GEOGRAPHICAL RESEARCH INSTITUTE HUNGARIAN ACADEMY OF SCIENCES

PLENARY SESSION OF CARPATHO-BALKAN GEOMORPHOLOGICAL COMMISSION BUDAPEST 7-10 SEPT. 1975

Guide

Compiled by

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BUDAPEST

1975

Geographical Research Institute, Hungarian Academy of Sciences

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PÉCSI, M.

1. EVOLUTION OF THE MOUNTAIN AND BASIN STRUCTURES

Hungary is situated in the middle of a basin[1] surrounded by the Alpine, Carpathian and Dinaric mountain ranges. The roundish Pannonian Basin is a relatively recent form, due to the Tertiary subsidence of the Variscan basement, concurrently with the uplifting of the encircling mountains.

Prior to the evolution of the basin state, by the end of the Palaeozoic, the Variscan basement became considerably shattered; its surface was subsequently furrowed in the early Mesozoic by parallel marine troughs of northeasterly trend. It was in these troughs that the Triassic, Jurassic and Cretaceous limestones and dolomites of what are today the Hungarian Mountains came to be deposited. Most extensive in the Triassic, these troughs underwent a considerable regression in the Jurassic and Cretaceous; on the surface of Triassic rocks exposed to subaerial weathering, a needle-karst-type planation, as well as laterite and bauxite formation, took place under a tropical climate in the Cretaceous and partly also in the early Tertiary.

Intense volcanism in the Upper Cretaceous was preliminary to the folding up of the Carpathian mountainous frame and to the subsidence of the block-faulted Mesozoic in the intra-Carpathian zone and in the basin interior. In the Eocene, the previously peneplanated Mesozoic blocks subsided in a mosaic pattern. The present-day Variscan basement formed, on the other hand, connected masses intercalated between the Mesozoic troughs, also during the evolution of the Carpathian frame, although parts of it were inundated by the early Tertiary seas. Large portions of it rose, however, during the Oligocene (indeed, some blocks of it even during the Miocene) as medium-altitude planated mountain stumps above the Mesozoic zones under the present-day Little Plain and Great Plains.

The most intense subsidence, and the conversion into a basin basement, of the crystalline was likewise preceded by intense volcanism. This megastructural-morphological change — the inversion of the relief — had begun in the Miocene, on the Helvetian-Tortonian border. The volcanism occurred along the marginal faults of the basin in one of the largest young volcanic girdles of Europe. The representatives of this girdle on Hungarian territory include the Visegrád and Börzsöny Mountains, the Cserhát Hills, the Mátra and Tokaj–Zemplén Mountains. These were produced by repeated eruptions, generally growing younger from west to east, and definitely ending in the Pliocene. This process went on concurrently with the folding up of the Flysch

[1] This basin is variously called the Carpathian, Pannonian and Middle Danube Basin in geomorphological literature.

Carpathians and with their uplifting, balanced by the stepwise and gradually accelerating subsidence of the Pannonian Basin. With regard to its crustal structure, the Pannonian Basin has a highly peculiar, unique configuration, whose traits have only recently been outlined by geophysical investigations, seismic deep sounding in particular. According to the results of these, the crust is 20 to 24 km thick beneath the basins, thinner than the world average; the encircling mountain ranges which have grown out of the Alpine–Carpathian–Dinaric geosynclines have a crust 32 to 60 km thick. Below the basin, the Moho surface forms a closed dome. Above it, the geothermal gradient in the basin is rather high.[2] The crust is thinnest where subsidence was deepest. This considerable thinning of the crust, as well as the abnormally close spacing of the Conrad and Moho interfaces, has been partly attributed to Tertiary volcanism: subsidence has in turn been attributed to a mass defect beneath the crust, brought about by volcanism (Balkay 1959, Szénás 1968). A factor presumably contributing to the thinning of the crust in the basin may have been the denudation of the uppermost crustal zones. The vast bulk of the products of denudation was redeposited in the foredeeps and in the flysch zone.

Although the partial subsidence of the basin had begun in the Upper Cretaceous, the basin as a morphological feature came to exist only in the late Tertiary, at the time of the greatest extent of the Pannonian sea. It became a continental basin in the geomorphological sense during the Upper Pliocene and the Quaternary. Hence, in a tectonic and morphological sense the Pannonian basin is a young structural basin filled by marine, and subsequently by fluvio-lacustrine, fluviatile and eolian sediments, whose subsidence was partly due to the synorogenic crustal displacements of the Carpathian upfolding and to the volcanic eruptions in the intra-Carpathian volcanic belt.

ZUSAMMENFASSUNG DER VORNEOGENEN ENTWICKLUNG UNGARNS

Gy. Wein

Zusammenfassung

Die neueren Tiefbohrungen, geophysikalischen Messungen und Schürfarbeiten im Gelände haben es möglich und sogar notwendig gemacht, den geologischen Aufbau und die Entwicklungsgeschichte des mit neogen Gesteinen bedeckten Untergrundes von Ungarn neu auszuwerten.

Von der präkambrischen tektonischen Etage, welche aus mehreren, voneinander nicht trennbaren Regions de plissement besteht, wissen wir sehr wenig. Wir zählen hierzu die epi-mesometamorphen Gesteine der Zentral-Karpatischen Schwelle (Zone der Soproner kristalliner Gesteine) und jene polymetamorphen Gesteine in epi-mesometamorphem Zustand, welche südwestlich von der haupttektonischen Linie Zagreb—Kules im Mecsek-Gebirge auf der Oberfläche zu finden sind und im neogenen Untergrund der Großen Ungarischen Tiefebene durch Bohrungen bloßgelegt wurden. Zu dieser Periode, die im Laufe mehrerer Geozyklen zustande kam, gehört auch basisch initialer Magmatismus (Amphibolit, Serpentin) und syn-posttektonischer Granitmagmatismus (Soproner Granitgneis, Granodiorit von Szalatnak, Bohrung 3.).

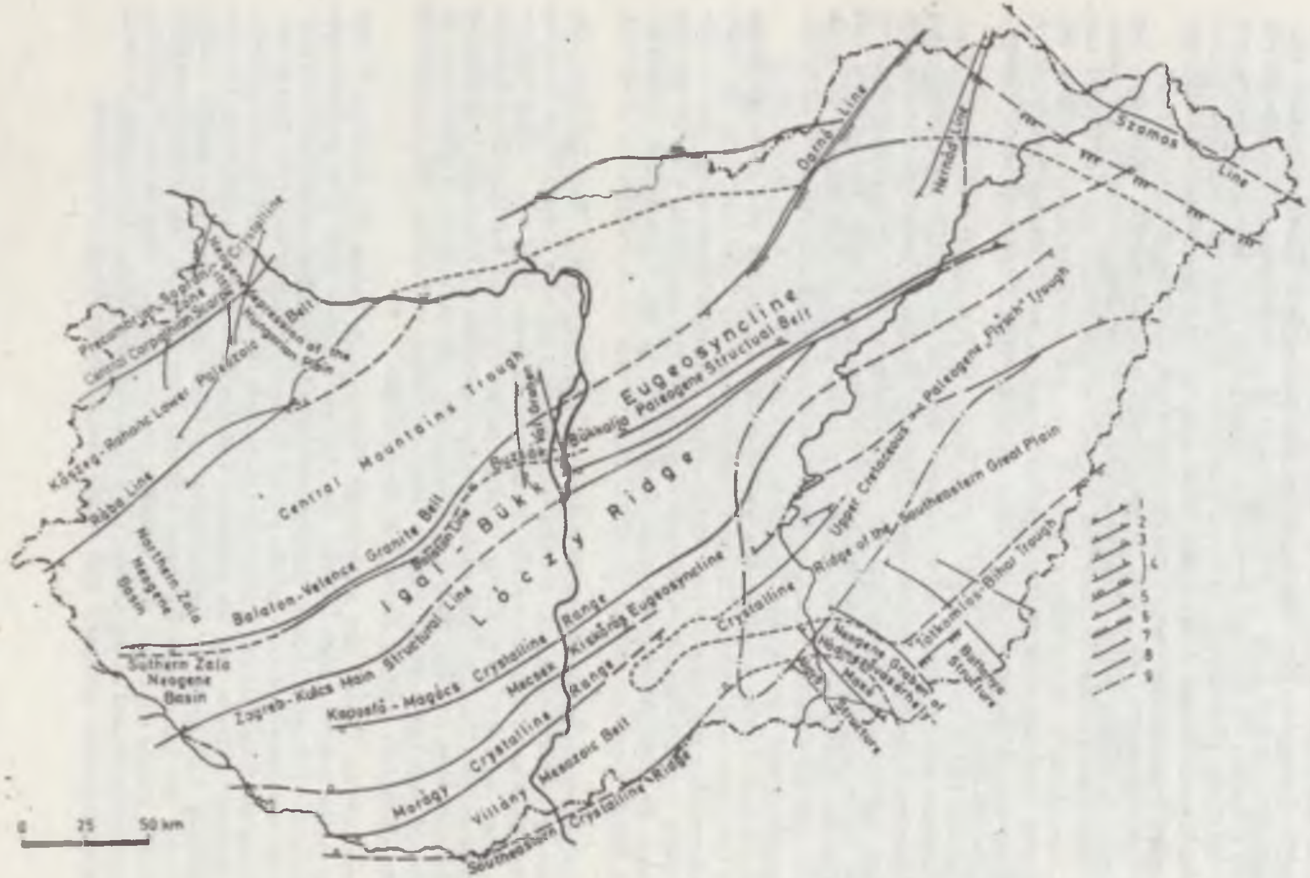
Die altpaläozoischen Bildungen haben sich entlang Strukturen entwickelt, welche mit den alpidischen Richtungen in großen Zügen übereinstimmen. In dieser Zeit wurde die Emersion, die auf die assyntischer (baikalischer) orogene Ära folgte, durch eine sich auf das Gebiet von fast ganz Ungarn ausdehnende geosynklinale Bildung von SW—NO-Richtung abgelöst. die durch dicke silurische (Ordovizium?) pelitisch-psammitische und devonische hauptsächlich karbonatische Sedimentschichten vertreten ist. Die anfänglich saure, dann basische Bildungen von initialem Vulkanismus fehlen auch hier nicht.

Die ganze Schichtfolge hat zwischen Devon und Unterkarbon (bretonische Phase) eine Epimetamorphose durchgemacht. Nachher wirkte sich der sich an die variszische Bewegungen knüpfende syntektonische Granitmagmatismus aus. Die variszischen Bewegungen haben sich auch in sehr starken Schuppungen geäussert. Die stellenweise auftretende starke retrograde Metamorphose wird dieser Bewegung zugeschrieben. Nach den variszischen Bewegungen mit posttektonischem Granitmagmatismus und subsequentem Quarzporphyr-Vulkanismus im Laufe des oberen Karbons und des Perms — ausgenommen die Eugeosynklinale von Igal — Bükk-Gebirge — ist das ganze Gebiet von Ungarn trockenes Land geworden.

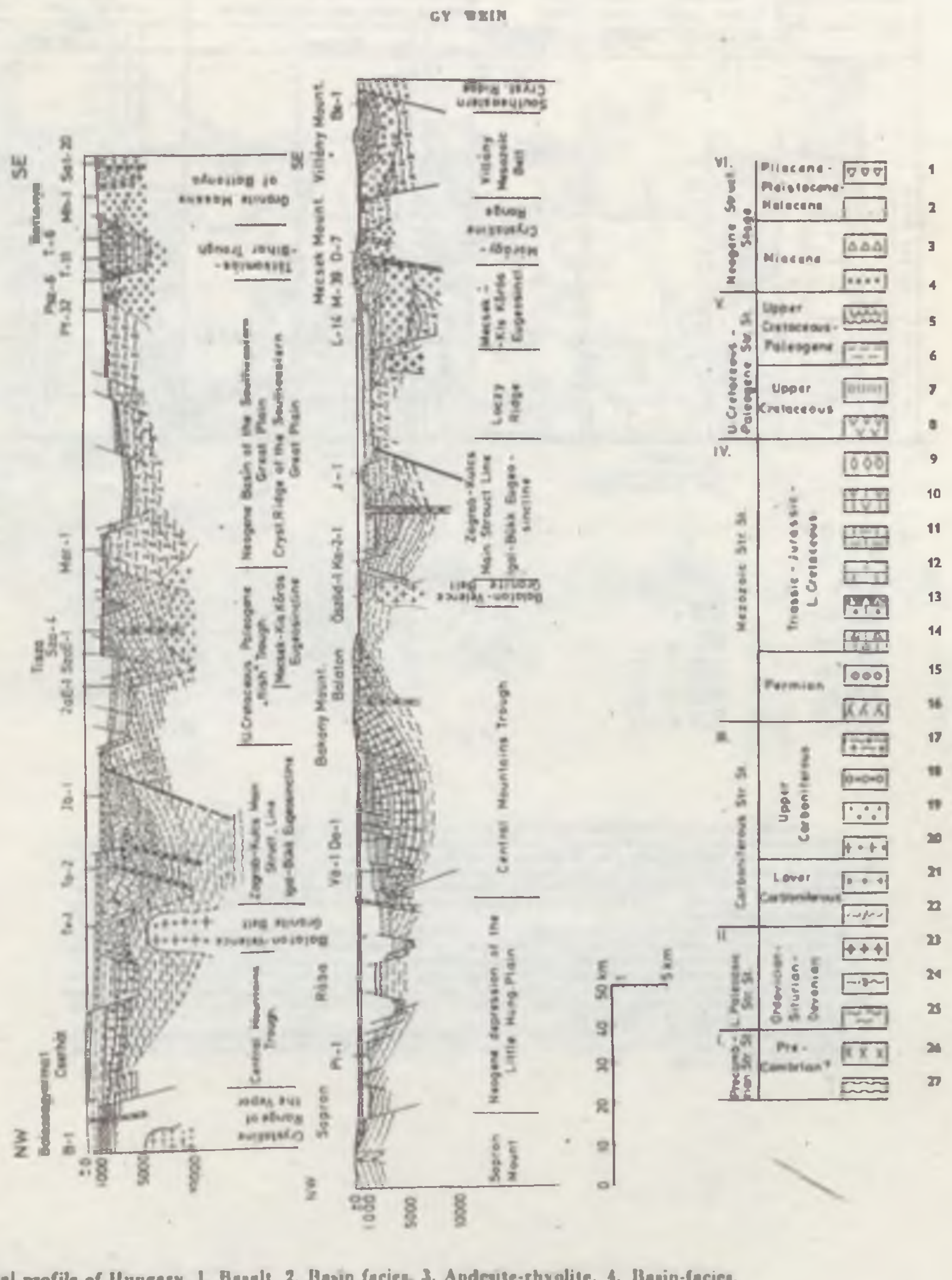
Während des alpidischen Zyklus bildeten sich die Sedimentationströge und zwischen ihnen die aus kristallinen Gesteinen bestehenden steifen Fluren entlang der Strukturen aus, die unter dem Einfluß altpaläozoischer und variszischer tektonischer Vorgänge entstanden. Der Lóczy-Rücken der sich südlich von der Hauptstrukturlinie Zagreb—Kules ausbildete, und die aus den kristallinen Gesteinen des präkambrisch-altpaläozoischenRückens der Ungarischen Südosttiefebene aufgebauten Blöcke vertreten die Urtisia, die in dieser Form schon während des Paläozoikums existierte.

Während des altalpidischen Zyklus haben sich der Trog des Ungarischen Mittelgebirges, die Eugeosynklinale von Igal—Bükk-Gebirge, die sich vom Karbon bis zum oberen Trias bewegte, die Eugeosynklinale von Mecsek-Gebirge—Kiskőrös und mesozoische Trog von Villány herausgebildet. Zwischen ihnen liegt der Lóczy-Rücken und an dessen Südrand der kristalline Rücken von Kaposfő—Mágocs und von Mórágy. Südöstlich vom altpaläozoischen Rücken der Ungarischen Südosttiefebene unterscheiden wir den Trog von Tótkomlós—Bihar. Initialer Vulkanismus ist in der Eugeosynklinale von Igal—Bükk-Gebirge (mittlere Trias) und in der Eugeosynklinale von Mecsek-Gebirge—Kiskőrös (untere Kreide) zu beobachten.

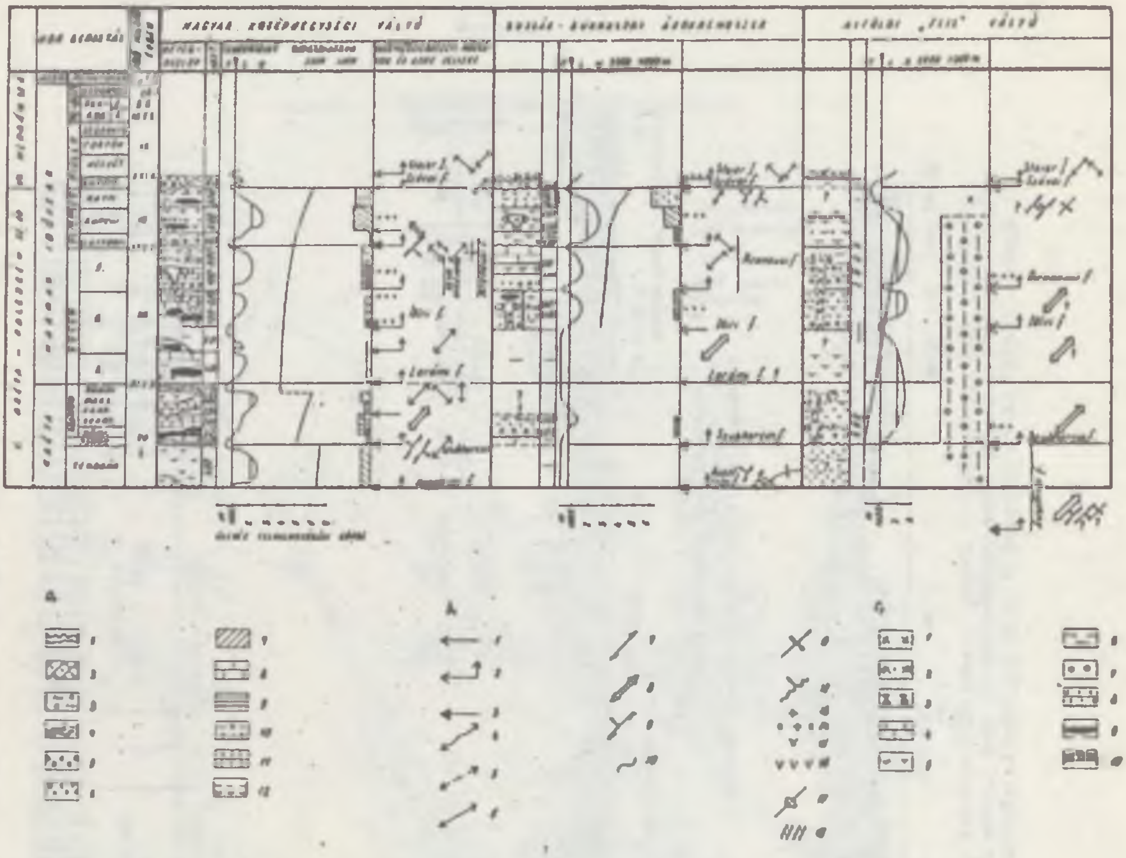
Die starken kompressiven Phasen der austrischen Bewegungen haben die mobilen Zonen aufeinandergeschuppt und gefaltet, aber Decken von alpinem Ausmaß sind nicht zustande gekommen. Ausnahme ist das Kőszeg-Rohoncer Gebirge, wo sich wahrschenlich unter Einfluß alpiner Tektonik die Gesteine metamorphisierten und die jetzige Schuppenstruktur entstand. Der neualpidische Zyklus begann mit Emersion am Anfang der Oberkreide (Turon). Dann folgte eine Senon-Transgression im Bakony Gebirge und im östlichen Teil der Tiefebene. Im östlichen Teil der Tiefebene Flyschbildung und neutraler Vulkanismus im Obereozän, dann eine starke kompressive Phase schlossen die Oberkreide-Paläogen Zeit ab. Darauf folgte die dilatationsartige Zerstückelungstektonik, welche im Laufe des Oligozäns und endlich des Pliozäns das Karpatenbecken in Blöcke zerstückelte und so die jetzige Tisia (Pannonische Masse) herausbildete. Dem Vorgang folgte ein subsequenter neutraler und saurer, dann finaler Basaltvulkanismus.



Major structural units of Hungary. Plotted by GY. WEIN. 1. Lower Paleozoic fault (Breton phase). 2. Carboniferous fault (Sudetic-Asturian phase). 3. Permo-Mesozoic basin forming faults. 4. Mesozoic normal fault (Austrian-Subhercynian phase). 5. Paleogene normal fault. 6. Paleogene reverse fault. 7. Neogene normal fault. 8. Boundaries of structural units. 9. Boundary of the "Flysch" Trough



Geological profile of Hungary. 1. Basalt. 2. Basin facies. 3. Andesite-rhyolite. 4. Basin-facies. 5. "Flysch" formation. 6. Epicontinental facies. 7. "Gosau" facies. 8. Basic volcanics. 9. Lower Cretaceous basic, alkalic volcanic rocks (diabase, bostonite, phonolite). 10. Tótkomlós facies. 11. Villány facies. 12. Mecsek facies. 13. Bükk facies (with initial T_1 volcanics). 14. Central Mountains facies. 15. Continental sequence. 16. Quartz porphyry. 17. Marine Permo-Carboniferous. 18. Continental deposits. 19. Finegrained granite porphyry. 20. Granite of Velence type. 21. Migmatitic granite of Mórágy type. 22. Epianchimetamorphic rocks. 23. Granite of Szalatnak type. 24. Polymetamorphic indiscriminable rocks. 25. Epimetamorphic rocks. 26. Granite gneiss. 27. Epi-to Mesozonal crystalline rocks



Vergleich von oberkretazischen und paläogenen tektonischen Etagen von G. Wein, 1970

a) *Zeichenerklärung des Faziesdiagrammes*: 1 = epi-mesozonale kristalline Gesteine; 2 = epimetamorphe Gesteine von epikontinentaler Abstammung; 3 = epimetamorphe Gesteine von Grauwacke-Ausbildung; 4 = epimetamorphe Gesteine von karbonatigem Charakter; 5 = Gesteine vulkanischer Herkunft; 6 = kontinentale Trümmersedimente; 7 = epikontinentale sandig-lehmige Sedimente; 8 = karbonatische Sedimente von offener See; 9 = Schichten von Fleckenmergel-Ausbildung; 10 = Schichten von Flysch-Ausbildung; 11 = Schichten von litoraler Ausbildung; 12 = Regressionsschichten

b) *Zeichenerklärung für tektonische Bewegungen*: 1 = orogene Phase; 2 = orogene Phase mit Steigung; 3 = kraftvolle orogene Phase; 4 = Streichrichtung der Schieferung; 5 = Streichrichtung der Lineation; 6 = Streichrichtung von Bruchlinien; 7 = Streichrichtung von horizontalen Schiebungen; 8 = Streichrichtung von bocheaufkommenden Bruchlinien; 9 = Streichrichtung und Vergenz von Aufschiebungslinien; 10 = gefaltete Schichtfolge; 11 = Streichrichtung von gefalteten Formen; 12 = Streichrichtung und Vergenz der Fältelung; 13 = saurer Magmatismus; 14 = saurer Vulkanismus; 15 = basischer Magmatismus; 16 = basischer Vulkanismus; 17 = Streichrichtung von Vulkaniten; 18 = regionale Metamorphose

c) *Zeichenerklärung für die ideale Schichtfolge von oberkretazischen und paläogenen Bildungen*: 1 = Andesit; 2 = Andesittuff; 3 = Rhyolith; 4 = Kalkstein; 5 = Mergel, Tonmergel; 6 = Ton; 7 = Konglomerat; 8 = Sandstein; 9 = Steinkohle; 10 = Bauxit

