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CONTENT

"OCEAN IN A DROP . . ."

Reflected in white, red and greenish-grey limestone beds, the hundreds of millions of years of the history of the vast "Mediterranean Sea" of the Mesozoic Era, the Tethys, are on record on Kálvária Hill at Tata, Hungary. In the vicinity you can also find records of the Tertiary period of earth's geological history, showing the effects of the large-scale Oligocene denudation and the gravelly-sandy detrital material of mountain-scouring watercourses; the Congeria-bearing clay and sand layers of the Pannonian Lake that existed here one million years ago; the structural and morphogenetic impact of sizeable tectonic movements at work since the Ice Age, with traces of associated hot spring activities; the loess, wind-blown sand and flood-deposited sediments blanketing the older formations.

A number of characteristic features of the history and lithology of the Mediterranean Mesozoic, notably the Late Triassic, Jurassic and Early Cretaceous, of the Transdanubian Central Mountains highland range can be studied in this area. The excellent outcrops and exposures of Kálvária Hill at Tata may greatly enhance a better understanding of a number of formations participating in the geological make-up of these areas. *You can draw important conclusions as to the events that took place in latest Triassic and earliest Jurassic times*, events that had led to a fundamental change in the character of marine sedimentation and in the composition of the fauna and flora (coal formation in the Mecsek Mountains, manganese ore deposition in the Bakony). *The peculiar facies of the Upper Triassic and Jurassic sequences and the problems of the Jurassic and Cretaceous boundary are timely research tasks being the subject of large-scale international scientific research.* The rough surface of the Upper Jurassic-Berriasian sediments is reminiscent of the one-time rocky coast of the Cretaceous sea. The break in sedimentation between the Berriasian and Aptian Stages was one of the main periods of bauxite deposition in Transdanubia. Pannonian sands and clays are connected with the development and filling up of Hungary's large basins. The travertine sequence of glacial age in the basement of the Grammar School of Tata has yielded a rich material of Paleolithic (Moustierian) artifacts. On Kálvária Hill, prehistoric chert pits have been uncovered in the course of geological investigations.

The outcrops and exposures of the Mesozoic basement horst of Tata and of its younger overburden have been studied by a number of scientists. During two decades I returned, myself, regularly, for shorter or longer spans of time, to this place, in order to explore the history of far-reaching ancient seas, lakes and lands and prehistoric cultures and to unravel their puzzle, backed by university students, fellow geologists, young scientists and workers on the staff of MÁFI (Hungarian Geological Institute). Particularly helpful to me in this long-term project was my colleague DR. G. VIGH.

The geologically most valuable parts of Kálvária Hill have been declared to be a Geological Conservation Area, by decree No 1225/1958 of the Council of Nature Conservancy. A scientific workshop, a base of vocational training, culture and education, Kálvária Hill's Geological Conservation Area has been looked after and sponsored by the staff and budget of the Hungarian Geological Institute. Let me take this opportunity to recommend its maintenance and protection to the attention of knowledge-seeking youths, experts, tourists and to that of the leading officials and inhabitants of Tata.

Budapest, September 1, 1972

DR. J. FÜLÖP

MEGATECTONIC SETTING

Composed of Permian to Mesozoic formations, the disproportional synclinorium structure of the Transdanubian Central Mountains shows a change along large transversal fault lines of northwest-southeast trend: Tata—Tatabánya and Váli-víz. Its northeastern part, from the Buda Hills up to the Gerecse Mountains is extremely block-faulted, with features indicative of a faulted-imbricated structure in the east, and north-south trending horst ranges in the west. The last-mentioned structure is the result of Upper Tertiary to Quaternary tectogenesis, contemporaneous with the formation of Hungary's large basins. The west-to-east, then north-to-south course of the Danube is controlled by this structure.

The young east-west and north-south trending structural lines have been superimposed at every turn by older, northeast-southwest and northwest-southeast trending ones. It is sufficient to cast a glance at the inserted Map of the Mesozoic Basement (Textfig. 1: in pocket) in order to be convinced of the validity of this statement. A striking phenomenon is also that the "Gravimetric High of Dad" belonging to the counter-limb of the Vértes Mountains falls in the strike of the Tata horst. As can be read off the map, in the western vicinity of the basement horst of Tata there is another, similar horst which is hidden from our eyes by a blanket consisting 30 to 50 m of Quaternary and Pannonian sediments (Textfig. 2). To the northeast, the Dachstein Limestone outcrop at Szomod village and the area of the gravimetric high between Szomod—Dunaalmás coincide with the structural strike of this basement horst.

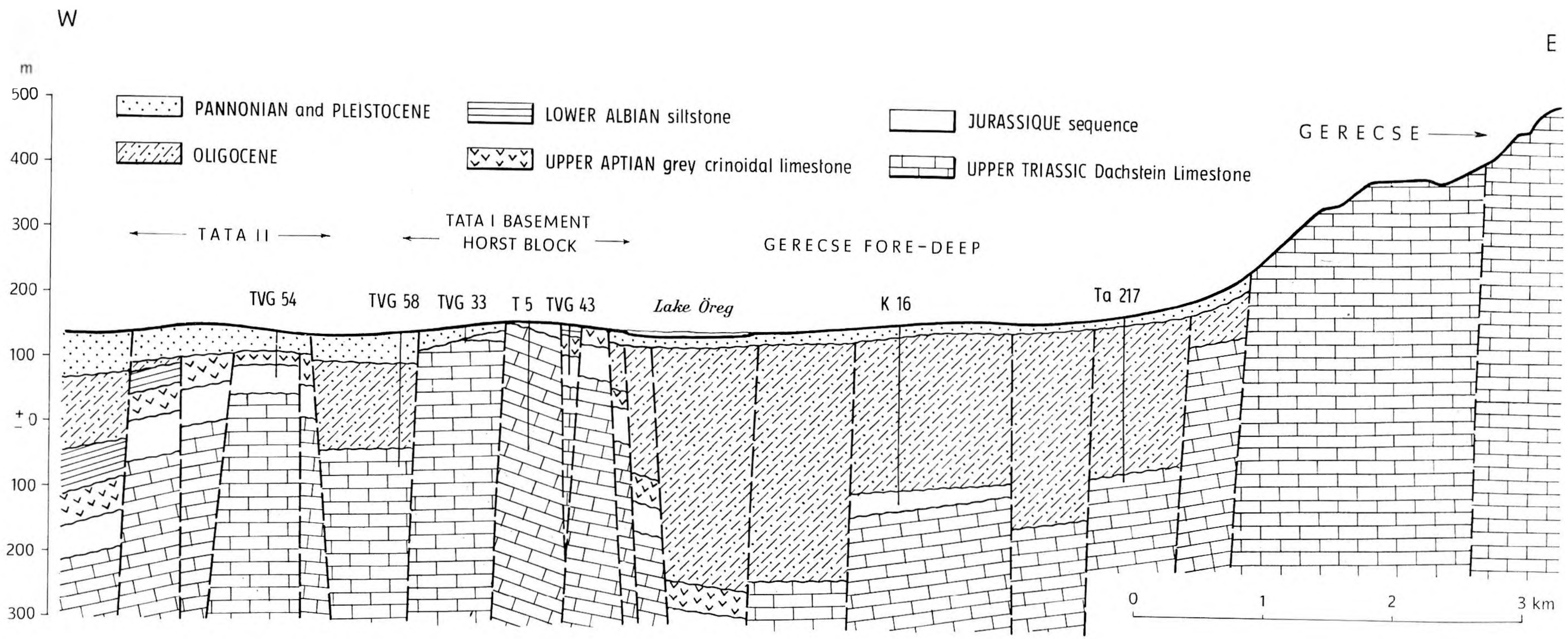
Tectogenesis has brought about considerable changes in paleogeography and in the accumulation of sediments in the neighbourhood of the Tatabánya Fracture Line since the Late Triassic up to the present time. In Late Triassic time the vicinity of Tata was the inner rim of the northwest limb of the Central Mountains Synclinorium. The far-reaching, flat sedimentary basin uplifted gradually in that direction. At Tata the Rhaetian Dachstein Limestone is reduced in thickness as compared to the sequences available in the centre of the Gerecse.

In the Jurassic Period dilatational movements led to a morphological differentiation of the area: deeper and shallower sedimentary basins were individualized, with "complete" and heavily discontinuous sequences and peculiar faciological features. The Jurassic System of Tata represents the deeper-water, "complete", continuous Jurassic facies with features of sedimentary environments somewhat shallower than the central part of the Northern Gerecse. The two areas are separated by a seamount range, partly with sedimentary sequences of Hierlatz type, heavily discontinuous and reduced in thickness.

In the Cretaceous Period the land surface and the sedimentary basin were further differentiated. A complete Neocomian developed only in the northern part of the Middle Gerecse, whereas the Neocomian of the Western Gerecse, up to the Tatabánya Fracture Line, is discontinuous. Southwest of this line, up to the margin of the Zirc Basin, there are no Neocomian deposits. The Lower Cretaceous of the Gerecse and that of the Bakony are totally different in facies: an emerged range should be supposed to have existed between the two. The Middle Cretaceous traceable in the axis of the Northern Bakony and the basement of the Vértes foreland along the Tatabánya Fracture Line changes its southwest-northeast strike and turns to southeast-northwest direction. The Aptian crinoidal limestones with essentially unchanged features can be found, throughout the Transdanubian Central Mountains range; the Albian sequence is, along the Tatabánya Fracture Line, different in character as compared to the developments in the Northern Bakony and the Vértes foreland.

In the closer vicinity of the Tata Horst the Eocene has been lost to denudation, the Oligocene and the Pannonian Stage being represented by formations of considerable thickness. During the Quaternary and the Holocene, sedimentary sequences of diversified lithology were formed.

Accordingly, the blocks of the Mesozoic basement at Tata are situated along a very significant transversal fracture of the Transdanubian Central Mountains, in the foreland of the Gerecse Mountains, where striking changes in the tectonic setting, the stratigraphy and geology of this highland range can be observed.



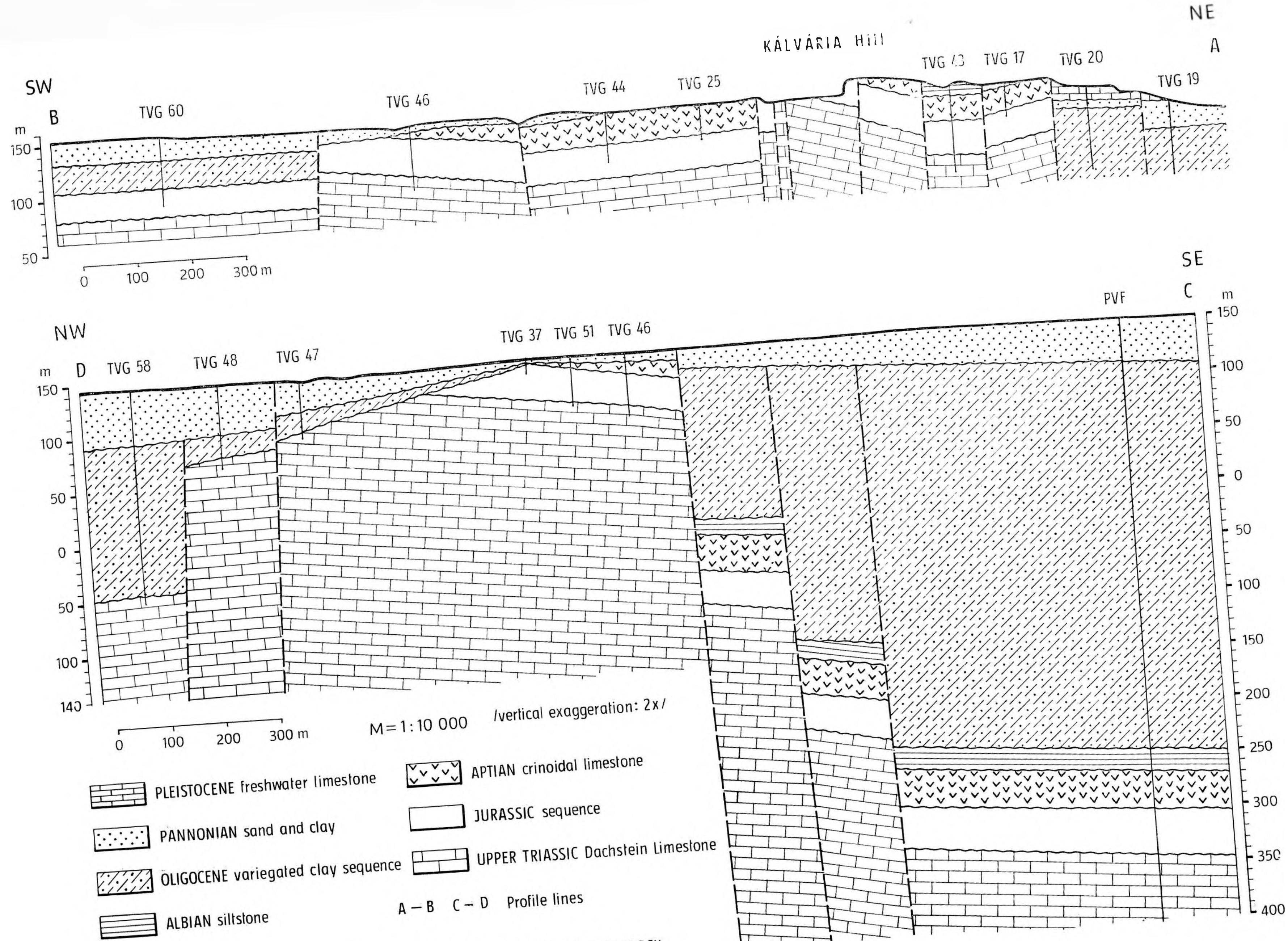
Textfig. 2: GEOLOGICAL SECTION ACROSS THE WESTERN FORELAND OF THE GERECSE MOUNTAINS

TATA AND TATA-W: TWO HORST BLOCKS OF THE MESOZOIC BASEMENT

It is the Water Tower and the tower of the ancient shot basting furnace, now used for look-out, behind the Grammar School and the Apprentice's Hostel of the Institute of Vocational Training (ancient Piarist Priory) standing on the high shore in the northwestern part of Lake Öreg and visible from afar, that indicate that structural high composed of Mesozoic rocks which is called the Kálvária Hill (Calvary Hill) after the Way of Cross compound built by Antal Schweiger about 1770 on the hilltop. The highest point of the hill lies at 166 m a.s.l. Around the hill unfolds before the visitor's eyes the Old Town of Tata built, itself, for the most part upon a Mesozoic basement. At the northern tip of the Lake stands the medieval Castle of Tata built on Aptian grey crinoidal limestones. This varied urbanistic-geographic setting hides an extremely rich socio-historical past that can be traced back — by the aid of the chert pits of Kálvária Hill and the Ice Age (Moustierian) campsite beside the Grammar School — to prehistorical times: a past that has never ceased to stand in an intricate interconnection with the natural resources of the environment. And this place of rich cultural traditions is where the Mesozoic basement horst crops out in the area precisely delineated on the map supplement (Textfig. 3: in pocket).

Excellent outcrops and quarries of Kálvária Hill offer most information on the geology of the Tata Horst. A series of quarries have exposed the Raetian, Jurassic and Aptian formations making up the horst. The historical, archeological and geological values of Kálvária Hill are now protected by state legislation against further destruction. A peculiar development of Upper Liassic limestones can be studied at the outcrop by the Csurgókút. The Mesozoic has been exposed in patches of different size in a number of places in the basement of the city. In earlier times it was the well-diggers that penetrated into the Mesozoic, nowadays it is the workmen of the communal services (canalization, water supply lines, etc.) and those digging foundations for larger buildings that expose the rocky basement of the city. For the preparation of the geological map of the basement blocks, we have had exposures made in the course of our work. The locations of these exploratory shafts and survey boreholes, together with the outcrops, have been indicated on the geological map supplement (Textfig. 3).

On the basis of investigations we could prove, with essentially higher precision the horst nature of the basement blocks which had been earlier recognized but explored just partly. The present state of our knowledge has been shown in Textfig. 3 and 4. As can be read off the map, the horst is tilted south-eastwards, the eastern rim is in elevated position with strata dipping towards the central part of the horst. Its cross-section of northeast-southwest strike shows up a stepped warp structure with Norian-Rhaetian Dachstein Limestone in its core, forming the bulk of the horst. The behaviour of this rigid body determined the tectonic mechanism responsible for the formation of the horst. Its predominant elements are subvertical fractures. Along these the adjacent rock bodies have partly had a sharp contact, partly they have been separated by a tectonic breccia of varying thickness. A particular group of the fractures is represented by the fissures filled with penecontemporaneous Jurassic rock material. The northeast-southwest and northwest-southeast trending fissures are older, the north-south and nearly east-west trending ones are younger, or were rejuvenated in later geological times (Miocene, Pliocene and Pleistocene). Of these the north-south trending fault running beneath the Grammar School and the Apprentice's Hostel, along which intensive hot spring activities took place during the Ice Age, has had a striking morphogenetic role, with considerable accumulation of travertine. In the southeast and southwest, the horst is bounded by steep faults of several hundred metres throw. This feature is less marked in the northeast. On the western side of the exposed horst, after the intervention of a narrow tectonic graben, there is another Mesozoic basement block under the surface.



Textfig. 4: GEOLOGICAL SECTIONS ACROSS TATA'S MESOZOIC BASEMENT HORST BLOCK

It was the Map of Bouguer Anomalies that called our attention to the occurrence of that second subsurface horst (Tata-W) separated by a graben of 200 to 250 m depth from Kálvária Hill proper (Tata). Its area and structural position are similar to those of the exposed Tata horst. A few boreholes have allowed an insight into its geological structure (Textfig. 5: in pocket). They have uncovered, in the footwall of Tertiary formations, Upper Albian dark grey siltstones and Aptian grey crinoidal limestones in the most complete profiles. The development of the Jurassic sequence is similar to that of Kálvária Hill's. It is underlain with a break in sedimentation by Dachstein Limestone making up the bulk of the subsurface horst.

Historical review

KÁROLY PETERS (1859) was the first to publish a statement of scientific value concerning the "red marble" of Tata. In his work "Die Umgebung von Visegrád, Gran, Totis und Zsámbék" he determined this rock as Megalodus-bearing Dachsteinkalk and he placed it in the "Liassic Stage" understood in a sense different from the present-day concept.

BENŐ WINKLER (1883), in accordance with the newer stratigraphic interpretation, assigned the Dachsteinkalk already to the Rhaetian Stage and he determined the megalodontids recoverable in abundance from the rock as *Megalodus triqueter* WULF.

LAJOS LÓCZY SR. (1906) had the megalodontids from the Dachsteinkalk investigated by FRIGYES FRECH, Professor in Breslau, who identified the species *Megalodus* cf. *tofanae* HOERN. var. *gryphoides* GÜMB. and *M. mojsvári* GÜMB.

NÁNDOR KOCH (1909) published data on the extension of the outcrop of the Dachsteinkalk.

In my work "A tatai mezozóos alaphegységrög földtani vizsgálata" (Examen géologique de la motte mésozoïque de Tata, 1954) I sought to present the Dachstein Limestone sequence in a form suitable for comparative studies, relying on its characteristics that could be observed and typified megaloscopically. The mode of occurrence of the Triassic and Jurassic rocks whose contact is characterized by an apparent conformity, though by a sharp boundary and marked differences in lithology and fossil content, was explained by a temporary break in sedimentation. In addition, the fissures, subsequent to Triassic sedimentation and filled with various Jurassic sediments, were discussed.

E. VÉGH—NEUBRANDT (1960), in the course of her investigations of the Upper Triassic of the Gerecse, undertaking large-scale field observations and laboratory studies, managed to distinguish rock types of typical development and of regional distribution whose regular combinations allowed her to subdivide the 1000- to 1200-m-thick Norian-Rhaetian sequence of dolomites, dolomitic limestones and limestones. In the upper part of the sequence she also identified a key horizon: a thin dolomitic limestone, yellow to red in colour, wavy, banded, with calcite-filled cavities, interbedded within white, compact limestone banks, overlain by a breccia containing black limestone grains with a corallinaceous-algal limestone atop. She used this horizon as a basis of comparison when pointing out that the topmost Triassic member above the key horizon was different in thickness in the various parts of the Gerecse. According to her opinion, the Lower Liassic limestones at Tata would lie directly on that key horizon. In her dissertation submitted in 1969 for obtaining the D. Sc. degree at the Hungarian Academy of Sciences, she summarized the results of her all-round studies on megalodontids. In that work she also published a revision of the megalodontid fauna so far recovered from Tata.

