopes on loess drifts, 30 — slopes on drifted sands, 31 — more important quarries, loam pits, sand pits, 32 — administrative boundaries of Praha.

Left-hand tributaries of the Vltava flow predominantly from west to east. They rise in shallow depressions in the peneplain surface, cut gradually down into the substratum of Barrandian rocks along their middle and lower course, and form deep, in places canyon-like valleys. Originally, they started in the peneplain surface and flew over the Cretaceous deposits. In the course of the Late Tertiary and especially Pleistocene hollowing of the Vltava valley, they cut down epigenetically into the Palaeozoic and Proterozoic substratum of Cretaceous rocks. A typical example of epigenetic development is the valley of the Motol brook in its middle and lower reaches. It forms a wide depression, limited in the north by the margin of the peneplain ("Bílá hora" and its environment), in the south by the remnants of the structural plateau of "Vidoule". In the depression the Ordovician substratum is exposed and the Motol brook cuts across the ridges built of Drabov and Skalec quartzites and running from west-south-west to east-north-east. The brook follows transverse dislocations between the individual structural ridges. The most interesting and geomorphologically important tributary of the Vltava is the Šárecký brook which in the narrow romantic erosion valley cuts down into the resistant Proterozoic lydites, and often serves as an example of the epigenesis.

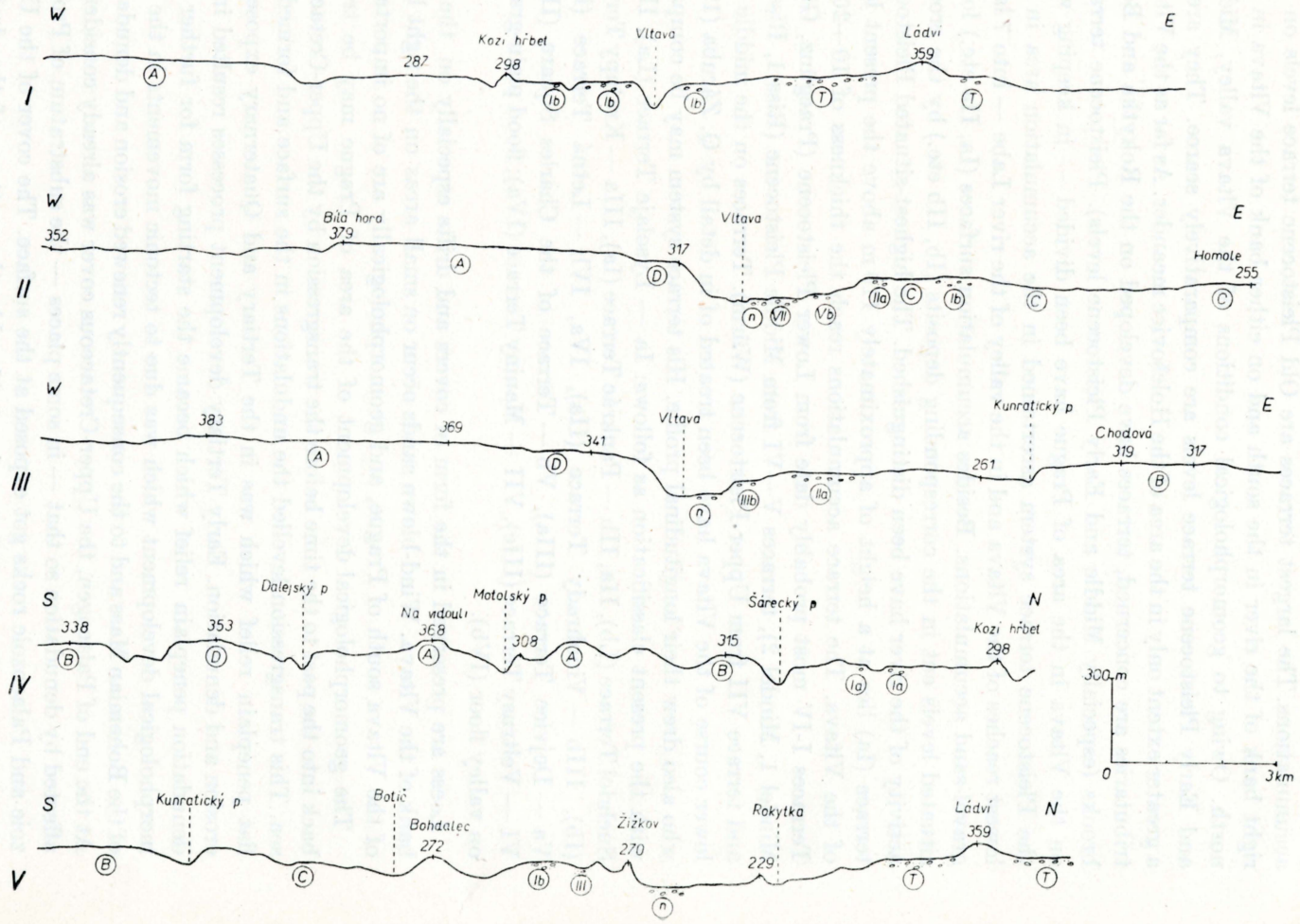
Right-hand tributaries of the Vltava display a somewhat different character owing to more advanced denudation of the area and a considerable occurrence of Quaternary terraces. The longest right-hand tributaries, the Rokytka and Botič brooks, belong to this area only with their lower courses flowing predominantly in wide valley. In places their course gets controlled by harder Ordovician rocks which they cut across (meanders of the Rokytka near Hloubětín, and of the Botič brook in Michle). The Kunratice brook in its middle reaches, before turning westwards (to the Vltava), has a typically assymetrical valley with abrupt right slope and following most probably old transverse dislocations (of Hercynian direction). Rain wash and deep erosion grooves and gorges have been developing in the slopes of deeply incised valleys.