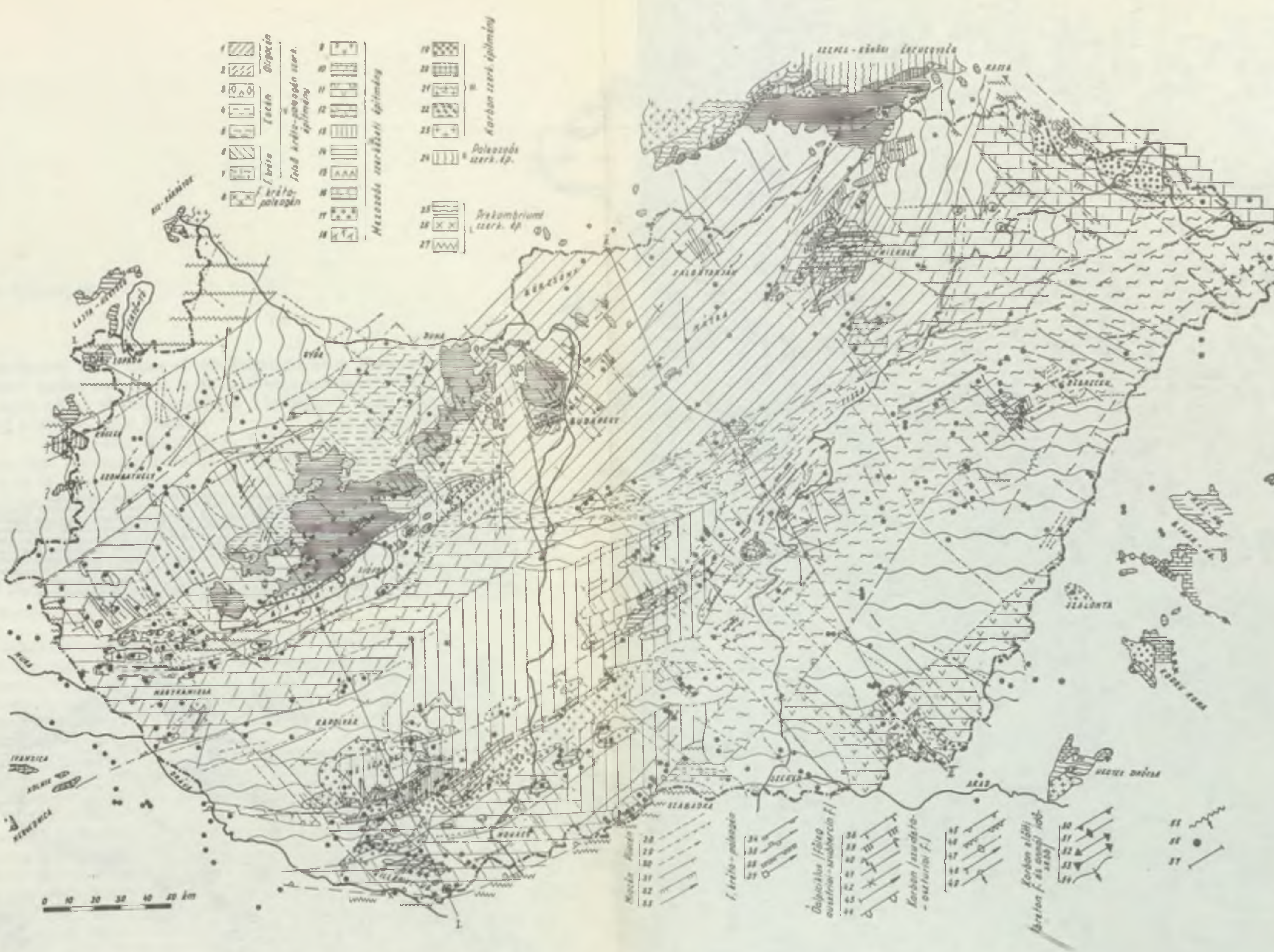


Abb. 1. Strukturgeologische Karte des mit Neogengesteinen bedeckten Beckenuntergrundes von Ungarn von G. WEIN, 1970

1 = epikontinentale Entwickelung; 2 = Flyschentwickelung; 3 = vulkanische Bildung; 4 = epikontinentale Entwickelung; 5 = Flyschentwickelung; 6 = epikontinentale Entwickelung; 7 = Flyschentwickelung; 8 = junge Granitoide; 9 = basisch-alkalischer Vulkanit (Unterkreide); 10 = Mesozoikum; 11 = Mesozoikum von Fótkomlós—Biharer Ausbildung (Trias—Unterkreide); 12 = Mesozoikum von Villányer Ausbildung (lückenhaftes Trias—Unterkreide); 13 = Mesozoikum von Mecseker Ausbildung (Trias-kreide—Cenoman); 14 = Mesozoikum von Ungarischer Mittelgebirgsausbildung (Trias—Cenoman); 15 = Diabas—Spilit—Gabbro (Oberanis—Ladin); 16 = Neupaläozoikum—Mesozoikum von Bükker Ausbildung (Oberkarbon—Nor); 17 = Perm von terrestrischer Ausbildung; 18 = Quarzporphyr (Unterperm); 19 = Oberkarbon von kontinentaler Ausbildung; 20 = Unter- und Oberkarbon von mariner Ausbildung; 21 = Kontaktgesteine, durchdrungen von Aplit-, Granit-Porphyr- und Quarzporphyradern (Karbon); 22 = Granit (Typ Velence—Oberkarbon); 23 = granitoide Gesteine (Typ Mórágy—Unterkarbon); 24 = epimetamorphe altpaläozoische Gesteine; 25 = polymetamorphe unabsonderliche kristalline Gesteine (Präkambrium—Altpaläozoikum); 26 = Granit—Granitgneis (Typ Sopron und Szalatnak—Präkambrium—Kambrium?); 27 = epi-mesozonale kristalline Gesteine (Präkambrium); 28 = Verwerfungslinie; 29 = Aufschiebungslinie; 30 = Vergenz; 31 = Verwerfungslinie; 32 = Aufschiebungslinie; 33 = Vergenz; 34 = Verwerfungslinie; 35 = horizontale Verschiebungslinie; 36 = Aufschiebungslinie; 37 = Vergenz; 38 = Verwerfungslinie; 39 = Aufschiebung; 40 = überkippte Falte; 41 = Faltensattel; 42 = Faltentrog; 43 = Vergenz; 44 = beckenformende Strukturlinie; 45 = Bruchlinie; 46 = Aufschiebung; 47 = Faltungsachse; 48 = Vergenz; 49 = Neigungsrichtung der Lineation und Schieferung von granitoiden Gesteinen; 50 = Hauptstrukturlinie; 51 = Faltungsachse; 52 = Streichrichtung der Fältelung; 53 = Vergenz der Fältelung; 54 = Streichrichtung der Schieferung auf Grund der Reflexionsmessungen; 55 = Neigungsrichtung von präkambrischen und paläozoischen magnetischen Anomalien; 56 = Tiefbohrung; 57 = Richtung des Profils

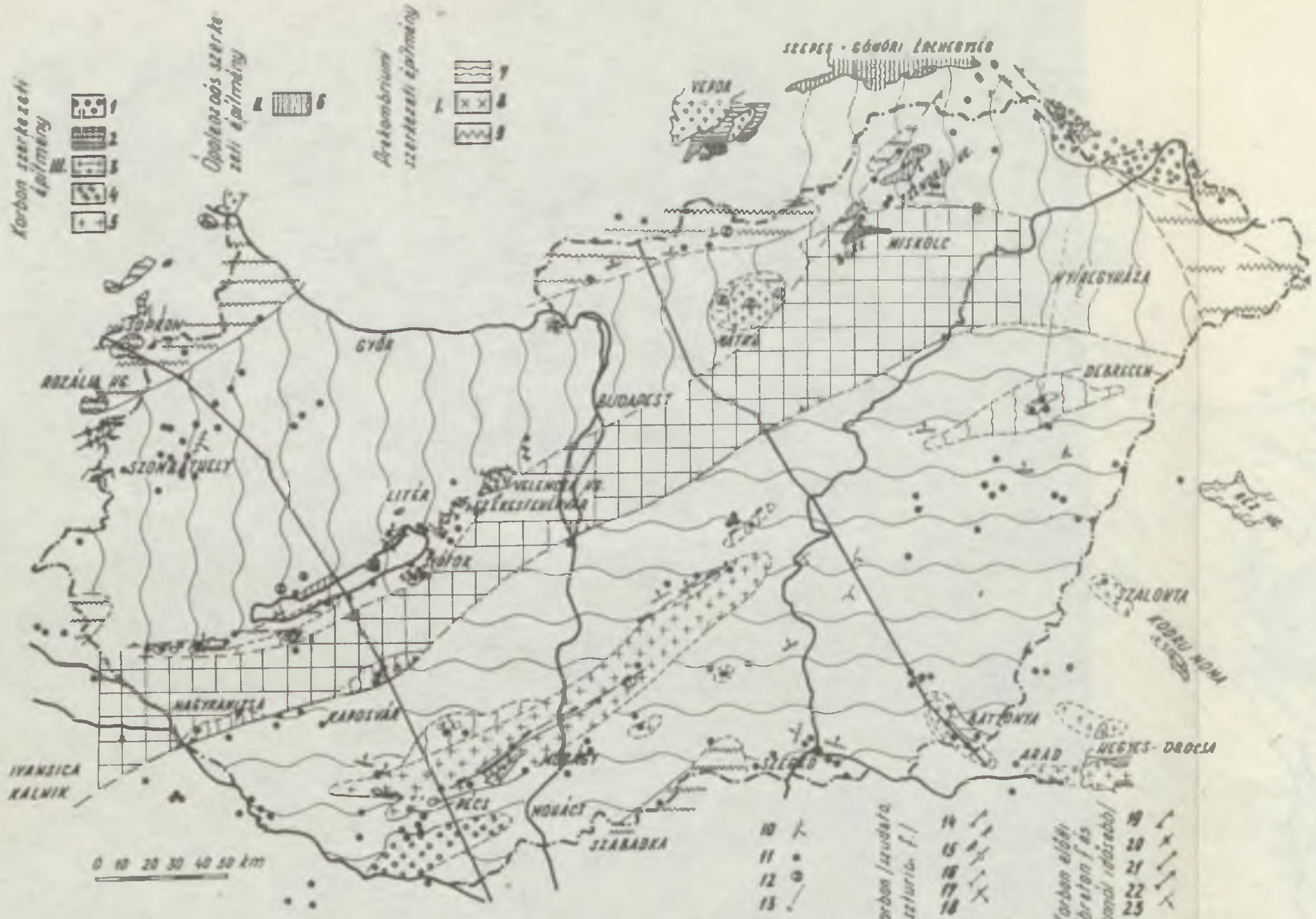


Abb. 2. Die strukturgeologische Karte der Unterlage der Perm-Schichtfolge von G. WEIN, 1970

1 = Oberkarbon von kontinentaler Entwicklung; 2 = Unter- und Oberkarbon vom mariner Entwicklung; 3 = Kontaktgesteine, durchdrungen von Aplit-, Granitporphyr- und Quarzporphyradern; 4 = Granit (Oberkarbon vom Velence-Typ); 5 = granitoide Gesteine (Unterkarbon vom Mórágy-Typ); 6 = epimetamorphe, altpaläozoische Gesteine; 7 = polymetamorphe, unabsonderliche kristalline Gesteine (Präkambrium, Altpaläozoikum); 8 = Granit, Granitgneis (Soproner und Szalatnaker Typ, Präkambrium—Kambrium?); 9 = epi-mesozonale kristalline Gesteine (Präkambrium); 10 = Einfallsrichtung der präkambrischen und paläozoischen magnetischen Anomalien; 11 = Tiefbohrung; 12 = als vulkanischer Einschluß beobachteter Basisgestein; 13 = Richtung des Profils; 14 = Bruchlinie; 15 = Aufschluß; 16 = Faltungsachse; 17 = Vergenz; 18 = Einfallsrichtung der Lineation und Schieferung von granitischen Körpern; 19 = Hauptstrukturlinie; 20 = Faltungsachse; 21 = Streichrichtung der Zerknitterung; 22 = Vergenz der Fältelung; 23 = Einfallsrichtung der Schieferung auf Grund der Reflexionsmessungen

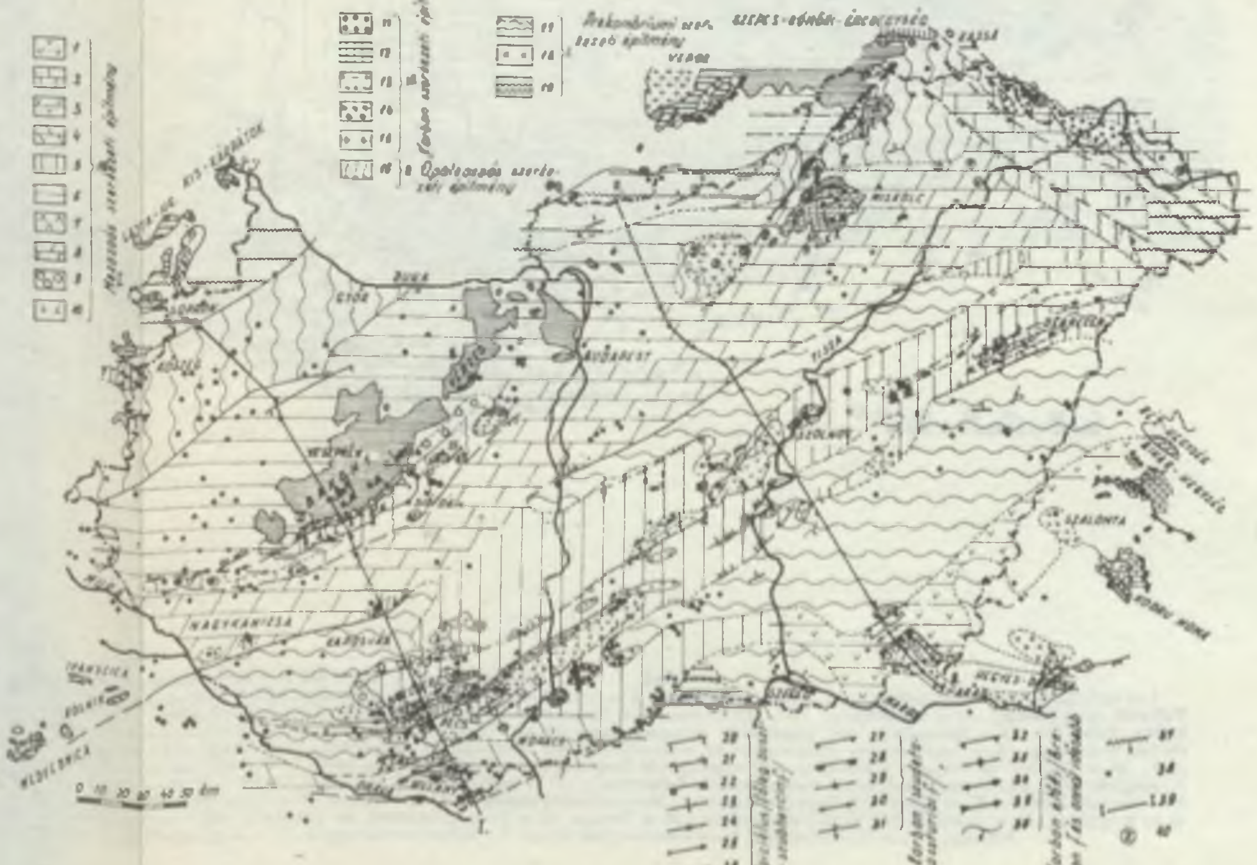
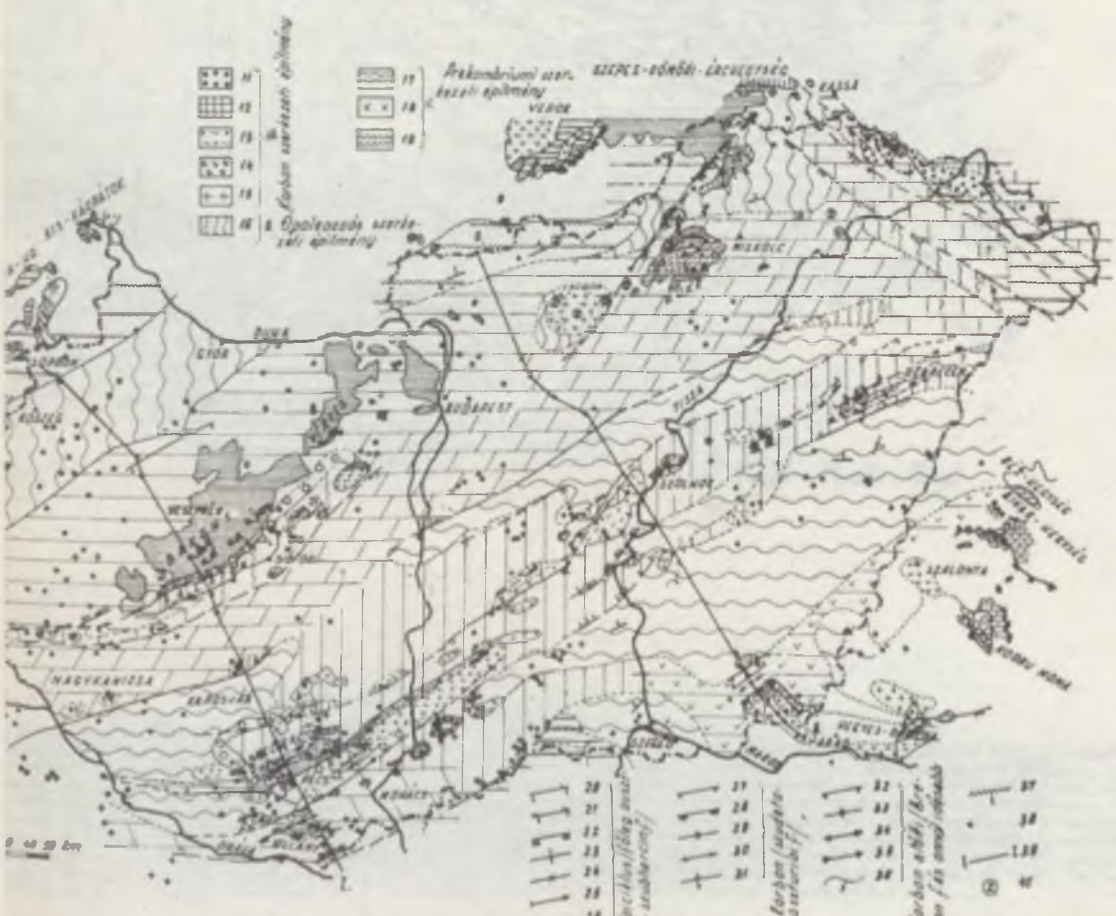


Abb 3. Strukturgeologische Karte der Unterlage der Oberkreide von G. WEIN, 1970

1 = basisch-alkalischer Vulkanit; 2 = Mesozoikum; 3 = Mesozoikum von Tótkomlós-Biharer Ausbildung Trias—Unterkreide); 4 = Mesozoikum von Villányer Ausbildung (lückenhaften Trias—Unterkreide); 5 = Mesozoikum von Mecseker Ausbildung Trias—Cenoman); 6 = Mesozoikum von Ungarischer Mittelgebirgsausbildung (Trias—Cenoman); 7 = Diabas—Spilit—Gabbro (Oberanis, Ladin); 8 = Neupaläozoikum—Mesozoikum von Bükker Ausbildung (Oberkarbon—Nor); 9 = Perm von terrestrischer Ausbildung; 10 = Quarzporphyr (Perm); 11 = Oberkarbon von kontinentaler Ausbildung; 12 = Ober- und Unterkarbon von mariner Ausbildung; 13 = Kontaktgesteine durchdrungen von Aplit-, Granitporphyr- und Quarzporphyradern; 14 = Granit (Typ Velence, Oberkarbon); 15 = Granitoide Gesteine (Typ Mórágy, Unterkarbon); 16 = epimetamorphe altpaläozoische Gesteine; 17 = polymetamorphe, unabsonderliche kristalline Gesteine (Präkambrium, Paläozoikum); 18 = Granit—Granitgneis (Soproner und Szalatnaker Typ, Präkambrium—Kambrium?); 19 = epi-mesozonale kristalline Gesteine (Präkambrium); 20 = Verwerfelungslinie; 21 = überkippte Falte; 22 = Aufschiebung; 23 = Faltensattel; 24 = Faltentrog; 25 = Vergenz; 26 = beckenformende Strukturlinie; 27 = Bruchlinie; 28 = Aufschiebung; 29 = Faltenachse; 30 = Vergenz; 31 = Neigungsrichtung von Lineation und Schieferung granitoider Gesteine; 32 = Hauptstrukturlinie; 33 = Faltenachse; 34 = Streichrichtung der Fältelung; 35 = Vergenz der Fältelung; 36 = Neigungsrichtung der Schieferung; 37 = Neigungsrichtung von präkambrischen und paläozoischen magnetischen Anomalien; 38 = Tiefbohrung; 39 = Richtung des Profils; 40 = Inklusion

Abb. 2. Die strukturgeologische Karte der Unterlage der Perm-Schichtfolge von G. WEIN, 1970

1 — Oberkarbon von kontinentaler Entwicklung; 2 — Unter- und Oberkarbon vom mariner Entwicklung; 3 — Kontaktgesteine, durchdrungen von Aplit-, Granitporphyr- und Quarzporphyradern; 4 — Granit (Oberkarbon vom Velence-Typ); 5 — granitoide Gesteine (Unterkarbon vom Mórágy-Typ); 6 — epimetamorphe, altpaläozoische Gesteine; 7 — polymetamorphe, unabsonderliche kristalline Gesteine (Präkambrium, Altpaläozoikum); 8 — Granit, Granitgneis (Soproner und Szalatnaker Typ, Präkambrium—Kambrium?); 9 — epi-mesozonale kristalline Gesteine (Präkambrium); 10 — Einfallsrichtung der präkambrischen und paläozoischen magnetischen Anomalien; 11 — Tiefbohrung; 12 — als vulkanischer Einschluß beobachteter Basisgestein; 13 — Richtung des Profils; 14 — Bruchlinie; 15 — Aufschluß; 16 — Faltungsachse; 17 — Vergenz; 18 — Einfallsrichtung der Lineation und Schieferung von granitischen Körpern; 19 — Hauptstrukturlinie; 20 — Faltungsachse; 21 — Streichrichtung der Zerknitterung; 22 — Vergenz der Fältelung; 23 — Einfallsrichtung der Schieferung auf Grund der Reflexionsmessungen



PÉCSI, M.

THE TRANSDANUBIAN MOUNTAINS

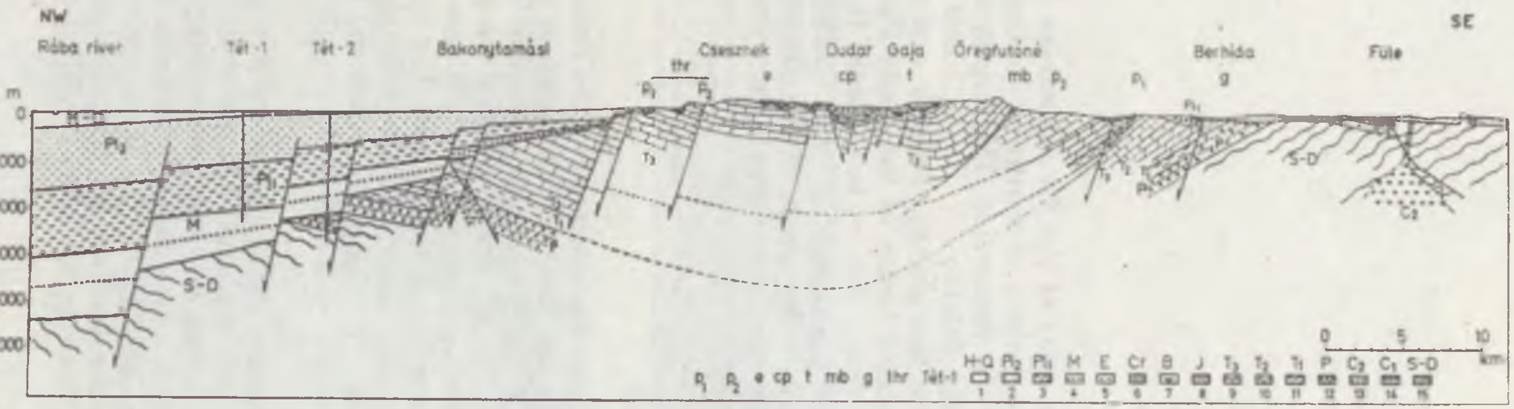
Regional subdivision

The individual block-faulted horst units of the Transdanubian Mountains are separated by smallish basins and grabens of northwest-southeast strike, perpendicular to the main trend of the mountains. The largest single unit is the Bakony, situated north of Lake Balaton and delimited against the Vértes by the Mór graben. Farther east and north there are the fault blocks and intercalated basins of the Buda–Pilis–Gerecse group It is to this latter group that we have joined the volcanic range of the Dunazug ("Danube nook"), although in forms and constitution it differs from them. The conspicuous valley gorge of the Danube divides the Dunazug unit more sharply from the Intra-Carpathian volcanic girdle than they are connected by morphological similarities.