The aim of present-day investigations

The magnificent outcrops and recoveries of the Tata horst block and the Geological Conservation Area, aesthetically selected as it is, have promoted the locality to a favorite object of outings for geology students and specialists, both Hungarian and foreign. Regular study of the geological formations is necessary from both didactical and scientific-comparative points of view. In the present work, I have sought to contribute to the understanding of the outcropping Triassic rocks and, relying on studies by SANDER, SCHWARZACHER and FISCHER suggesting original ideas, to illustrate the Dachstein Limestone sequence, complemented with the lithological log of the borehole of 200 m depth drilled into the ground of the quarry-yard, in a lithologically more up-to-date way.

In the "white limestone" quarries of Kálvária Hill the Rhaetian Dachstein Limestone is exposed in 10 to 15 m thickness (Plate I, Textfig. 7—10, of which Textfig. 8 in pocket).

The topmost 6 metres of the Dachstein Limestone are constituted by greenish-grey, calcite-mottled, shallow-water Megalodus limestones and by interbedded yellowish-grey layers, banded and of uneven stratification, locally breccious, slightly dolomitic, of intertidal ("lofer") facies (Textfig. 10, Cyclothems a-é).

The topmost member is underlain by 5 metres of limestone, greenish-grey, compact, sparsely Megalodus-bearing. It is followed by an interbedded layer of 60 cm thickness, yellowish-grey, thinly laminated, underlain by a 70-cm-thick grey nodular limestone bed with slightly observable features of intraformational breccia (Textfig. 10, Cyclothem f).

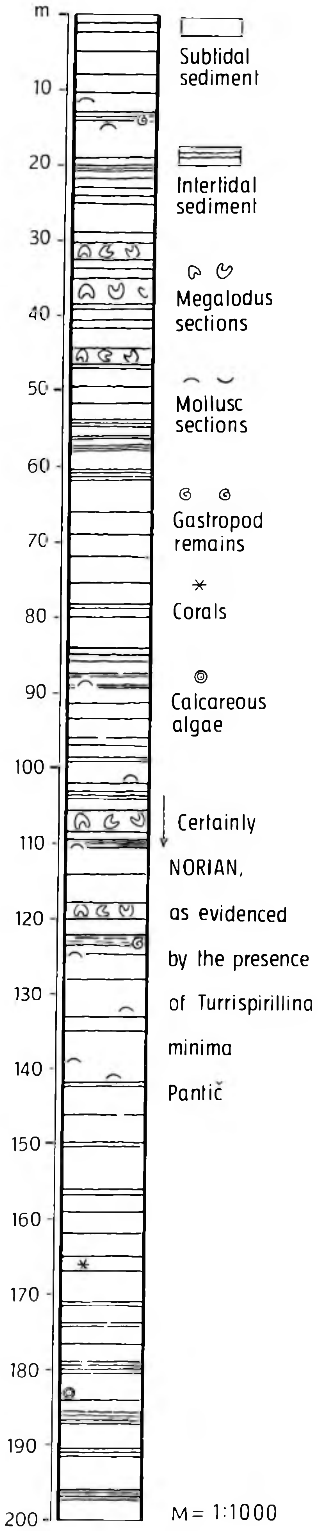
Macrofauna of the exposed part of the sequence: Greater part of the megalodontid fauna available from Tata seems to derive from the 6-m-thick megalodontid-rich member underlying the Lower Liassic limestones. (These strata were of largest surficial extension, the deposits underneath being less fossiliferous.) During her last revision of the megalodontid fauna of Tata, E. VÉGH—NEUBRANDT determined solely Rhaetian species (Plate II):

	specimens
Conchodon infraliasicus STOPP.	3
Conchodon cfr. *infraliasicus* STOPP.	2
Neomegalodon mojsvári (HOERN.)	2
Neomegalodon aff. *mojsvári* (HOERN.)	1
Neomegalodon mojsvári incisus (FRECH.)	2
Neomegalodon scutatus (SCHAFH.)	1
Neomegalodon cfr. *scutatus* (SCHAFH.)	1
Neomegalodon sp.	6
Rhaetomegalodon cfr. *bajotensis* VÉGH—NEUBR.	2
Rhaetomegalodon incisus (FRECH.)	17
Rhaetomegalodon cfr. *incisus* (FRECH.)	8
Rhaetomegalodon incisus cornutus (FRECH.)	23
Rhaetomegalodon cfr. *incisus cornutus* (FRECH.)	2
Rhaetomegalodon sp.	6

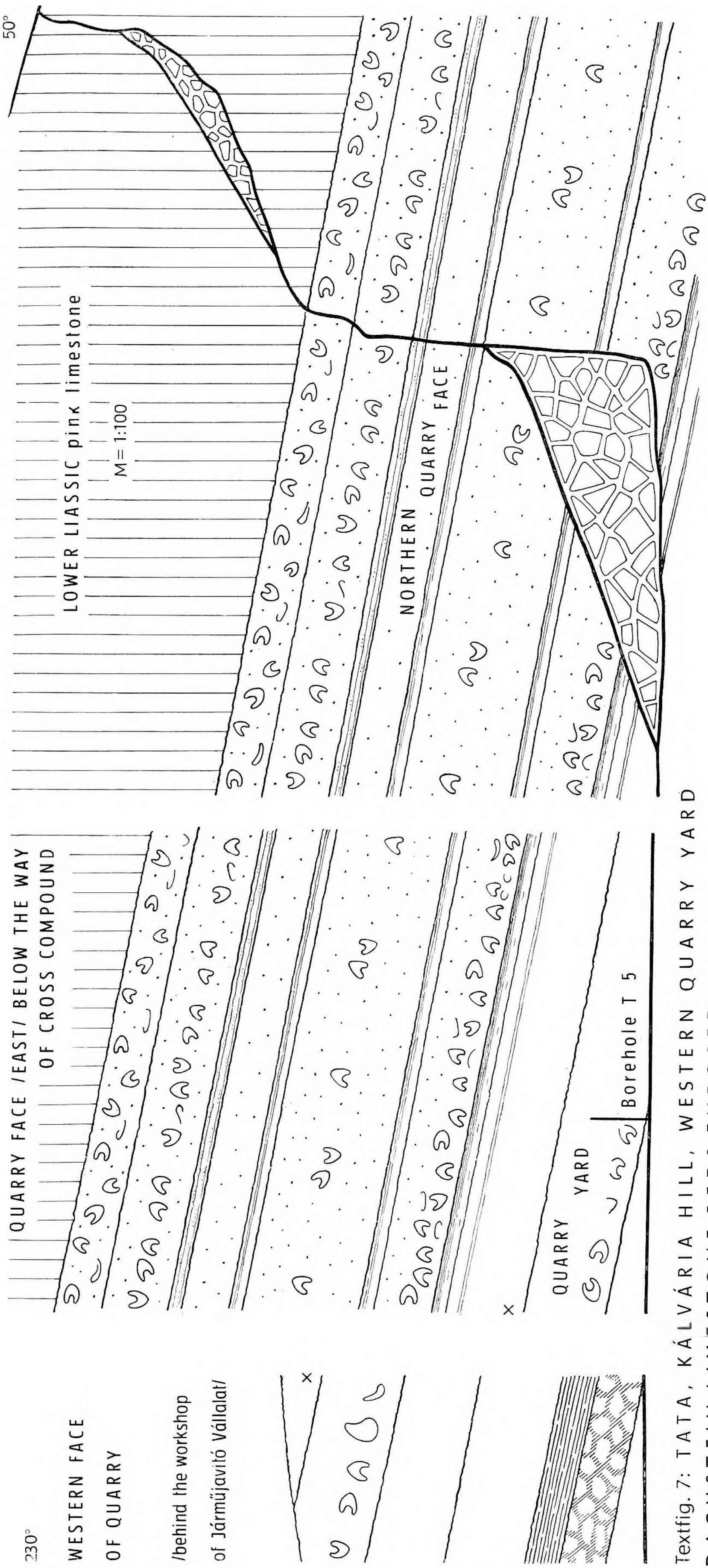
As proved by field study, the megalodontids occur exclusively in greenish-white, calcarenitic (calcite-mottled) limestone beds, being absent in the interbedded layers of intertidal origin. Occasionally, they are restricted to definite bivalve-bearing horizons (possibly representing a single population only); in other places, they are scattered over much of the limestone bed. Their position and preservation state are rather varied. In the majority of the cases, they lie with their lateral side or apex down, though megalodontids standing with their apex up (in living position?) can also be encountered. 100 megalodontid specimens each were studied in four limestone beds in respect of their mode of enclosure, with a view to a more accurate assessment of the frequency of their three different positions and of the percentages of the complete and one-valved specimens. Here are the results:

				
Uppermost Dachstein Limestone bed	21	31	34	14
Second	7	43	42	8
Third Megalodus limestone bed	9	22	63	6
Fourth	7	62	15	16

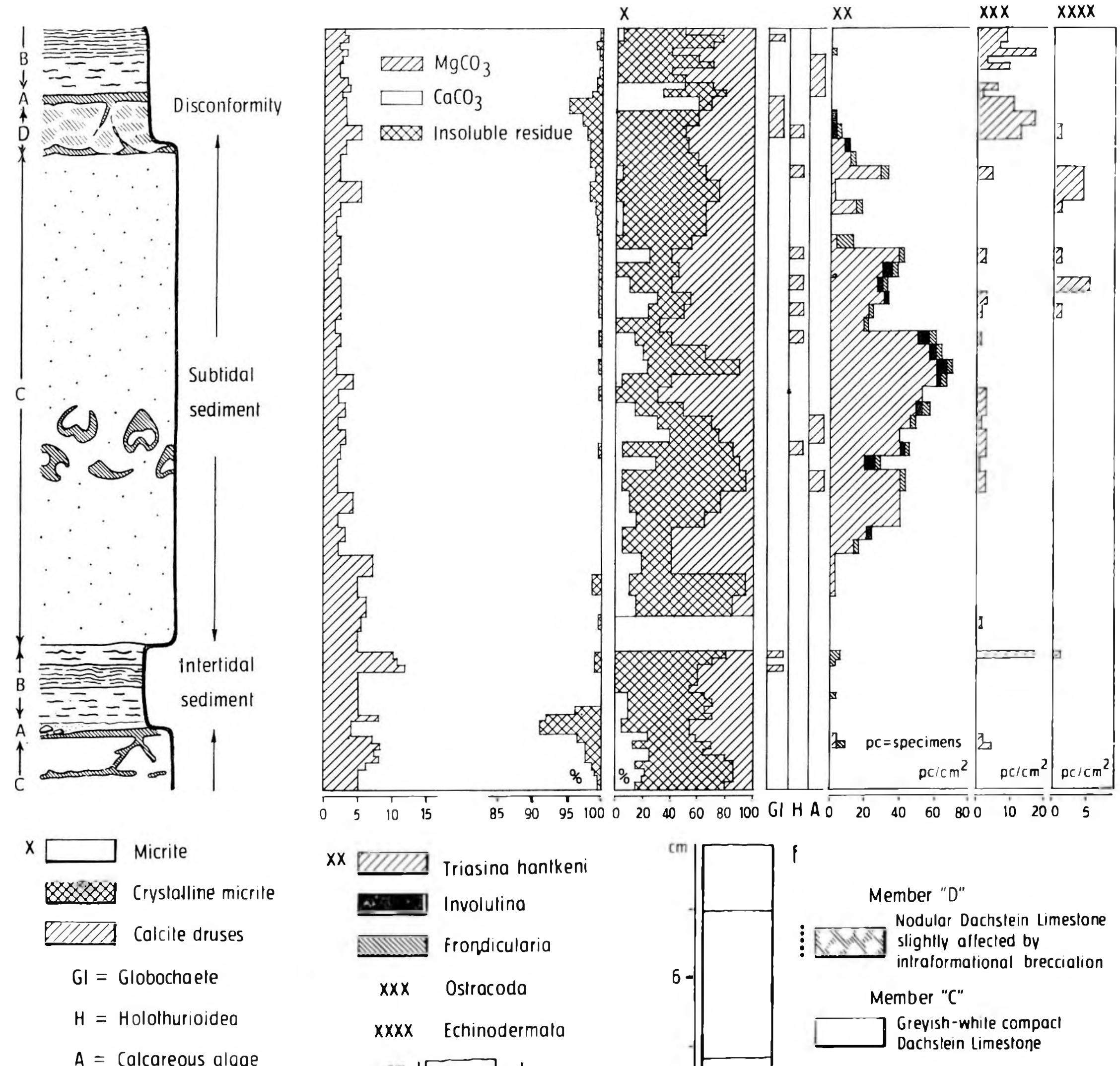
Lying mostly on their lateral side or upside down, the fossils are indicative of a thanatocoenosis of bivalves removed from their original positions in agitated waters. Shelled specimens are sparse. The original test was lost to dissolution in most of the cases and a thin calcite crust was formed by an invard growth of calcite crystals on both sides of the resulting cavity which has finally been filled with light red calcilutite (Plate II, Fig. 4).



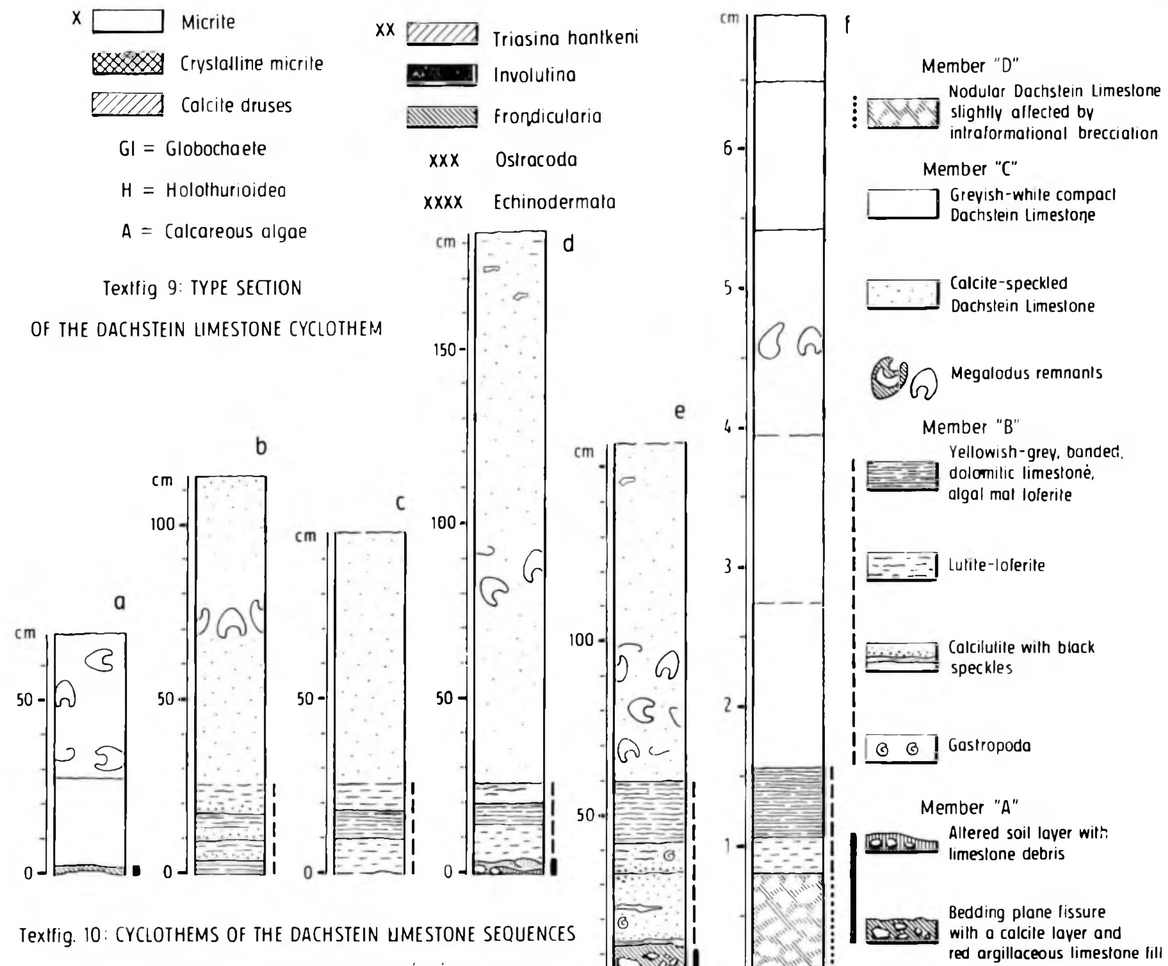
Textfig 6:
SYNOPTIC GEOLOGICAL PROFILE OF BOREHOLE T 5



Textfig. 7: TATA, KÁLVÁRIA HILL, WESTERN QUARRY YARD
DACHSTEIN LIMESTONE BEDS EXPOSED



Textfig 9: TYPE SECTION OF THE DACHSTEIN LIMESTONE CYCLOTHEM



Textfig. 10: CYCLOTHEMS OF THE DACHSTEIN LIMESTONE SEQUENCES EXPOSED ON THE SOUTHWEST SIDE OF KÁLVÁRIA HILL

Microfauna of the exposed part of the sequence: Characteristic microfossils of the Dachstein Limestone are the foraminifers of which *Triasina hantkeni* MAJZON is most frequent. Altough in a low number of specimens, *Frondicularia woodwardi* HOWCH. and *Pseudonodosaria* sp. are common. Involutina are rather diversified: *I. tumida* (KRISTAN), *I. sinuosa* (NEYM.), *I. communis* (KRISTAN), *I. impressa* (KRISTAN), *I. turgida* (KRISTAN). In addition, the following forms can be encountered: *Glomospirella* sp. and *Glomospira* sp., sporadical specimens of *Dentalina* sp., *Trochammina* sp., *Tetrataxis* sp., *Lenticulina* sp., *Agathammina austroalpina* KRISTAN, *Ophthalmidium* sp., *Gaudryina racena* TRIFONOVA and *Trocholina crassa* KRISTAN (determinations by E. VADÁSZ—ÚJVÁRI).

In some members of the sequence the representatives of Ostracoda are comparatively frequent. Ossicles of echinoderms (Echinoidea, Holothurioidea) and gastropod remnants can also be found in subordinate quantities. Calcareous algae (Problematicum 4, FLÜGEL) can be found in exceptional cases only.

Sedimentation conditions (an interpretation relying on the fundamental statements of SANDER, SCHWARZACHER and FISCHER). From the viewpoint of sedimentation, the sequence, easily accessible to examination on the surface as it is, can be split up into six cyclothems (Textfig. 10). Of these the upper five cyclothems form a megacycle, the strata underneath make up the top of the next megacycle. The general characteristics of the megacycles are illustrated in Textfig. 9. Their lower boundaries are indicated, as a rule, by a disconformity. Below this there is a limestone bed with desiccation cracks and subsolution phenomena (cavities and dissolved mollusc shells), the cracks and cavities being filled with brownish-red, ochre-yellow or greenish-grey matter (Plate V, Fig. 3).

The disconformity surface is overlain by a thin layer of brownish-red, ochre or greenish-grey, slightly argillaceous limestone (sometimes just a clayey bedding plane), occasionally with debris from the limestone bed underneath: Member A (Plate V, Fig 4). This characteristic layer was produced during an ephemeral emergence. Its material is a local weathering product which was mixed with carbonate sediment at the retreat of the sea (occasionally, owing to the activity of sediment-feeding organisms), a pelletal texture was produced. In rare cases, problematic microfossils and Ostracoda valves also occur in it.