From the oldest accumulations, denudation fragments of Tertiary (Upper Miocene) sands and gravels have been preserved. They may be well traced in the southern part of the map (Sulava) at an altitude of 355 m, i.e. 160 m above the surface of the river. They reach the thickness of about 30 m. Sands and gravels often cemented into limestones or even conglomerates occur on the left bank of the Vltava in the south-western part of the map (north of Chýnice, west of Zadní Kopanina, near Lochkov, Slivenec and Bílá Hora). They usually lie higher than the Sulava deposits and very often at the level of the surface of the peneplain. The Zdiby gravels and sands (Pliocene?) extend as far as the north-eastern part of the map. They fill the depression between the structural ridges of Ládví and Čimice at a height of 325 m — their maximum thickness being 40 m — and occur at a lower-situated denuded level further to the north.

Terraces on the river Vltava in the area of Prague are represented by terrace accumulations. The largest terraces are Old Pleistocene terrace levels on the right bank of the river in the south and on either bank of the Vltava in the north. Owing to geomorphological conditions of the Vltava valley, Middle and Early Pleistocene terrace levels are comparatively scarce. They are of a greater extent only in the area of the Holešovice meander. As far as the Vltava tributaries are concerned, terraces have developed on the Rokytka and Botič brooks (especially Middle and Early Pleistocene levels). Pleistocene terraces on the Vltava in the area of Prague have been divided — in keeping with the Pleistocene terrace system ascertained in the accumulation area in the lowest reaches of the Vltava and in the valley of the river Labe — into 7 large gravel-sand accumulations. Besides accumulation surfaces (Ia, IIa etc.) lower situated levels cut in the corresponding deposits (Ib, IIb etc.) by the erosive activity of the river have been distinguished. The highest-situated Pleistocene terrace (Ia) lies at a height of approximately 110 m above the present level of the Vltava. The terrace accumulations reach the thickness of 10—20 m. Terraces I-IV most probably date from Lower Pleistocene (Praegünz, Günz, Mindel 1, Mindel 2), terraces V—VI from Middle Pleistocene (Riss 1, Riss 2), and terrace VII from Upper Pleistocene (Würm). Terraces on the middle and lower course of the Vltava have been treated of in detail by Q. Záruba (1942) who also drew their longitudinal profile. His terrace system may be compared with the present classification as follows: Ia — Lysolaje Terrace (La), Ib — Suchdol Terrace (Lb), IIa, IIb — Pankrác Terrace (Ia), IIIa — Kralupy Terrace (Ib), IIIb — Vinohrady Terrace (IIa), IVa, IVb — Letná Terrace (IIb), Va — Dejvice Terrace (IIIa), Vb — Terrace of the Charles Square (IIIb), VI — Veltrusy Terrace (IIIc), VII — Maniny Terrace (IVa); flood plain-gravels on valley floor (IVb).