Structural and morphological evolution

The Little Plain and Great Plains basins are separated by the Transdanubian Mountains. This range has, just like the Mecsek mountains, a crystalline basement. The long marine trough of northeast-southwest trend that developed late in the Palaeozoic was mainly filled with a sequence of Triassic limestones and dolomites, of more or less pronounced South Alpine affinities. Most of this trough was laid dry at the end of the Triassic, but its northern side was inundated by the Jurassic and Cretaceous and then also by the Tertiary seas. Along the mountain axis, the individual structural units performed a complicated ballet of subsidences and upliftings irregular in space and time.

In the Cretaceous, however, the surface of the mountains was still rather uniform. Under a tropical climate it was deplanated to a low but extensive peneplain. This is proved by the bauxites and laterites widespread in the mountains. From the Upper Cretaceous onwards, in the phases of orogeny that resulted in the folding up of the Carpathians, the Transdanubian Mountains underwent block-faulting with the development of graben subsidences and horst-type karsted hills. In the Tertiary, the blocks uplifted to various



Profile across the Bakony Mountains (after Gy. Wein, 1969)

1 — Holocene-Pleistocene river-laid sand and gravel and flood-laid soils; 2 — Upper Pannonian sand and clay; 3 — Lower Pannonian (Pliocene) clay marls; 4 — Miocene gravels and sand (in the Dudar basin, including the Upper Oligocene); 5 — Eocene coal seams and carbonatic rocks; 6 — Lower Cretaceous (Aptian-Albian-Cenomanian) limestones and calcareous marls; 7 — bauxite and related formations; 8 — Jurassic limestones; 9 — Upper Triassic dolomites and limestones; 10 — Middle Triassic limestone; 11 — Lower Triassic aleurolite, marl and limestone; 12 — Permian sandstones and conglomerates; 13 — Upper Carboniferous granite prophyry; 14 — Lower Carboniferous conglomerate and clay shales; 15 — Silurian-Devonian phyllite and crystalline limestone; t — uplifted remnant of tropical peneplain; cp — cryptoplane; e — exhumed peneplain, locally covered with a Miocene gravel sheet; mb — mountain-border bench; p_2 — Pannonian bench of abrasion; p_1 — piedmont surface (pediment); g — Pleistocene piedmont surface modelled in little consolidated sediment (glacis); thr — remodelled tropical peneplain in threshold position; Tét-1-2 — prospect wells

altitudes were worn down and partly turned into marginal half-planes, while the graben-type intramontane basins were being filled with waste. The surface elements in threshold position were covered with gravel sheets derived from the north and south, from the crystalline regions which at that time were still higher than the Transdanubian Mountains region. This state of affairs continued up to the end of the Miocene. It was at the end of the Miocene, and even more in the Pliocene, that the Transdanubian Mountains rose above their surroundings. Their present-day mean altitude of 500 m, however, is the result of late Pliocene and Pleistocene uplifting.

Two members of the Transdanubian Mountains, notably the Bakony and Vértes, possess highly similar structures composed of several more or less isolated blocks. The rocks constituting them, largely Triassic limestones and dolomites, have a general northwesterly dip. In the southern forelands of these mountains, Palaeozoic rocks are exposed. In the Bakony, the Lower Triassic overlies a Permian sandstone which in turn overlies a Carboniferous phyllite Indeed, south of the Balaton even the granitic basement is at a quite small depth below the surface. South of the Vértes, on the other hand, the basement granite constitutes a batholith rising above the surface in the form of the Velence Hills. The Vértes and the Velence Hills are separated from one another by a shallow graben. One peculiar difference between the Bakony and the Vértes is that in the southwestern part of the Bakony and in the so-called Balaton Upland, a rather large-scale basalt volcanism took place during and after the Upper Pannonian crustal movements. The extensive basalt covers were subsequently worn down to monadnocks.

The blocks and intercalated graben basins of the Gerecse Mountains are arranged in a north-south-trending pattern. In the Eastern Gerecse, however, and in the Buda–Pilis Mountains, the relief-controlling structural lines strike northwest-southeast, i.e. perpendicularly to the main trend of the Transdanubian Mountains. From the Upper Cretaceous onwards, graben subsidences took place along these structural lines, with horst blocks left standing between them. In the grabens, Eocene–Oligocene and Miocene seashore deposits accumulated.

Types of planated surfaces

Despite the intense structural dissection, the summit levels of the horst blocks of various altitude of the Transdanubian Mountains turned out to be due to a process of planation. Besides the summit levels of planation, these blocks carry on their flanks narrow marginal ledges and benches[5], and the block mountains as a whole are surrounded by broad foothill surfaces. These latter are partly pediments sculptured in dolomite and partly glacis of erosion modelled in little consolidated Tertiary deposits.

[5] The marginal benches due to planation are in part remnants of ancient piedmont surfaces whose base levels of erosion were the Lower and Middle Pliocene seas; others are terraces of abrasion. The process of abrasion is convincingly documented in the forelands especially of the Bakony, Vértes and Mecsek.

The summit levels of various altitudes, due to planation, were interpreted in various ways by various workers. According to Bulla (1962), a continuous tropical planation took place on the exposed Palaeozoic and Mesozoic blocks from the Upper Cretaceous to the Middle Pliocene. According to Pécsi (1969), on the other hand, the continuous tropical planation of the Transdanubian Mountains went on only up to the beginning of the Eocene, and the surfaces of planation themselves are polygenetic in origin, because the remnants of a Tertiary terrestrial gravel sheet encountered even on the summit levels of these mountains suggest that the gravels had been transported by streams coming from the neighbouring crystalline mountains onto the Transdanubian Mountains region which by that time had already undergone tropical planation. Hence, the Mesozoic regions were in the Miocene the forelands, pediments and indeed the pediplains of the Palaeozoic crystalline mountains. In the Pliocene, when these crystalline mountains had foundered, the Transdanubian Mountains emerged as an archipelago from the Pannonian Sea. Along the shores of this latter, benches of abrasion came to exist, which today constitute mountain-border benches or steps.

There is no proof for a continued tropical planation beyond the beginning of the Eocene. The tropical climates of the Jurassic and Cretaceous gave rise to needle karst forms and laterite and bauxite deposits widely distributed over the mountain blocks (Bakony, Vértes, Gerecse, Buda Mountains). Today, these forms are encountered at the graben bottoms, covered with Eocene limestones and also other sediments. An analysis of the structure of the Transdanubian Mountains, the correlate deposits indicative of the modes of deplanation (laterites and bauxites) and their redeposited varieties, including also the disposition in space of these correlate deposits, has revealed tropical planation to have extended in the Cretaceous most probably over the entire Transdanubian Mountains region. This vast low tropical peneplain was uplifted to various altitudes by the differentiated structural movements — block upliftings and subsidences — that took place from the Upper Cretaceous onward. The individual blocks can, on the basis of their distinctive present-day morphological positions, be subdivided in five groups.

Cryptoplane

Elements of a planated surface remained unworn only on those blocks which in the Eocene had subsided to be covered by a complex of limestones. This cover then protected them from further wear. Some blocks sank deeper during the Tertiary, giving rise to small intramontane basins or foreland basins. It is these forms that are included in the group of cryptoplanes (Fig. 14). In the karst hollows of the Eocene-covered needle-karsted cryptoplanes there are substantial bauxite deposits especially on the margins of the Bakony and Vértes. The types of cryptoplane were established and documented as a result of the exposures occurring in the bauxite mines.

Tropical planated surfaces in threshold position

Some blocks carrying remnants of the Cretaceous planated surfaces now occupy the position of piedmonts or low rises in the Bakony, Vértes and Gerecse. This group includes further the low-lying fault blocks of the Southern Bakony and Balaton Upland, too. The tropical forms and weathering products have mostly been worn down, but there are traces of them in spots. Locally the tropical laterite and red residual clay is restricted to joint fissure fillings. Elsewhere there are on the surface small spots or scattered pebbles of a Tertiary gravel, usually consisting of red-tinted quartz. This suggests the ancient tropical surface to have undergone a pedimentation in subsequent times.

Tropical planated surface uplifted to summit-level position

This group includes those highest blocks of the Bakony and Gerecse whose surfaces bear no trace of tropical forms or correlate deposits (Kőris Hill, Papod, Tés Plateau, Nagy-Gerecse, etc.). However, on the lower levels surrounding them (400 to 500 and 200 to 250 m) there are in the mouths of dry valleys remnants of redeposited red tropical clays. The planated summit levels, presumably modelled in the Upper Cretaceous by tropical planation, were considerably worn down in the Tertiary. However, data on the depth and modes of erosion are not yet sufficient.

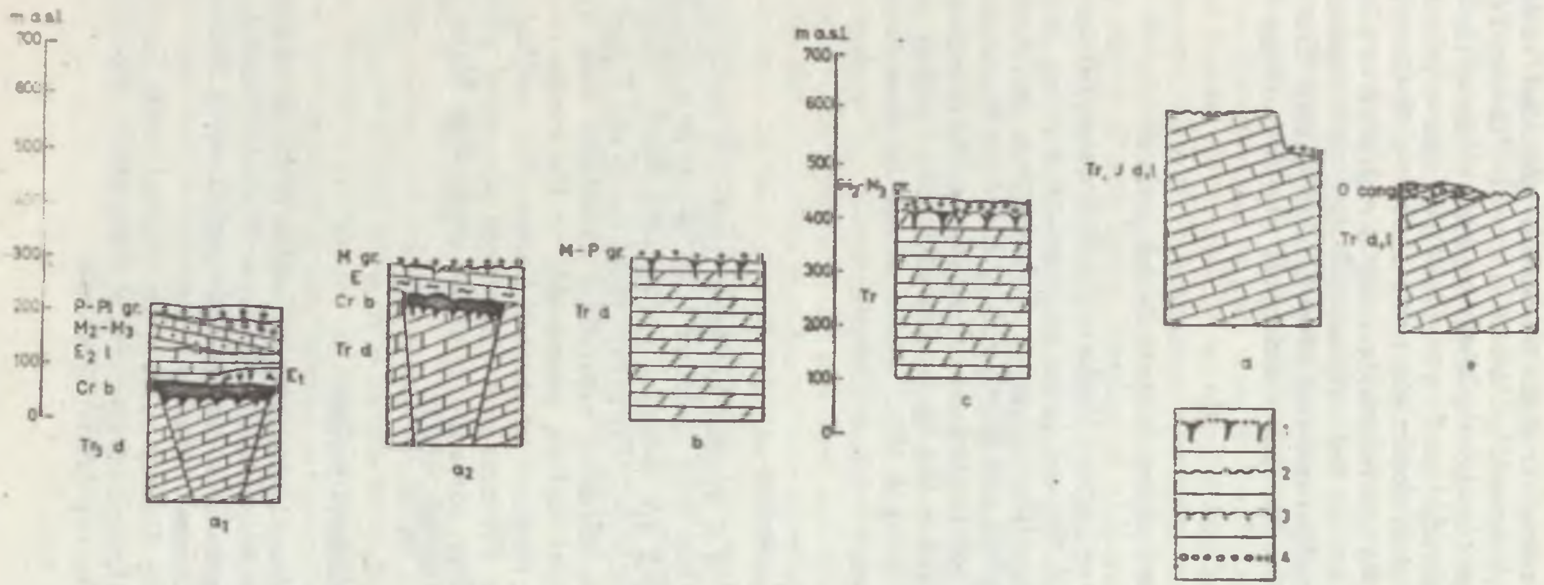
Buried blocks in uplifted position

The uplifted remnants of a tropical surface of planation within this group are covered by a more or less thick sequence of sediments or a sheet of gravel (see Figs. 13 and 14). They are consequently covered despite their elevated position (semiexhumed surfaces). The gravel sheet up to the Upper Miocene was dumped from the surrounding crystalline mountains onto the lower-lying portions of the tropical surface, presumably in the course of a process of pedimentation. These elements of the relief were then uplifted to their present altitudes by the Pliocene and Pleistocene structural phases (e.g. Farkasgyepü in the Bakony, some blocks of the Buda–Pilis Mountains, the Romhány block in the Cserhát, etc.).

Exhumed blocks in summit-level position

In the Buda and Pilis Mountains and in the Cserhát Hills east of the Danube bend there are Mesozoic blocks uplifted above their surroundings which were once covered by Oligocene sandstones and conglomerates. Some of them have been completely exhumed since, however.

The conglomerate locally directly overlies the tropical needle karst, contributing to its wear. The lithologic composition of the gravelly deposit suggests a derivation from a nearby crystalline mountain.



. Schematic position of the tropical planated surfaces in the Transdanubian fault blocks (after M. Pécsi, 1968)

a_1–a_2 — buried tropical surface remnant on the mountain border or in an intermontane graben; b — low threshold surface with traces of tropical weathering, truncated by subsequent pedimentation; c — uplifted but still covered tropical surface, pedimented when the Tertiary gravel cover was being deposited on it; d — uplifted tropical surface remnant, fully truncated in the Tertiary; e — semiexhumed, uplifted surface remnants, pediplanated in the Tertiary (e.g. Oligocene) in the forelands of the crystalline massifs: their subsiding portions wear a conglomerate cover; P–Pl gr — Pliocene–Pleistocene gravel; M_2–M_3 — Middle Miocene marl, limestone and gravel; E–E_2l — Middle Eocene limestone; E_1 — Lower Eocene dolomite detritus; Cr b — Upper Cretaceous bauxite; Tr d — Triassic dolomite; M gr — Miocene gravel; M_2–M_3 gr — Middle and Upper Miocene conglomerate; O cong. — Oligocene sandstone and conglomerate; Tr–J d, l — Triassic–Jurassic dolomite, limestone. 1 — Remains of a tropical weathering, with kaolinite and red clays; 2 — unconformity; 3 — needle-karsted remnant of a tropical surface; 4 — gravel rags on the surface

The presence of gravelly correlate deposits in the Transdanubian Mountains and its borders reveals that tropical planation could not have been continuous throughout the Tertiary. The Lower Oligocene conglomerate, the Upper Oligocene gravelly sand, the Aquitanian and Burdigalian gravels of the Lower Miocene, the gravels of the Helvetian and Tortonian prove the processes of pedimentation that took place in the foreland of the Palaeozoic crystalline mountains, then still rather high and undergoing repeated vertical movements. True, correlate deposits indicative of a tropical or subtropical weathering — kaolinite-bearing varicoloured and red clays — did come to exist in other periods of the Tertiary. Still, in certain stages of the Eocene, Middle Oligocene and Miocene, deplanation on the structurally displaced, sinking or rising relief by tropical planation must have been restricted to brief episodes. The left-over forms and correlate deposits suggest surface evolution to have been a polygenetic one, with repeated pedimentation dominating the episodes of tropical planation.

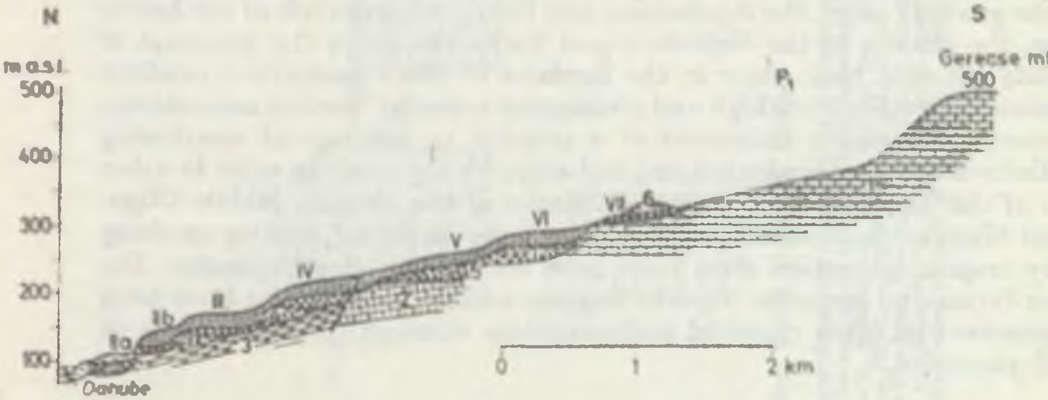
Mountain-border half-planes

In [illegible] iocene, the main agency of relief modelling on the borders of the mountains rising above the Pannonian sea was abrasion resulting in mountain-border half-planes. After the retreat of the Pannonian sea, pedimentation and glacis formation resumed their dominant role on the margins of the continuously rising blocks. These forms of planation were, however, dissected into interfluvial ridges by processes of valley sculpture in the warmer climatic phases of the Quaternary. Another episode with a climate suitable for pedimentation and glacis formation set in in the Upper Pliocene, when under a warm semiarid climate pedimentation was dominant, whereas in the cold and dry periglacial climatic phases of the Pleistocene, relief modelling by cryoplanation was the most extensive process. This is why, on the gentle slopes of the foothill areas, terraces, pediments and glacis of cryoplanation are fairly widespread.

Minor forms of erosion and accumulation

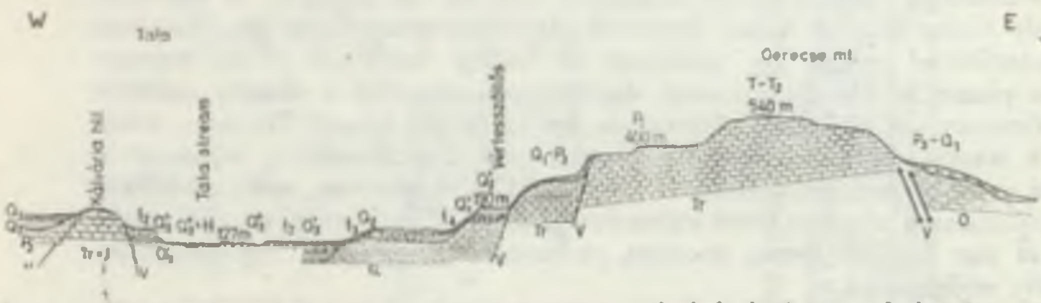
In the fault blocks, largely consisting of limestone and dolomite, of the Transdanubian Mountains, fault-controlled karst valleys are rather frequent. Most of them are dry over most of the year, and their flanks are as steep as those of a canyon in some sections. On the flanks of almost every block there are lapiès slopes and dry caverns hanging above the valley bottom. On the mountain borders, hot karst springs of big yield tend to occur, particularly in the Buda Mountains. Active since the end of the Tertiary, these springs have given rise to travertine-covered half-planes matching the levels of the one-time floodplains in the forelands of the respective mountain sections. There are instances of up to five travertine levels at various altitudes on top of terrace deposits (Figs. 15 and 16).

The absence of big connected cave systems has been attributed to the tectonic shattering of the rocks constituting these mountains. This is why in the limestone basement of the intramontane basins there are huge water-bearing cavities. Inrushes of water from these cavities are a constant menace to coal and bauxite mining in these basins. The slopes and basin topographies in the limestone basement of the intramontane basins there are huge water-bearing cavities. Inrushes of water from these cavities are a constant menace to coal and bauxite mining in these basins. The slopes and basin topographies



Danube terraces on the northern border of the Gerecse Mountains (after M. Pécsi, 1964)

P_1 — Upper Pliocene pediment; IIa—IIb — Würm and Riss—Würm terraces; III — Riss terrace; IV — Mindel terrace; V — Günz terrace; VI — Pre-Günz terrace, travertine-covered (coeval with Danube glacial phase); VII — Upper Pliocene terrace, travertine-covered; 1 — Mesozoic undivided; 2 — Cretaceous sandstone; 3 — Eocene marl; 4 — Oligocene conglomerate; 5 — terrace gravel; 6 — travertine; 7 — slope loess



Geomorphological profile across the western block-faulted part of the Gerecse Mountains and of the terraces of the Tata Stream (Pécsi, 1969)

Tr — Triassic limestone; Tr + J — Triassic and Jurassic limestone; O — Oligocene sand and clay; P_1 — Upper Pannonian (Pliocene) sand and clay; Q_1 — Early Pleistocene terrace (gravel); Q_1 — Early Pleistocene travertine; Q_3 — Upper Pleistocene travertine; Q_3' — Upper Pleistocene terrace gravel and sand; Q_3'' — Late Upper Pleistocene river-laid sand and gravel; $Q_3'' + H$ — floodplain deposits of the Tata Stream

$T-T_1$ — surface of planation, covered with rags of a Tertiary gravel sheet, presumably the remnant smoothed by pedimentation of a surface once in the piedmont region of the ancient crystalline mountains; P_1 — abrasion beaches of the Pannonian (Pliocene) sea; P_1-Q_1 — Upper Pliocene–Lower Pleistocene glacis surface; Q_1-P_1 — Upper Pliocene — Lower Pleistocene pediment; t_1-t_4 — Pleistocene terraces of the Tata Stream. The remains of "Vértesszőllős Man" (early Pleistocene) and the remnants of his implements and hearth were found in this horizon

of these mountains are smoothed by mountain-type slope loess cloaks of varied thickness. This type of loess has the peculiar lithologic feature that the fine-grained stratified loess packs constituting it are separated by rhythmic intercalations of sand or rock debris. The relief covered with loess or loessoid deposits bears typical derasional valleys. Deep loess gullies modelled by erosion, due to anthropogenic influences, are quite numerous locally. Microforms due to Pleistocene ground frost, deflation, cryoturbation and solifluction are classified as accessory elements of the landscape.

TECTONICS OF THE BUDA MOUNTAINS

Wein, Gy.

Summary

The Buda Mountains lies in the part of the Hungarian Central Mountains which, during the early Alpine orogenic phases, endured large-scale horizontal displacement, thus the strike-direction of the Mesozoic sequence is nearly perpendicular to that of the Central Mountains (i.e. it is of NW—SE direction). During the history of evolution to be outlined below this lineament-like fracture zone, which had probably developed before the Alpine phase in NW—SE direction, renewing in different forms predestinates the further structural formation of this area.

As it is concluded from the surficial excavations of the Velence Mountains and from the volcanic inclusions of the Visegrád—Szentendre Mountains, in the floor of the Mesozoic strata of the Buda Mountains Precambrian Meso- and Old-Paleozoic epimetamorphic rocks are expected which endured subsequent metamorphism problably due to the Hercynian syn- and postkinematic magmatism. In this area the role of such trend of the Tertiary subvolcanites is hardly known.

The geosyncline period of the Early Alpine cycle started here probybly in the Upper Permian and in the Lower and Middle Triassic it resulted in the formation of thick carbonaceous sequences. The oldest Mesozoic formation is the Ladinian diplopora-bearing dolomite sequence which can be observed both on the surface and in deep-bores. Its minimal thickness is 1500 metres. After the so-called transitional sequence of rose-yellow-coloured strata of several hundred metres thickness but being assigned to the Ladinian, the „Raibl" strata consisting of the alternation of Carnian marly dolomite, flinty limestone and bitumenous dolomite are situated. The alternating formation of the „Raibl" strata introduced a new but more differentiated phase of the basin formation having subsided uniformly till this period (Labian phase). In the area of the Buda Mountains the Carnian and Norian strata developed in two facies. The first one is the „flinty-dolomitic", the second oen the „dolomitic-limestone" formation. These formations are believed to be of shallow (dolomitic-limestony) and deeper (flinty-dolomitic) coral-shoals formed in the zones subsiding with different rates and lying nearly parallel with each other along the former strike-direction of the „Central Mountains". After the Norian the southeastern margin of the Central Mountains' trough of the recent Buda Mountains became land. Rheatian, Jurassic and Lower Cretaceous formations are known only in the internal part of the through of the Central Mountains, i.e. in the Pilis and Gerecse Mountains.

Probably during the Austrian and Mediterranean phases the Hungarian Central Mountains endured strong compressive impacts which resulted in first the slight arching, later the scale-formation and largescale horizontal displacement of the Mesozoic strata till they became situated their position perpendicular to the recent direction of the Central Mountains. The transgressing Lower Eocene strata were deposited onto this overstrained and fractured, often mylonitized dolomite-limestone complex.

The Eocene sea transgressing from the NW inundated the Buda Mountains during the ever renewing subsidence phases. The Upper Eocene sea inundated already the whole area. The Laramian and Ilyrian phases were of dilatation character, with vertical (synkinematic) movements. Fractures formed probably, too, along which the coal-basins of Nagykovácsi, Solymár and Vörösvár subsided. The Eocene period was completed by the Pyreneean phase characterized by contraction movements. The stress had been also of NW—SE direction in this case, too, and originated structures accompanied with scale-like faults of SE vergency. These movements were considerably weaker than the Austrian-Mediterranean ones completting the Early Alpine cycle. The fragmentation of the rocks can be observed only along the fault lines, larger-scale overthrusts the traces of neutral volcanism can be followed, partly in the andesite and rhyolite like gravels of the Middle and Upper Eocene basal conglomerates and partly in the dykes of abundant andesite and biotite content, discovered by deep-bores. The telethermal minerals and trace element concentration formed as a result of the Pleistocene thermal water activity relate on ore-formation below resp. within the Mesozoic strata of the Buda Mountains, which can be assigned to Paleogene, probably Neogene magmatism.