Member B is represented by intertidal sediments:

The so-called "loferites" are limestones or dolomitic limestones perforated by shrinkage pores (Plate III, Fig. 3; Plate V, Fig. 1, 4: "P", and Plate VII, Fig. 4, 5, 7). The shrinkage pores and cavities account as a rule for 15 to 30% of the rock volume. In the majority of the cases they are aligned along stratification, being often flush and filled partly with calcilutite, partly with sparite. There are algal mat loferites (Plate III, Fig. 1 and Plate V, Fig. 2) (always dolomitic), nodular loferites (partly of fecal origin) and homogenous ones. Their organic assemblage is poor in species: algal mat, scant foraminiferal and ostracod fauna and worm tracks (Plate VII, Fig. 6, 8, 9).

Lutites are compact limestone and dolomitic limestone beds, grey, yellowish-grey or pink in colour, occasionally grey- or black-speckled. Laminated lutites are often converted into intraformational breccia (Plate III, Fig. 2): a manifestation of early diagenesis. Lutites are poorly fossiliferous or totally devoid of fauna as well. They may contain Gastropoda, sporadical Foraminifera and Ostracoda as well as small representatives of Bivalvia.

Member C is represented by greyish-white limestones, compact, calcite-speckled, frequently with megalodontids (Plate III, Fig. 2:"C", 3). The tiny calcite mottles were produced by the recrystallization of Foraminifera (primarily, *Triasina hantkeni*) (Plate VI, Fig. 1—3). This development is the main, usually the terminal, member of the cyclothem. It overlies Member B without any break in sedimentation or with a sharp boundary. It is composed of calcarenites of carbonate groundmass and of featureless calcipelites. As a rule, it shows a pseudo-oöidic, less frequently, an oöidic or lumpy texture. Its organic association is diversified: Megalodontidae, algae of higher organization and Foraminifera. Its environment of origin is a shallow sea below the intertidal zone (a shallow-water backreef lagoon).

In rare cases the cyclothems may include a regressional Member D as well, as shown in Fig. 10 (lithologic log f at the base): grey nodular limestones slightly resembling intraformational breccias.

The cyclothems represent periods of eustatic low-amplitude changes in sea level (with a periodicity of 20,000 to 40,000 years). The intertidal laminae of algal mat origin, 1 to 1.5 mm thick, may be regarded as "annual rings".

Shrinkage structures: The emergence phase of the Dachstein Limestone cyclothems is evidenced by desiccation cracks parallel or normal to the bedding planes (Plate III, Fig. 4) formed on the disconformity surface and below it and by subsolution cavities filled (or coated) by calcite and altered weathering products. Typical shrinkage structures are manifested by the post-depositional fills of the inside or the shells of megalodontids.

Characteristic morphological elements of tidal sediments are the shrinkage pores (Plate III, Fig. 3 and Plate V, Fig. 1, 4:"P") as well as the prismatic fissures of small to medium size. They have been coated by calcite and filled by calcilutite post-depositionally. Another frequent morphological phenomenon of intertidal sediments are the intraformational breccias (Plate III, Fig. 2 and Plate V, Fig. 1:"R").

Penecontemporaneous tectonic fissures: The Dachstein Limestone is traversed by countless fractures or fissures of tectonic origin. Most frequently, their thickness varies between a few cms and a few dms. For the most part, they are filled with compact (micritic) red, slightly argillaceous limestone. This shows a banding usually normal to the fissure wall (Plate IV, Fig. 1). Less frequently red crinoidal limestone may also play the role of fissure fill. The presence of Dachstein Limestone debris in the fissures is often conspicuous (Plate IV, Fig. 2—3). The most peculiar red argillaceous limestone fissure fills observable on the surface are of 110 to 130° or 290 to 310° strike, respectively. Some of the fissures of tectonic origin filled with red limestone still continue in the Lower Liassic limestone overlying the Dachstein Limestone Formation. Their origin can be put partly to the Triassic-Jurassic boundary, partly ascribed to tectonic effects which were in operation during Liassic sedimentation.

The Dachstein Limestone sequence of borehole T. 5

Borehole T. 5, which has uncovered the Dachstein Limestone Formation in 200 m thickness, was drilled behind the building of a co-operative workshop manufacturing vehicles and spare parts to them, in the southwestern abandoned quarry of Kálvária Hill. Lithologically, the Formation is constituted by cyclically deposited, subtidal limestones of backreef facies interbedded with intertidal sediments (loferites, lutites). The results of examination of the sequence and a few examples of cyclothems have been shown in Textfigs. 6, 10—14 and 15 (of which Textfig. 11, 12, 13, 14 in pocket).

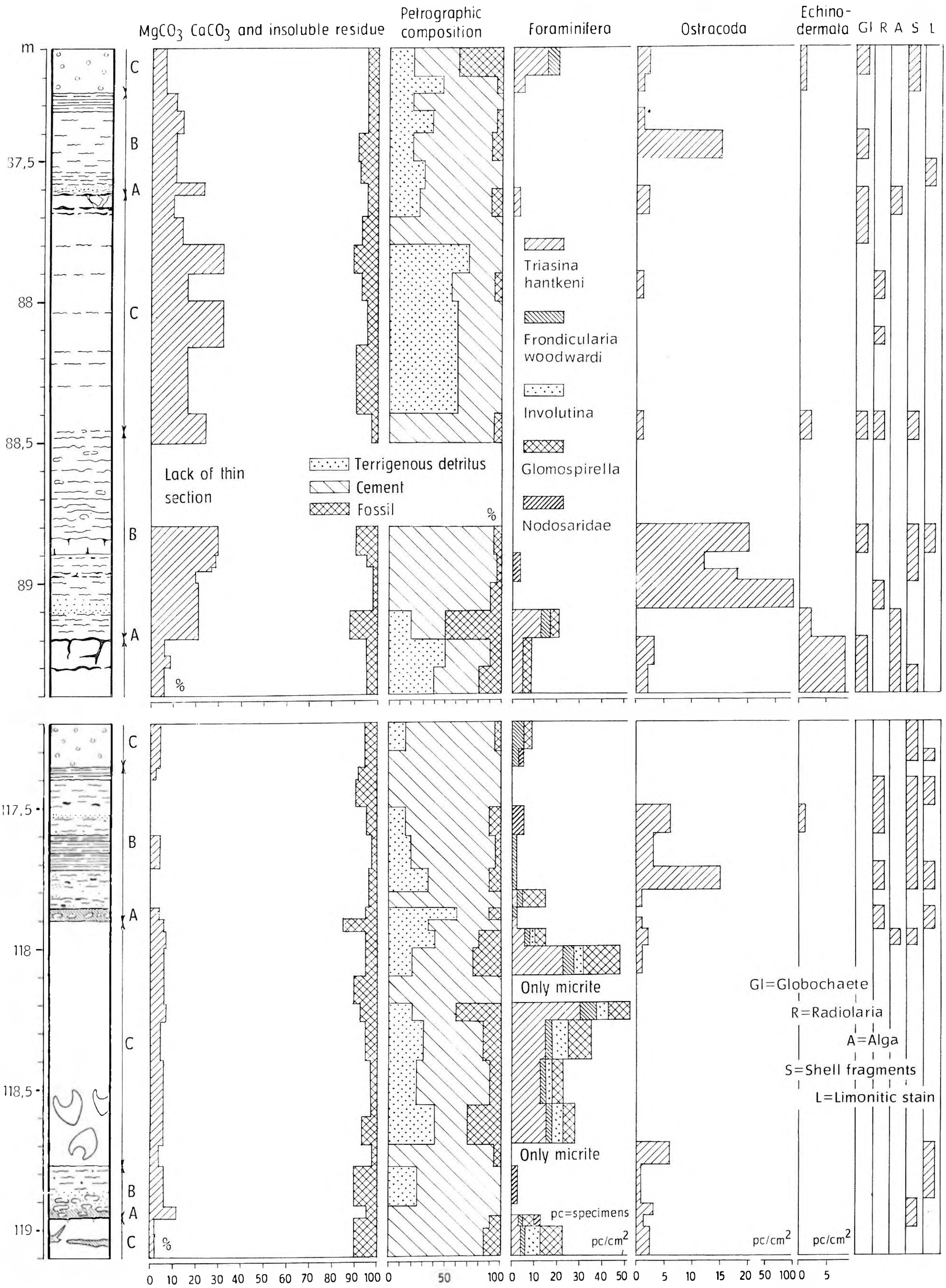
The megalodontid sections found in cores are indeterminable and thus unsuitable for subdividing the sequence. Relying on an examination of the cyclothems of the Dachstein Limestone Formation in the Northern Alps, SCHWARZACHER established megacycles consisting of five or six members each. These could be recognized just approximately in borehole T. 5.

The quantity of the insoluble residue and that of magnesium carbonate show up a slightly opposed correlation. The insoluble residue was found to be present in a comparatively high quantity in the upper one-third of the sequence, the magnesium carbonate in the lower two-thirds. Between 70 and 85 m, where the dolomite content is comparatively higher, recrystallization is the heaviest, being the weakest in the 85 to 100 m interval. The quantity of microfossils varies parallel to that of inorganic detritus.

A trend was recognized to exist in the relationship between clastic maxima and microfossil maxima. Between 0 and 50 m the maxima of microorganisms follow with some delay the clastic peaks. Here the clastic frequency curve rises steep (frequently stating with a maximum), to decline then rather progressively. In the 50 to 100 m interval, the clastic and microfossil maxima usually coincide. The clastic frequency curve is symmetrical, though it may have two or more maxima. Between 100 and 200 m the maximum of the microfossil curve precedes the clasticity peak which is usually of symmetrical shape. The calcarenitic nature of the sediment and the formation of pseudo-oöids and oöids are confined to a definite horizon of each cyclothem. With respect to this, in the lower part of the sequence the abundance of microfossils attains its maximum earlier, to be then delayed gradually, thus running for a while in parallel with the peak of the quantity of clastic material; finally, it follows with some delay the rapid appearance of the latter. What is the reason for this gradual delay in the cyclical invasion of the microfauna? It seems to be due to an overall change in the marine environment, which reduced the extension of the characteristic microfaunal assemblages of Member C to increasingly more and more remote and possibly smaller and smaller areas.

Leading elements of the microfauna are Foraminifera (Plate VIII) which show greatest abundance and variety in the calcarenites of Member C.

According to E. VADÁSZ—ÚJVÁRI's investigations, they show the following distribution: *Triasina hantkeni* MAJZON is common (Plate VIII, Fig. 13—15) being particularly abundant in the pseudo-oöidic to oöidic facies. *Triasina hantkeni* var. *elliptica* MAJZON could only be observed in the upper part of the sequence. Involutina are represented by a greater number of species: *I. tumida* (KRISTAN) (Plate VIII, Fig. 12), *I. sinuosa* (NEYM.), *I. tenuis* (KRISTAN), *I. communis* (KRISTAN), *I. pragsoides* (OBERHAUSER) and *I. minuta* KOEHN—ZANINETTI. They occur most frequently in the upper part of Member C, below the greenish-grey argillaceous horizons. *Frondicularia woodwardi* HOWCH. (Plate VIII, Fig. 4—5) and *Frondicularia* sp. are common, occurring in compact sediments. Again these sediments carry, in relatively high abundance, the representatives of Glomospirella and Glomospira (Plate VIII, Fig. 10—11). Subordinate fossils are: *Nodosaria* sp., *Dentalina* sp., *Spiroplectammina* sp., *Planulina* sp., *Pseudotextularia* sp. (Plate VIII), *Rectoglandu-*



Textfig. 15: CYCLOTHEMS FROM THE COLUMN OF BOREHOLE T.5

lina sp., *Endothyra* sp., *Ammobaculites* sp., *Trochammina* sp., *Trocholina* sp. and *Turrispirillina minima* (PANTIČ) (Plate VIII, Fig. 9).

According to the opinion of A. ORAVECZ—SCHEFFER, the foraminiferal fauna is of Upper Norian to Lower Rhaetian age. No characteristic form of either older or younger stratigraphic position could be identified. On the basis of the occurrence of *Turrispirillina minima* (PANTIČ) the borehole sequence below the uppermost 100 m should be assigned certainly to the Norian Stage.

Ostracods are indicators of facies. Thick-shelled forms (*Bairdia* div. sp.) can be found in calcarenites, while aphaneritic layers are characterized by the abundance of thin-shelled forms.

In the upper part of the sequence a few Radiolaria, and subordinate crustacean coproliths and echinoid and holothurioid debris can also be observed. *Stomiosphaera sphaerica* KAUFMANN, Globochaete and calcareous algae play only a subordinate role among the microfossils (Plate IX).

I n s u m m a r y, let us conclude that the Dachstein Limestone sequence of Tata is a typically cyclic formation (interbedded with layers of Lofer facies) which was deposited in a large, shallow-water, "back-reef" lagoon under the conditions of low-amplitude eustatic sea level oscillations and of a gradual subsidence and filling-up of the sea bottom. Judging by its peculiar megalodontid and foraminiferal fauna, the exposed member and the upper part of the sequence uncovered by the drilling of borehole T. 5. belong to the Rhaetian. The sequence of borehole T. 5, from 103 m downward, must be assigned, on the basis of the presence of *Turrispirillina minima* (PANTIČ), to the Norian.

Additional boreholes penetrated into the Dachstein Limestone

In the area of the Tata horsts, Dachstein Limestone underlying Lower Liassic limestones with a break in sedimentation, though without any striking angular unconformity, has been penetrated by the following additional boreholes:

TVG—24, in the 60.0 to 62.7 m interval	TVG—51, in the 37.3 to 40.0 m interval
TVG—33, in the 15.0 to 18.6 m interval	TVG—52, in the 28.9 to 29.5 m intreval
TVG—43, in the 74.5 to 78.2 m interval	TVG—55, in the 94.8 to 111.8 m interval
TVG—45, in the 156.6 to 158.5 m interval	TVG—56, in the 65.0 to 67.5 m interval
TVG—46, in the 40.5 to 55.0 m interval	K—25, in the 37.8 to 307.0 m interval

The Dachstein Limestone suits underlying the Lower Liassic limestones belong, as suggested by their geological structure and development, to one and the same stratigraphic member, but the Lower Liassic limestones can be occasionally shown to overlie different beds.

Dachstein Limestone in the immediate foot-wall of Tertiary formations has been penetrated by the following boreholes:

TVG—32, in the 13.6 to 20.2 m interval	TVG—58, in the 184.1 to 195.7 m interval
TVG—42, in the 158.6 to 161.7 m interval	TVG—61, in the 52.2 to 70.0 m interval
TVG—47, in the 41.2 to 50.0 m interval	TVG—62, in the 45.0 to 52.2 m interval
TVG—48, in the 63.3 to 74.5 m interval	TVG—63, in the 220.5 to 223.4 m interval
TVG—53, in the 14.1 to 37.0 m interval	

REFERENCES

FRECH, F. 1910: Die Leitfossilien der Werfener Schichten und Nachträge zur Fauna des Muschelkalkes der Cassianer und Raibler Schichten, sowie des Rhaet und des Dachsteindolomites (Hauptdolomit). — Result. d. Wiss. Erforschung d. Balatonsees. I. I. Anhang, Pal. II. Band VI.

FÜLÖP, J. 1954: Examen géologique de la motte mésozoïque de Tata. (Summary) — Földt. Közl. 84. 4.

KOCH, N. 1909: Die geologischen Verhältnisse des Kalvarienhügels von Tata. (Summary) — Földt. Közl. 39.

LÓCZY L. ID. 1906: Geológiai megfigyelések a tatai Kálvária-hegyen. — Földt. Közl. 36.

PETERS, K. 1859: Die Umgebung von Visegrad, Gran, Totis und Zsámbék. — Jahrb. Geol. Reichsanst. 10.

SZABÓ, I. 1961: Die Ausbildungen der mesozoischen Scholle von Tata aus der Jurazeit. — Ann. Inst. Geol. Publ. Hung. 49. 2.

VÉGH—NEUBRANDT, E. 1960: Petrologische Untersuchung der Obertrias-Bildungen des Gerecsegebirges in Ungarn. — Geol. Hung. Ser. Geol. 12.

VÉGH S.-NÉ 1969: Triász Megalodontidák fejiődése és földtörténeti jelentősége. — Acad. doct. diss. Manuscript.

WINKLER B. 1883: A Gerecse és Vértes hegység földtani viszonyai. — Földt. Közl. 13.

TRIASSIC-JURASSIC BOUNDARY

The boundary between Triassic and Jurassic formations can be studied excellently, over a length of 200 m, in the abandoned quarries of Kálvária Hill. The contact is seemingly conformable between the Lower Rhaetian Dachstein Limestone and the Lower Liassic (U. Hettangian-Sinemurian) overlying it immediately and represented by yellowish-red (pink), disproportionately crinoidal-, Brachiopoda-Cephalopoda-bearing limestone. The top layer of the Dachstein Limestone can be traced without any change in thickness over the entire length of the exposure. Neither a weathering crust, nor terrigenous forms or materials can be found on its surface. The basal layer of the Lower Liassic limestone is of uniform thickness, too. Neither debris deriving from the footwall, nor any other terrigenous sediment material could be observed within them. The formation boundary is quite even, being a kind of bedding plane (Plate X, Fig. 1).

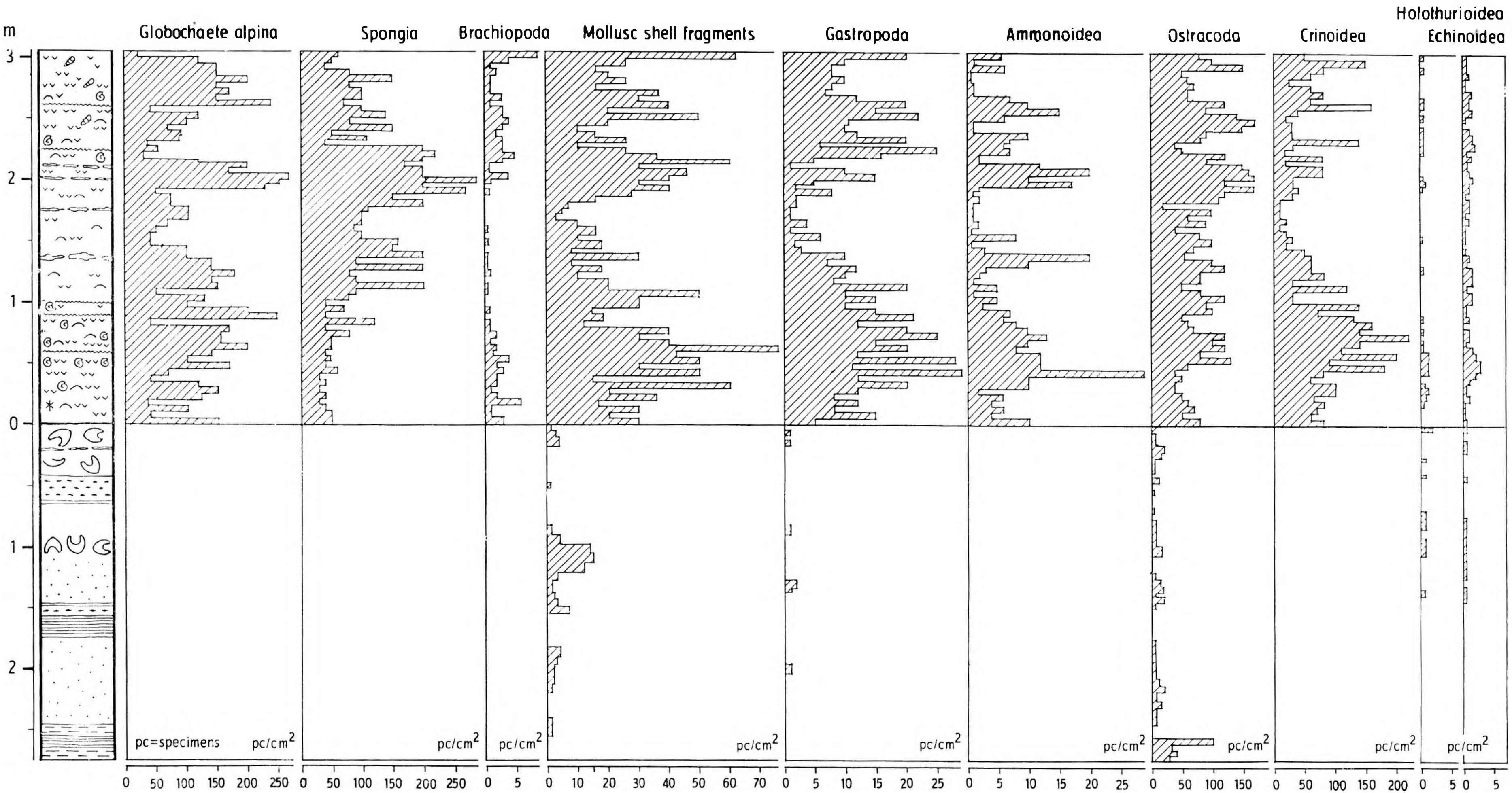
The presence of longer break in sedimentation, i.e. a considerable hiatus, is evident — in spite of the seeming conformity — from the different chronostratigraphic positions of the two adjacent formations (a point discussed elsewhere), moreover, it can be established directly by observation on the spot. On one hand, erosion taken place parallel to bedding plane is indicated by the occurrence on the formation boundary of halved megalodontid remnants (Plate X, Fig. 2); on the other hand, by the lack of even the slightest transition between the cyclothems of the Dachstein Limestone underneath and the geological features of the overlying Upper Liassic limestone. The former disappears uncompleted and abruptly, the latter appears immediately, carrying entirely new features.