Loess are preserved in the form of covers and drifts especially on the left bank of the Vltava. Wind-blown sands occur on small areas on the right bank of the Vltava south of Prague, and geomorphologically are of no importance.

The geomorphological development of the area of Prague may be traced back into the past to the time before the transgression by the Upper-Cretaceous sea. This transgression levelled the undulations in the surface and formed the flat peneplain relief which was in the Tertiary and Quaternary exposed to erosion and denudation. Early Tertiary development processes resulted in the denudation peneplain relief which became the starting form for further geomorphological development which was due to tectonic movements in the area of the Bohemian Mass and to the consequently renewed erosion and denudation. At the end of Palaeogen, the Upper-Cretaceous cover was already considerably affected by denudation so that — in some places — the substratum of Proterozoic and Palaeozoic rocks got exposed at the surface. The cover of the Upper Creataceous sediments influenced considerably the pattern of the drainage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network in this area (epigenesis), although — during the cutting down of the streams into the older substratum — petrological and tectonic conditions of underlying rocks were of definite importance as well. The present geomorphological character of the region is in places influenced by the original Pre-Cretaceous substratum. As may be seen from fragments left behind after the accumulation activity of the Upper-Cretaceous sea — preserved in places on structural ridges — structural formes have not been affected too much by the Tertiary and Quaternary denudation.

Hydrographical axis and erosion basis for the development of the relief in the area of Prague is the south-north course of the Vltava. Since the very beginning of the Pleistocene no substancial changes took place in the course of the main stream. Only in the southern part of Prague, the river bed shifted in Early Pleistocene towards the west, and in the northern part of Prague a large meander was developing near Holešovice, the origin of which was due to a barrier of resistant Ordovician quartzites which made the stream shift its bed. An important factor in levelling the undulated surface are accumulation loess. It has been deposited prevailingly by western winds to form several covers corresponding genetically to individual Pleistocene terrace accumulations, except the oldest ones. Relations between accumulations of loess and terraces were studied on a classical locality in Sedlec (left bank of the Vltava) in northern part of Prague. Numerous exposures in the area of Prague as well as in the whole central Bohemia were affected by Pleistocene frost weathering (cryoturbation). The comparatively rugged and genetically varied relief offered good conditions for the origin and development of the City of Prague.

Cross-profiles to the geomorphological map of Praha. A — higher-situated level of denudation plateaus of Neogene age (lowered Central Bohemian Peneplain), B — lower-situated level of denudation plateaus of Neogene age, C — denudation plateaus of Pleistocene age, D — structural plateaus of Neogene age, T — plateau of Pliocene sands and gravels (Zdiby stage), I—VII — Pleistocene terraces (a — accumulation surface of the terrace, b — erosional surface of the terrace), n — surface of valley plain. — Příčné profily ke geomorfologické mapě Prahy. A — vyšší úroveň denudačních plošin neogenního stáří (snížená středočeská parovina), B — nižší úroveň denudačních plošin neogenního stáří, C — denudační plošiny pleistocenního stáří, D — strukturní plošiny neogenního stáří, T — plošina pliocenních písků a štěrků (zdibské stadium), I—VII — pleistocenní terasy (a — akumulační povrch terasy, b — erozní povrch terasy), n — povrch údolní nivy.

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