After the uplift following the Pyreneean phase (infraoligocene denudation) the Oligocene sea transgressed from the East. The partition period of dilatation character started at that time. Along the synsedimentary fault systems of several hundred metres thickness and of mainly NW—SE direction thick Ologicene sandstone and mainly marl strata were deposited (Helvetian phase). The valley systems (Solymár-valley, Ördögárok, Pilis fault) which had decisive orographic role in the Pleistocene, formed at that time.

During the Upper Oligocene the area of the Buda Mountains emerged and formed an island which was surrounded by the Miocene sea. The Neogene movements were manifested by synkinematic vertical movements (Savian, Early and Late Styrian phases) and by the formation of ancient- and new fault systems. Along the renewing great fault system of the Pilis the neutral and acidic Neogene volcanism gets the surface, the traces of which are inidcated by tuff-levels in the southern margin of the Buda Mountains (Tétény-plateau).

During the Pliocene the Buda Mountains became a peninsula but its major part was inundated by the transgressing Upper Pannonian inland sea. The recent Buda Mountains emerged only at the end of the Upper Pannonian and it had continuously emerged during the Pleistocene and got its recent face by different erosion processes.

A [illegible] oligocén-pleisztocén [illegible] időszaka) [illegible]. Szerk.: DR. WEIN GY. 1973
1 = meg nem [illegible] korú [illegible]; 2 = oligocén [illegible]; 3 = miocén-pliocén [illegible]; 4 = miocén-pliocén [illegible]; 5 = [illegible]; 6 = pleisztocén szelektív pozitív jellegű mozgást végző rög; 7 = szelvény iránya

Oligecene - Pleistocene fault system of the Buda Mountains /period of breaking up/. Compiled by dr. Gy. WEIN, 1973.

1 = fault line of undeterminable age; 2 = Oligocene fault line; 3 = Miocene - Pliocene fault line; 4 = Miocene - Pliocene fold saddle; 5 = Pleistocene fault line; 6 = uplifted blocks, characterized by selective-positive Pleistocene movements; 7 = direction of profile.

A Budai-hegységben kimutatható eocén (főleg pireneusi fázis) törésrendszere. Szerk.: Dr. Wein Gy. 1973.
1 = nyomás iránya; 2 = rögökön és kőzeteken megfigyelt mozgás iránya; 3 = vetővonalak; 4 = feltolódási vonalak; 5 = szelvény iránya

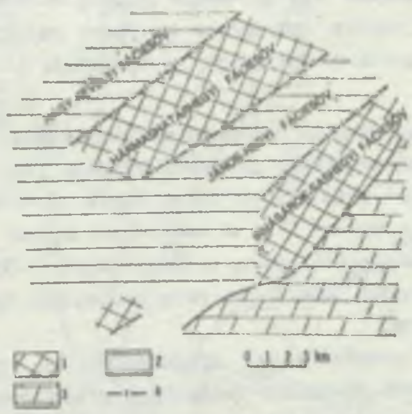
Eocene fault system observed in the Buda Mountains /mainly Pyrenean phase/. Compiled by dr. Gy. WEIN, 1973.

1 = direction of pressure; 2 = direction of movement observed on blocks and rocks; 3 = fault lines; 4 = reverse fault lines; 5 = direction of profile.

Fault system of the Buda Mountains formed during the Upper Triassic and continued till the Lower Eocene period /mainly Austrian-Maditerranean phases/. Compiled by dr. Gy. WEIN, 1973.

1 = direction of pressure; 2 = direction of movements observed on blocks and rocks; 3 = fault line; 4 = horizontal shiff; 5 = reverse fault; 6 = fold saddle; 7 = fold basin; 8 = crushed zone; 9 = boundary of triassic facies zones; 10 = direction of profile.

The Pleistocene movements followed in several phases which could be more or less demonstrated by the terrace and travertine levels formed on them. The measure of uplift proved to be 120 metres in the Lower Pleistocene (Wallachian I and II phases), 100 metres in the Middle Pleistocene (Passadenian I and II, Baku phases), 60 metres in the Upper Pleistocene (Baltic phase), i.e. 280 metres in total. When taking into account the recent level of the Danube that value amounts to about 370 metres. As the higher-grade fix-point measurements these movement are recently also in progress. The thermal water activity which started probaby at the end of the Upper Pannonian or in the Levantinian is a result of the uplift of the Buda Mountains. As the uplift and simultaneously the cut-off the of valleys has progressed the place of thermal water springs was displaced towards the margin of the mountains till it reached its recent location, the line of Danube.



A Budai-hegység triász geoszinklinális képződményeinek eredeti (ausztriai-mediterrán mozgások előtti) elhelyezkedése. Szerk.: Dr. Wein Gy. 1972

1 = karni-nóri tűzköves dolomitos kifejlődés; 2 = karni-nóri dolomitos-mészköves kifejlődés; 3 = ladini dolomitos képződmények; 4 = fáciesövek határa

The geological position of triassic geosynclinal formations of the Buda Mountains /prior to the Austrian-Mediterranean movements/. Compiled by dr. Gy. WEIN. 1972.

1 = Carnian - Norian flinty dolomitic formations;
2 = Carnian - Norian dolomitic - limestone formations;
3 = Ladinian dolomitic formations;
4 = boundaries of facies zones.

М. Печи

Геоморфологическая эволюция плоскогорья Буда (Венгрия)

Плоскогорье Буда представляет систему горстовых возвышений (средняя высота 350—550 м), разделенных друг от друга грабеновидными котловинами и долинами. Основание плоскогорья сложено триасовыми доломитами и известняками, которые в юре и нижнем мелу были пенепленизированы в тропических климатических условиях. Во время верхнего мела планационный рельеф и его основа были расчленены на отдельные блоки. Эта блоковая дифференциация продолжалась и в палеогене, когда оформилась система горстовых блоков и грабеновых котловин.

До середины эоцена этот блоковый рельеф был подвержен новой планации в аридных климатических условиях, во время которых разрушенные материалы были отложены в периферии грабеновых котловин, центральные части которых заполняются болотными отложениями.

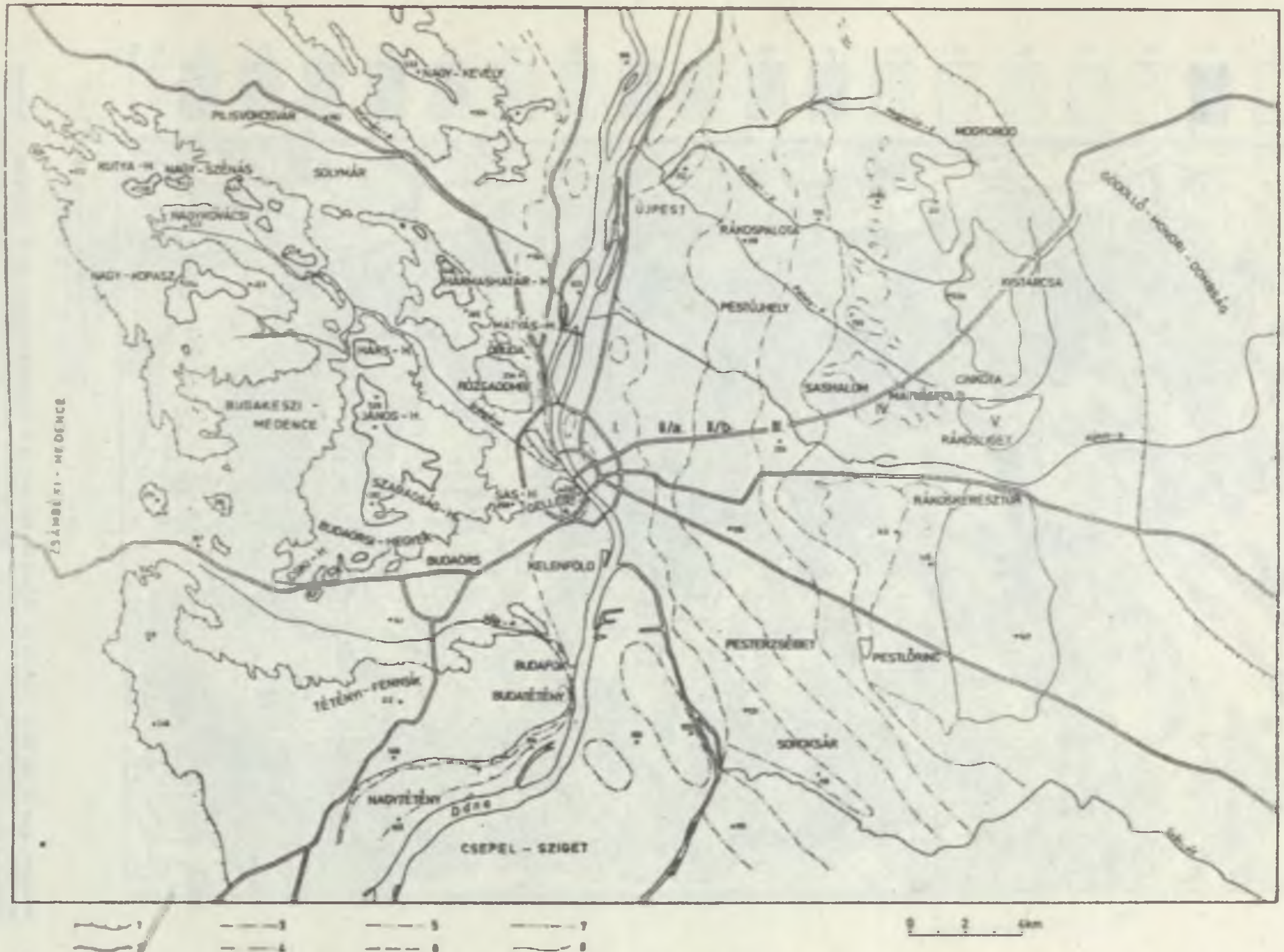
В верхнем эоцене южные части плоскогорья Буда были заняты морскими бассейнами, отложения которых погребают древний рельеф. Поднятия в начале олигоцена осушают эти части плоскогорья и на них накапливаются песчаные и галечниковые материалы (песчаник „Харшхегъ"), которые и в настоящее время устанавливаются в самых высоких частях горстовых блоков (например в Нагъ-Сенас — 551 м и др.). Там, где песчаник „Харшхегъ" был небольшой мощности денудационные процессы обнажают древнюю планационную поверхность.

Более поздняя олигоценовая трансгрессия в грабеновых котловинах накапливает глинистые отложения „Кишцел" (например в котловине Будаорш), а движения по древним разломам поднимают горстовые блоки на несколько сотен метров.

В нижнем миоцене проявляются новые тектонические движения, которые оформляют предгорные понижения, расположенные между кристаллическими грядами, которые окружают плоскогорье Буда. Эти понижения заполнены грубой галькой. Отложения среднего миоцена богаты вулканическим пеплом, что связано с эрупциями в соседних плоскогорьях областях. В верхнем миоцене накапливаются прибрежные тортонские известняки плато Тетени и сарматские известняки в западной части плоскогорья Буда. В большой части плоскогорья песчаники „Харшхегъ" заполняют формы предыдущей тропической планации.

В конце миоцена общее погружение создает условия для вторжения мелководного панонского бассейна, воды которого залили южную часть Буды (блок Сабадшаг-хегъ — 430 м). В конце панона бассейн отступил и на панонских отложениях накапливаются верхнеплиоценовые травертины (в Сабадшаг-хегъ), которые свидетельствуют о болотно-озерных палеогеографических условиях.

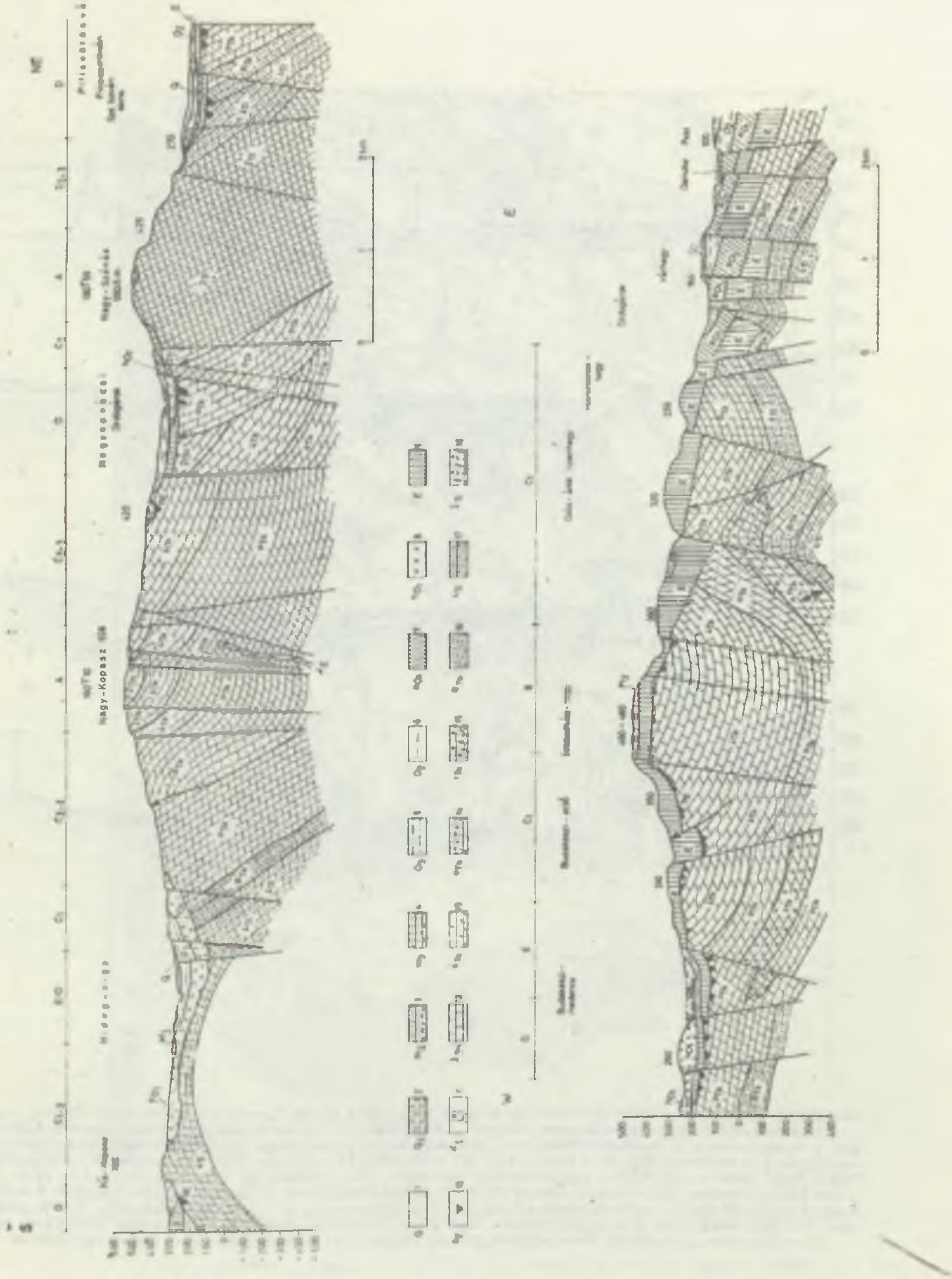
Современное плоскогорье Буда является результатом влашских и паседонских движений после отложения травертина. В это время образуется Пештинская низменность и долина р. Дуная, уровень которого является базисом эрозии плоскогорья. Этапы формирования долин отмечают образования травертина на 300—350 м, 240—250 м (Донау-Гюнц), 200—220 м (гюнц-миндель), 160 м (миндель-рисс) абсолютной высоты. В нижнем и среднем плейстоцене плоскогорье очень сильно поднималось над Пештенской низменностью — почти на 300 м. В Буде долины приурочены к грабеновидным понижениям. Высокие части горстовых блоков представляют собой или вершинные уровни, остатки древних поверхностей выравнивания (например Нагъ Сенас — 550 м) или поверхности, покрытые палеогеновыми или неогеновыми отложениями (Сабадшаг-хегъ). Такой же характер имеют и небольшие горсты в подножье плоскогорья (Розадомб — 234 м, Гелерт-хегъ — 22 №). В грабенах, хотя и редко, встречаются криптогорсты (Пилишперешвар).



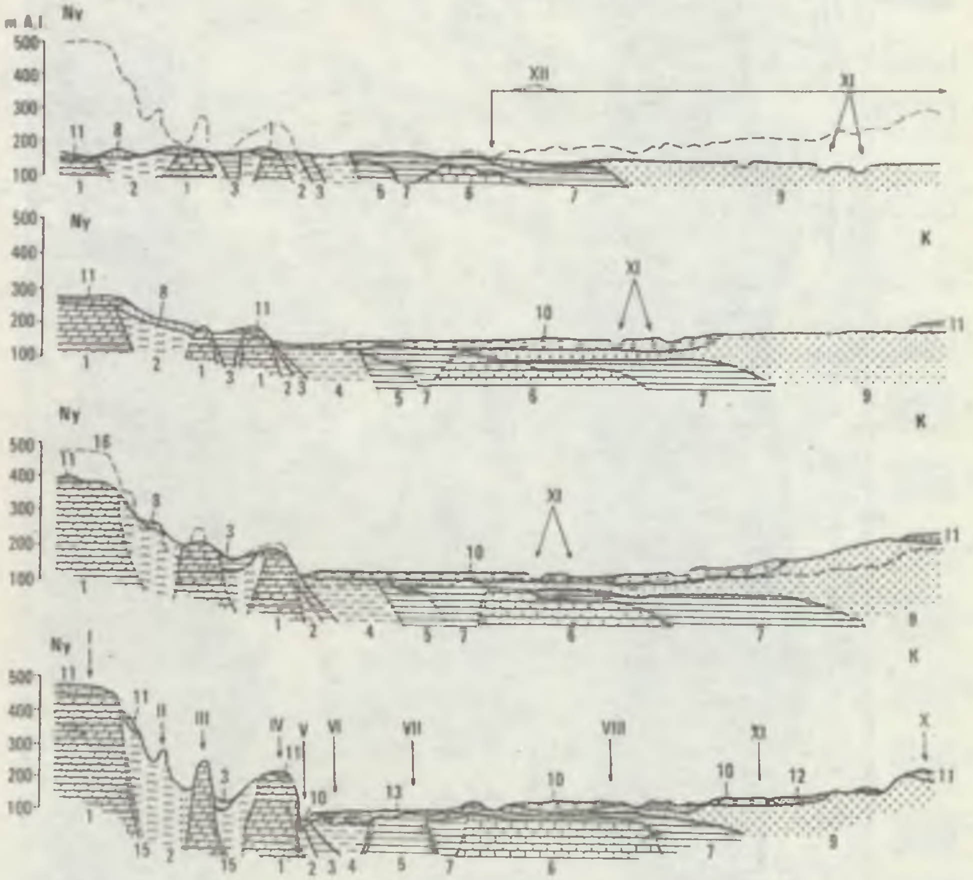
Budapest és környékének orográfiai térképe. (Szerk.: Kertész Á.) — 1 = hegyrögök határa; 2 = hegyrögök magasabb szintjei; 3 = I. sz. terasz határa; 4 = II. sz. terasz határa; 5 = III. sz. terasz határa; 6 = III. sz. terasz felső határa; 7 = IV. sz. terasz határa; 8 = V. sz. terasz határa

Orographical Map of Budapest and Environment. (Compiled by Á. Kertész) — 1 = border of blocks; 2 = highest level of blocks; 3 = border of terrace I; 4 = border of terrace II; 5 = border of terrace III; 6 = upper border of terrace III; 7 = border of terrace IV; 8 = border of terrace V

Geological Map of the Buda Highlands. (Based on the map of F. SZENTES compiled by Á. KERTÉSZ) — *Holocene formations*: 1 = alluvial deposits; 2 = peat; 3 = loessic sand; 4 = wind-blown sand; 5 = terrace I., pebbles and sand. *Pleistocene formations*: 6 = loess; 7 = terrace II. – III.; pebbles and sand; 8 = travertine (the same mark for Pliocene travertine). *Pliocene formations*: 9 = clay and sand, 10 = sand, gravelly sand, sandstone. *Miocene formations*: 11 = Lajta-limestone and coarse limestone; 12 = pebbles and sand. *Oligocene formations*: 13 = sand, sandstone, clay; 14 = Kiscell-clay; 15 = Hárshegy sandstone. *Eocene formations*: 16 = Eocene layers in general. *Triassic formations*: 17 = limestones; 18 = dolomites; 19 = border of formations in general; 20 = border of blocks. T = Trias, E = Eocene, O = Oligocene, M = Miocene, P = Pliocene, Q = Pleistocene, H = Holocene. Indices show the periods



Geomorphological Types of the Mountain Blocks of the Buda Highlands (After Pécsi, M. and Wein, Gy.) — A = exhumed, planated horsts in summit-level position; B = buried horsts in uplifted position; C = horsts in foothill position; 1 = totally buried horsts; 2 = semi exhumed horsts; 3 = totally exhumed foothill horsts; D = buried surfaces of planation in graben position; E = glacis de erosion; 1 = Pleistocene loess and blown sand; 2 = Pleistocene travertine; 3 = Upper Pliocene sand, clay, travertine; 4 = Sarmatian conglomerate and limestone; 5 = Upper Oligocene sandy clay; 6 = Middle Oligocene „Kiscelli clay"; 7 = Lower Oligocene „Marl of Tard"; 8 = Lower Oligocene „Hárshegy sandstone"; 9 = Eocene formations; 10 = Eocene, reworked bauxite and conglomerate; 11 = Eocene acid dike; 12 = Upper Triassic „Dachstein" limestone; 13 = Upper Triassic „Hauptdolomit" (Carnian); 14 = Upper Triassic coarse dolomite (Carnian); 15 = Upper Triassic cherty dolomite; 16 = Upper Triassic — Raiblian — marl, limestone, dolomite; 17 = Middle Triassic pink coloured dolomite (Ladinian); 18 = Middle Triassic Dipl. dolomite (Norian)



Morphogenesis of the Pest Plain Section of the Danube Valley since Upper Pliocene. (Compiled by M. Pécsi) — a = morphological and geological view in upper Pliocene (Astian stage); b = at the beginning of Pleistocene (Günz glaciation); c = cross-section in the earlier Pleistocene (Mindel glaciation); d = present day geomorphological and geological conditions; I = Széchenyi Hill; II = Márton Hill; III = Sas Hill; IV = Gellért Hill; V = Danube; VI = Nagykörút, VII = Mező Imre street; VIII = Rákoskeresztúr cementery; IX = Rákoshegy railway station; X = Erdő Hill; XI = Palaeo Danube; XII = deposit area of alluvia from the Danube and its tributaries; 1 = dolomite; 2 = Buda marl; 3 = Kiscell clay; 4 = Mediterranean beds; 5 = Sarmatian clays; 6 = Sarmatian limestone; 7 = Pannonian clay; 8 = Pannonian sand; 9 = Upper Pliocene sand; 10 = Pleistocene gravel; 11 = travertine; 12 = blown sand; 13 = fluviatile sand and silt; 14 = anthropogenous filling; 15 = fracture fault; 16 = present day surface

The geomorphological map of the mountain types in the Buda Highlands. Edited by Pécsi, M. and Juhász, Á., 1972 (In the classification of travertine floors research results to be published by Scheuer, Gy. and Schweitzer, F. have been used) — A = Exhumed block horst in summit position; A_1 = Partly exhumed block horst in summit position; B = Buried block horst in summit position; B_1 = Partly exhumed block horst in step position; C_1 = Fully buried block horst in piedmont-threshold position; C_2 = Partly exhumed block horst in piedmont-threshold position; C_3 = Fully exhumed piedmont horsts; D = Buried block in graben position; E = Piedmont surfaces (glacis); F = Low plateau of cuesta (scarpland) feature (mainly structural surface); G = Flood-plains, valley bottoms; 1 = Structural slopes, partly piedmonts; 2 = Erosional valleys; 3 = Dry valleys, gullies; 4 = Derasional valleys; 5 = First flood-free terrace (II/a); 6 = Second flood-free terrace (II/b); 7 = Fourth flood-free terrace (IV); 8 = Inter-valley rounded ridges; t_1 = Travertine in the first flood-free terrace level, 10 m relative height above the Danube; t_2 = travertine on the second flood-free terrace (R/W interglacial); t_3 = Travertine on the third flood-free terrace; t_4 = Travertine on the fourth terrace, 60–80 m relative height above the Danube and up to 140 m in the valleys of the secondary brooks; t_5 = Travertine layer No. 5, 90–130 m relative height above the 0 level of Danube; t_6 = Travertine layer No. 6, 120–130 m relative height above the 0 level of Danube; t_7 = Remains of travertine layer No. 7 in a height of 270–280 m above the 0 level of Danube; t_8–t_9 = Travertine layers in summit position in the Buda Highlands, 350–400 m above the 0 level of Danube

NEW ASPECTS IN THE FORMATION OF THE FRESH-WATER LIMESTONE SERIES OF THE ENVIRONS OF BUDA MOUNTAINS

Scheuer, Gy.—Schweitzer, F.