It can be proved by detailed sedimentary investigations that the formation boundary traceable as a sharp line without any transition separates two totally different formations, despite the apparent conformity between foot- and hanging walls. This is illustrated convincingly by Textfig. 16 and 17 (the latter in pocket).

As regards lithology and genetic conditions, the Dachstein Limestone can be shown to represent a thick sequence of cyclothems produced by regular alternation of subtidal (calcarenite) and intertidal (calcipelite) sediments and ephemeral emergences (desiccation cracks and subsolution cavities): a sedimentary sequence deposited in a far-reaching, flat, lagoon-like sedimentary basin as a result of oscillations of sea-water level responsible for the cyclothems. The Lower Liassic (U. Hettangian-Sinemurian) brachiopodal-cephalopodal limestones are of shallow-water, sublittoral origin (aphaneritic and bioclastic texture). The sedimentary basin did not lose its pelagic communications throughout the time-span under consideration, it was deeper and its bottom was more dissected than in the case of the Dachstein Limestone. Sedimentation was progressive, rhythmically changing and just subordinately interrupted (with possible emergences of bottom close to the water level).

The most striking change can be observed in the composition of the fossil assemblage. At the formation boundary, the most typical fossils of the Dachstein Limestone, megalodontids, the Triasina and Glomospirella genera and several foraminiferal species such as *Involutina sinuosa*, *I. communis*, *I. tenuis*, *I. tumida*, disappear abruptly, completely and once for all, while the foraminiferal species *Frondicularia woodwardi* becomes very subordinate. On the other hand, in the Lower Liassic limestones the tests or skeletal fragments of Brachiopoda, Cephalopoda and Crinoidea, respectively, appear, again suddenly, thus defining the character of the formation. Initially represented by sporadical traces, the remnants of Brachiopoda, Cephalopoda and Crinoidea become quite common. The fossil content of the sediment has considerably increased and the persistent groups occur themselves in higher quantity and with greater specific abundance.

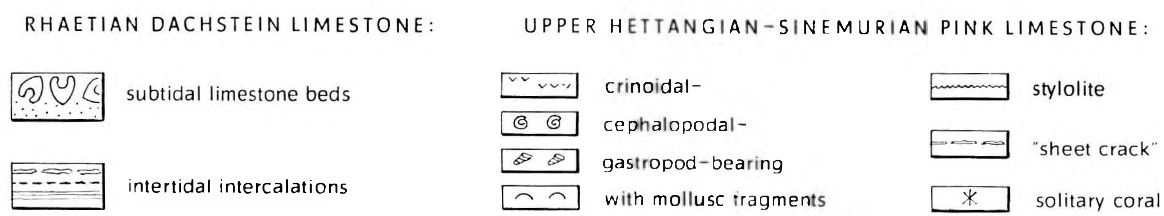
As for the geological events of the second half of the Rhaetian and the greater part of the Hettangian, no manifestation thereof is available in the Triassic and Jurassic of Kálvária Hill. The substantial differences in the development of the formations do reflect the considerable break



Textfig. 16:

TEST DATA ON THE TOPMOST TRIASSIC AND THE LOWERMOST JURASSIC

TATA, KÁLVÁRIA HILL



in sedimentation between them and the radical changes of sedimentary conditions. Just hypotheses can be relied on, however, as to how one process could cease, what happened till the beginning of the other and how this took place. One of the hypotheses is an overall and continuous submergence with subsolution and submarine erosion in the second half of the Rhaetian and over the majority of the Hettangian: a natural explanation for the lack of terrestrial and littoral forms and sediments. A second hypothesis suggesting the establishment of a terrestrial regime would allow a simpler interpretation of the complete hiatus embracing the major part of the Hettangian in the footwall of the Upper Hettangian-Sinemurian formations in the northern part of the Transdanubian Central Mountains.

JURASSIC-BERRIASIAN SEQUENCE

Prehistoric man had mined flint; in historical times, his splendour-liking descendants quarried "red marble" on Kálvária Hill. At present, breakstone worked by blasting is supplied for road construction.

After thousands of years of interest of direct practical aim, regular scientific observations on the multitude of rock properties, aimed at classifying, evaluating and genetically interpreting the phenomena, have been conducted only in the last two centuries. Thanks to these scientific results, it cannot be doubted now that the 40- to 42-m-thick red rock sequence of Tata's Kálvária Hill was formed in the Jurassic and the Berriasian and that the succession of different, superimposed geological formations represents a regular sedimentary cycle.

Lithologically, the Jurassic-Berriasian sequence can be readily subdivided. At the base, some 20 m of light red limestone can be found. It is overlain by 14 m of red crinoidal limestone, followed, in turn, by some 60 to 80 cm of red, nodular calcareous marl. Those are the constituents of the Liassic Group. The Dogger is represented, at its base, by 3 to 4 m of red argillaceous limestone with Mn nodules. This formation ends with some 30 to 40 cm of dark red, coarse-grained, crinoidal limestone overlain by 20 to 30 cm of brownish-grey Bositra limestone. The Upper Dogger is constituted by 1 to 1.2 m of liver-brown to dark grey chert. The Malm-Berriasian is represented by 0.5 m of light grey intraformational limestone breccia, 0.1 to 0.8 m of red argillaceous, nodular, cephalopodal limestone and 0.1 to 2.5 m of dark red to light grey cephalopodal limestone. The group of formations exposed on Kálvária Hill is replaced by formations of different facies in the boreholes of Tata's vicinity.

The author's efforts for developing an up-to-date lithostratigraphy have been confronted by the following difficulties:

(a) the lack of an up-to-date lithostratigraphic classification of the Jurassic and Berriasian formations and of a comprehensive description and proper nomenclature of either Tata or the analogical Central Mountains formations;

(b) in the majority of cases, the investigations carried out on Kálvária Hill and its vicinity are insufficient for a comprehensive description of lithostratigraphic units to be established;

(c) because of the low thickness the assignment to corresponding category is problematic.

To overcome those difficulties, the present writer has decided to refer provisionally to lithologically individualized rock bodies (units of tectogenetic and sedimentological evolution) representing one or several stratigraphic stages, as formations of the Jurassic-Berriasian deposits combined being referred to as Jurassic-Berriasian sequence. As to the naming of the formations, the author proposes to use "nomen nudum" for the moment. And it remains for the coming years to develop a strict terminological system for the formations. For the entire complex under consideration, the name "*Kálvária Hill (Jurassic) sequence*" has been proposed.

Crucial from the biostratigraphical viewpoint, ammonites can be recovered from the Lower and Upper Liassic, the Lower Dogger as well as from the Kimmeridgian, Tithonian and Berriasian. The Middle Liassic and the Oxfordian has yielded only sporadical specimens (just a few of them, for several decades of investigations!). An ammonoid fauna sampled by up-to-date techniques is available only from the Malm-Berriasian Group and the exposure at Csordakút spring. Because of the insufficiency of fossils and of the availability of hiatuses, concealed or recognizable from the Toarcian up in the geological column, the detectability of complete chronozones is *a priori* doubtful.

The genera Axotrix and Lombardia as well as the biozones of Stomiosphaera, Cadosina and Calpionellidae species can be readily used for subdividing the Kimmeridgian, Tithonian and Berriasian biostratigraphically. Conditions of abundance and association could be relied on in determining the vertical range of the Lower to Middle Liassic foraminiferal faunae, of the Upper Liassic to Lower Dogger *Bositra buchi* (ROEMER) beds and of the Bathono-Callovian radiolarian cherts.

Chronostratigraphic assignments and geochronological evaluations have been done on the basis of biostratigraphic evidence, lithostratigraphic subdivision and analogies.

The stratigraphy of the Jurassic and Berriasian of Kálvária Hill has been summarized in Text-fig. 18 (in pocket).

Liassic formations on Kálvária Hill

Pink limestone (Upper Hettangian-Sinemurian)

Disproportionately crinoidal limestone, pink to yellowish-red, aphaneritic, microbioclastic with intraclasts and subordinate intraformational breccia characterized by the presence of brachiopods and cephalopods.

Review of the relevant literature

After Robert Townson, who, in his travelogue on Hungary (1797), had characterized Tata as a town built on red marble, hosts of authors reported on the Jurassic of Kálvária Hill and its vicinity. Reference has been made here only to those of them who have contributed considerably to the understanding (or, eventually, misunderstanding) of the Lower Liassic limestones under discussion:

Ferenc Hauer (1853, 1854, 1865) described two new ammonite species, *A. Ferstli* and *A. hungaricus*, from the Liassic of Tata, referring to the locality just as "...Dotis in Ungarn".

Relying on the presence of Arietites, Benő Winkler (1883) assigned the red limestones, exposed on Kálvária Hill, to the Lower Liassic.

L. Lóczy sr. (1906) stated the presence of all three units of the Liassic.

N. Koch's work "Geological conditions of Kálvária Hill at Tata" (1909a), the first up-to-date, comprehensive, treatise on this area. This author, relying on fossils, subdivided the Lower Liassic into two members:

A lower one, 10 to 12-m-thick, constituted by pink compact limestones containing mainly Brachiopoda: "*Terebratula punctata* Sow., *T. punctata* Sow. var. *ovatissima* Opp., *T.* sp. (cfr. *punctata* Sow. var. *Andleri* Opp.), *T. nimbata* Opp., *T. Beyrichi* Opp., *T. Uhligi* Gey., *T. juvavica* Gey., *Waldheimia mutabilis* Opp., *W. Appeninica* Zitt., *Rhynchonella variabilis* Schl., *Rh. Matyasovszkyi* Böckh, *Rh. pseudopolypticha* Böckh, *Rh. Greppini* Opp., *Rh. inversa* Opp., *Rh. Cartieri* Opp., *Rh.* cfr. *retusifrons* Opp., *Spiriferina alpina* Opp., *Sp. brevirostris* Opp., *Sp.* cfr. *rostrata* Schl." — On the basis of his examination of poorly preserved cephalopods, he determined the following species: "*Arietites* cfr. *perspiratus* Wähner, *A.* cfr. *proaries* Neum., *A.* cfr. *Hungaricus* Hauer, *A.* sp. (cfr. *supraspiratus* Wähner), *Schlotheimia* sp. and *Aulacoceras* sp.". Relying on ammonoids, he identified the stratigraphic position of the lower member with the *Psiloceras megastoma* and *Arietites proaries* beds of the Northeastern Alps. He also mentioned in his list a bivalve which he determined as *Anomia numismalis* Qu.

The upper member, some 5 to 6-m-thick, is constituted by "red-coloured cephalopodal limestones". Its fauna comprises the following forms: "*Terebratula Beyrichi* Opp., *T. nimbata* Opp., *Phylloceras cylindricum* Sow., *Ph.* sp., *Arietites Conybeari* Sow., *A.* cfr. *Cordieri* Canav., *A.* sp. (from the group of *A. semisulcatus* Y. and B.), *A.* sp. (from the group of *A. spiratissimus* Qu.), *Aegoceras* sp., *Schlotheimia Boucaultiana* Orb., *Schl.* sp., *Tmaegoceras Lacordaieri* Michelin, *Aulacoceras* sp.". He identified the second member with the *Arietites rotiformis* horizon of the Northeastern Alps.

In his work "Contribution to the knowledge of the genus 'Tmaegoceras'" (1909b) he gave the paleontological description of *Tmaegoceras lacordaieri* Mich., then the first and single representative of this genus known in Hungary.

1961 was the year of publication of a paper that had been presented by I. Szabó at the International Conference on the Mesozoic, Budapest 1959. This author expounded in it his standpoint based on careful field observations and comprehensive paleontological-stratigraphic studies. In his discussion the Lower Liassic was subdivided into three units:

(a) The *lower unit* is pink, poor in Brachiopoda. Its fauna consists of the following species: "*Proarietites proaries* Neum., *Charmasseiceras ventricosum* Sow., *Ch.* cfr. *pseudoventricosum*, *Paracaloceras coregonensis* Sow., *P.* cfr. *grunowi* Hau., *Alpinoceras perspiratum* Wähn., *Schlotheimia marmorea* Opp., *Pseudotropites* cfr. *ultratriasicus* Can., *Ectocentrites petersi* Hau." Judging by the species listed, it represents the *Storthoceras megastoma* and *Schlotheimia marmorea* horizons of the Hettangian Stage. Consequently, the *Psiloceras calliphyllum* horizon is totally absent.

(b) The *middle unit* agrees in lithology with the lower one, with locally interbedded

red nodular lenses containing hosts of Brachiopoda. Fauna: "*Terebratula punctata* Sow. var., *T. juvavica* GEY., *T.* cfr. *gregaria* SUESS, *T. himeraensis* GEMM., *T. rudis* GEY., *Waldheimia* aff. *apenninica* ZITT., *W. baconica* BÖCKH, *W.* cfr. *engelhardti* OPP., *W. alpina* GEY., *W. mutabilis* OPP., *Spiriferina alpina* OPP., *Sp. brevirostris* OPP., *Sp. obtusa* OPP., *Glossothyris aspasia* MGH. var. *minor* ZITT., *Rhynchonella plicatissima* QU., *Rh.* cfr. *pseudopolyptycha* BÖCKH, *Rh.* cfr. *fissicostata* SUESS, *Rh. fascicostata* UHLIG, *Rh. cartieri* OPP., *Rh. latifrons* STUR." Most of the afore-listed Brachiopoda occur already in the lower unit and except for a few, they are not transient into the upper unit. Here the transient forms are larger than in the middle unit.

Beside the numerous brachiopods a few ammonite species and one representative of Bivalvia the following forms have also been found: "*Arietites (Coroniceras)* cfr. *conybeari* Sow., *A. (C.)* cfr. *cordieri* CAN., *A. (C.) semisulcatus* Y. et B., *A. (C.)* cfr. *rotiforme* Sow., *Vermiceras spiratissimus* QU., *Tmaegoceras lacordairei* MICHELIN, *Ectocentrites canavarii* BON. and *Anomya numismalis* QU." The representatives of Arietites indicate the presence of the Sinemurian *Arietites bucklandi* and *A. rotiformis* horizons.

(c) The *t h i r d u n i t* is constituted by thick-bedded, darker-red, stylolitic limestones, with a dark red, manganese-mottled intraformational breccia layer atop. Beside the frequent representatives of Phylloceras and Lytoceras, its characteristic fossils are: "*Arnioceras rejectum* FUC., *A. speciosum* FUC., *A.* cfr. *fallax* FUC., *Asteroceras stellaris* Sow., *Boucaulticeras boucaultianum* ORB., *Oxynoticeras inornatum* PIA, *Oxynoticeras* sp. Larger Brachiopoda: *Spiriferina alpina* OPP., *Sp. brevirostris* OPP.". Relying on the fauna, I. SZABÓ assigned the third unit to the Lotharingian Stage.

Lithostratigraphy

On the basis of megaloscopic examinations the *pink limestone formation* can be split up, with a view to bedding, colour shades and textural characteristics, into three members:

- the l o w e r m e m b e r of 10 m thickness is characterized by totally pink shades (colour like that of human skin) and by hardly recognizable stratification;
- the m i d d l e m e m b e r of 4 m thickness is of the same colour but it is strikingly well bedded;
- finally, the u p p e r, 6-m-thick m e m b e r has become individualized on account of its red colour shades, its intraclasts visible to the naked eye and its limestone grains coated by ferruginous-manganiferous matter (Textfig. 19 and Plate XI, Fig. 1).

General feature of the formation is the stylolitic nature of the overwhelming majority of strata contacts. The fabric of the limestone, usually aphaneritic as it is on fresh fracture surfaces, *viz.* the presence of lenses, intraclasts and intraformational breccias, is visualized primarily by the weathered rock surfaces and by careful megaloscopic examination. Relatively frequent, though not conspicuous, are the narrow limestone fissure-fills corresponding in colour to the enclosing rock.

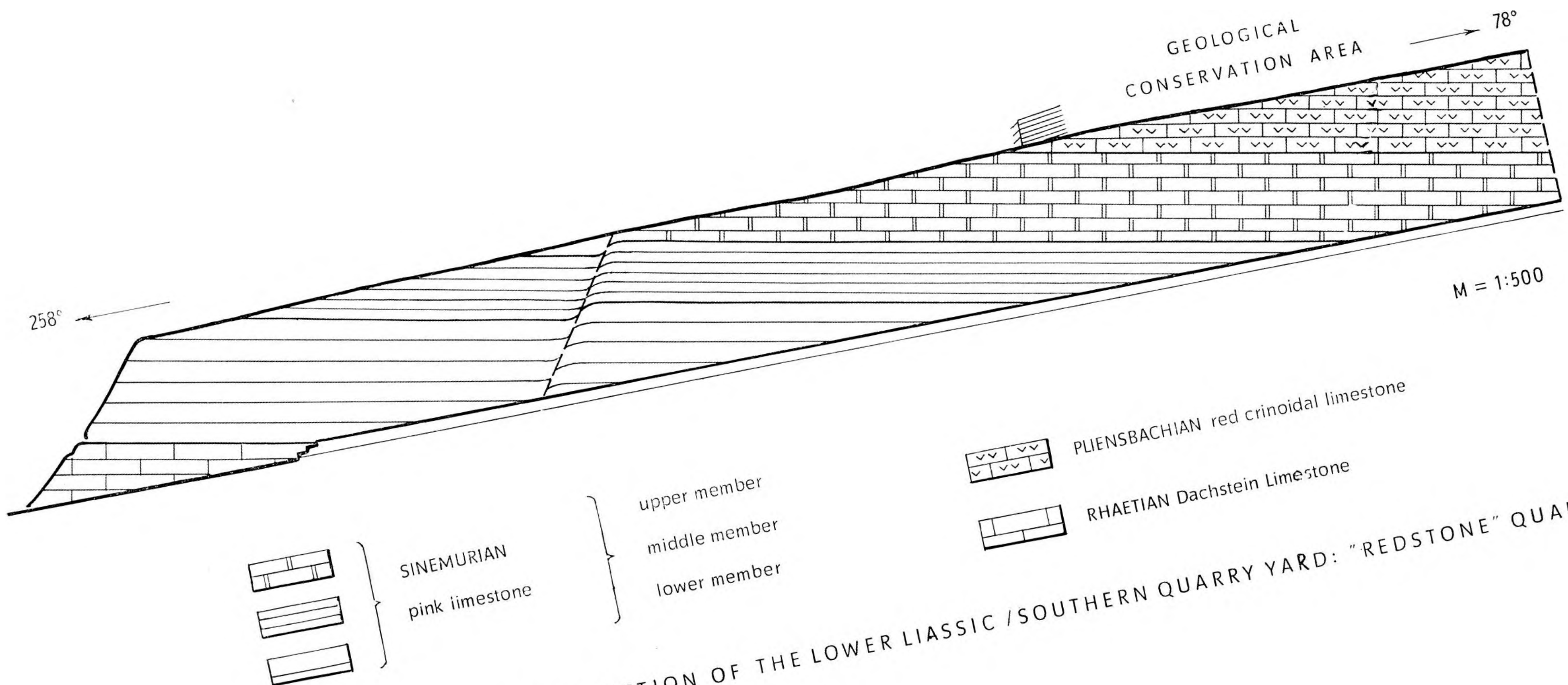
The results of detailed field examinations may be summarized, member by member, as follows:

I. The l o w e r m e m b e r of the pink limestone formation is 10 m thick, pale yellowish-red and poorly bedded (Textfig. 20: in pocket).

The Dachstein Limestone is overlain by 90 cm of limestone, calcarenitic, with colour shades darker than the bulk of member I and with plenty of crinoid, cephalopod, gastropod and brachiopod tests and ossicles. In the lower one-third of this limestone bed there are segregations parallel to bedding plane, consisting of calcipelit nuclei coated by radiaxial calcite. The upper part of the limestone bed is richly bioclastic and oncolitic. The lowermost stratum is overlain by a limestone bed of similar thickness, but lighter in colour and porcelain-like, aphaneritic in texture. The calcipelitic texture seems to be due, in some respect, to a decrease in bioclastic content. The next limestone bed, somewhat thicker than the preceding ones, is again a bioclastite of rich and diversified composition.

In the upper part of member I the bioclasts show a considerable decrease in abundance as compared to the lower 3 metres. This sequence is characterized again by a porcelain-like, aphaneritic texture. Lenses consisting of bioclastic and calcipelitic bands, internal segregations (which can be found in the inner part of the layers) and small calcitized internal moulds of Brachiopoda are common.

II. The m i d d l e m e m b e r of the pink limestone formation is 4 m thick. It is pale yellowish-red, but, unlike the lower member, well stratified (Plate XI, Fig. 1). The results of its megaloscopic and microscopic examinations are shown in Textfig. 21 (in pocket). The strata are of different thickness: thick limestone beds at the base, thinner strata in the upper part. Separation of the one deposited calcipelitic-crinoidal bioclastic sediment into crinoidal lenses and a calcipelitic matrix is a common phenomenon. Internal segregations occur only in one horizon. In a few beds the texture of the rock is dotted with intraclasts which are difficult to recognize. The top of the fifth bed counted from the bottom is heavily pyritized. The greenish-grey clay film on the bedding planes was formed



Textfig. 19: TATA, KÁLVÁRIA HILL. TYPE SECTION OF THE LOWER LIASSIC /SOUTHERN QUARRY YARD: "REDSTONE" QUARRY/

as a result of the decomposition of pyrite. Brachiopod remnants are frequent, ammonoids are less so, gastropods are subordinate.

III. The upper member of the pink limestone formation is 6 m thick. Of pink colour, it is well bedded. The results of its examination are illustrated in Textfig. 22 (in pocket). Bedding planes are stylolitic. At the base, beds of striking intraclastic texture alternate with aphaneritic ones. In the upper part of the member the intraclasts gain overall distribution and clasts broken off a more and more consolidated sediment are coated by ferruginous-manganiferous matter. Member III is terminated by an intraformational breccia layer containing iron-manganese-coated, tiny nodules (having single limestone fragments at their centre). Brachiopod remnants and ammonite moulds are frequent. Large Ausseites sections can also be observed.

The present writer has made efforts to illustrate the lithology of Lower Liassic pink limestone formation by the results of laboratory examinations of type samples and by the spectral analyses of rock specimens sampled member by member (see Table 1).

Table 1

Mineralogical, petrographical and geochemical analyses of a type sample of Lower Liassic pink limestone

Chemical composition (%):

SiO_2	0.92
TiO_2	tr
Al_2O_3	1.83
Fe_2O_3	0.16
FeO	0.02
MnO	0.02
MgO	0.38
CaO	54.50
Na_2O	0.04
K_2O	0.20
$+H_2O$	0.40
P_2O_5	0.02
CO_2	41.91
organic C	0.03
Total:	100.43

Rare elements (ppm): from the lower (I), middle (II) and upper (III) members of the formation

	I	II	III
B	60	30	30
Ba	120	72	56
Co	15	20	15
Cr	18	15	10
Cu	16	20	12
Ga	2	2	2
Mn	80	140	120
Ni	60	60	26
Pb	19	20	19
Sr	500	420	420
Ti	100	100	100
V	36	36	32

Mineralogical composition (%):

Chemo- and biogenic:	
calcite	93.6
dolomite	1.7
pyrite	0.5
limonite	0.2
Total:	96.0
Colloidal:	
illites	1.5
alumogel (?)	1.7
Total:	3.2
Detrital:	
quartz	0.2
feldspar	0.1
Total:	0.3

Microminerological analyses (specimens):

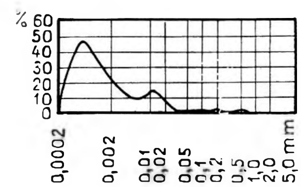
Heavy minerals:		Light minerals:	
Magmatic:		Detrital:	
none		quartz	34
Metamorphic:		orthoclase	6
none		plagioclase	12
Epigenic:		Chemogenic:	
pyrite	93	chalcedony	46
limonite	7	glauconite	2
Total:	100	Total:	100
		Quartz grains of good preservation, poorly rounded	

Specific weight:	2.90
Volume weight:	2.59
Porosity:	11.40%
pH:	8.30
O_{Fe}:	16.00

Grain size composition (%) of insoluble residue (1.65%):

0.5 —1.0 mm	0.2	1.0
0.2 —0.5	0.2	
0.1 —0.2	0.4	
0.06 —0.1	0.2	
0.02 —0.06	0.8	32.2
0.01 —0.02	17.5	
0.005—0.01	13.9	
0.002—0.005	17.1	66.8
0.000—0.002	49.7	

Granulometric curve:



Sedimentological phenomena

In the Lower Liassic limestone a couple of typical manifestations of sedimentological processes can be observed. These require to be discussed in fuller detail and to be interpreted genetically. Phenomena of this kind are the segregations formed on the one-time basin bottom and within the deposited sediment; the plastic deformation of differentially diagenized sediment; its tearing up into intraclasts and intraformational breccia; finally, the oncoidal or ferruginuous-manganiferous coating of detrital grains. Synsedimentary cracks, penecontemporaneous fissure fills and neptunian dikes are frequent.

External and internal segregations can be observed in the lower and, less frequently, the middle members of pink limestone formation. In both cases this means the separation of the sediment which consisted of biocalcarenite and calcilutite components, into 10-to 20-cm-long laminae and bands on one hand and a calcilutite matrix on the other. External segregations (occuring on the surface of the layers) seem to have been produced by selective deposition of the mud stirred up by a rather intensive wave action. They are common in the lower part of the formation.

Internal segregations are aligned parallel to bedding plane but never on itself. Their spacing varies following the cases; in some levels it is only a few centimetres; in other cases they are widely dispersed; occasionally, they occur in groups.

As regards their morphological characteristics, their upper part is a "crown", coated by radiaxial calcite and calcipelite-centred, irregularly domed on top and straighter lined at the base. Below the "crown" there is a banded-lenticular, calcipelitic and biocalcarenitic "base" grading into the texture of the enclosing rock (Textfig. 23, Plate XIII). Upward in the profile of pink limestone formation, the calcite-coated "crown" of the segregations will gradually flatten, to result finally in a thin calcite band.

The development of internal segregations, in spite of certain morphological similarities, cannot be identified with the sheet cracks described by Fischer (1964). In the Lower Liassic sequence no algal mats or desiccation cracks are available. The present writer believes that the internal segregations are of early diagenetical origin: they appear to have been generated by the effects of the gas production of decaying organic matter at definite sedimentation rate and grain composition and pulsating pressure due to water movement.

Plastic deformation of sediment, intraclast-dotted texture, oncolites and intraformational breccia. As a result of mechanical strains due to the extremely rapid consolidation of the calcareous ooze, the following features can be observed to accompany the lenticular pattern referred to already:

— lasting plastic deformation (Plate XII, Fig. 2) and
— intraclast-dotted texture gradually increasing in abundance up in the profile.

The detrital grains in the latter are characterized by:

— blurred outlines and
— conformable or a little dissimilar lithology.

In the upper part of member III, they are of strikingly distinct outline, being partly clay-filmed or coated by iron-manganese oxide matter, respectively (Plate XII, Fig. 4).

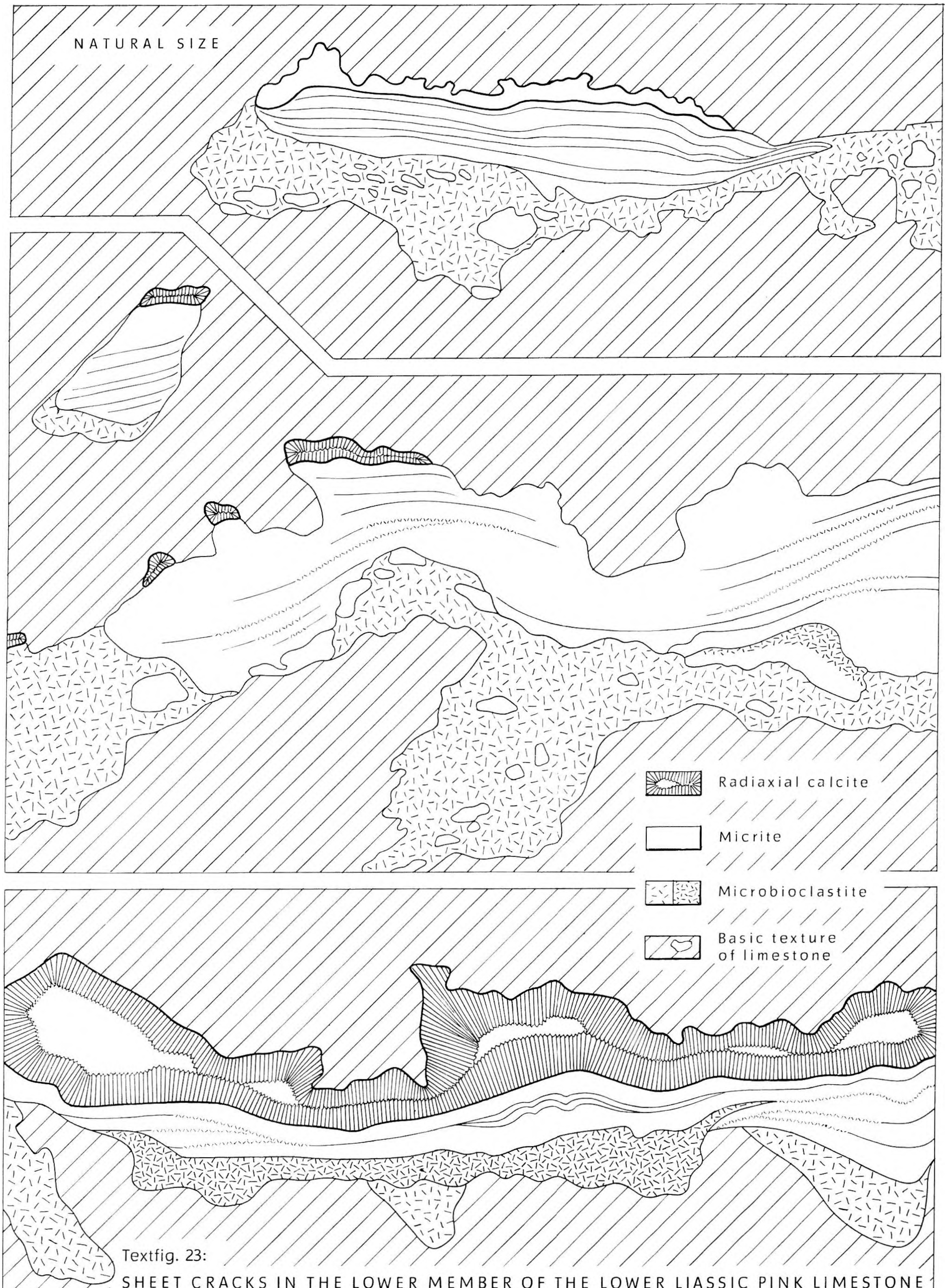
The oncolite bed quoted from the basal stratum of the lower member is a typical sediment deposited in a shallow-water, agitated environment. The snow-ball-like growth of onkoid grains produced by detritus-cementing algae and the uneven thickenings due to displacements can be readly observed on the individual oncoid globules (Plate XII, Fig. 1).

The uppermost layer of the upper member is represented by intraformational breccia. It is constituted by brecciated fragments of consolidated limestone with subordinate calcipelitic cement (Plate XII, Fig. 3).

Synsedimentary fractures, neptunian dikes. Synsedimentary fractures or fissure-fills of different size simultaneous with Lower Liassic sedimentation can be found in all three members of the pink limestone formation. They are mostly thin (0.5 to 1 cm thick) and of uneven outline. Their colour is very similar to that of the enclosing rock in the majority of the cases, so that they are hardly discernible and traceable. Occasionally attaining tens of centimetres in thickness (Plate XIV, Fig. 4), their fill is often banded and sometimes of strikingly different tonality. At the base of member III (Plate XIV, Fig. 2) transversal, edge-shaped fissure-fills occur.

A strikingly common feature of fissure-fills is the sporadical biocalcarenite content, if any, of their calcipelitic rock matter. Only the calcipelitic component of the pink Lower Liassic limestones seems to participate in their constitution. As belived by the present writer, the following genetical circumstances of fissure formation may account for the above phenomenon:

In the course of Liassic sedimentation the limestone bedrock was repeatedly fractured, but this fracturing gradually declined with the increasing softness of the unconsolidated bottom sedi-



Textfig. 23:
SHEET CRACKS IN THE LOWER MEMBER OF THE LOWER LIASSIC PINK LIMESTONE

ment, unsuitable for fracturing. Because of the vacuum-like suction effect of the opening fissures, a sediment of micrite size filled the fractures, after being filtered by the bioclastic filtering mass of the undiagenized mud layers.

Thin section examinations

Thin sections were prepared of samples taken with an average spacing of 5 cm from the wall of the abandoned quarry exposing the total vertical range of the Lower Liassic pink limestone formation. Sampling was done in a direction normal to stratification. Detailed examination of the resulting thin sections allowed an insight into the geology and lithogenesis of the sequence. The quantity per square centimetre of components observable under the microscope was determined by D. Zilahy. On the basis of the evaluation of the results and experiences, the following conclusions can be drawn:

Viewed under the microscope, the Lower Liassic pink limestone shows, as a rule, a biomicritic texture. In addition, lumpy (Plate XVII, Fig. 7) and pelletal texture is common; and subordinate pseudo-oöidic (Plate XVII, Fig. 8) and mozaic-sparite texture types can also be recognized. Characteristic constituents of the microfossil assemblage are *Globochaete alpina* Lombard (Plate XVII, Fig. 4), a diversified benthonic foraminiferal fauna (Plate XVII, Fig. 1—3), sponge spicules (Plate XVII, Fig. 5), thin and thick Ostracoda valves (Plate XV, Fig. 1), and skeletal detritus of echinoderms, mainly crinoids (Plate XV, Fig. 3). Mollusc shell fragments, tiny gastropod (Plate XV, Fig. 2), ammonoid and brachiopod sections and skeletal elements are frequent (Plate XVII, Fig. 6) and sections of Bositra appear.

It is only the foraminiferal fauna that can be differentiated in fuller detail. Characteristic forms of the assemblage are *Involutina liassica* (Jones), *Trocholina* sp. [*Tr. turris* Frentzen, *Tr. conica* (Schlumberger), *Tr. nova* sp. Radoičić] and *Frondicularia* sp. (*Fr. brizaeformis* Bornemann). *Ophthalmidium*, *Nodosaria* (*N. mutabilis* Terquem) and *Lenticulina* sp. are frequent. *Ammodiscus*, *Gaudryina*, *Rectoglandulina*, *Dentalina*, *Marginulina*, *Cornuspira*, *Pseudonodosaria* and *Astacolus* sp. occur less frequently. At the base of the sequence, *Frondicularia woodwardi* Howchin, a species earlier considered to be limited to the Rhaetian Stage, can also be found, though in a small number of specimens. The predominance of Foraminifera corresponds to the basal horizon of member I. A density of 200 specimens per cm^2 can even be observed there, the average being 80 specimens per cm^2. In the middle part of the horizon the frequency declines considerably, though the foraminiferal content still remains significant in the rest of the pink limestone formation. In the upper part of member I the average frequency is 50 specimens per cm^2, it is the lowest in member II (30 specimens per cm^2), to become again significant in member III (70 specimens per cm^2).

The wide distribution of Globochaete remnants is conspicuous. The highest frequency value in member I is 290 specimens per cm^2, the lowest is 25, the average being 100. Variability from sample to sample is considerable and the frequency curve shows heavy fluctuations. In member II a marked decrease can be observed: max. 160, min. 15, average 50 specimens per cm^2. Variability is mean. The predominance of Globochaete occurs in the upper member, with a maximum of 390 and an average of 180 specimens per cm^2. Variability is very marked.

The role of sponge spicules in the fossil assemblage is very significant. Less frequent at the base and the top of the lower horizon of the lower member and at the middle of the upper horizon and, finally, in the lower part of member III, they are very abundant throughout the rest of the formation. Their highest abundance is observed in the upper part of member III with a maximum of 950 and a minimum of 200 specimens per cm^2. Variability by samples is very high.

Gastropod and ammonoid shell elements occur with striking frequency in the lower horizon of member I. In addition, gastropods are rather frequent in member III as well.

Ostracods are available in great number. Their vertical distribution in the sequence does not show any substantial differentiation. Their frequency curve is wavy and the variability by samples is mean. The average frequency varies vertically between 50 and 100 specimens per cm^2.

Beside the above, crinoid ossicles are important texture-forming elements, attaining relatively high proportions in the lower part of member I and in member III.

Of the inorganic components, pyrite plays a rather significant role, being abundant in some basal strata of member I already. It is predominant in the middle part of the upper horizon of member I, playing a considerable role and being abundant in some strata of member II as well. Rather scant over much of member III, it shows again a marked increase at the top.

Beside the above major biogenic and residual components, the following organic elements can be observed in subordinate quantities in thin sections: Radiolaria, Brachiopoda, Echinoidea, Holothurioidea. In some strata, Bositra sections characteristic of younger stratigraphic units appear, too.

No close correlation could be observed to exist in the distribution of fossil frequencies. The paleoecological conditions were, except for some minor fluctuations, consistenty favourable for the development of this shallow-water biocoenosis over the whole stratigraphic range of the pink limestone formation. Key elements for genetic interpretations have been benthonic foraminifera, sponge spicules, brachiopods, gastropods and echinoderms.

Lower Liassic Ammonites

by

B. Géczy*

It was Professor J. Fülöp's honouring confidence that allowed me in 1972 to re-study Tata's classical Lower Liassic ammonite collection deposited at the Museum of the Hungarian Geological Institute. I am profiting of this opportunity to thank him for his generous lending me the material for study. The fauna was collected by B. Dornyai, J. Fülöp, N. Koch, A. Liffa, L. Lóczy, I. Szabó, E. Vadász, E. Végh—Neubrandt and Gy. Vigh. Since the fauna is only partly identical with that examined by I. Szabó, I could not afford a revision of Szabó's excellent work (1961), of course. With a view to the score of years, that have elapsed since I. Szabó's publication, the time seems to be ripe for a work of this kind now.

The evaluation of ammonites has been rendered difficult by the following circumstances:

- The fauna, as a rule, is in a poor state of preservation. In 1909 N. Koch described 15 species from the Lower Liassic of Tata. He could exactly identify four of these. Five species were referred to as cfr. and six could be determined only generically. This uncertainty is due to the subsolution of the internal moulds studied: a handicap to examining inner whorls and suture lines. Unfortunately enough, it is the oldest ammonites, most significant from the viewpoint of geochronology and paleogeography, that could not be recovered from the gangue.
- A classical fossil collection, it lacks the advantages of an up-to-date and careful quantitative sampling. The only lucky exception to this rule has been the Toarcian fauna of Csurgókút which J. Fülöp and G. Vigh sampled in an up-to-date way, layer by layer. Since earlier samplers usually contented themselves with referring to the source of the samples just as "Tata, Kálvária-domb", it cannot be decided now in what kind of distribution these ammonites may occur in the Lower Liassic limestones? Stratigraphic evaluation of Tata's Lower Liassic certainly requires further layer-by-layer sampling of standard profiles. Because of the lack of standard stratigraphic records of this kind we could not afford to seek either to establish a zonal scale or to determine the thickness of zones.
- Tata's fauna is of Mediterranean character with an absence of Northwest European zonal index fossils. This circumstance makes it particularly difficult to evaluate the Lower Liassic faunae, as the vertical ranges of Mediterranean index fossils are much less known than those of the Northwest European indices. In spite of these difficulties, the fauna suggests the presence of the following stratigraphic stages (or zones, respectively):

Upper Hettangian

I. Szabó (1961, p. 470) listed the following Lower Liassic ammonites from Tata: *Proarietites proaries* Neum., *Charmasseiceras ventricosum* Sow., *C.* cfr. *pseudoventricosum*, *Paracaloceras coregonensis* Sow., *P.* cfr. *grunowi* Hau., *Alpinoceras perspiratum* Wähn., *Schlotheimia marmorea* Opp., *Pseudotropites* cfr. *ultratriasicus* Can., *Ectocentrites petersi* Hau.