Summary

In the eastern margin of the Buda Mountains the recent karst wells pour partly in the first flood-free terrace of the Danube, partly intflood-plain levels, partly in the Danube, bed, i.e. in the deepest levels of the Holocene relief and nearly in the same height above sea level. In their, previous environs they formed marshes and lakes which disappeared due to human intervention (catchment, ground levelling;)

On the basis of the above regularities the fresh-water limestones of same age formed nearly in the same height. Accordingly, from the hydrogeological conditions of the springs precipitating the fresh-water limestone being situated in different heights above sea level conclusions can be drawn concerning the Upper Pliocene and Pleistocene evolution periods throughout which the recent stage has developed.

In addition to the terraces the geomorphological changes are most conspicuously reflected by the fresh-water limestones. Authors having studied the fresh-water limestones in the margin of the Gerecse Mountains in 1973 called the attention ot the processes on the basis of which fresh-water limestones have formed in different heights above sea level from the Upper Pleocene to the Holocene during eight distinguishabke phases.

As to the geological and geomorphological investigations considerable uplift took place in the Buda Mountains in several phases. The fresh-water limestone occurring in the Szabadság Mountain in a height of 499 metres a.s. l. indicates that in the period of fresh-water limestone formation the waterbearing formations were saturated with karst water. Consequently, from the end of the Upper Pliocene up to our days static karst water of nearly 400 metres height has flown out from the water-bearing rock.

The fresh-water limestones occurring in several levels in the Buda Mountains prove that since the Upper Pliocene there has been a continuous spring activity.

When having investigated the locations of the fresh water limestones on the basis of paleogeomorphological and terrace-morphological conditions it was obvious (and the locations were drawn up as to these aspects) that a part of them follows the valleys of NW—SE direction crossing the Buda Mountains, the other part follows the margin of the Danube valley from Pomáz down to the Gellért Hill ( )

The Szabadság Mountain and its close environs form a separate central part. Before the Lowermost Pleistocene structural movements and the subsequent formation of valley system a central spring activity was active in this area which resulted in the formation of fresh-water limestone series of lacustrine-marshy and thetaratic type. This spring activity extincted due to the valley systems formed by the Upper Pliocene — Lower Pleistocene tsructural movements.

In the Buda Mountains five central areas developed where the locations of the fresh-water limestones are concentrated around a significant erosion valley (Németvölgy, Ördögárok, Solymár valley, Dera creek and Danube valley;

In the area of the Buda Mountains the Upper Pannonian inland sea regressed as a result of the slow regional crust movements and this completed the marine-lacustrine sedimentary series. In the Szabadság Mountain the completing phase of the Upper Pannonian sedimentary cycle is represented by lime-mud dissected by limestone banks.

The levels of the fresh-water limestones series of covered karstic origin being the oldest and most extended formations in this area are connected to this region (Hármaskut plateau, Normafa, 499 and 472 m. a.s.l.; Observatory, Poineer Camp, 472 and 445 m a.s.l.; Budnörs Hill—Kakukk Hill—Széchenyi Mountain, 417—435 m a.s.l.).

The geomorphological structure and position of the fresh-water limestone series (the level of 499—472 metres is of lacustrine-marshy, that of 472—445 metres is of theraratic structure) seem to evidence that the János Mountain — Szabadság Mountain group of the Buda Mountains slightly emerged at the end of the Upper Pliocene and became a slowly upward-moving terrain. Only faunistic data may decide whether the fresh-water limestone level represent the levels of piedmont surfaces before the valley formation, or they had been dissected by the Upper Pliocene—Lowermost Pleistocene vertical movements and got different heights above sea level (T. VIII.—T. VIII/a phase

The Upper Pliocene—Lowermost Pleistocene strong vertical structural movements resulted in the considerable decrease of the karst-water level and the start of the spring activity of the deeper levels, due to which new fresh-water limestone series have formed. The locations occurring

in a height of 360—370 metres a.s.l. (Alkony street: 360 m , Felhő street: 370 m) indicate these levels which, at the same time, fix the beginning of the formation of the Ancient Németvölgy.

As a result of the periodic vertical uplift of the mountains the deepening of considerable rate of the greater valley systems of the area was initiated, (Németvölgy, Ördögárok valley, Solymár valley, Dera creek valley). This process promoted and accelerated the öreparation of the karst levels of deeper levels and the beginning of the spring activity of deeper level. As a result of these processes depending on the geomorphological conditions fresh-water limestone series of great thickness and of lacustrine-marshy and thetaratic type have developed the major part of which is connected to the secondary valleyes following the alluvial fan terrace of the Ancient Danube (No. V.). The fresh-water limestone levels represent ever younger spring levels towards the former erosion base of the erosion valleys. The height above sea level of the occurrences appears between 240 and 180 metres in case of every valley which form several levels and several formation phases — Pusztahegy, Monalovác, Harapovács upper (240—230 metres) and Hűvösvölgy (240—200 m), Gellért Hill, Ezüst Hill, Üröm Hill, Péter Hill (220—190 m), Majdán plateau, Kálvária Hill, Ezüst Hill (180—170 m) lower levels ;

In the course of the valley-deepening periods being connected to the structural movements of mainly uplifting tendency of the mountains the levels of the fresh-water limestone series formed always from deeper-lying karst wells of the karst formations. Thus, the levels of the fresh-water limeston series indicate ever younger phases in the ever deeper levels.

In the boundary of the Upper Pliocene — Lower Pleistocene the fresh-water limestone series follow the levels of the huge alluvial fan of the Ancient Danube in the Pest Plain of subsiding trend.

On the basis of their morphological situation, the fresh-water limestone levels of 370—360 m, 275 m, 240—230 m, 220—210 m and 200—195 m seem to evidence the partition of the alluvial fan terrace of No. V. of the subsiding Pest Plain. Consequently, as to the above-mentioned fresh-water limestone levels this may include the terrace substance VII, VI and V of the Ancient Danube crossing the Visegrád Bend and accumulating in the subsiding Pest Plain.

In possession of the available date the levels of 360—370 m, 275 m and 240—230 m are assigned to the T. VII., those of 220—210—195 metres to the T. VI. and T. V. formation phases

In the eastern margin of the mountains nearly in N—S direction the levels of fresh-water limestones occurring in a height of 150—160, 130—140 and 120 metres above sea level can be observed which being connected to the terrace valley of the Ancient Danube represent a separate formation phase, i.e. those of T. IV., T. III and T. II

The youngest fresh-water limestones being recently also in formation are found close to the eastern foothill of the mountains, in the first flood-free terrace of the Danube (II/a), in a height of 105—107 m a.s.l. This is the T. I. formation phase.

It is apparant from the above-mentioned facts that the fresh-water limestone series of the Buda Mountains have formed in eight greater formation phases from the Upper Pliocene up to the present which reflect also the meausre and phases of the tectonic movements taking place in the Quaternary.

In the morphological effect of the Buda Mountains being differentiated in the Quaternary space and time the tectonic movements of remarkable measure resulted in the formation and evolution of five greater valleys in the area of the mountains (Németvölgy, Ördögárok valley, Solymár valley, Dera creek valley and Danube valley). This geomorphological surface evolution is demonstrated by the levels of the fresh-water limestone series being connected to the erosion valleys mentioned above.

The main phase of the fresh-water limestone formation and the levels of fresh-water limestones connected to the valley systems can be paralleled with the temporal rhythm of crustal movements along the Danube elaborated by Pécsi M. (1959, 1962) in his fundamental work, with the terraces of the Danube — Nos I., II/a., II/b., III., IV., V., VI., VII., and with the levels VIII. and IX. of the piedmont surfaces formed before the Upper Pliocene valley-formation.

NORTH HUNGARIAN OR INTRA-CARPATHIAN MOUNTAINS

This mountainous region of Hungary includes two rather different structural and morphological types of mountains.

Of the Mesozoic blocks wedged in between the volcanic mountains, the Bükk and the North Borsod Karst are most extensive
Both overlie a Palaeozoic base. Their history of evolution much resembles that of the Transdanubian Mesozoic Mountains. The central planated plateau of 900 m mean altitude of the Bükk Mountains is surrounded by a lower level planation and by a broad but dissected foothill surface. The latter is in its turn surrounded by zones of glacis of erosion and accumulation .

Whereas the North Borsod Karst is of the exhumed and partly of the threshold type, the Mesozoic blocks of the Western Cserhát are uplifted planated blocks covered with an Oligocene conglomerate ( ).

The Bükk and the North Borsod Karst carry the most typical karst forms of Hungary; the most frequent ones include dolinen, uvalas, lapiès fields, sinkholes and spring caverns. In the Bükk Mountains caverns with abundant remains of a Palaeolithic culture (Szeleta, Subalyuk caverns) have been discovered. Of the numerous caverns, the most famed one, the 22 km long Aggtelek cavern with its magnificent stalactites and huge halls is in the North Borsod Karst.

Remains of the Late Tertiary stratovolcanoes of the Intra-Carpathian volcanic girdle

The Intra-Carpathian volcanic elements of the Northern Hungarian Mountains were produced by Miocene volcanism. Early Tertiary, largely Eocene volcanism also left some traces, but this was an insignificant precursor to the large-scale Neogene volcanism, which produced one of the most extensive volcanic regions of Europe. The volcanic eruptions exhibited a shift in time, growing younger from west to east. The mountains near the Danube bend are Middle Miocene in the main; the Tokaj–Zemplén Mountains) are Upper Miocene to Lower Pliocene. The volcanoes mostly belonged to the stratovolcanic type. Lava effusions were interrupted by repeated scatterings of ash, locally indeed with the dominance of scatter products. The Visegrád Mountains , the Börzsöny , the Cserhát (and the Mátra largely consist of andesite lavas, tuffs and agglomerates. Farther east, in the foreland of the Bükk, and especially in the Tokaj–Zemplén Mountains, rhyolite also played an essential role besides andesite and in some mountain groups it even gained the upper hand.

The volcanic hill groups of the Danube bend, the Cserhát, and to some extent also the Mátra had constituted tall stratovolcanoes at the beginning

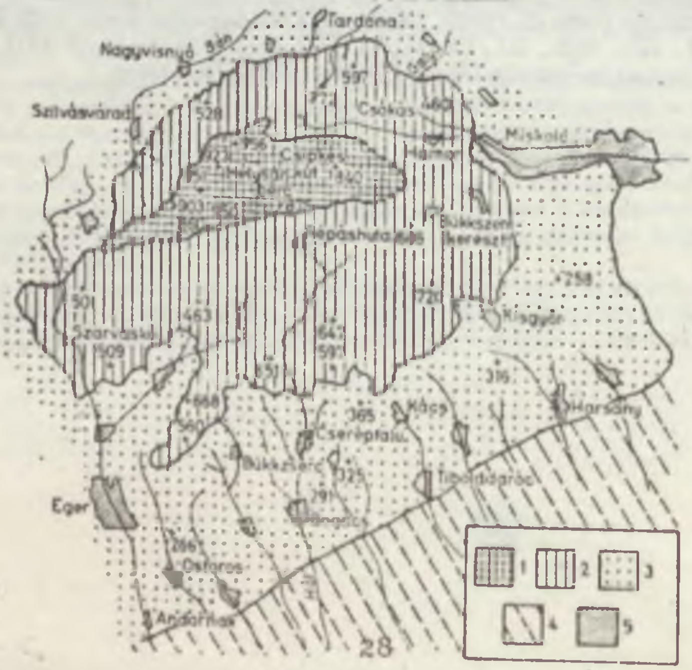


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Fig. 17ab. Morphological profile of the Bükk Mountains and its foreland (constructed by Z. Pinczés)

a. I — High Bükk, Miocene upper planation level; 2 — Middle Bükk, Miocene middle planation level; 3 — Lower Bükk, Upper Pliocene piedmont (glacis of erosion); 4 — alluvial fan of the Bükkalja (glacis of accumulation); 5 — habitations; b. I — High Bükk; II — Middle Bükk; III — Low Bükk; IV — alluvial fans of the Bükkalja ($Q_1 - Q_3$). V — idem (Q_4); VI — alluvial plain of the Tisza (H_1)

of the Tortonian, but by the end of that stage they were already substantially worn down. Their environments were covered up to the 400 to 500 m level of today by nearshore deposits of the Upper Tortonian sea. The summit

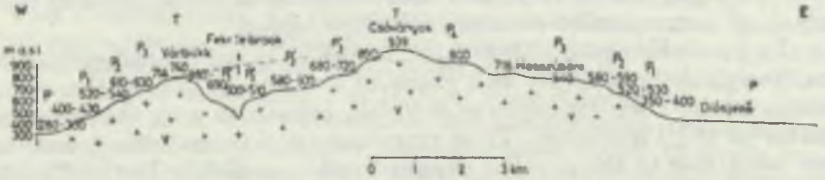


Fig. 18. Morphological cross section of the Börzsöny Mountains (after M. Pécsi, 1963)

T — remnant of Upper Miocene (Tortonian) level of planation, $P_{1-3,4}$ — inferred Sarmatian–Pannonian piedmont steps. P_1 — Upper Pliocene piedmont surface; P — foothill surface (glacis of erosion), remodelled in the Pleistocene, $P'_{1\,2\,3}$ — intramontane piedmont steps; V — Helvetian–Tortonian volcanics

Fig. 19. Morphological cross section of the Mátra Mountains (constructed by A. Székely)

1 — Middle Oligocene; 2 — Upper Oligocene (Lower Chattian) schlier; 3 — idem, hard sandstone; 4 — Upper Oligocene (Upper Chattian), less consolidated schlier; 5 — Lower Miocene sediments (varicoloured clay, friable sandstone, Lower rhyolite tuff, lignite seams); 6 — Helvetian schlier; 7 — subvolcanic bodies (laccoliths, dykes) etched out by differential erosion; 8 — Tortonian volcanics (andesite agglomerate, tuff, rhyolite tuff); 9 — Sarmatian deposits (clay marl, etc.); 10 — Upper Pannonian brackish clay and sand; 11 — Quaternary (alluvial fans, slope deposits, loess, etc.); 12 — Middle rhyolite tuff; I — Sarmatian level of planation, summit level; II — Lower Pannonian mountain-border bench; III — Upper Pannonian mountain-border bench (middle bench); IV — Upper Pliocene piedmont surface (glacis); V — Quaternary surfaces of denudation and accumulation; A — structural basins of the Mátraalja; B — upper laccolith set; C — lower laccolith set; D — Upper Chattian sandstone bench; E — basins of denudation of the Mátraalja; F — basins of denudation of the Trans-Mátra region

levels rising above said altitudes can be considered the structural remnants of the ancient centres of eruption. These had undergone a substantial subtropical planation (presumably a pediplanation) in the Tortonian, and also in the Sarmatian.

After the Tortonian, the levels which today lie 350 to 400 m a.s.l. probably were the piedmont-type forelands of the Intra-Carpathian crystalline masses (today on Czechoslovak territory). The streams flowing through them deposited on them a gravelly waste produced by processes of pedimentation. The Pannonian sea formed embayments reaching far north between the mountains of today; some of the mountain-border benches might be due to its abrasive activity.

All the volcanic mountains are surrounded by a more or less broad outward-sloping foothill surface sculptured in little consolidated sediments, beginning at altitudes of 200 to 300 m a.s.l. The foothill began to develop in the Upper Pliocene. Subsequently, in the Pliocene and Pleistocene, it was strongly dissected by the streams running off the mountains towards the subsiding Great Plains.

Since the Intra-Carpathian stratovolcanoes had risen over little consolidated early Tertiary clayey and sandy marine deposits, the thinner lava sheets and dykes surrounding the central masses of the volcanoes were deeply worn down. In the Cserhát Hills, for example, there are locally only traces of some dykes exposed on the surface. In the northern forelands of the ancient volcanoes, there is a hilly region consisting of loose sediments, part of which is of a basin character. This is the region separating the Intra-Carpathian volcanics and the Mesozoic mountains intercalated between them from their Slovakian counterparts. This is how the broad Sajó and Ipoly basins came to exist, more or less along the Hungarian–Slovakian frontier. The slopes and flat interfluvial rises of the broad valleys are covered with a thick blanket of Pleistocene loamy slope deposits.

In the hilly regions, the warm-humid phases of the Pleistocene resulted in intensified valley sculpture, whereas the cold-humid phases gave rise to large-scale solifluction. In the cold-dry phases, processes of cryoplanation and deflation were dominant. In the southern forelands of the mountains facing the Great Plains there is a broad zone of fluviatile alluvial fans and of glacis of accumulation covered with slope loesses.

In the North Hungarian Mountains, as well as in the Transdanubian Mountains, periglacial pediments and glacis of erosion are among the more conspicuous forms. Their evolution was closely connected with the cold semiarid climates of the Pleistocene. Their transformation (remodelling) was, on the other hand, due to the peculiar types of valley modelling in the Pleistocene. By and large, the mountains of Hungary were areas of degradation during the Pleistocene. Under the periglacial climates, the higher levels of the mountains underwent a profound cryofraction which locally resulted in the formation of ledges and terraces of cryoplanation. On the exposed, hard rocks, a great deal of eluvial debris could form, and the slopes were covered with stone fields and rockflows. The finer waste produced by cryofraction was repeatedly reworked by the wind, meltwaters and solifluction. It was finally deposited as eolian loess, slope loess and deluvia at the feet of the mountains and in the intramontane basins.

DIE ENTSTEHUNG UND DER FORMENSCHATZ DES WESTLICHEN MÁTRAGEBIRGES

Dr. András Székely

Zusammenfassung

Die Zentrallandschaft, das Herz des westlichen Mátragebirges ist das Kövicsestal, das älteste, bedeutendste, und eines der größten Täler des Gebirges. Im Kövicsestal und in seiner Umgebung sind auch ältere korrelative Materiale erhalten geblieben, so daß das Tal wichtige Anhaltspunkte für die Gestaltung und die Reliefentwicklung des ganzen Mátragebirges in sich birgt.

Das mittlere Zagyvatal sowie die mittleren und unteren Abschnitte des Kövicsestales waren bereits zur Zeit des Ausklingens der großen vulkanischen Tätigkeit in die Tiefe gesunken, so daß die seichte Bucht des Tortonameeres in die Randgegend des Mátragebirges eindringen konnte. In der Bucht wurden Sedimente des leicht entsalzten und süßen Wassers, später die des offenen Meeres abgelagert. Über die Tätigkeit der postvulkanischen, kieselhaltigen warmen Quellen legen die Kieselschiefer und Limnoquarzite, über die abschließende vulkanische Tätigkeit die Schichten von Riolittuff Zeugnis ab. Vom Gesichtspunkt der Geomorphologie sind die aus durchgespültem Bentonit und Tuff sowie aus verwittertem Andesit bestehenden Schichten die wichtigsten, weil sie die schon damals bedeutende Denudation des Gebirges bezeugen. Die Bohrung No. 4. in Hasznos (an der Abbildung I = III) hat diese Schichten in einer Mächtigkeit von 130 m durchgeschnitten. Die tortonischen und sarmatischen Denudationsprodukte sind *noch* überwiegend feine Sedimente, durchgespülter Stuff, Bentonit, verwitterte Andesit, Lehm und Sand, die Zeugen einer starken, noch unter einem wärmeren Klima stattgefundenen arealen Erosion sind.

Im oberen Sarmatsabschnitt wurde das untersuchte Gebiet langsam gehoben, die Abtragung wurde daher kräftiger und an der Küste des zurückweichenden Sarmatameeres sind gewaltige Schuttkegel vorgedrungen. Die obersarmatische-niederpannonische Abtragung stellt auf dem untersuchten Gebiete das Höchstmaß der Denudation dar. Die Abtragungsprodukte erreichen stellenweise eine Mächtigkeit von 200 m. Diese korrelativen Sedimente haben sich bereits mit einer bedeutenden Erosionsdiskordanz an die denudierten Ränder des Andesitgebirges abgelagert. Außer den korrelativen Sedimenten spricht auch dieser Umstand für die obertortonisch-niedersarmatische Denudation. Gleichzeitig mit der Hebung wurde auch das Klima kühler. Die obertortonisch-niederpannonischen Denudationsprodukte bestehen abwechselnd aus Schotter- und durchspülten Tuffbänken und in den höheren Horizonten kommt bereits gröberes Geröll vor. Zu dieser Zeit trat schon die lineare Erosion in den Vordergrund, wie dies auch aus der Zusammensetzung des korrelativen Materials (Schotter, stellenweise Geröll) sowie aus der Lagerung hervorgeht. Diese Schichten wurden nämlich schon in den wichtigsten Talpforten abgeladen, das Urwassernetz war demnach schon ausgestaltet. In dem oberen Pannon ist unser Gebiet eingesunken und der oberpannonische See drang bis zu dem Fuße des Mátragebirges vor.

Der jüngste und bedeutendste Rhythmus des Gestaltungsprozesses der Oberfläche ist der oberpliozäno-quartäre Rhythmus. Diese rhythmische Hebung ist ebenfalls durch Klimaänderungen gekennzeichnet. Die Hebung ging auf dem Gebiete des Gebirges nicht überall gleichmäßig vor sich. Das Mátragebirge selbst hat sich in bedeutend kräftigerem Maße gehoben, als die Randgebiete und das Gebirgsvorland, wie dies die Reliefformen, vor allem aber die Formen des Kövicsestales, genau widerspiegeln. Während der Kövicsesbach in seinem Gebirgsabschnitt ein 150—160 m tiefes Tal ausmeißeln konnte, wurde

von demselben Bach vor dem Gebirgsrand im Zagyvatale ein schöner, fächerförmiger Schuttkegel von gewaltiger Mächtigkeit aufgebaut. Während der Pleistozänvereisung ging eine starke frostbedingte Zersplitterung des Gesteins vor sich, so daß auf den Graten und Rücken des Gebirges weitausgedehnte Steinmeere entstanden sind. Im Zagyvatal wurden die Steinmeere mit einer dünnen (1—4 m) lößhaltigen Sand- und sandigen Lößdecke überzogen. Vor dem Piedmont und an den sanft abfallenden Hängen hat die Solifluktion mächtige (4—8 m) Löß-, Lehm-, Sand- und Bodenschichten angehäuft.

Der Formenschatz des Kövicsestales und seiner Umgebung

Das Tal kann nach seinen Reliefformen in drei Teile geteilt werden. Im oberen Abschnitt haben sich die Quellenzweige in das Hochplateau des Gebirges rückschreitend eingeschnitten. Diese Einschnitte wurden durch dei Strukturlinien vorgezeichnet. Die Täler sind vornehmlich in den im Laufe der postvulkanischen Tätigkeit gelösten, kaolinisierten Zonen entstanden, während die dazwischen stehenden Grate mit den Hydroquarzflößen und den verkiesten Zonen identisch sind. Wo sich die Quellenzweige treffen (Bei Mátrakeresztes) breitet sich das Tal plötzlich aus. Hier liegt das prächtige Talbecken von Mátrakeresztes (Abb. 2. Aufnahme 1.) Das Becken kennzeichnen vier schön entwickelte Stufen über der Talsohle (holozäne Terrasse) (Abb. IV. I—IV).