On the basis of the fauna he suggested the presence of the *Storthoceras megastoma* and *Schlotheimia marmorea* horizons of the Hettangian Stage. The *Megastoma* Zone is an equivalent of the *Alsatites liasicus* Zone (Dean *et al.*, 1961, p. 445), the *Marmorea* Zone is that of the *Schlotheimia angulata* Zone (l. c. p. 446). Consequently, the fauna belongs to the Middle and Upper Hettangian.

The collection of the Hungarian Geological Institute does not certify convincingly the presence of the Middle Hettangian. The internal moulds of *Arietites perspiratus* which L. Lóczy determined in 1908 are in a very poor state of preservation, partly enclosed in the gangue, their outer part thus being inaccessible to examination. Their ribbing is different from the arched ornamentation of *Alsatites perspiratus*. According to Blind (1963, p. 101), *Alsatites perspiratus* was recovered from Bed 7 of the standard stratigraphic section of Breitenberg, thus being Middle Hettangian.

The Upper Hettangian seems to be represented by the following species: *Alsatites?* sp., *Paracaloceras coregonensis* (Sowerby in de la Beche, 1831), (Plate XV, Fig. 4), *P. grunowi* (Hauer, 1856), *Charmasseiceras marmoreum* (Wähner, 1882).

* pp. 30—32

The specimen determined, again by L. LÓCZY, as *Arietites* cfr. *proaries* NEUM. is also poorly preserved, so that its assignment to the genus Alsatites can be only conditional. According to BLIND (1963, p. 101), "*Arietites*" *(Alsatites) proaries* was recovered, at Breitenberg, from Bed α_{2-1} of the Liassic, i.e. from the Upper Hettangian. An unambiguous Upper Hettangian age is suggested by the species *Paracaloceras coregonensis* which BLIND described as *Arietites (Alsatites) coregonensis* similarly from Bed α_{2-1}. Since BLIND believes that Alsatites extend beyond the Hettango-Sinemurian boundary (l.c. Abb. 21), some overlapping may be possible here, too. This holds true particularly of the earlier zonal index fossil, *Charmassciceras marmoreum*, which in England was found in the Lower Sinemurian (DONOVAN 1952, p. 635), while in the Swabian Alps it occurs in the topmost Upper Hettangian (uppermost zone, "m", of Bed α_{2-1}).

Sinemurian

The Sinemurian Stage is represented by the following species: *Ectocentrites* s. l. sp., *Tmaegoceras crassiceps* POMPECKJ, 1901 (Plate XVI, Fig. 1), *Pseudotropites?* sp., *Boucaulticeras boucaultianum* (D'ORBIGNY, 1844), *Charmasseiceras* cfr. *charmassei* (D'ORBIGNY, 1844), *C.* n. sp., *Coroniceras? hungaricum* (HAUER, 1856), *C. (Metophioceras) gracile* (SPATH, 1924) (Plate XVI, Fig. 2), *C. (Metophioceras) janus* SPATH, 1924, *C. (Metophioceras)* cfr. *caesar* (REYNÈS, 1879), *C. (Metophioceras)* cfr. *rougemonti* (REYNÈS, 1879), *C. (Metophioceras)* cfr. *rotarium* (BUCKMAN, 1925), *C. (Metophioceras)* cfr. *conybeari* (SOWERBY, 1816), *C. (Metophioceras)* cfr. *cordieri* (CANAVARI, 1888), *C. (Metophioceras)* sp., *C. (Paracoroniceras) oblongaries* (QUENSTEDT, 1884), *Arnioceras* cfr. *paucicosta* FUCINI, 1902, *A.* cfr. *semicostatum* (YOUNG et BIRD, 1928), *A.* cfr. *geometricum* (OPPEL, 1856), *A.* cfr. *dimorphum* PARONA, 1897, *A.* sp. aff.? *rejectum* FUCINI, 1902, *A.?* sp., *Caenisites* n. sp. aff. *brooki* (SOWERBY, 1818), *Asteroceras* cfr. *saltriense* PARONA, 1896, *Eparietites* cfr. *undaries* (QUENSTEDT, 1884), *E.* sp., *Paroxynoticeras?* sp., *Oxynoticeras* cfr. *stenomphalum* PIA, 1914.

Lower Sinemurian

I. SZABÓ verified the "*Arietites bucklandi* and *A. rotiformis*" Horizons of the Sinemurian by the following fossils: *Arietites (Coroniceras)* cfr. *conybeari* SOW., *A. (Coroniceras)* cfr. *cordieri* CAN., *A. (Coroniceras) semisulcatus* Y. et B., *A. (Coroniceras)* cfr. *rotiforme* SOW., *Vermiceras spiratissimus* QU., *Tmaegoceras lacordairei* MICHELIN, *Ectocentrites canavarii* BON.

The comparatively rich fauna available is an unambiguous testimony to the presence of both zones of the Lower Sinemurian *(Bucklandi* and *Semicostatum)*.

The *Bucklandi* Zone

The *Bucklandi* Zone is evidenced by the Coroniceras (Metophioceras) species very frequent in Tata's fauna. Notably, Metophioceras are indicative of the base of the Sinemurian all over the world *(Conybeari* Subzone*)*. The genus Pseudotropites and the species *Tmaegoceras crassiceps* and *Charmasseiceras charmassei* belong to the *Bucklandi* Zone, too.

The *Semicostatum* Zone

Zonal index fossil of the *Semicostatum* Zone is *Arnioceras semicostatum*. Also a representative of the Lower Sinemurian is *A. geometricum* which, according to WALLISER (1956, p. 214), would have appeared already in the *Bucklandi* Zone and persisted till the Late Sinemurian. The exact time ranges of the other Arnioceras species described by FUCINI and PARONA are unclear. Similarly the presence of the *Semicostatum* Zone is indicated by *Coroniceras (Paracoroniceras)* cfr. *oblongaries* (conf. GUÉRIN-FRANIATTE, 1966, p. 157) and *Boucaulticeras boucaultianum* (conf. DONOVAN, 1954, p. 31, WISSNER, 1958, p. 51).

Upper Sinemurian

I. SZABÓ certified the presence of the Lotharingian Stage, i.e. the Upper Sinemurian, by the following fauna: *Arnioceras rejectum* FUC., *A. speciosum* FUC., *A.* cfr. *fallax* FUC., *Asteroceras stellaris* SOW., *Boucaulticeras boucaultianum* D'ORB., *Oxynoticeras inornatum* PIA, *Oxynoticeras* nov. sp.

Upper Sinemurian ammonites sampled earlier derive from several localities: in 1913 DORNYAY recovered several larger smooth Gleviceras specimens from "the basement of the new District Court Mansion". These belong to new species and probably indicate the *Oxynotum* Zone. On Kálvária Hill, I. Szabó collected in 1955 a very poorly preserved *Paroxynoticeras?* sp. which is unsuitable for chronological interpretation. Accordingly, it remains a further task to verify faunistically the presence of the middle and upper parts *(Oxynotum* and *Raricostatum* Zones*)* of the Upper Sinemurian on Kálvária Hill.

The *Obtusum* Zone

Adopting the new French zonal scale (Mouterde *et al.* 1971, p. 4), the present writer has assigned the *Turneri* Zone, considered to be the final member of the Lower Sinemurian by Dean *et al.* 1961, to the *Obtusum* Zone. With a view to the occurrence of *Caenisites* n. sp. aff. *brooki*, it is probable that the lowermost part *(Caenisites brooki* Subzone*)* of the *Obtusum* Zone s. l. can also be found at Tata. *Asteroceras* cfr. *saltriense* seems to belong to the *Obtusum* Zone. Eparietites indicate the upper part of the *Obtusum* Zone *(Denotatus* Subzone*)*.

* * *

The youngest member of the fauna, *Oxynoticeras* cfr. *stenomphalum* may indicate the higher part of the Sinemurian, though the single specimen available is insufficient for proving this suggestion.

Liassic Brachiopoda fauna from Tata

by

G. Vigh*

Recovered from Liassic sediments in the municipal area of Tata, 170 brachiopod specimens have been available for study at the Museum of the Hungarian Geological Institute. This rich assemblage derives from several localities. The fossils were collected by different samplers (L. Lóczy sr., N. Koch, I. Szabó, etc.). Unfortunately enough, their exact source is unknown. Thus the determined brachiopod assemblage is, in spite of its great number of specimens, unsuitable for exact horizonting.

What cannot be doubted is to conclude that 149 of the 170 specimens belong to the Lower Liassic (Hettangian-Sinemurian), while 17 specimens from Csurgókút and 4 from Kálvária Hill rather suggest the presence of the Middle Liassic.

Both N. Koch (1909a) and I. Szabó (1961) published sizeable lists of the Brachiopoda recovered from Lower Liassic sediments. Unfortunately, the two publications contradict each other. N. Koch describes his 19 species as having been recovered "from pink, compact brachiopod-bearing limestones" that would belong to the Upper Hettangian *(Psiloc. megastoma* and *Ariet. proaries* Zone and *Ariet. laqueus* and *Schlotheimia angulata* Zone, respectively). On the other hand, I. Szabó refers to the presence of just a few Brachiopoda at the base of the Lower Liassic sequence without listing genera or species. All the more numerous is the assemblage, including 20 species or so, he quotes from the middle part of the Lower Liassic representing, according to him, the *Ariet. bucklandi* and *A. rotiformis* Zones. Out of this sequence, N. Koch mentions only two Terebratula species. An identification thus seems to be unfeasible.

Finally, a careful analysis of the faunal list alone (Table 2) allows the writer to conclude that not a single form confined to and characteristic of the Hettangian Stage can be found. A few forms transient from the Upper Triassic (e.g. *Rhaetina gregaria* Suess) are still present in the higher parts of β *(Oxynotum-Raricostatum* Zone). A considerable part of the species are such as occurred sporadically already in the Hettangian, but their acme corresponds to the Sinemurian *("Terebratula"* cfr. *juvavica* Gey., *Zeilleria? mutabilis* Opp., *"Rhynchonella" cartieri* Opp., *"Rh." plicatissima* Qu., etc.). It can also be concluded, for that matter, that none of the species available seems to be unambiguously characteristic of the Sinemurian Stage alone.

As for the conditions of predominance, the writer agrees most with I. Szabó's opinion. A few of the 149 representatives of Brachiopoda may derive also from the Hettangian, yet the Sinemurian Stage should be considered to be the source of the majority.

If the examined fauna be compared to the most important brachiopod faunae published from the Mediterranean realm, certain connections with the Central Apennines and, moreover, with the Austrian Northern Alps can be recognized. Despite the *non*-Hierlatz facies of Tata's Lower Liassic, the fauna under consideration does compare in greatest measure to the Hierlatz fauna.

Among the brachiopods 21 specimens, indicative of the Pliensbachian Stage first of all, were found. One Rhynchonella specimen belonging to the scherina-glycinna group is characteristic exclusively of the Pliensbachian Stage. Within the Gerecse area these forms have largest populations

*pp: 32—35

G. VIGH	speci-mens	N. KOCH (1909)	speci-mens	I. SZABÓ (1961)	speci-mens
Kálvária Hill, Upper Hettangian-Sinemurian					
"*Rhynchonella*" *plicatissima* QU. 1852	25	*Rh. plicatissima* QU.	1	*Rh. plicatissima* QU.	9
"*Rhynchonella*" sp. ind. (? *plicatissima* QU.)	1			*Rh. plicatissima* QU.	1
"*Rhynchonella*" sp. (aff. *plicatissima* QU.)	1				
"*Rhynchonella*" sp. (ex gr. *plicatissima* QU.)	1	*Rh. plicatissima* QU.	1		
"*Rhynchonella*" *zugmayeri* GEMM. 1878	2			*Rh.* cfr. *fissicostata* SUESS	2
"*Rhynchonella*" "*variabilis*" (SCHLOTH.)	1	*Rh. variabilis* SCHLOTH.	1		
"*Rhynchonella*" aff. *stanleyi* GEMM. 1878	2				
"*Rhynchonella*" cfr. *latifrons* STUR m. s. in GEY. 1889	1			*Rh. latifrons* STUR	1
"*Rhynchonella*" sp. (aff. *latifrons* STUR m. s. in GEY.)	3			*Rh. latifrons* STUR *Rh.* cfr. *pseudopolyptycha* BÖCKH	2 1
"*Rhynchonella*" sp. (n. ssp. ? aff. *latifrons* STUR m. s. in GEY.)	1			*Rh. latifrons* STUR	1
"*Rhynchonella*" *fascicostata* UHL. 1880	1			*Rh. fascicostata* UHL.	1
"*Rhynchonella*" aff. *fascicostata* UHL.	1	*Rh. Matyasovszkyi* (sic!) BÖCKH	1		
"*Rhynchonella*" sp. (aff. *fascicostata* UHL.)	1				
"*Rhynchonella*" *cartieri* OPP. 1861	4	*Rh. Cartieri* OPP.	1	*Rh. Cartieri* OPP.	4
"*Rhynchonella*" sp. (aff. *cartieri* OPP.)	2	*Rh. variabilis* SCHLOTH.	2		
"*Rhynchonella*" sp. (ex gr. *cartieri* OPP. — *retusifrons* OPP.)	2	*Rh. Cartieri* OPP.	1		
"*Rhynchonella*" sp. (ex gr. *cartieri* OPP. — *retusifrons* OPP.)*	1	*Rh. variabilis* SCHL.	1		
"*Rhynchonella*" cfr. *retusifrons* OPP. 1861	1				
"*Rhynchonella*" sp. (aff. *retusifrons* OPP.)	1	*Rh. plicatissima* QU.	1		
"*Rhynchonella*" sp. ind.	6	*Rh. Matyasovszkyi* (sic!) BÖCKH *Rh. pseudopolyptycha* BÖCKH *Rh.* cfr. *retusifrons* OPP.	1 1 1		
Prionorhynchia? *greppini* OPP. 1861	1	*Rh. Greppini* OPP.	1		
Prionorhynchia? sp. [aff. *flabellum* (MGH.)]	1				

* Pathological specimen

G. Vigh	speci-mens	N. Koch (1909)	speci-mens	I. Szabó (1961)	speci-mens
Prionorhynchia? sp. (ex gr. *polyptycha* Opp.) 1861	1				
Pisirhynchia? sp. [*meneghinii* (Zitt.)]?	1	*Rh. inversa* Opp.	1		
Rhynchonellina? sp.	1	*Ter. punctata* Sow.	1		
Rhynchonellina? sp. ind.**	1	*Ter.* sp. (cfr. *T. punctata* Sow. var. *Andleri* Opp.)	1		
Spiriferina alpina Opp. 1861	29	*Sp. alpina* Opp.	25	*Sp. alpina* Opp.	1
Spiriferina sp. (aff. *apenninica* Canav.)	1	*Sp.* cfr. *rostrata* Schloth.	1		
Spiriferina sp. (? *apenninica* Canav.)	2	*Sp. alpina* Opp.	2		
Spiriferina sp. (? *cantianensis* Canav.)	1	*Sp. alpina* Opp.	1	*Sp. alpina* Opp.	1
Spiriferina obtusa Opp. 1861	1			*Sp. obtusa* Opp.	1
Spiriferina sp. (? *gryphoidea* Uhl.) 1880	2	*Sp. alpina* Opp.	2		
Spiriferina brevirostris Opp. 1861	1	*Sp. brevirostris* Opp.	1		
Spiriferina cfr. *brevirostris* Opp.	2				
Spiriferina sp. ind.	5	*Spiriferina alpina* Opp.	4		
Spiriferina sp. ind.**	1				
"*Terebratula*" cfr. *juvavica* Gey. 1889	5	*Ter. juvavica* Gey.	1	*Ter. juvavica* Gey. *Ter. punctata* Sow. var.	2 3
"*Terebratula*" *ovimontana* Böse	2			*Waldh. baconica* Böckh	2
"*Terebratula*" sp. (aff. *sphenoidalis* Mgh. in Gemm.)	1				
Rhaetina gregaria (Suess) 1854	5			*Ter.* cfr. *gregaria* Suess	4
Glossothyris aspasia (Mgh.) 1853	2	*Ter. nimbata* Opp.	2		
Glossothyris cfr. *aspasia* (Mgh.)	2	*Ter. nimbata* Opp.	2		
Glossothyris sp. [? *aspasia* (Mgh.)]	1	*Waldh. Apenninica* Zitt.	1		
Glossothyris aspasia minor (Zitt.)	1			*Gl. aspasia* Mgh. var. *minor* Zitt.	1
Glossothyris sp. ind.	1				
Glossothyris? sp.**	1	*Ter. Beyrichi* Opp.	1		
"*Waldheimia*" *waehneri* (Gemm.) 1878	1				
"*Waldheimia*" *ampezzana* Schlosser	1	*Ter. Beyrichi* Opp.	1		
"*Waldheimia*" sp. (? *ampezzana* Schlosser)	1			*Waldh.* aff. *apenninica* Zitt.	1
"*Waldheimia*" sp. (aff. *engelhardti* Opp.)	1			*Waldheimia* cfr. *engelhardti* Opp.	1

** Juvenile specimen

G. Vigh	speci-mens	N. Koch (1909)	speci-mens	I. Szabó (1961)	speci-mens
"*Waldheimia*" sp. [aff. *meneghinii* (Par.)]	2			*Ter. rudis* Gey.	2
"*Waldheimia*" sp.	2	*Ter. Uhligi* Gey. *Ter. juvavica* Gey.	1 1	*Ter. juvavica* Gey.	1
Zeilleria? mutabilis (Opp.) 1861	9	*Ter. juvavica* Gey. *Waldh. mutabilis* Opp.	1 1	*Waldh. mutabilis* Opp.	5
Zeilleria? cfr. *mutabilis* Opp.*	1				
Zeilleria? sp. [ex gr. *stapia* (Opp.) — *mutabilis* (Opp.)]	1	*Waldh. mutabilis* Opp.	1		
Kálvária Hill, Pliensbachian s. l.					
"*Rhynchonella*" sp. aff. *glycinna* Gemm. 1874	1				
Glossothyris cfr. *aspasia* (Mgh.) 1853	1	*Ter.* cfr. *aspasia* Mgh.	1		
Pygope adnethensis Suess	1			*Ter. erbaensis* Pict.	1
"*Waldheimia*" aff. *ampezzana* Schloss.**	1	*Waldh.* cfr. *Ewaldi* Opp. sp.***	1		
Csurgókút, Pliensbachian s. l.					
Spiriferina sp.	1				
Glossothyris aspasia (Mgh.) 1853	11	*Ter. aspasia* Mgh.	8	*Ter. aspasia* Mgh.	2
Glossothyris cfr. *aspasia* (Mgh.)	2	*Ter. (Pygope) aspasia* Mgh. var. *Myrto* Mgh.***	2		
Glossothyris sp. ind.	1	*Waldh.* cfr. *apenninica* Zitt.***	1		
Pygope adnethensis (Suess)	1	*Ter. adnetica* Suess***	1		
Pygope sp. [aff. *adnethensis* (Suess)]	1			*Ter. erbaensis* Pict.	1

*** Determination by K. Kulcsár (1914)

in the Carixian Substage. The other 20 specimens deriving, as shown on their labels, mostly from the vicinity of Csurgókút belong, for the most part, to the group of *Glossothyris aspasia* Mgh. Although present in the Sinemurian and not unfrequent in the Hierlatz facies either, *G. aspasia* attains its acme, both in the Apennines and the Transdanubian Central Mountains, in the Pliensbachian and does not extend into the Toarcian. Accordingly, Brachiopoda suggests the presence of the Pliensbachian both at Kálvária Hill and Csurgókút.