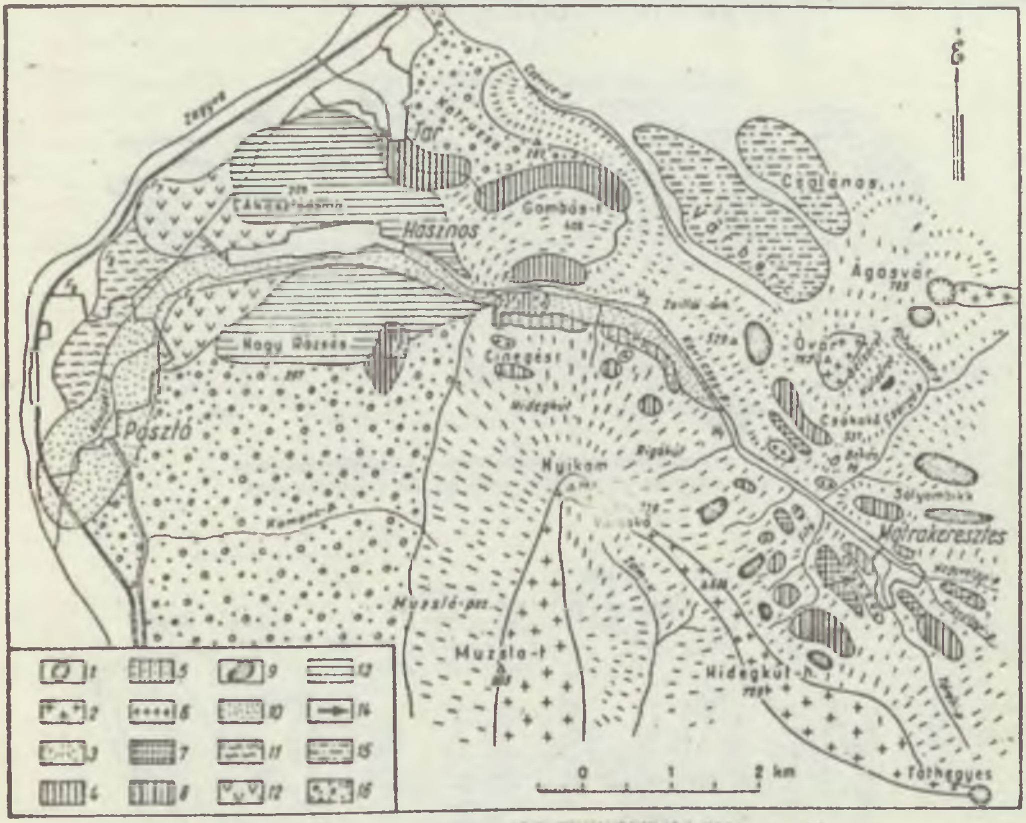
Die Stufenränder sind an vielen Stellen durch Bruchlinien vorgezeichnet, stellenweise stimmen sie mit den Grenzen der Gesteinstreifen überein. Diese Stufen dringen trichterförmig in die Täler, sind demnach durch die Erosion bedingt, ihre Entstehung wurde bloß durch die Bruchlinien und die leichter verwitternden Gesteinstreifen präformiert und gefördert. Der Erosionscharakter der Stufen ist besonders an den Erosionshorizonten, an den Hängen des Óvárberges ausgezeichnet zu beobachten (Abb. 5.). Hier sind an den Stufen erosionsbedingte Unterspülungen und Betteinschnitte zu sehen. In den jungen, rückschreitend eingeschnittenen Nebentälern sind die Stufenränder durch wunderschöne kleine Wasserfälle angedeutet (Abb. 6.).

Zwischen Hasznosi-vár (Burg) und der Mündung des Vadóka-Baches breitet sich das mittlere Kövicsestal bedeutend aus (Abb. 4. Aufnahme 2.). Dieses ist teilweise ein struktureller Graben. Die Stufen sind nicht so schön geformt wie in dem Talkessel von Mátrakeresztes und sind inzwischen stark abgetragen worden. Auch das Relief ist stärker. Die umgebenden Hänge sind sehr steil. Die Stufen wurden durch die Bäche, die diese steilen Hänge entlang laufen, stark zerstört, und auch die zahlreichen Erdrutsche trugen das ihrige bei. Diese Rutschungen wurden durch die steilen Hänge, die Struktur, die jungen Bewegungen, sowie durch die Unterspülungen in gleichem Maße gefördert. Die tiefer liegenden Schichten der vulkanischen Schichtreihe bestehen aus verlehmten Andesittuff, das Liegende ist sandiger Lehm (Schlier). Durchnäßt bieten diese Schichten eine ausgezeichnete Gleitbahn. Im W des Hasznos-Berges tritt eine vollständige Änderung des Formenschatzes ein. Der Gebirgscharakter wird durch die kennzeichnenden Züge einer Ebene und eines Gehügels abgelöst. Gewaltige, fächerförmige Schuttkegel folgen einander (Abb. 3.). Über dem holozänen Schwemmkegel sind drei pleistozäne Schuttkegel zu sehen.

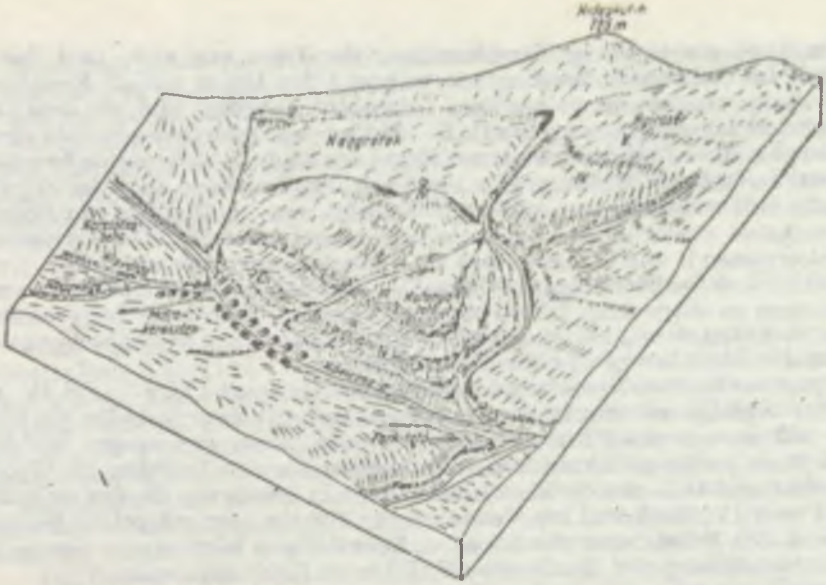
Kennzeichnend für den Gebirgsabschnitt des Kövicsestales ist die starke Talasymmetrie, die im allgemeinen von der Struktur bedingt ist, und ihre Entstehung zumeist den die Täler quer durchschneidenden Schichteinfällen verdankt. An den Schichtköpfen entstehen nämlich steilere, an den Schichtplatten sanftere Abhänge. An anderen Strecken wurde die Entstehung der Talasymmetrie durch die strukturellen Bewegungen gefördert; an manchen Stellen schuf die erodierende Arbeit der Bäche die Asymmetrie des Tales. Den oberen und den mittleren Abschnitt des Kövicsestales umsäumen von allen Seiten sehr steile Abhänge. Über diesen liegt die flache, jüngst aufgestückelte Hochebene des Mátragebirges. Die Hochebene ist eine durch die tortonisch-sarmatische Erosion entstandene Rumpffläche. Die primären vulkanischen Formen sind spurlos verschwunden, bloß die Reste der einstigen Eruptionszentren ragen noch als Gipfel oder höhere Rücken empor. Die schönsten sind Ágasvár und Tóthegyes. Die Mehrzahl dieser, aus der Hochebene emporragenden Gipfel tragen Erosions-Denudationsformen. In zahlreichen Fällen wurde das härtere Gestein zu Gipfeln herauspräpariert.

Bei dem Ausgang des oberen Pannons war das Relief noch bedeutend sanfter. Während der starken Hebung, die den jungen Rhythmus im Oberpliozän und im Quartär kennzeichnet, ging eine starke Einschneidung der Täler vor sich, und das Relief wurde lebhafter. Im Gebirgsabschnitt wurde während der 160 m tiefem Einschneidung des Tales eine riesige Gesteinmenge aus dem Tale abtransportiert und vor dem Gebirgsrande als gewaltiger Schuttkegel angehäuft. Die Stufen des Gebirgsabschnittes des Bachtales, ebenso wie die übereinander gelagerten Kegel des Schuttkegelsystems beweisen den abschnittweisen Verlauf der Hebung. Ein Vergleich der Terrassen und der Schuttkegel spricht ebenfalls dafür, dass in dem oberen Pleistozän und im Holozän auf dem untersuchten Gebiete keine wesentlichen Verschiebungen eingetreten sind. Die Terrassen, bzw. die Schuttkegelterrassen I. und II. haben sich als Übergangsterrassen entwickelt. Zwischen der Stufe I- und II. und der Schuttkegelterrasse IIb. sind keine wesentlichen Unterschiede oder Abweichungen zu entdecken. Diese Terrassen lassen sich noch im Zagyvatale ungestört verfolgen, ihre Gestaltung wurde demnach durch die Senkung des südlicher gelegenen Vorraumes, des Jászság (Jazygien) einheitlich bedingt.

Demgegenüber können die sehr hoch gelegenen Horizonte II, III und IV nur im Gebirgsabschnitt verfolgt werden, in dem unteren Abschnitt verschwinden sie (Abb. 7). Dies beweist, daß im unteren Pleistozän der Vorraum hinter der jungen Hebung des Gebirges noch stark zurückgeblieben war. Aus diesem Grunde konnten im Gebirgsabschnitt drei starke und bedeutende Niveaudifferenzen in Form von Stufen ausgemeißelt werden (II, III und IV), während im Vorraum nur ein einziger mächtiger Schuttkegel aufgebaut wurde. Die Entstehung des höchsten Schuttkegels können wir demnach zeitlich mit der Ausmeißelung der Horizonte IV, III und II identifizieren.



Geomorphologische Kartenskizze der West-Mátra. 1. Stark verstümmelte Reste der einstigen Eruptionszentren. — 2. Gipfel- und Gratreste der sarmatischen Rumpffläche. — 3. Abgetragene steile Andesitabhänge. — 4. Obersarmatisch-niederpannonisches Verwitterungsprodukt. — 5. Erosionsstufe No. I. — 6. Erosionsstufe No. II. — 7. Erosionsstufe No. III. — 8. Erosionsstufe No. IV. — 9. Erosionsstufe No. V. — 10. Holozäne Terrasse und Schuttkegel No. I. — 11. Neupleistozäner Schuttkegel No. II. — 12. Neupleistozäner Schuttkegel No. IIb. — 13. Unterpleistozäner Schuttkegel. — 14. Einstige Stromrichtung. — F_1—F_4 Aufschlüsse. — H_1—H_4 Bohrungen in Hasznos. — 15. Flache denudierende Rücken. — 16. Die Terrassen des Zagyvaflusses und die Schuttkegel der Zuflüsse

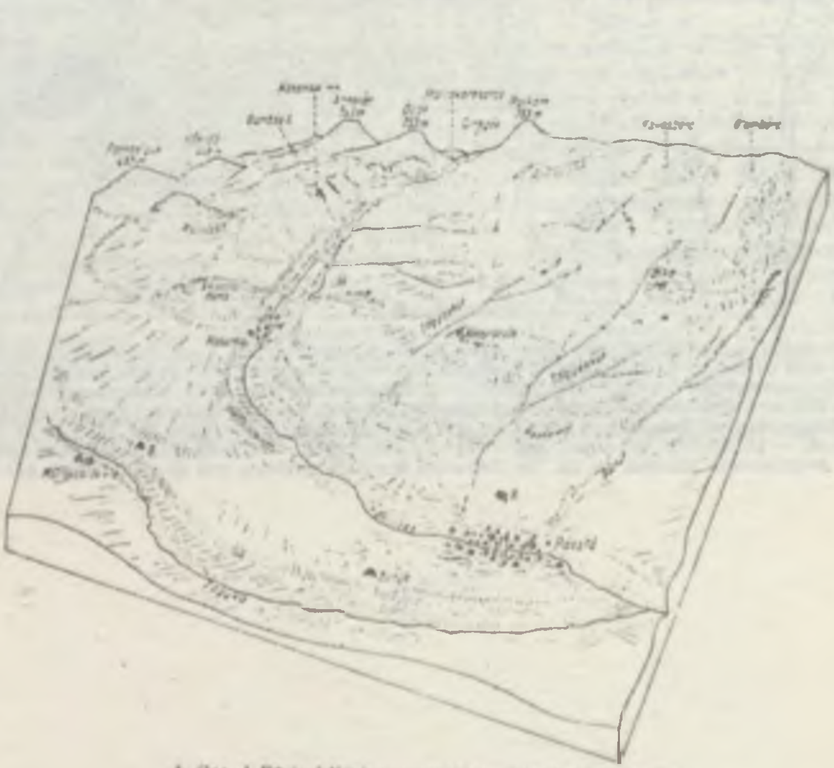


2. ábra. A Mátrakeresztesi-völgymedence tömbszelvénye. I = I. sz. lépcső, — II = II. sz. lépcső, — III = III. sz. lépcső, — IV = IV. sz. lépcső, V = V. sz. lépcső

Blockdiagramm des Talkessels von Mátrakeresztes. I = Stufe No. I. — II = Stufe No. II. — III = Stufe No. III. — IV = Stufe No. IV. — V = Stufe No. V.

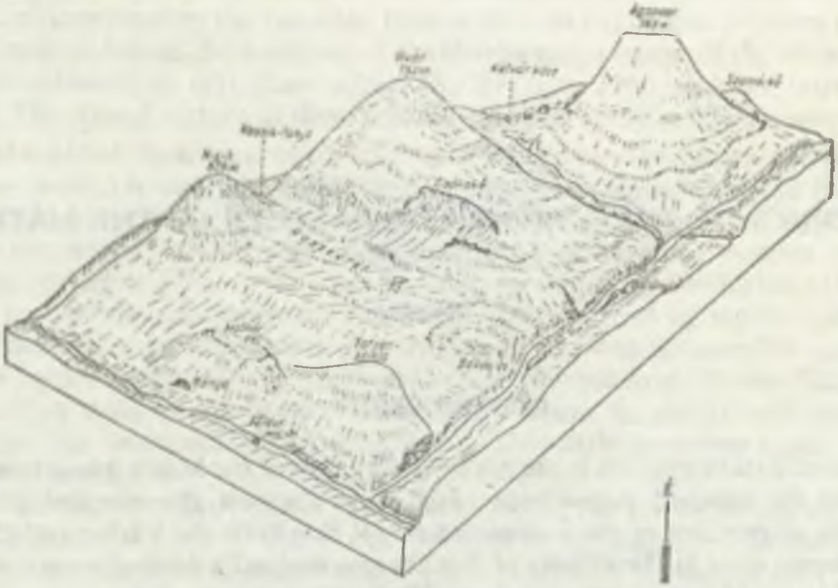
3. ábra. Az Alsó-Kövicses-völgy tömbszelvénye a hordalékkúp-rendszerrel

Blockdiagramm des unteren Kövicsestales mit dem Schuttkegelsystem

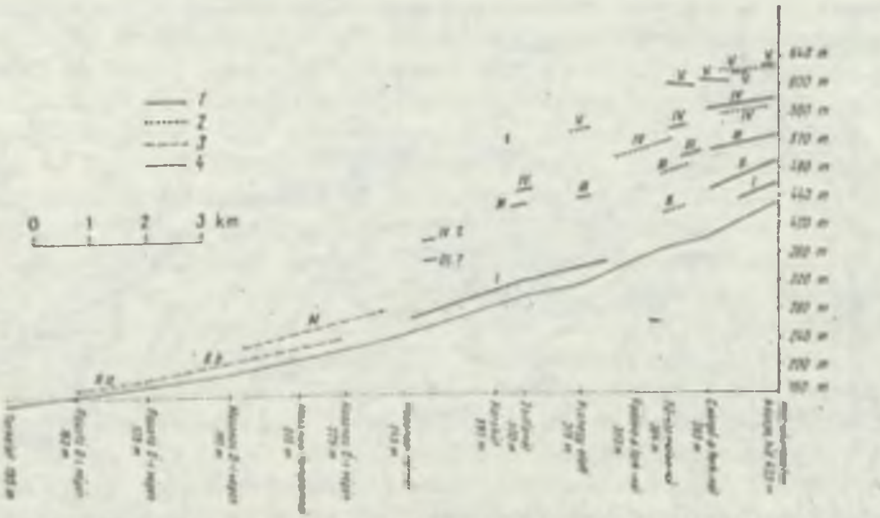


4. ábra. A Középső-Kövicses-völgy és környékének tömbszelvénye

Blockdiagramm des mittleren Kövicses-tales und seiner Umgebung



5. ábra. Az Ágasvár és Óvár az eróziós szintekkel
Ágasvár und Óvár mit den Erosionshorizonten



6. ábra. A Kövicses-völgy eróziós lépcsőinek és teraszainak hossz-szelvénye. 1. Baloldali eróziós szintek (I—V.) — 2. Jobboldali eróziós szintek (I—V.) — 3. Hordalékkúpok (IIa, IIb, M) — 4. A Kövicses-patak jelenlegi esésgörbéje

Längsschnitt der Erosionsstufen und Terrassen des Kövicsestales. 1. Erosionsstufe an der linken Seite (I—V.) — 2. Erosionsstufe an der rechten Seite (I—V.) — 3. Schuttkegel (IIa, IIb, M) — 4. Gefällkurve des Kövicses Baches

TECTONICS OF THE NORTHWESTERN SLOPE OF THE MÁTRA MOUNTAINS

J. MEZŐSI

INTRODUCTION

The investigation area lies in the northwestern part of the Mátra Mountains mass, as shown on the attached map-scheme *(Fig. 1)*. In the west, the morphological patterns and the disposition of the formations reveal that both the Várhegy of Hasznos and the volcanic mass in the vicinity of Tar are in a markedly down-dropped position with regard to the Mátra Mountains mass. The fracture system of the Zagyva Graben is also indicative of tectonic movements. Consisting mainly of andesites and their tuffs and subordinately of dacitic tuffs, the Helvetian to Lower Tortonian volcanic complex is presently about 300 m thick. It rests on the schlier formation overlying the Helvetian lignite formation. These formations are locally covered by a thick talus mantle concealing both the majority of the andesite dykes of the Mátra Mountains sedimentary foreland and the tectonic lines intersecting the formations.

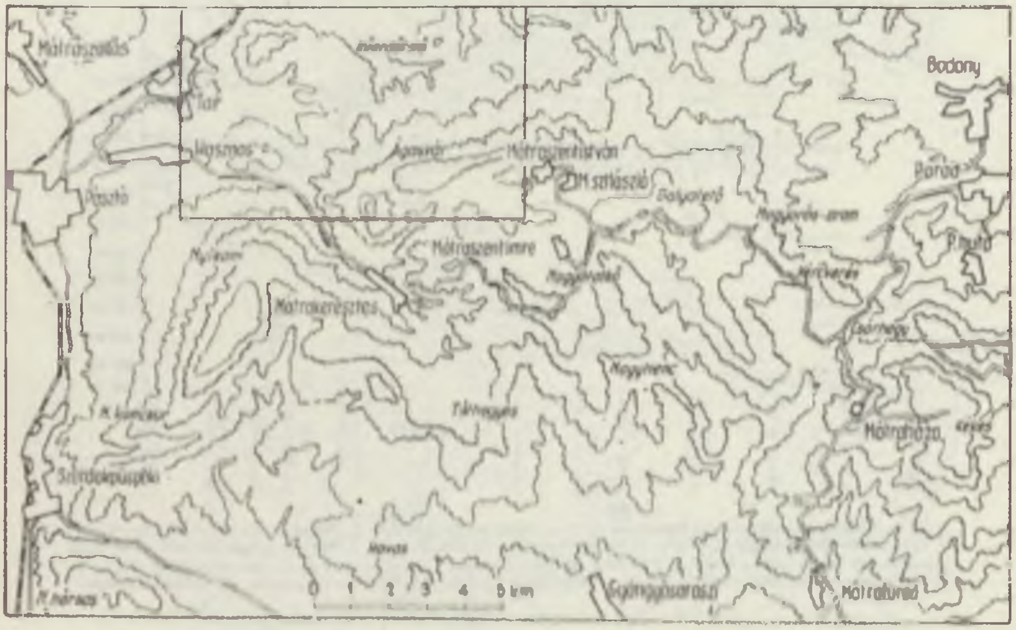


Fig. 1. Geologic map of the area investigated.

As shown by drilling in the broader environs of the Mátra Mountains (Sóshartyán, Szécsény) and by the xenoliths recovered from the deeper portions of the Mátra Mountains andesites, the basement of the northwestern sector of the mountains seems to be constituted by crystalline schists [K. BALOGH, 1966. and BALOGH—KŐRÖSSY, 1968.]. The eroded surface of these schists, has been overlain by Paleogene sediments.

The oldest formation uncovered by drilling near the Mátra Mountains northwestern border is the clay — clay-marl — sandstone sequence of the Rupelian stage which was hit at 401.50 m depth during the drilling of borehole Nagybátony-I, but which was not yet cut through at 1537 m, where drilling was stopped. It is overlain first by an Upper Oligocene sequence, then by 250 m of Burdigalian deposits. The lower part of the last-mentioned formation is represented by marine sediments with larger pectinids, the upper part, in turn, by 16 to 60 m of so-called Lower Dacitic Tuff of peculiar white colour which used to be referred to as "Lower Rhyolite Tuff". Exploratory drilling was stopped at the point where the dacitic tuff underlying the Helvetian lignite formation was reached, so that little is known about their actual thickness and facies.

After the Late Burdigalian continental phase the Helvetian epoch began by a slow ingression of the sea. The slow subsidence of the region is indicated, on the one hand, by the clay mineralization of the upper portion of the dacitic tuffs (a phenomenon suggestive of inundation!), on the other hand, by the deposition of lignite seams.

Whereas in the vicinity of Mátranovák and Homokterenye the lignite formation consists of three seams, at the Mátra Mountains northern foot it includes only two of them. Seam II is of deep-bog origin, including a barren intercalation of 0.7 to 0.8 m thickness. The higher-seated Seam I is of shallow-bog origin. The seams have dip angles of 165° — 185°/6° — 12°.

After the deposition of the lignite formation the rate of subsidence was accelerated, which gave rise to gradual pinching out in southern direction of the lignite. The lignite formation is overlain, after a thin intercalation of Chlamys sands (which may locally lack), by marly, micaceous siltstones (schlier) which usually contain a poor fauna. In Csutaj pit and Szalajka brook the author of the present paper collected the following fossils which were determined by M. BOHN—HAVAS [MEZŐSI, 1966]: gastropods — *Turritella beniosti* COSSMANN et PAYROT, *Turritella subangulata* BR., *Ringicula (Ringiculella) auriculata buccinea* BR., *Rissoa sp.*, *Neritina sp.*, *Turritella sp.*, *Polynices sp.*, *Columbella sp.*, *Cantharus sp.*, *Drillia sp.*, *Natica sp.*, *Clavatula sp.*, bivalves — *Venus (Clausinella) basteroti* DESH., *Solenocurtus candidus* REN., *Pinna sp.*, *Venus sp.*, *Tellina sp.*,; foraminifers — *Robulus sp.*, *Nonion sp.*, *Nodosaria sp.*,; fragments of Ostracoda and Echinus. From another locality of the Szalajka Valley, I. CSEPREGHY—MEZNERICS [1954] quoted the following mollusc species: *Protoma cathedralis paucicincta* SACCO, *Architectonica simplex* BRONN, *Nassa (Usita) restituta hörnesi* MAYER, *Nassa (Caesia) cf. inconstans* HOERNES et AUINGER, *Ancilla (Baryspira) glandiformis* LAMARCK, *Conus (Conospira) dujardini* PHIL., *Ringicula (Ringiculella) auriculata buccinea* BROCCHI, *Leda (Lembulus) fragilis* CHEM., *Angulus (Oudardia) compressa* BROCCHI. In the upper reaches of Szalajka brook SCHRÉTER [1940] found *Brissopsis sp.* specimens, north of Kőerdő Hill he collected *Ringicardium danubianum* MAYER and MACOMA *elliptica* BROCCHI var. *ottnangensis* R. HOERN.

In the geological survey borehole Hasznos-I, in Helvetian schlier, the following forms were found and determined by M. MUCSI: *Stenothyra sp.*, *Potamides sp.*, *Venus sp.*, *Tellina sp.*, *Arca sp.*, *Cardium sp.*, and *Pinna sp.*

Ingression was replaced by regression, coupled this time with andesitic volcanism, as early as the second half of the Helvetian. The first layers of the about 60- to 100-m-thick agglomerated andesite tuffs and andesites are still intermingled with marine sands and clays; these tuff layers are stratified, their material is graded. The best exposure is in the Csevice Valley near Tar and in the vicinity of Tyukod Hill. The tuffs are also represented in the core of the survey borehole Hasznos-l (southern slope of Hegyes Hill). At the time of lava effusion that followed the Helvetian tuff eruptions the area under consideration was an emergent land already.

At the Helvetian—Tortonian boundary appears the so-called pumiceous Middle Dacitic Tuff. Its upper member was redeposited in Early Tortonian time, as evidenced by its being mixed with Lower Tortonian volcanic detritus in a number of places. Its thickness is 70 m or so in the Fehérkő mine of the Csevice Valley and 60 m in borehole Tar-29. In the survey borehole Hasznos-l it is merely 39 m thick, but it should be taken into consideration that drilling was started from within this formation.