Proposal on standard profile and formation name

The fact that Kálvária Hill has been declared a Geological Conservation Area has provided a guarantee that, in the southern, so-called "Redstone Quarry", on the abandoned quarry face trending 78—254°, everybody can study, in a continuous section of more than 100 m length, the continuously sedimented sequence of pink limestones, aphaneritic, intraclastic and, less frequently, intraformationally brecciated, brachiopodal-cephalopodal and sparsely crinoidal. Dipping at 75/11° and totalling 20 m in thickness, a sequence that extends from the Triassic-Jurassic boundary up to the Middle Liassic red crinoidal limestones (Textfig. 19). Representing the Lower Liassic, and frequently the Middle Liassic as well, in the northern part of the Transdanubian Central Mountains, these limestones form a rather extensive, independent formation. The writer proposes to use as type section (i.e. stratotype) the Lower to Middle Liassic sequence exposed well in the quarries of Mt. Pisznice near Lábatlan village. He also proposes to name it Pisznice Limestone Formation.

As far as the Liassic sediments of the areas farther away are concerned, the Pisznice Limestone belongs to the Ammonitico Rosso (Flaserkalk) taken in the broader sense; it is less red than the typical Ammonitico Rosso and it does not include any argillaceous-nodular rock type at all. No manifestation of subsolution and no hardground are available. The afore-listed characteristics and the greater thickness are features distinctive from the Adneth Limestone as well.

Red crinoidal limestone (Pliensbachian)

Review of the relevant literature

L. Lóczy sr. (1906) was the first to point out that the Middle Liassic too could be shown to be present on Tata's Kálvária Hill.

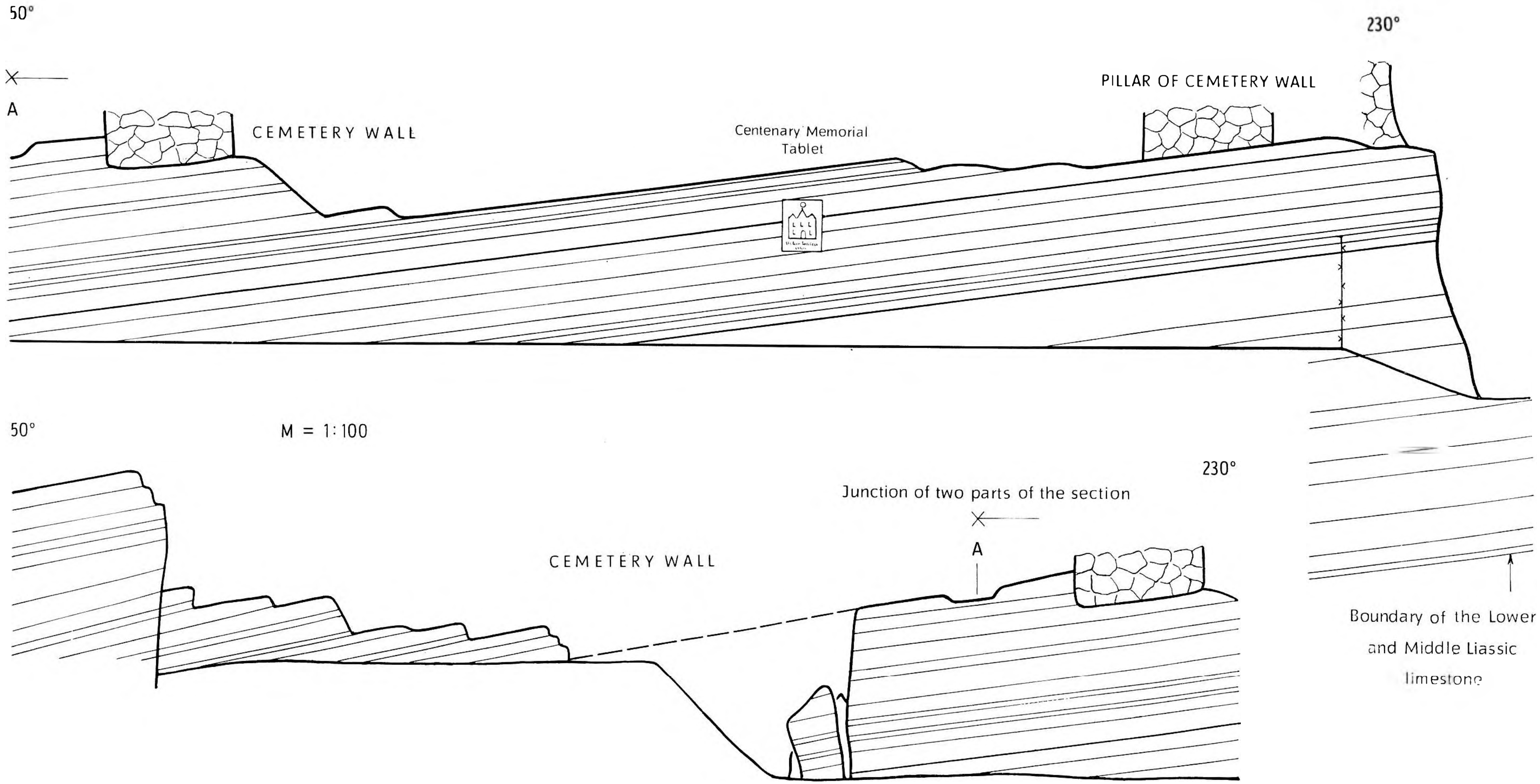
N. Koch (1909) discussed Tata's "dark red crinoidal limestones" in fuller detail. He showed them to occur both on Kálvária Hill and "in the basement of the farm building facing Úri Street" and at Csurgókút. From the last-mentioned outcrop, he even listed fossils he had determined: "*Pecten* sp. (cfr. *P. Ponzii* Gemm.), *Diotis* sp. (cfr. *D. janus* Menegh. sp.), *Terebratula* cfr. *Aspasia* Menegh., *Terebratula* sp. ind., *Spiriferina?* sp. ind., *Phylloceras* sp. (from the group of *Ph. Meneghinii* Gemm.), *Belemnites* sp. ind.". Relying on analogies, he suggested "these strata to indicate the presence of the lower part of the Middle Liassic".

K. Kulcsár (1914), in his work "The Middle Liassic formations of the Gerecse Mountains", also published the results of his revision of Tata's Middle Liassic fauna. In this connection, he listed the following fossils: "*Terebratula adnethensis* Suess, *T. (Pygope) aspasia* Mgh., *T. (Pygope) aspasia* Mgh. var. *myrto* Mgh., *Waldheimia* cfr. *apenninica* Zitt., *W.* cfr. *Ewaldi* Opp., *Pecten* cfr. *cingulatus* Phyllips, *Diotis janus* Mgh. sp., *Posidonomya* sp., *Leda* sp., *Ceromya* cfr. *Batellii* Fuc., *Rhacophyllites* sp., *Phylloceras* sp. (cfr. *Ph. Wähneri* Gemm.), *Lytoceras* sp. (from the group of *L. andax* Mgh.), *Belemnites* sp". Agreeing with N. Koch, he indicated the fauna to be of basal Middle Liassic age, too.

In an adaptation of his paper held at the International Conference on the Mesozoic, Budapest (1961) he complemented his earlier results with new data and statements concerning Tata's Middle Liassic. He stated that "the thick-bedded, red crinoidal limestones with manganese nodules (?) are conformable on the Lower Liassic compact limestones". According to him, "the lower part of the crinoidal limestone sequence does not contain any macrofossil, but the upper part has yielded hosts of fossils: "*Terebratula adnethensis* Suess, *T. punctata* Sow., *T. erbaensis* Pict., *Glossothyris aspasia* Mgh., *Gl. aspasia* Mgh. var. *Myrto* Mgh., *Ceromya* cfr. *batellii* Fuc., *Pecten* cfr. *rollei* Stoll., *P.* cfr. *cingulatus* Phillips, *P.* cfr. *pontii* Gemm., *Avicula (Oxytoma) inaequivalvis* d'Orb., *Posidonia* sp., *Leda* sp., *Belemnites* sp., *Lytoceras* sp. (from the group of *L. andax* Mgh.), *Rhacophyllites* sp., *Phylloceras* cfr. *meneghinii* Gemm., *Ph.* cfr. *wähneri* Gemm.". He noted that the fauna was accompanied by a few poorly preserved representatives of Deroceras. On the basis of the fauna he placed the entire crinoidal limestone sequence in the Middle Liassic Pliensbachian (s. str.) Stage. Unlike N. Koch, he assigned also the manganiferous-cephalopodal beds of Csurgókút to the Middle Liassic, the *Amaltheus margaritatus* and *A. spinatus* Zones of the Domerian. Since B. Géczy dated the fauna recovered from there, as Toarcian we will return to this question later.

Geological features

Characteristic formation of Kálvária Hill is the Middle Liassic (Pliensbachian) red crinoidal limestone (Plate XI, Fig. 3) exposed in the old "Redstone Quarry". Its basal strata can be studied on the quarry face of the Geological Conservation Area above the Lower Liassic limestones, on the intraformationally brecciated final bed of these containing small Fe-Mn nodules (Plate XI, Fig. 2). Its middle part, more than 10 m thick, is exposed in the cliff face beneath Jewish Cemetery. The uppermost beds, overlain by Upper Liassic red nodular calcareous marls can be examined on the unearthed paleorelief above the big fault and in the wall of the fissure occurring there (under the shelter). Their total thickness is 14 to 15 m (Textfig. 24).



Textfig. 24: MIDDLE LIASSIC /PLIENSBACHIAN/ RED CRINOIDAL LIMESTONE. KÁLVÁRIA HILL BESIDE THE CEMETERY WALL

The red crinoidal limestone formation is represented by a rhythmic alternation of calcipelites and calcarenites of a few centimetres thickness and of predominantly crinoidite-calcarenite character. Exception to the rule are only a couple of purely biocalcarenitic (crinoidite) layers in the lower and middle parts of the topmost calcipelitic horizon of 1 to 1.5 m thickness. On the bottom that had become gently sloping the thin calcipelitic calcareous ooze layer was split up into lumps, nodules, totally disintegrated or still more or less contiguous, or it underwent a plastic deformation due to water movement (Plate XVIII, Fig. 1—4). Bedding is distinct, the bedding planes being of stylolitic nature. The sequence of the red crinoidal limestone formation ends with a hardground.

Macrofossils (Brachiopoda and Cephalopoda) are sporadical. The Brachiopoda fauna sampled earlier was revised by G. VIGH (see in the previous chapter). In the relatively higher parts of the substrate, with the progress differentiation of the bottom suspension-feeding crinoids seem to have formed a kind of crinoid lawn interrupted by the deposition of calcipelite as a result of the regular recurrence of some kind of influence. An earlier-sampled ammonite specimen labelled as "Kálvária Hill, beneath the church" was identified with *Fuciniceras* cfr. *pseudofieldingi* (FUCINI, 1904), a Lower Domerian species, by B. GÉCZY.

Synsedimentary fracturing can be recognized in this formation, too. The resulting fissures have been filled with aphaneritic-micritic matter, a phenomenon common in the Lower Liassic.

The analyses of the type specimen of the Pliensbachian red crinoidal limestone are presented in Table 3.

Table 3

Mineralogical, petrographical and geochemical analyses of a type sample of Pliensbachian red crinoidal limestone

Chemical composition (%):

SiO_2	0.45
TiO_2	0.05
Al_2O_3	1.03
Fe_2O_3	0.41
FeO	0.04
MnO	tr
MgO	0.43
CaO	55.02
Na_2O	0.07
K_2O	0.09
$+H_2O$	1.18
P_2O_5	0.01
CO_2	41.78
organic C	0.06
Total:	100.62

Rare elements (ppm):
from the lower (I), middle (II) and upper (III—IV) members of the Middle Liassic sequence

	I	II	III	IV
B	30	30	30	30
Ba	25	150	120	300
Co	15	48	40	32
Cr	10	12	15	13
Cu	12	25	20	20
Ga	2	3	3	2
Mn	120	200	300	320
Ni	48	100	60	74
Pb	26	26	15	10
Sr	360	240	360	420
Ti	100	100	100	100
V	46	15	20	20

Mineralogical composition (%):

Chemo- and biogenic:	
dolomite	95.3
calcite	2.0
hematite	0.4
organic matter	0.1
Total:	97.8
Colloidal:	
illite	1.8
Detrital:	
quartz	0.3
muscovite	0.1
Total:	0.4

Microminerological analyses (specimens):
(0.06—0.2 mm fraction of insoluble residue)

Heavy minerals:	
Magmatic:	
rutile	2
Metamorphic:	
garnet	18
tourmaline	6
Epigenic:	
pyrite	8
limonite	4
Total:	38

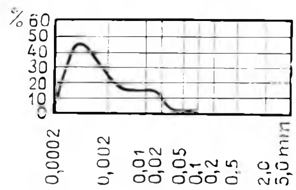
Light minerals:	
Detrital:	
quartz	19
muscovite	7
Chemogenic:	
chalcedony	8
Total:	34

The quartz grains are in a poor state of preservation. Some mineral grains are coated by limonite.

Grain size composition (%) of insoluble residue (2.05%):

0.1 —0.2 mm	0.0	1.3
0.06 —0.1	1.3	
0.02 —0.06	3.6	36.2
0.01 —0.02	16.7	
0.005—0.01	15.9	
0.002—0.005	17.7	62.5
0.000—0.002	44.8	

Granulometric curve:



Specific weight:	2.64
Volume weight:	2.40
Porosity:	10.00%
pH:	8.85
O_{Fe}:	20.5

Thin section examinations

The better understanding of the red crinoidal limestone formation was made possible by the examination of rock specimens sampled at about 5 cm intervals over a continuous section. The results are summarized in Textfig. 25 (in pocket).

The texture is usually composed of biomicrite, less frequently, pelmicrite and intrabiomicrite. Crinoid ossicles are rockforming. Significant fossils are Globochaete, Foraminifera, Silicospongia and Ostracoda tests and skeletal detritus of Echinoidea, Holothurioidea, Brachiopoda, Ammonoidea, Gastropoda and Mollusca (Bositra) (Plates XIX and XX).

The share of *micritic* groundmass in the sequence varies between 9 and 90%. Poorest in the lowermost 3 m, it attains there a maximum of 44%, a minimum of 9% and an average of 20%. In the 3—4 m interval the micrite content is high as compared to the over- and underlying strata: a maximum of 46%, a minimum of 25% and an average of 40%. In the 4—11 m interval it shows a moderate trend of increase as compared to the basal horizon: the average is 25%. The uppermost beds of the red crinoidal limestone formation are characterized by a high micrite content: a maximum of 90%, a minimum of 16% and an average of 50%.

Lumps belonging to the group of *intraclasts* are tiny allochemical components (Plate XIX, Fig. 8) varying between a tenth of mm and 1 mm or so in diametre. These have originated from semi-consolidated lime-mud. Their quantity is usually low, though in some samples they account for 25% of the rock texture. They can be observed in almost all samples recovered from the basal two metres of the sequence, where their highest abundance is 25%, the average being 5—6%. In the 6—9.5 m interval they are present in the half of the samples, varying in quantity between 0 and 20% with an average of 2—3%. Finally, the samples of the 10.7—11.3 m interval contain them in 0 to 10%.

Pellets are oval allochems of tenth of millimetre size and of distinct outline contrasting with their darker colour against the lighter groundmass (Plate XIX, Fig. 9). It is mainly in the lower part of the sequence that they are characteristic of texture. The maximum of their abundance is 35%, though the value of 20% is often attained in the lower third of the sequence. Their diametre is 0.1 mm. In the lowermost 6.5 m their quantity is considerable, in the 6.5 to 13 m interval it is subordinate, and above 13 m no pellet can be found.

Fossils or their *detritus* are the most significant allochemical components of the rock texture. Their quantity varies between 10% and 90%, their size does usually so between 0.1 and 1.2 mm, though in some samples a sharply individualized fine fraction can also be observed which is difficult to distinguish from the groundmass and for which the systematic position of the source material cannot even be specified. In the lowermost 3 metres the quantity of fossils is high: a maximum of 75%, a minimum of 30% and an average of 55 to 60%. In the 3 to 4 m interval they occur in comparatively lower quantity: a maximum of 50%, a minimum of 27% and an average of 35%. In the 4 to 11 m interval the fossil content is considerable, with an average of about 60%. Above 11 m it is relatively low: 40 to 50% on the average, to decrease then upwards and stabilize at about 20% at the top.

Sparite is represented primarily by continued growth around fossils, respectively it is due to the recrystallization of these (Plate XIX, Fig. 3, 5; Plate XX, Fig. 1, 2, 5—9). (Porefilling, cement-like sparite is practically absent.) The maximum of sparite is 25%. A general trend is the upward decrease of the quality of sparite. In the basal 3 metres sparite is considerable. Between 3 and 12 m it can be found in low quantity. Above 12 m no sparite component is available.

Analysis of the quantitative distribution of fossils:

The skeletal elements of echinoderms are usually predominant faunal elements, being represented mainly by crinoid fragments, less frequently by fragments of echinoids and holothurioids (Plate XIX, Fig. 1—6, Plate XX, Fig. 9). Varying in size between 0.1 and 1.3 mm, they hardly show the slightest degree of attrition. 20 to 750 specimens could be counted in 1 cm^2. This quantity showed the following distribution: from 0 to 4 m a maximum of 530, a minimum of 70 and an average of 250 to 300 specimens; from 4 to 9.5 m a maximum of 750, a minimum of 140 and an average of 400; in the topmost member a maximum of 590, a minimum of 20 and an average of 200 to 250 specimens with markedly decreasing upward trend.

Remnants of Globochaete could be observed in the greater part of the thin sections. In the lower two-thirds they are sporadical, being available in low quantities: attaining a maximum of 50 specimens per cm^2. From 9.1 to 10.3 m they are totally absent. Above 10.3 m their quantity becomes considerable.

Foraminifera are represented by benthonic forms (Plate XX, Fig. 3). Although not abundant, 0 to 40 specimens per cm^2, they can be found in 90% of the samples. They form an assemblage less diversified as compared to the Lower Liassic foraminiferal fauna. Large and thick-walled forms are frequent. The genus Lenticulina is predominant. The genera Nodosaria and Pseudonodosaria (Rectoglandulina) are also frequent. *Frondicularia brizaeformis* is a species of comparatively uniform distribution. Frequent in the Lower Liassic, the genera Ophthalmidium and Trocholina are very unfrequent in the red crinoidal limestone formation.

Sponge spicules are confined to the upper part of the sequence, where they can be found in considerable quantity: a maximum of 140 specimen per cm². They are constituted by calcite in all of the cases.

Tiny (embryonic) brachiopods are characteristic of the 6.5 to 8.2 m interval, being sporadical elsewhere. Their highest abundance falls in the 7.8 to 8.2 m interval where they attain the 30 specimens per cm² figure.

Bositra sections are characteristic of the 9.3 to 12.5 m interval. Between 9.3 and 9.5 m they attain 60 specimens per cm².

Small gastropod shells too occur in the upper third of the sequence (Plate XX, Fig. 1). Their quantity is a maximum of 40 specimens per cm².

Unidentifiable mollusc shell detritus can be observed similarly in the upper part of the sequence (Plate XX, Fig. 2), their maximum being 50 specimens per cm².

Ammonites are represented partly by embryons, partly by adult specimens (Plate XX, Fig. 2, 8). In the 1.1 to 1.9 m interval mainly the adults are enriched, with a maximum of 50 specimens per cm². In the upper part of the sequence the embryonic forms are represented by relatively few specimens, but in a rather steady quantity.

Ostracods can be observed in almost all samples (Plate XX, Fig. 5). They show an uneven quantitative distribution. Their highest abundance varies rhythmically between 5 and 100 specimens per cm².

Correlation of constituents:

Leaving aside evident correlations (e.g. the inverse correlation between micrite- and fossil content), let us point out just a few characteristic relationships such as the opposite frequency trends of pellets and intraclasts, the parallel increase of Globochaete specimens and micrite content as well as the coincidence of brachiopod and crinoid maxima.