Controlled by rejuvenated fracture lines, Early Tortonian volcanism also yielded a considerable amount of lava. It brought about fissure volcanoes (e.g. Stremina crest), parasitic craters (e.g. the valley of Csörgő brook), minor volcanic cones (e.g. Kőerdő Hill) and, in some places, thin lava flows which were dismembered by subsequent erosion (e.g. on the southern side of the Farkaslyuk).

The volcanic cones consisting of andesites of dacitic nature (Óvár and Ágasvár), the subvolcanic, fresh, dark grey pyroxenic andesites and amafitic andesite masses and dykes appear to be of nearly equal age. In many cases a connection can be shown to exist between the subvolcanic products and the dykes. The dykes have not pierced the Upper Tortonian tuffitic limestones of Leithakalk facies anywhere; consequently, they are older than the Leithakalk. On the other hand, they are younger than the Lower Tortonian volcanic complex, because this is intersected by dykes.

The depressions of the resultant volcanic landscape were inundated by Late Tortonian sea, which thus produced the diatomite deposit of Hasznos and the tuffitic limestones of the Szalajka Valley near Tar, respectively. In addition, a faint eruption of pyroclastics should also be reckoned with, as evidenced by the rhyolite tuff bands intercalated within the sediments here. The thickness of the diatomite formation can be estimated at about 120 m in borehole Hasznos-4, that of the tuffitic limestones at about 70 m in borehole Tar-29. To the east of this area, the latter formation is only represented by thin rags which could escape erosion.

According to determinations by M. Bohn—Havas [Mezősi, 1963], the tuffitic limestones contain the following fossils: foraminifers — *Venus (Clausinella) basteroti* Desh., *Cyprina grinodica* Ben., *Pecten aduncus* Eichw. (fragment), *Phacoides (Linga) columbella* Lam., *Pitaria (Paradione) chione* Lam., *Arca sp.*, *Lucina sp.*, *Mactra sp.*, *Meretrix sp.*, *Tapes sp.*, Out of Bryozoans, *Vincularia sp.*, was recognized by Kolosváry.

According to J. Noszky Sr. [1927], at the confluence of Madarász and Csertő brooks there is a small patch of tuffaceous sediments of Leithakalk facies. They contain, beside *Amphistegina vulgaris* and *Heterostegina costata*, ill-preserved specimens of *Conus fuscocingulatus* Bronn., *Panopaea menardi*, *Cardium turonicum* May., *Pecten sp.*, *Lucina sp.*, *Serpula sp.* and *Dentalium sp.* At this locality, however, the tuffitic limestones are already redeposited, the autochtonous deposit being farther east.

After the withdrawal of Late Tortonian sea, this region also witnessed an intensification of erosion. On the norther side of the Mátra Mountains crest, talus fans were accumulated which presently vary between 10 and 30 m in thickness, locally attaining 95 m.

The northwestern part of the Mátra Mountains is characterized by a faulted structure with chess-board-patterned fault-grabens and minor horsts. The present-day tectonic pattern of the investigation area is the result of repeated tectonic movements.

The earliest detectable tectonic movement of the area corresponds to the time of Late Helvetian volcanism. In fact, in the Ágasvár range, at the Szamárkövek and in Csörgő brook the Middle Dacitic Tuff is flanked by fracture lines of WNW—SES trend. Farther east, the Lower Tortonian volcanic complex lies, as exposed today, immediately on the Helvetian schliers, as the Helvetian volcanic complex and the Middle Dacitic Tuff are absent. Both these formations reappear farther east in the Polinka Valley along a fracture line of similar trend. The fracturing of the Helvetian lignite formation and of the schliers as well as their progressive plunging under the Mátra Mountains mass seems to correspond to the date of this faulting.

The second phase of differential movement coincided with the time of Early Tortonian volcanism when fissure volcanoes and minor parasitic craters were formed. Such a fissure volcano seems to be represented by the narrow crest running from Ágasvár towards Mátraszentiván, a volcanic range controlled by a fracture line of ENE—WSW trend. The similarly trending stretch of the valley of Csörgő brook and the WNW—ESE-trending valley of Narád brook also appear to belong to this category.

Lower Tortonian tectonic trends are also indicated by the dykes which partly coincide with the afore-mentioned directions and partly are of E—W or N—S trend. Both types of dykes represent lava masses of various sizes which have intruded into open fissures. The eventual vertical dislocations along dykes must be either pre- or post-volcanic, because dilatation joints, as a rule, cannot be supposed to be connected with, any major vertical displacement. The slight contact effects observable along the dykes were examined by Bognár and Póka [1964].

Post-Miocene crustal movements, whose manifestations can be distinctly demonstrated, were considerable, too. Whereas the earlier faults are oriented roughly ENE—WSW and WNW—ESE, respectively, the Miocene faults strike either NE—SW or NW—SE.

Most of the 150 deep boreholes drilled in the investigation area have reached the Burdigalian Lower Dacitic Tuff. With reference to this level, the size of displacement can be determined. On the basis of the plotted profiles, tectonic movements of various ages can be readily shown to have occurred. The gradual disintegration of the Helvetian schlier began as early as Late Helvetian volcanism.

Profile A—B of *Fig. 3* (70°—250°) extends from the borehole Nagybátony-109 drilled into the western bank of Kecskés brook, towards Ágasvár. Near Felső-Katalinbánya there is a horst-like hill. The eastern continuation of the andesite dyke exposed on the Csutaj can be encountered partly in underground workings, partly in minor dyke portions exposed to the surface. The volcanic rock hit at about 530 m in borehole Nagybátony-224 may be a portion of an andesite apophysis or of a subvolcanic body. Towards Ágasvár, the Helvetian schlier grows gradually thicker, to attain

Fig. 2. Geologic structure of the area.

Legend: 1. Slope-detritus, alluvium; 2. Upper Pannonian sand; 3. Upper Tortonian tuffaceous limestone, diatomaceous earth; 4. Lower Tortonian andesite and andesite-tuff; 5. Dacite-tuff; 6. Helvetian andesite and andesite-tuff; 8. Helvetian coal series; 9. Burdigalian dacite-tuff; 10. Upper Oligocene; 11. Fracture-line; 12. Direction of geologic section.

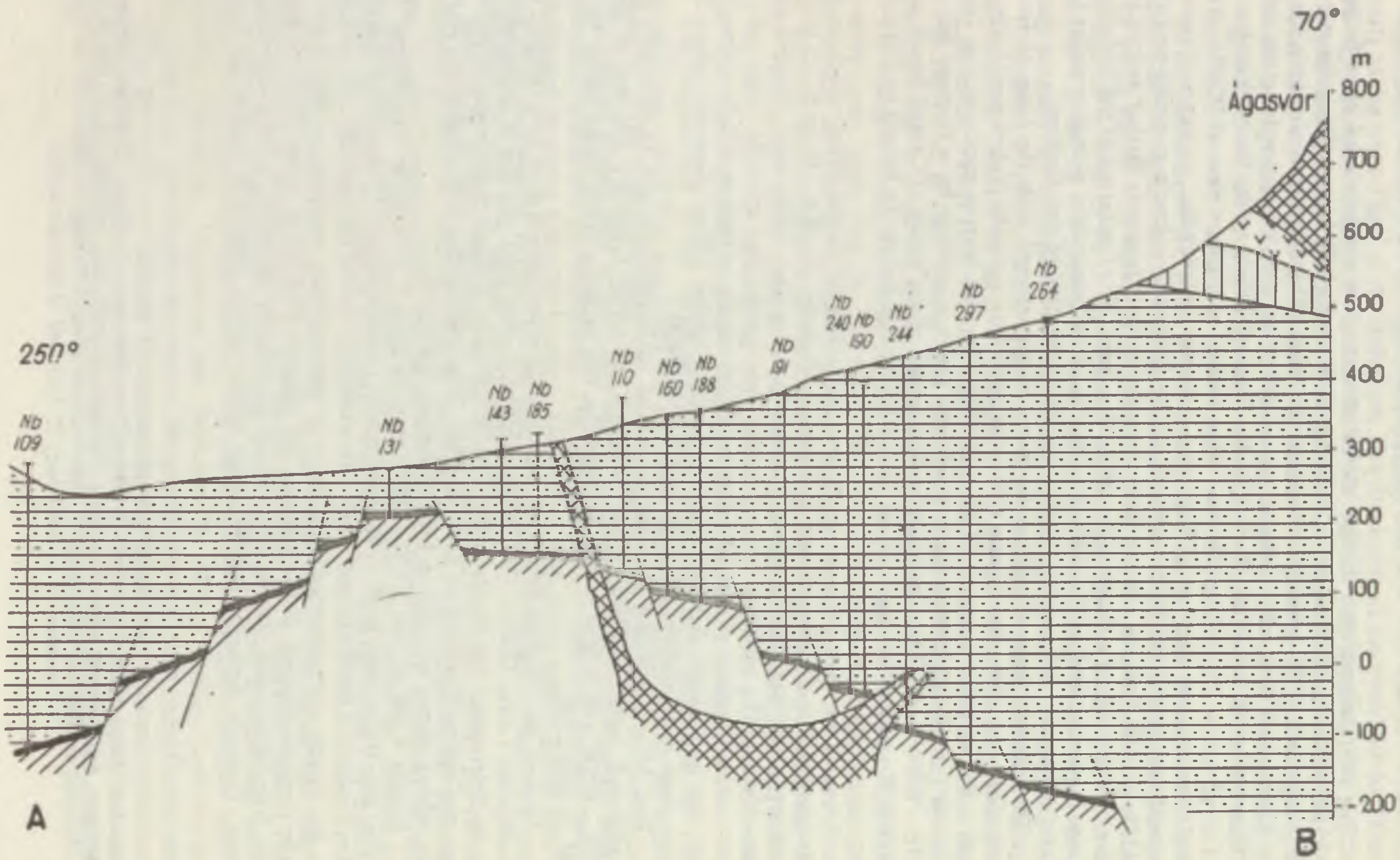


Fig. 3. Geologic section in the direction A—B on Fig. 2.

about 700 m in thickness beneath the Upper Helvetian agglomeratic andesite tuffs. The chess-board-patterned fracturing of the schlier and its southward tilting seem to be due to Latest Helvetian crustal movement. Later movements changed but little the position of the schlier. The faults strike at about 60° to 240° and 130° to 310°, respectively. Stratification planes dip usually southward at 6° to 12°.

Examination of geological structure along a profile (C—D, *Fig. 4*) of NE—SW orientation will also show the southward growth in thickness of the Helvetian schlier. In Tarkő brook — at about 330 m elevation a.s.l. — the Burdigalian Lower Dacitic Tuff is exposed. The borehole Nagybátony—105, drilled into the ridge between Sziget and Bükkös brooks, reached the Lower Dacitic Tuff (absolute elevation: +33 m) as high as at 413.4 m depth. Farther southwest, the tuff lies at nearly 550 m depth (absolute elevation: —80 m) in borehole Nagybátony—186.

The andesite dyke, exposed on the ridge running between Nagy Bec meadow and Tarkő brook in the eastern part of a profile (E—F) of approximately E—W trend (*Fig. 5*), may be the off-shoot of a large subvolcanic body. This seems to be evidenced, on the one hand, by borehole Nagybátony—268 which, after crossing the lignite formation, was stopped at 443.6 m depth; on the other hand, by borehole Nagybátony—259 drilled into the bed of Sziget brook, which intersected the andesites twice, beneath 95 m of scree. Not far from here is the andesite dyke of the ridge between Sziget and Bükkös brooks. The andesite dyke, exposed in the bed of Bükkös brook, also seems to be connected with the afore-mentioned subvolcanic body. All of these andesite dykes strike NNW—SSE. The minor peaks of the Lower Dacitic Tuff along the profile are, for the most part, members of a southeastward horst range.

In Late Pliocene time a large NE—SW-trending fault graben was formed in the western part of the region. Whereas the Late Helvetian and Early Tortonian movements stroke at 60° to 240° and 130° to 310°, respectively, the strike of this fault graben corresponds to 30°—210°. The faults detected by Noszky Sr. [1927], Schréter [1940], and Szentirmai [1965], faults extending from Kőerdő Hill southwestwards, are only part of this system, as evidenced by the three boreholes, Tar-3, Tar-29, and Hasznos-4, drilled into the graben axis. Of these, the Lower Dacitic Tuff — exposed about one kilometer and a half farther east — was reached, at nearly 596 m depth, by only the borehole Tar-3 in the northeastern part of the fault graben. Drilled in the middle stretch of the graben, borehole Tar-29 cut tullitic limestones under clayey talus down to 77 m depth. Underneath, 60 m of Lower Tortonian agglomeratic andesite tuffs followed. These were in turn underlain by the Middle Dacitic Tuff, again of 60 m thickness. The Helvetian schlier began at 447.5 m but was not cut through, as drilling was stopped at 675 m depth. However, considering the thickness of this formation in the near-by boreholes, the Burdigalian Lower Dacitic Tuff might be expected to occur here at about 820 m depth. The Upper Tortonian diatomite-bearing sequence, exposed near the Várhegy of Hasznos, was found to occur between 104 and 221 m in borehole Hasznos—4 (at the southwestern tip of the graben). This observation can be used for conclusions as to the height of faulting here. Since in the valley of Kövecses brook, near borehole Hasznos—4, the Middle Dacitic Tuff, marking the Helvetian—Tortonian boundary, is exposed to the surface, the fault plains must be steep. (Would this not be the case, so the Middle Dacitic Tuff would border on the older formation occurring on the eastern side of the fault.) Nota bene, borehole Hasznos—4 was stopped within Lower Tortonian andesite tuffs at 304 m depth.

One of the benches of this comparatively deep graben (about 450 m deep, as shown by drilling) is the fault detected by Noszky Sr. and Schréter. Parallel with it, there runs another, larger fault, indicated by Szentirmai, along which the Middle

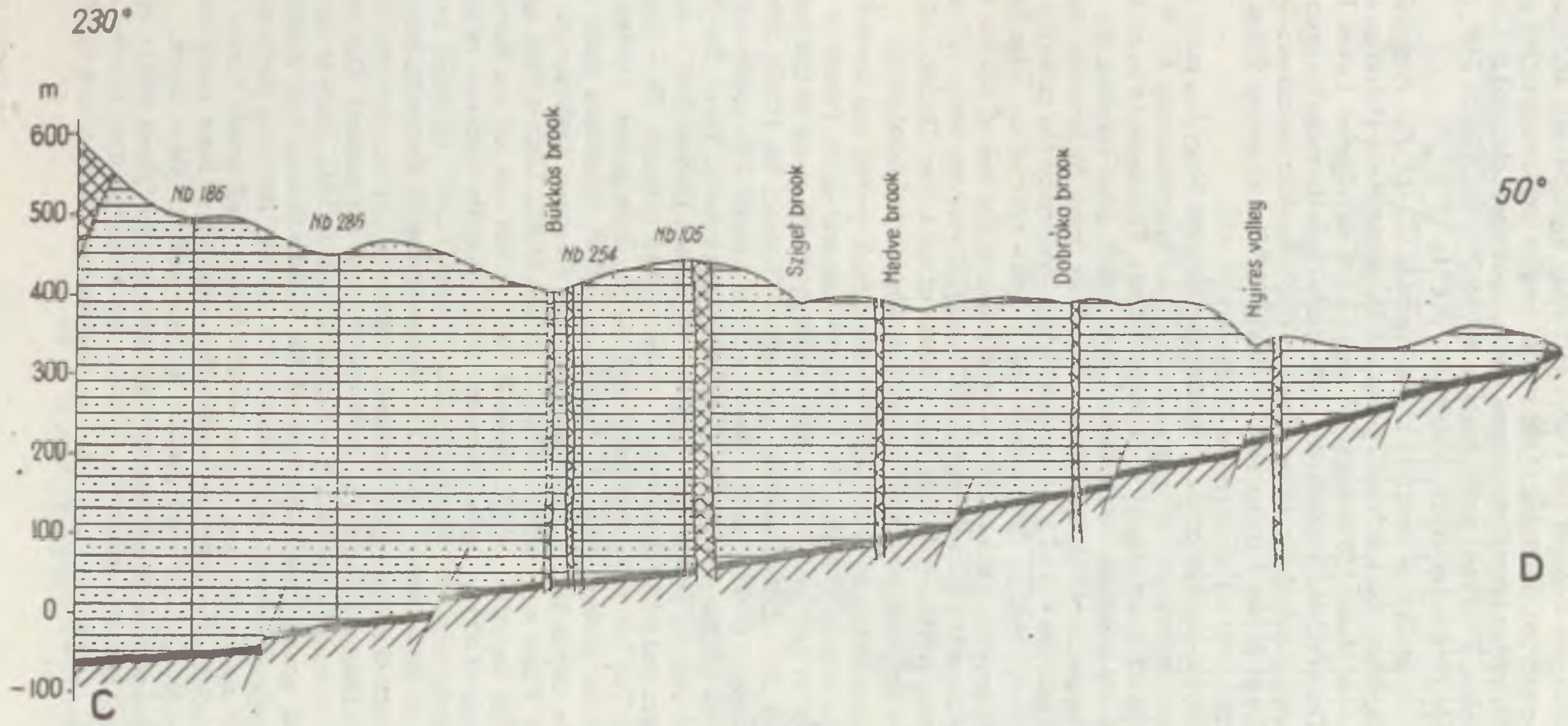


Fig. 4. Geologic section in the direction C—D, on Fig. 2.

Dacitic Tuff appears in the neighbourhood of the Helvetian schlier. It is in this large depression that the so-called „Szakadás gödre" was formed. Here only the Upper Helvetian agglomeratic andesite tuffs were intersected by borehole Tar—4.

In the vicinity of Gombás Hill this graben was filled up in Late Pliocene to Early Pleistocene time. The talus deriving from Mátrakeresztes is constituted partly by clay-mineralized amafitic andesites of onion-shaped (curbicortical) weathering, partly by dark grey, less weathered pyroxenic andesites. In addition to them, debris of jasper, opal, chalcedony, and veined quartzite are common, the last of which sometimes carry parasitic baryte plates. These are likely to represent residues of erosion of the baryte veins occurring in the vicinity of Mátrakeresztes.

Similarly in Late Pliocene time, a fault system of approximately NW—SE strike was formed. As the most eloquent example of it, the environs of Hegyes Hill may be quoted. The geological survey borehole on the southern slope of Hegyes Hill cut first the Middle Dacitic Tuff and then penetrated into Helvetian schlier at 173 m depth. However, at about 100 m south of the bore-head, the schlier is already exposed to the surface. This part of the Kövecses Valley has been controlled by this fault. The valley stretch by the Várhegy is also connected with the same fault. Between boreholes Hasznos—2 and Hasznos—3 there is a difference of 96 m in the hypsometric position of the Burdigalian Lower Dacitic Tuff, a phenomenon which is also due to a fault of NW—SE trend. The outcrop of the Middle Dacitic Tuff on the eastern slope of Gombás Hill is also fault-controlled, since Helvetian schlier lies close to it on the eastern side.

The NE—SW-trending fracture lines in the vicinity of Fehérkő mine near Tar village are known from earlier literature data [Noszky Sr., 1927., Schréter, 1940., Kubovics, 1963].

PHYSICO-GEOGRAPHICAL OBSERVATIONS IN THE SURROUNDINGS OF ISTENMEZEJE

by

Gy. Hahn

Summary

The geological and geomorphological evaluation of the hill regions not only promoted the exploration of new raw materials and mineral deposits, but also yielded important scientific results (investigations into karsts, interpretation of the periglacial phenomena, detecting of pediments, piedmont benchlands, peneplains, etc., relationship between tectonics and morphology). Now when the fundamental steps in developing applied geomorphology, such as geomorphological and soil-erosion mapping of Hungary, study of microlandscapes, geographical interpretation of physiographic evidence (landscape evaluation), have already been made, it is necessary to present these results of fundamental research by the example of a concrete small area.

The region of Istenmezeje, a sector of the Upper Tarna Hill Range forming a portion of the Heves-Borsod Hill Region between the Salgótarján and the Sajó Basin, was thought to be suitable for this purpose and thus got to the centre of our interest. The bentonite mine at Istenmezeje represents one of the largest bentonite deposits of Hungary. It was discovered during the large-scale geological prospects of the 1950's and, thanks to the further development, the geological evaluation of the region was completed by 1963. Relying on these results, we have started the geomorphological mapping of the area which enabled us to perform its complex physiographic evaluation. The results obtained can be summarized as follows:

1. The sandstone formations occurring in the environs of Istenmezeje cannot be dated from the Chattian stage of the Upper Oligocene alone, as the rocks overlying the bentonite deposit date from the Miocene (Helvetian-Tortonian); the deposit is older, dating from about the Helvetian-Burdigalian boundary, the foot of the bentonite deposit is Burdigalian or Upper Oligocene (Chattian), respectively.

2. Prospecting and mining development permitted to recognize an intensive tectonic fracturing and locally even to determine the chronology of faults.

3. Morphological description and the attached maps and photographs demonstrate the principal features of the area: a) recent, b) uplifted, and c) eroded structures.

4. Along wich crustal movements, the erosion-derasion processes have also played an essential role in shaping the present landscape.

5. The Tarna river flows in an erosion valley controlled by fracture lines. The sides of this valley have been affected by derasion. The valley floor is covered by scree filling 10 to 25 m thick resting on the sandstone bedrock, which provides evidence on an earlier erosion.

6. The physiographic landscape evaluation of the region furnished a brilliant example for the interaction of mining and soil mechanics, deep boring development, methods of geological estimation of mineral resources, physiographic factors, communications, and geography of settlement and population.

Litological basic map. — 1 = sandstone; 2 = rhyolite, rhyolite tuff; 3 = clay, silt; 4 = coal measures; 5 = alluvium and material of mixed composition removed from slopes; 6 = scree (clay, sand); 7 = sands and fine-grained gravels; 8 = water stream with bridge; 9 = intermittent stream, abandoned stream bed; 10 = fault with indication of fault throw; 11 = dip; 12 = dip of the bentonite deposit; 13 = isolines of the foot, m; 14 = borehole; 15 = adit; 16 = worked-out section; 17 = mine boundary, deposit boundary; 18 = railway on the surface, headway; 19 = highway; 20 = settlement

Геоморфологическая карта. — 1 – русло оврага эрозионного происхождения; 2 – небольшой овраг эрозионного происхождения, эрозионное борозда; 3 – ручей; 4 – временный водоток, старица; 5 – конус выноса; 6 – долина эрозионно-деразионного происхождения; 7 – деразионная долина, низина; 8 – расширения долины эрозионного происхождения; 9 – заполненная сухая долина; 10 – небольшое поднятие на разрушенной поверхности; 11 – небольшая низина на разрушенной поверхности; 12 – разница между уровнями поверхности высотой меньше чем в 20 м.; 13 – та же от 20 до 50 м.; 14 – та же от 50 до 100 м.; 15 – та же больше чем в 100 м.; 16 – поверхность и край террасы; 17 – поверхность и край останца эрозионного и деразионного происхождения; 18 – поверхность и край наиболее низкого пьедмонта; 19 – поверхность и край среднего пьедмонта; 20 – поверхность и край наивысшего пьедмонта; 21 – возвышенность между эрозионно-деразионными долинами; 22 – останец эрозионного происхождения; 23 – седловина эрозионно-деразионного происхождения; 24 – водораздел; 25 – разрушающиеся эрозионно-деразионные склоны крутизной до 15°; 26 – тот же от 15° до 30°; 27 – тот же свыше 30°; 28 – эрозионно-деразионные штабильные склоны свыше 30°; 29 – склон с оползней; 30 – место открытия новой шахты; 31 – предлагаемое место открытия новой шахты; 32 – бурение; 33 – штольни; 34 – шахта; 35 – сброс; $P_2 - Q_1$ – поверхность верхнего плиоцена и нижнего плейстоцена; Q_1 – поверхность нижнего плейстоцена; Q_2 – поверхность среднего плейстоцена; Q_3 – поверхность вер-

GEOMORPHOLOGICAL STUDY OF THE BUDAKESZI BASIN

JUHÁSZ, Á.

The Budakeszi Basin is located on the southern part of the Buda Mountains. It is bordered on the W and on the S by the Páty-Telki resp. the Budaörs-Páty tectonic graben, on the E by the Szabadság Plateau and on the N by the Nagy-Kopasz Mountain Block series.

The average height above sea level is 300 m and the area is of heterogeneous geomorphological character and varied lithological structure due to a very complicated surface development and changes in the structure. The most important rocks in the surface are: Triassic dolomite and limestone formations, Eocene limestone, marl, clay; Oligocene Hárshogyi sandstone, clay; Miocene sandy clay, gravels, limestone; Pannonian sand, and finally Pleistocene loess, slope sediment and Holocene alluvial deposits.

Along the main strikes /NW-SE and "Highland strike" perpendicular to this/ the old surface from late Cretaceous has become dissected into mountain blocks and horsts. As a result ofcontrary tectonic movements the various mountain blocks were elevated or subsided into very different heights and during the Tertiary and Pleistocene they had been subjected to numerous and various kinds of denudating factors. This results in the present geomorphological structure mostly consisting of mountain form elements of very particular development. As a result of development being different in various places the surface forms can be grouped in the following types similarly to other members of the Transdanubian Highlands. /Pécsi M. 1973./ 1. exhumed block, horst in summit position; 2. partly exhumed block in summit position; 3. burried block in summit position; 4. partly exhumed block in step position; 5. fully burried block in piedmont-threshold position; 6. partly exhumed block in piedmont-threshold position; 7. fully exhumed piedmont horst; 8. burried block in graben position.

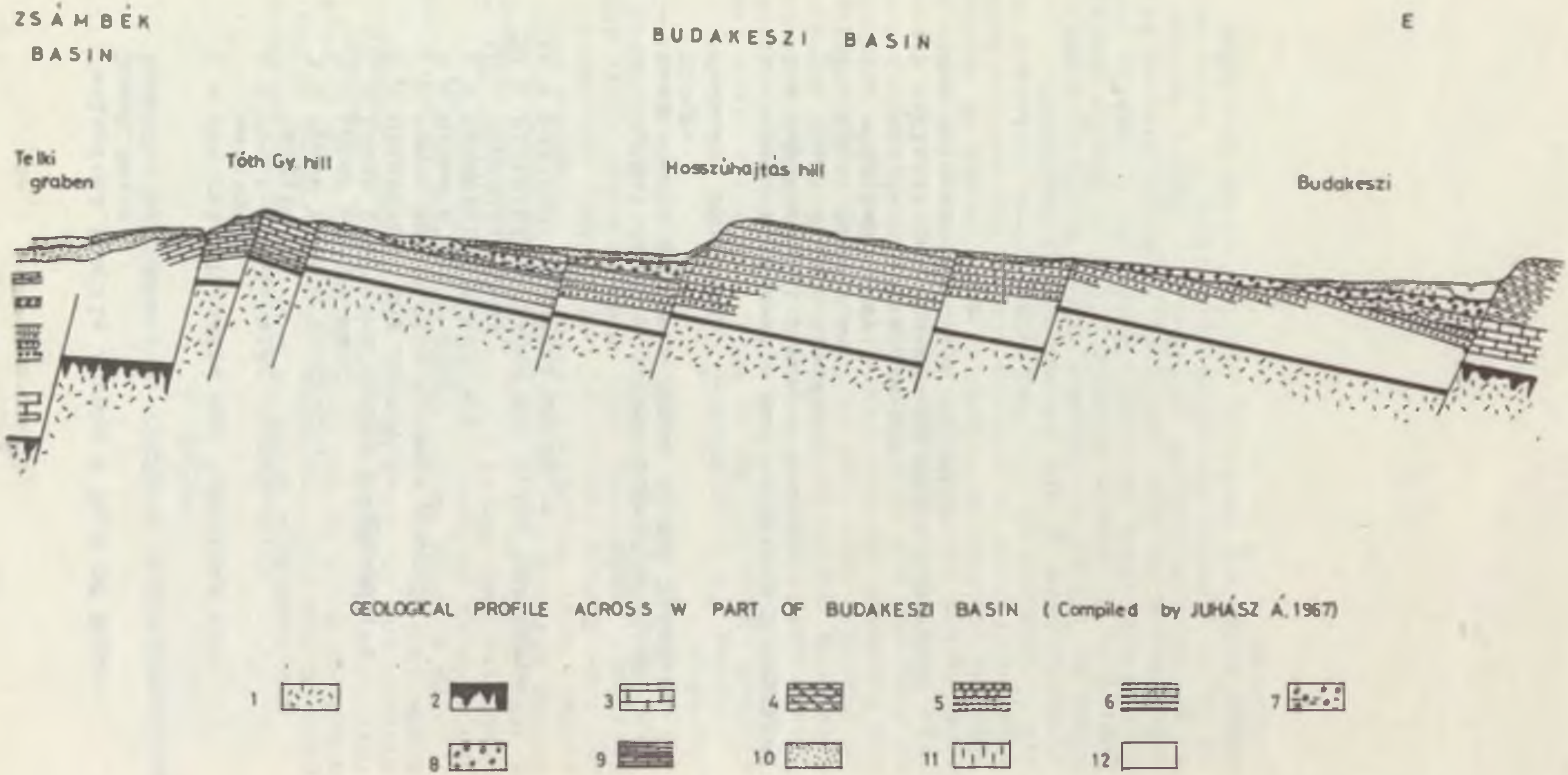
Fig. 1. Geological Profile Across W Part of Budakeszi Basin
Compiled by Juhász, Á. 1967.

1 = Mesozoic dolomite and limestone formations
2 = Tropical planated surface with bauxite
3 = Upper Eocene limestone
4 = Upper Eocene marl
5 = Lower Oligocene coarse conglomerate
6 = Oligocene fine sandstone
7 = Lower and Middle Miocene gravels
8 = Miocene sandy clay
9 = Sarmathian limestone
10 = Pannonian sand
11 = Pleistocene loess and slope sediments
12 = Holocene alluvial deposits

Fig. 2. Geological Profile Across E Part of Budakeszi Basin and Main Types of thb Mountain Blocks
Compiled by Juhász, Á. 1975.

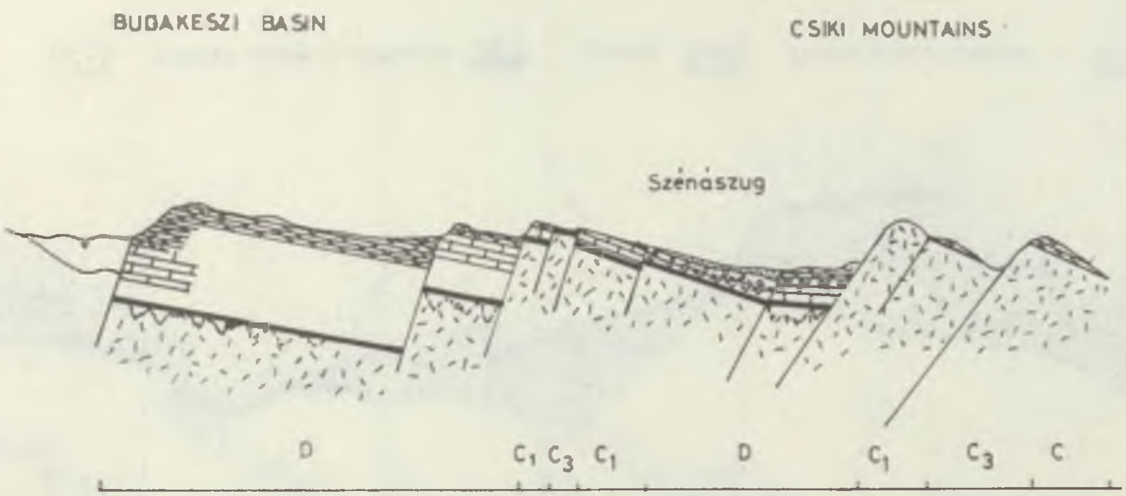
1 = Mesozoic dolomite and limestone formations
2 = Hypothetical planated surface
3 = Upper Eocene limestoce
4 = Upper Eocene marl
5 = Oligocene clay
6 = Middle Miocene gravels
7 = Pleistocene loess and slope sediments
8 = Holocene alluvial deposits

Fig. 1.



GEOLOGICAL PROFILE ACROSS W PART OF BUDAKESZI BASIN (Compiled by JUHÁSZ Á. 1967)

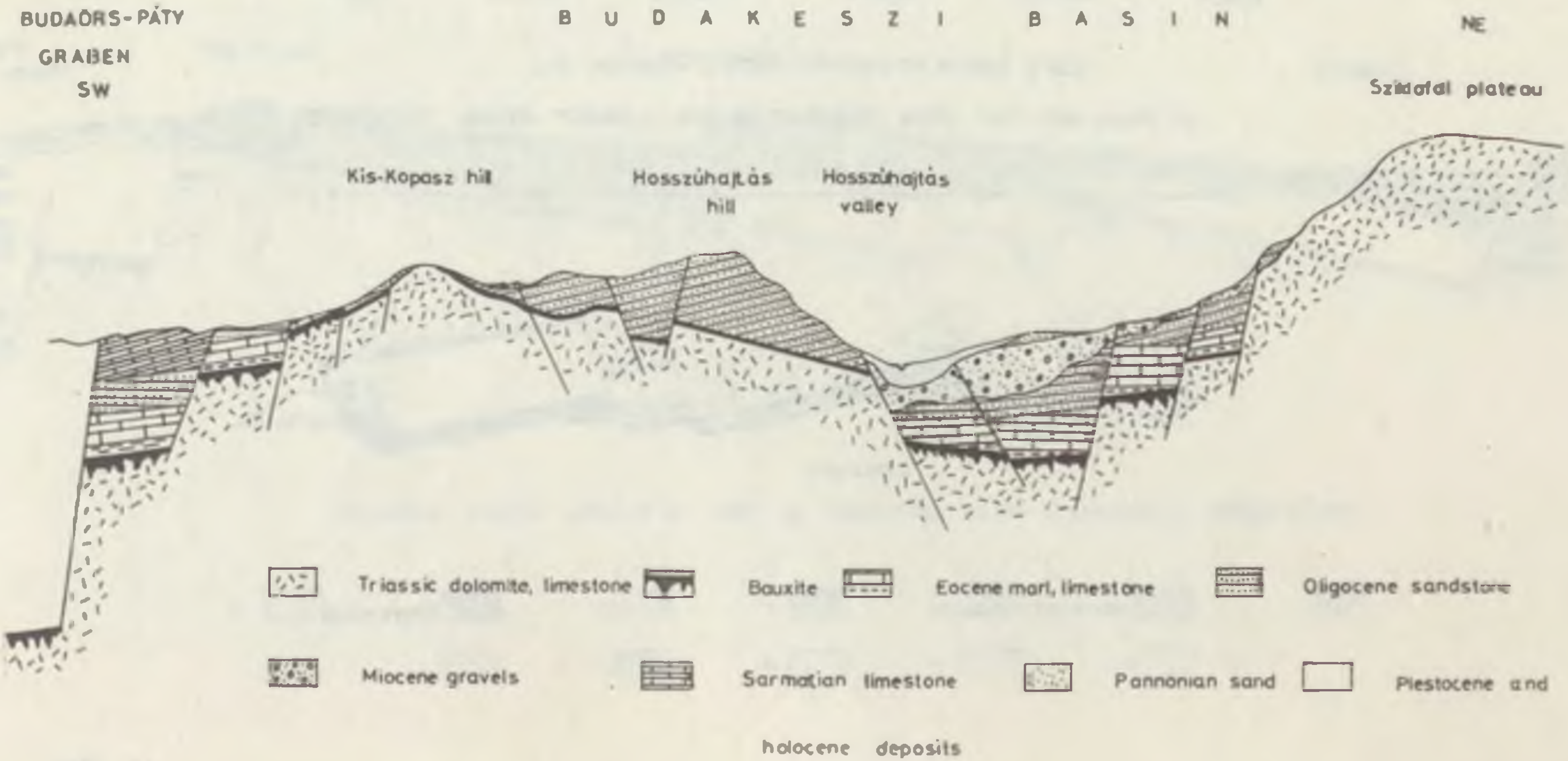
Fig. 2.

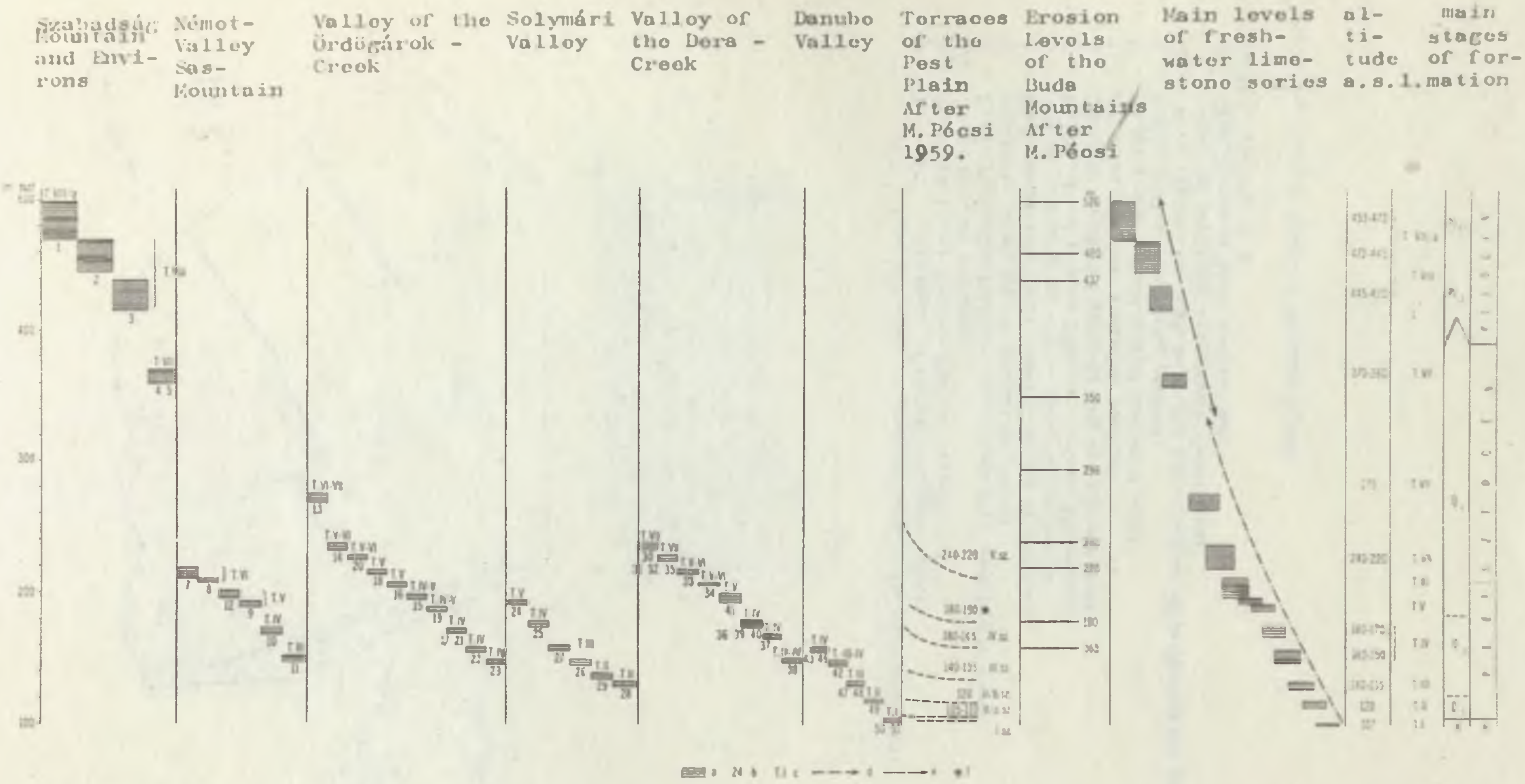


GEOLOGICAL PROFILE ACROSS E PART OF BUDAKESZI BASIN AND MAIN TYPES OF THE MOUNTAIN BLOCKS (Compiled by JUHÁSZ Á 1975)

Fig. 3.

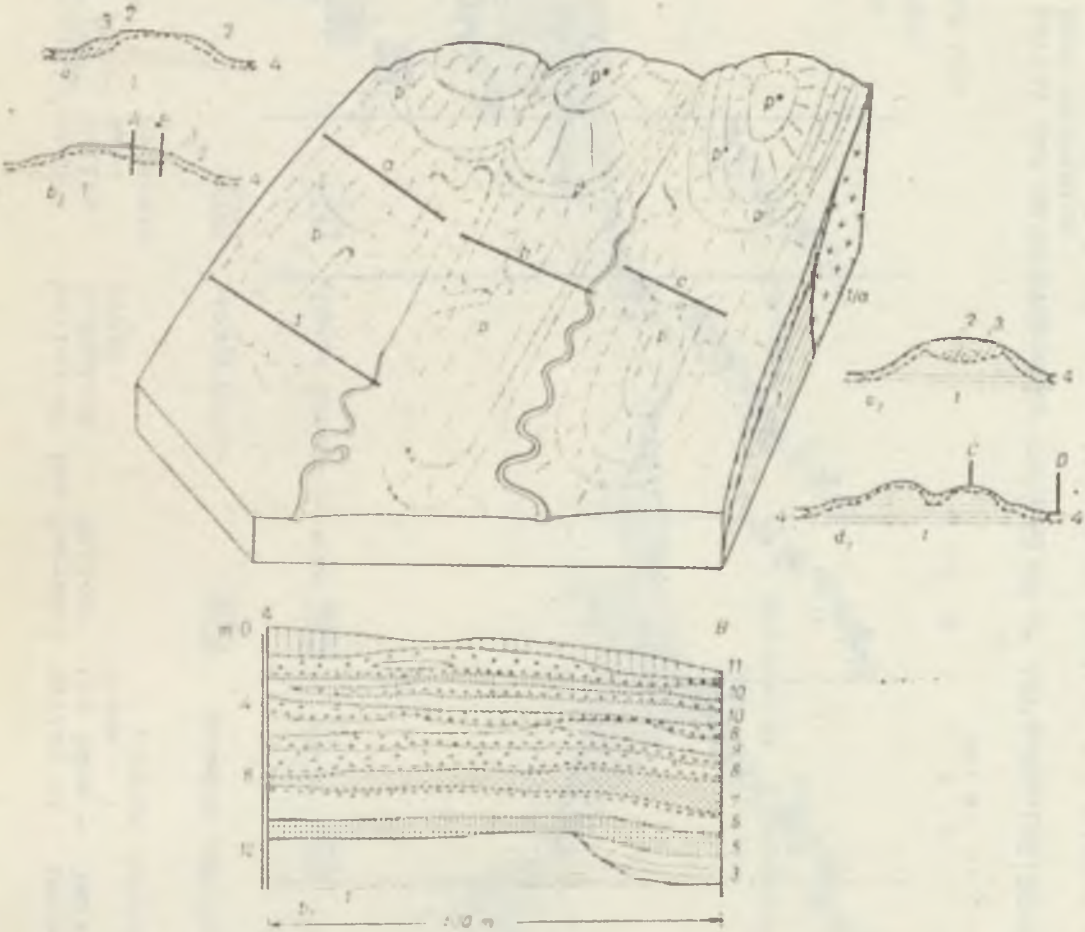
GEOLOGICAL PROFILE OF W PART OF THE BUDAKESZI BASIN (Compiled by Á.JUHÁSZ 1975)





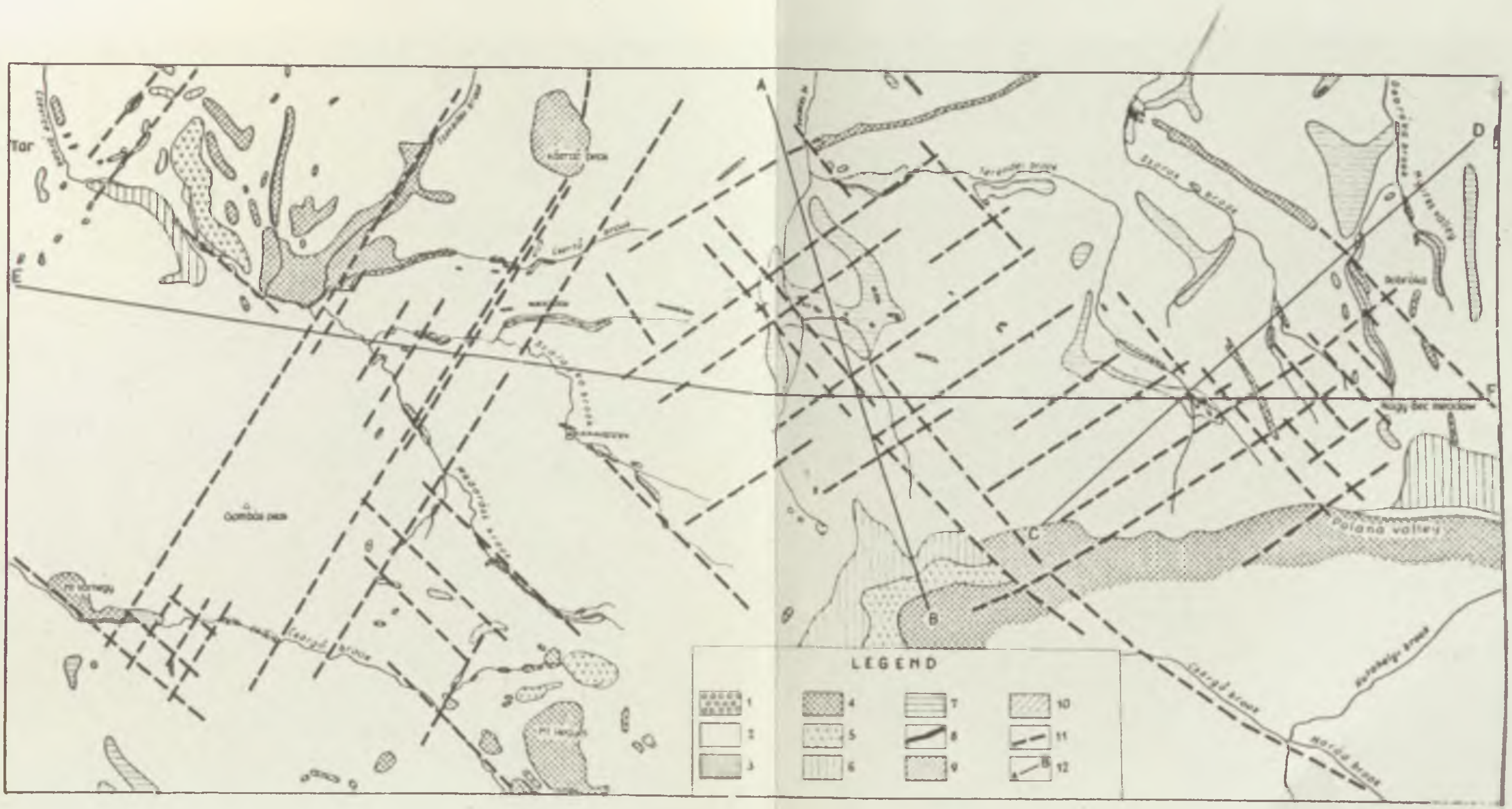
Levels and Main Stages of Formation of the Fresh-Water Limestone Series Joining with the Valleys of Buda Mountains

a = levels of fresh-water limestone series; b = places of occurrence; c = from T I to T VIII/a = main stages of formation of the fresh-water limestone series. The altitude of the T V. stage of formation is 195-210 m a.s.l., that of the T VI. stage of formation is 210-220 m a.s.l.; d = fresh-water limestone levels observed on the Eastern brink of the Buda Mountains joining with the Danube valley; e = fresh-water limestone levels formed as a result of discontinuous upward structural movements of the János and Szabadság Mountains and of valley formation in connection with this; f = an inserted level of 15-20 m appears between the alluvial cone terraces IV. and V. between Csömör and Cinkota resp. the Rákos and Palota creek.



Principal types of slope deposits of dissected pediments

P' — P'' — P''' — remnants of earlier pediment surfaces
P — Dissected Upper Pliocene-Pleistocene pediment
1/a — Late Tertiary volcanics
1 — Upper Pannonian-Pliocene sand, sandy clay with lignite seams
2 — Pleistocene slope-deposit blanket in general
3 — Proluvial gravely-sandy deposits on top of pediment
4 — Alluvia in general in valleys dissecting pediment
5 — Fossil red soil (Upper Pliocene — Early Pleistocene)
6 — Intensely weathered proluvia rich in sand and debris
7 — Red-brownish clay, alteration products
8 — Proluvia rich in sand, gravel and local debris
9 — Loamy-adobey weathering products
10 — Grey plastic clay with lenticular intercalations of proluvium (in places with traces of periglacial cryogenetic phenomena)
11 — dark brown or black erubase soil
C—D — see Figs 4, 5.



Tar
E
A
D
F
B
C
Polana valley
Gombás peak
LEGEND
1
2
3
4
5
6
7
8
9
10
11
12