Subdivisions of the sequence:

On the basis of studying thin sections, rock texture, with microscope the Middle Liassic red crinoidal limestone sequence can be split up into three parts:

The *lower part* extends from 0 to 4 m. The texture consists of biomicrite, biointramicrite and biopelmicrite. The micrite content is low to mean (9—50%), the share of fossils is mean to high (25—75%), the quantity of pellets or intraclasts is considerable (attaining even 20% in many cases), that of sparite being subordinate. The quantity of crinoid ossicles varies between 70 and 530 specimens per cm², that of Globochaete between 0 and 18, that of Foraminifera between 6 and 20, that of the ostracods between 0 and 18. Molluscs and in the bulk of the strata of ammonites are scant, but the only definitely ammonite-rich bed occurs here, too. Sponge spicules, Brachiopoda, Bositra and Gastropoda could not be observed at all.

The *middle member* extends from 4 m to 9.5 m. It is characterized by a poor to medium micrite content (10—45%), and a medium to rich fossil content (15—80%). The role of intraclasts increase up in the profile. Sparite is subordinate. This is where the quantity of crinoid ossicles attains its maximum: 550 to 600 specimens per cm². Globochaete are sporadical, Foraminifera can be observed regularly in poor to medium quantities. Sponge spicules occur just exceptionally. This member is where brachiopods occur in considerable quantity. Mollusc shell fragments and detritus of Bositra, gastropod and ammonite tests occur sporadically. It is at the base and the top of this member that ostracods can be observed in considerable quantities.

In the *upper member* (between 9.5 and 14.5 m) the micrite content is mean to high, showing an increase upwards. The fossil content shows an opposite trend of variation. Intraclasts and pellets are insignificant, sparite being hardly observable. The quantity of crinoids is medium to poor, showing a marked decrease upwards. Globochaete become significant, showing an upward increase. Foraminifera too attain their highest abundance in this member. Bositra gain some significance at the base, sponge spicules at the top of the member. Mollusc shell fragments and gastropod remnants have their greatest share here, too. Ostracods are available in medium to high quantities.

The quantitative determination of textural elements and the comparing of the results of measurements were performed, according to uniform principles, by J. Haas and E. Edelényi.

Stratigraphy

In the lithostratigraphic sense the red crinoidal limestone may be considered a formation. As far as its lithological features are concerned, it is only the topmost part that shows some difference, but this does not account for the establishment of a formation. On the basis of its lithological characteristics visible to the naked eye it would be difficult to split it up into minor units. The afore-mentioned, topmost part can be separated as independent member.

The Middle Liassic red crinoidal limestone occurs in patches of varying size in the Transdanubian Central Mountains. The sequence exposed on Tata's Kálvária Hill is proposed to be its type section. The name proposed for it is Törökbükk Limestone on the basis of the typical development of the crinoidal limestones uncovered in Törökbükk quarry.

From the biostratigraphic viewpoint, only a poor Brachiopoda fauna and the quantitative ratios of crinoid ossicles and Lenticulina specimens can be relied on. Chronostratigraphically, an evidence to rely on is provided by the fact that the age of both the over- and underlying formations could be determined and by the presence of *Fuciniceras* cfr. *pseudofieldingi* (FUCINI, 1904), a form indicative of the Domerian, and by the brachiopod fauna recovered.

The Brachiopoda fauna of the Pliensbachian is very poor. The available material collected for decades consists of 21 specimens representing 5 species. As a result of a revision by G. VIGH, what had been determined and published as *Waldheimia* cfr. *ewaldi* OPP. sp. by K. KULCSÁR (1914) proved to be juvenile individuals of "*Waldheimia*" aff. *ampezzana* SCHLOSS., while *Waldheimia* cfr. *apenninica* ZITT. was found to be a *Glossothyris* sp. ind. From the chronostratigraphic viewpoint, it is the species "*Rhynchonella*" *glycinna* GEMM. and *Pygope adnethensis* SUESS that are of greatest importance, being known, at the present state of knowledge, exclusively from the Middle Liassic. *Glossothyris aspasia* MGH. reached its greatest expansion in the Pliensbachian, but in the Transdanubian Central Mountains and the Alps it can be found in the Lower Liassic as well. Although described from the Middle Liassic, "*Waldheimia*" *ampezzana* SCHLOSS. is not unfrequent in the Lower Liassic either.

Of course, the chronostratigraphic boundaries considered to agree with lithostratigraphic and subordinate zonal boundaries are of only an approximate accuracy. Their significance, however, is emphasized by their coincidence with extensive diastrophic movements on the Lower-Middle Liassic and the Middle-Upper Liassic boundaries.

Red nodular calcareous marls (Toarcian)

Review of the relevant literature

The data the author could find in the literature on Tata's Upper Liassic are very scant and obscure.

Although L. LÓCZY SR. (1906) had referred to the presence of the Upper Liassic, he had not produced any evidence to support his statement.

Remarkably enough, N. KOCH (1909) did not even mention the Upper Liassic in his work. He considered to be Lower Dogger the "brownish-red, nodular limestones" he had observed to form minor patches above the Middle Liassic crinoidal limestones.

I. SZABÓ (1961) described "Upper Liassic (Toarcian-Aalenian) clayey, nodular, laminated" limestones from which he listed the following rich fauna: "*Lytoceras rasile* VAC., *L.* cfr. *francisi* OPP., *Hildoceras* cfr. *pectinatum* MGH., *H. bifrons* BRUG., *Frechiella kammerkarensis* STOL., *Leioceras opalinum* REIN., *Dumortieria* cfr. *levesquei* D'ORB., *D.* sp., *Erycites* sp., *Phylloceras mediterraneum* NEUM., *Ph. baconicum* HANTKEN et PRINZ, *Ph. nilssoni* HÉB. var., *Ph. szabói* PRINZ, *Ph. ultramontanum* ZITT., *Pleydellia aalenensis* BUCK., *Ludwigia* cfr. *murchisonae* SOW., *Hammatoceras* cfr. *planinsigne* VAC., *H.* sp.". The faunal assemblages of the two stratigraphic stages could not be separated from each other because of the inaccuracy of sampling.

Geological features

The Upper Liassic red nodular calcareous marls can be readily examined on the face of the big normal fault traversing the Geological Conservation Area as well as on the uncovered rock surface, at the upper level of the Conservation Area and in the large fissure unearthed there (Plate XI, Fig. 4). Their thickness is as low as 60 to 80 cm. Their geological development is uniform, being readily

Table 4

Mineralogical, petrographical and geochemical analyses of a type sample of Toarcian red nodular calcareous marls

Chemical composition (%):

	from intranodular matrix:	from nodules:	
SiO_2	17.46	12.89	5.30
TiO_2	0.24	0.14	0.12
Al_2O_3	4.94	3.69	2.09
Fe_2O_3	2.12	1.48	1.06
FeO	0.10	0.11	0.04
MnO	0.18	0.18	0.14
MgO	1.04	2.76	0.26
CaO	39.03	40.93	50.26
Na_2O	0.10	0.11	0.06
K_2O	1.74	1.44	0.04
$-H_2O$	0.52	0.26	—
$+H_2O$	2.96	1.76	1.87
P_2O_5	0.07	0.04	0.06
CO_2	29.42	33.65	38.58
SO_3	0.08	0.11	0.05
Total:	100.00	99.55	99.93

Rare elements (ppm):

B	50
Ba	250
Co	22
Cr	20
Cu	6
Ga	6
Mn	1800
Mo	10
Ni	34
Pb	20
Sr	200
Ti	300
V	15

Mineralogical composition (%):

Chemo- and biogenic:	
calcite	86.7
dolomite	1.2
hematite (limonite)	1.1
pyrite	0.1
organic matter	0.1
Total:	89.2
Colloidal:	
illite	6.0
kaolinite	1.5
Total:	7.5
Detrital:	
quartz	1.0
feldspar	0.2
Total:	1.2

Microminerałogical analyses (specimens):

Heavy minerals:

Magmatic:	
hypersthene	2
diopside	3
rutile	1
Metamorphic:	
andalusite	1
actinolite	8
disthene	1
garnet	40
epidote	12
zoisite	2
tourmaline	1
chlorite	3
Epigenic:	
pyrite	26
Total:	100

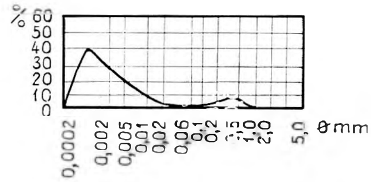
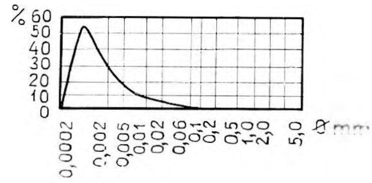
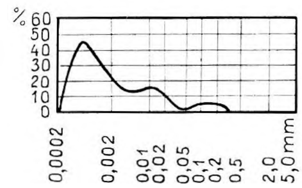
Light minerals:

Detrital:	
quartz	59
orthoclase	12
plagioclase	19
muscovite	10
Total:	100

Light mineral fraction represents 98.04 weight % of the insoluble residue.

Quartz grains are fresh, slightly rounded at the angles.

Specific weight:	2.75
Volume weight:	2.50
Porosity:	10.00%
pH:	8.13
O_{Fe}:	53.00

Grain size composition of insoluble residue (%): from intranodular matrix:			from nodules:				Granulometric curves:
			(a)		(b)		of matrix:
0.5 —1.0 mm	0.0	6.4	0.0	0.0	0.0	1.7	
0.2 —0.5	5.9		0.0		0.3		
0.1 —0.2	0.3		0.0		1.0		of nodules:
0.06 —0.1	0.2		0.0		0.4		
0.02 —0.06	4.4	26.8	3.5	22.2	1.6	35.4	
0.01 —0.02	8.7		6.9		17.3		
0.005—0.01	13.7		11.8		16.5		
0.002—0.005	20.5	62.8	20.6	73.6	19.2	62.9	
0.000—0.002	42.3		53.0		43.7		

delimitable both at the base and the top. Their footwall is a hardground. The red clayey, limestone-noduled facies indicates an extremely low rate of sedimentation, condensed and characterized by continuous dissolution of calcium carbonate. The relevant mineralogical, petrographical and geochemical analyses are shown in Table 4.

Thin section examinations

As shown by the examinations of thin sections, the Upper Liassic calcareous marls are of micritic, subordinately pelletic, sparry texture. Quartz grains 5 to 35 μ in diametre are frequent (0 to 100 specimens per cm²). The fossils are not rockforming, their quantity is substantially lower than in the Lower and Middle Liassic:

The frequency of *Globochaete* specimens, usually broken-corroded, varies between 1 and 90 per cm². The representatives of *Cadosina* measuring 14 to 23 μ seem to represent two new species. One is characterized by a thin (1.5 to 4 μ), ring-shaped test-wall, glass-like translucent, having a sharp inner contour (Plate XXI, Fig. 3). The other form differs from the former by its thicker wall (4—8 μ). The shell wall consists of very thin radial fibres. The frequency of Cadosina is 0 to 10 specimens per cm². *Foraminifera* are very scarce, just a few specimens could be observed. The frequency of *sponge* spicules is 10 to 90 specimens per cm². *Thin mollusc shells*, identified as *Bositra* occur with a frequency of 5 to 120 specimens per cm² (Plate XXI, Fig. 5—6). *Other mollusc remnants* occur with a frequency of 0 to 30 specimens per cm² (Plate XXI, Fig. 7—9). Elements of *ammonite* and *gastropod* tests could be recognized with 0 to 10 specimens per cm² frequency (Plate XXI, Fig. 4, 6—9). Less frequently though, skeletal detritus of *echinoderms* can also be found (1—20 specimens per cm²). Occasionally, a few juvenile *brachiopods* and *ostracods* could also be observed.

M. Sidó analyzed the w a s h i n g r e s i d u e of the red nodular calcareous marls. She found skeletal elements of crinoids (calice, stem ossicles, cyrus fragments, crooks), some echinoid needles and skeletal detritus, a couple of ammonite embryons and mollusc shell fragments, a number of different fish teeth and ostracod valves. In addition she determined some radiolarians and many foraminiferal specimens.

The foraminiferal assemblage is rather rich, though not diversified; the genera of the Nodosaridae family that predominate. The representatives of Nodosaria, Dentalina, Lenticulina, Astacolus, Marginulina and Lingulina are present in greater number. A couple of Euguttulina can also be observed. In heavily recrystallized material the following species could be identified: *Nodosaria tenera* Franke, *N. simplex* (Terquem), *N. candela* Franke, *N.* sp., *Dentalina integra* (K. et Zw.), *D. pseudocommunis* FRANKE, *D. subulata* FRANKE, *D. varians* TERQUEM, *D.* cfr. *nodigera* TERQUEM, *D. glandulinoides* FRANKE, *D.* sp., *Pseudonodosaria* sp., *Lingulina* sp., *Marginulina simplex* (TERQUEM), *M.* cfr. *dumortieri* TERQUEM, *M.* sp., *Frondicularia* sp., *Astacolus* cfr. *plebeia* TERQUEM et BERTHOLIN, *A. pulchra* TERQUEM, *A.* cfr. *matutina* D'ORB., *A.* cfr. *antiquata* D'ORB., *Lenticulina varians* BORN., *L. convoluta* BORN., *L. metensis* TERQUEM, *L. gottingensis* (BORN.), *L.* sp., *Eoguttulina simplex* (TERQUEM), *E.* sp., *Spirilina* sp., *Ammodiscus* sp.

Of the macrofossils only ammonoids are contained in the Upper Liassic red nodular calcareous marls. These are internal moulds unshelled and usually complete. They occur rather frequently, though only a poor material could so far be recovered because the fossiliferous localities are of difficult access and the gangue is of faint thickness. Out of the fauna made him available, B. GÉCZY has determined the following species: *Holcophylloceras* sp., *Calliphylloceras* sp., *C.* cfr. *mediojurassicum* PRINZ, *Lytoceras* cfr. *rasile* VACEK, *Erycites* cfr. *subquadratus* GÉCZY, *Polyplectus pluricostatus* (HAAS), *Hammatoceras* sp., *Frechiella* sp., *Pseudomercaticeras* sp., *Paroniceras* sp., *Pleydellia* sp., *Dumortieria* sp.

Stratigraphy

Lithostratigraphically, the Upper Liassic red nodular marls, in spite of their low thickness, may be regarded as an independent formation. In the northern Transdanubian Central Mountains they are of largest extension of all Upper Liassic formations. The present writer proposes to designate the quarry at Kisgerecse as its type section and to name it Kisgerecse Marl Formation.

Chronostratigraphically, according to B. GÉCZY's opinion, *Polyplectus pluricostatus* is frequent in the Middle Toarcian (*Bifrons* Zone) of the Bakony area. In addition, the Upper Toarcian *Phymatoceras erbaense* Zone is likely to be present and the presence of the *Dumortieria meneghinii* Zone, coming next to the former, can be certified.

The *Phymatoceras erbaense* Zone is indicated by *Pseudomercaticeras* sp. and *Paroniceras* sp. *Frechiella* sp. belongs either to the lower part of the *Erbaense* Zone or it may possibly represent the *Hildoceras bifrons* Zone. DONOVAN (1958) believes that *Pseudomercaticeras* characterizes the lower part of the *Erbaense* Zone, *Paroniceras* its upper part.

The presence of the *Dumortieria meneghinii* Zone is certified by *Dumortieria* sp. and *Pleydellia* sp. These are predominant elements of the fauna. Despite the lack of a more precise determination, a close connection with the *Dumortieria* and *Pleydellia* fauna of the same zone of Tűzkövesárok ravine at Csernye can be shown to exist. The species *Erycites* cfr. *subquadratus* GÉCZY, *Erycites* sp. and *Hammatoceras* sp. also seem to have been recovered from the Upper Toarcian.

Csurgókút Limestone (Toarcian)

Review of the relevant literature

N. KOCH (1909) described as "Upper Dogger manganiferous limestone" the sequence overlying the Middle Liassic limestones, "observable on the left side of the path leading down to Csurgókút, on the 'Tanoda' Square (now Április 4 Square)". "In the lowermost part a pink limestone showing a compact texture in thin section with traces of manganese can be found. Next to follow is a kind of equally pink rock densely dotted with manganese grains which shows a very rich microfauna in thin section. Higher in the profile there is a uniformly grey, compact limestone owing its colour to densely packed manganese grains quite distinct in thin section; finally, the top is occupied by a brick-red, compact limestone entirely impregnated with manganese and locally quite black because of its high manganese content. The total thickness of the strata is an estimated 1 1/2 to 2 m". On the basis of the species which he determined as *Phylloceras disputabile* ZITT. and *Lytoceras* cfr. *Adeloides* KUDERN. he assigned the beds at Csurgókút to the Upper Dogger.

I. SZABÓ (1961) assigned "the dark grey, brick-red or purple limestones of conchoidal fracture with manganese dendrites of 1 to 3 per cent Mg content" "to the Domerian Stage of the Middle Liassic": the *Amaltheus margaritatus* and *A. spinatus* Zones. Beside lamellibranchs, gastropods and brachiopods sampled from the topmost manganiferous strata, he determined the following ammonite fauna: "*Lytoceras sutneri* GEYER, *L. spirorbis* GEMM., *Grammoceras varicostatum* FUC., *G. celebratum* FUC. var. *italica* FUC., *Polyplectus pluricostatus* HAAS, *Pleuroceras* cfr. *spinatum* BRUG., *Phylloceras* sp., *Hildoceras lavinianum* MGH., *Harpoceras* cfr. *algovianum* OPP., *Coeloceras italicum* MGH."

Geological features

The exposure is on the high western shore of Lake Öreg, at the lake facing the corner of Április 4 Square in front of the Apprentice's Hostel, north of Csurgókút spring.

Above the Middle Liassic red crinoidal limestones there is, in a few metres thickness, a Lower Toarcian sequence of peculiar development, pinching out lenticularly, which has not been overlooked by earlier workers, but whose stratigraphic position was determined erroneously (Textfig. 26: in pocket, and Plate XXII).

The Lower Toarcian sequence is separated from the Middle Liassic by a thin layer of clay overlain by a total of a metre and a half of limestone gradually pinching out. This has nodular and intraformational breccia structure with the characters of "slumping". Its colour is brown at the base and dark grey at the top. Above it there are 30 to 50 cm of dark grey limestone (stained by Fe and Mn-oxide) in which a netlace of flat-to-curved syngenetic fissures, filled with red calcipelitic (biomicritic) limestone, can be observed. Along the contact with the intraformational breccia underneath, Mn dendrites can be found.

In the upper part of the sequence an alternation of rock lenses with Bositra and ammonites with brick-red, compact limestones can be observed. At the very top the sequence ends with a thin layer of purple-red intraformational breccia and, above it with a red cephalopodal limestone surrounded by grey manganiferous or Mn-mottled limestones. The surface of the cephalopodal limestone and of the topmost grey limestone carries a thick Mn-oxide crust. The Mn-oxide crust and the dissolved ammonites of the paleorelief testify to the presence of a hardground.

The Lower Toarcian Csurgókút Limestone Formation is overlain — with the lack of the Upper Liassic and the Lower Dogger — by Bathono-Callovian chert beds.

On the basis of thin section examinations, Csurgókút Limestone Formation can be split up into two different parts. The lower part is constituted by limestone beds, nodular and intraformationally brecciated with Fe- and Mn-oxides and by limestones showing thin, flat-to-curved fissure fills. The limestone is made up, for the most part, of well-sorted calcitized shell fragments, 15 to 30 μ in size (these seem to be unknown, tiny calcareous fossils) (Plate XXIII, Fig. 9—10) with Fe- and MnO mottles. In subordinate number single echinoid needles and thin mollusc shell fragments could be observed. In the upper part of the sequence there are sediments of micritic and biomicritic texture with Fe-, and Mn-oxide mottles atop. Biogenic skeletal elements: Cadosina, Bositra, detritus of ammonites, large crinoid elements, gastropod shells, ostracod valves, brachiopod embryons, large and thick-walled benthonic foraminiferal specimens and subordinate sponge spicules (Plate XXIII, Fig. 2—8).

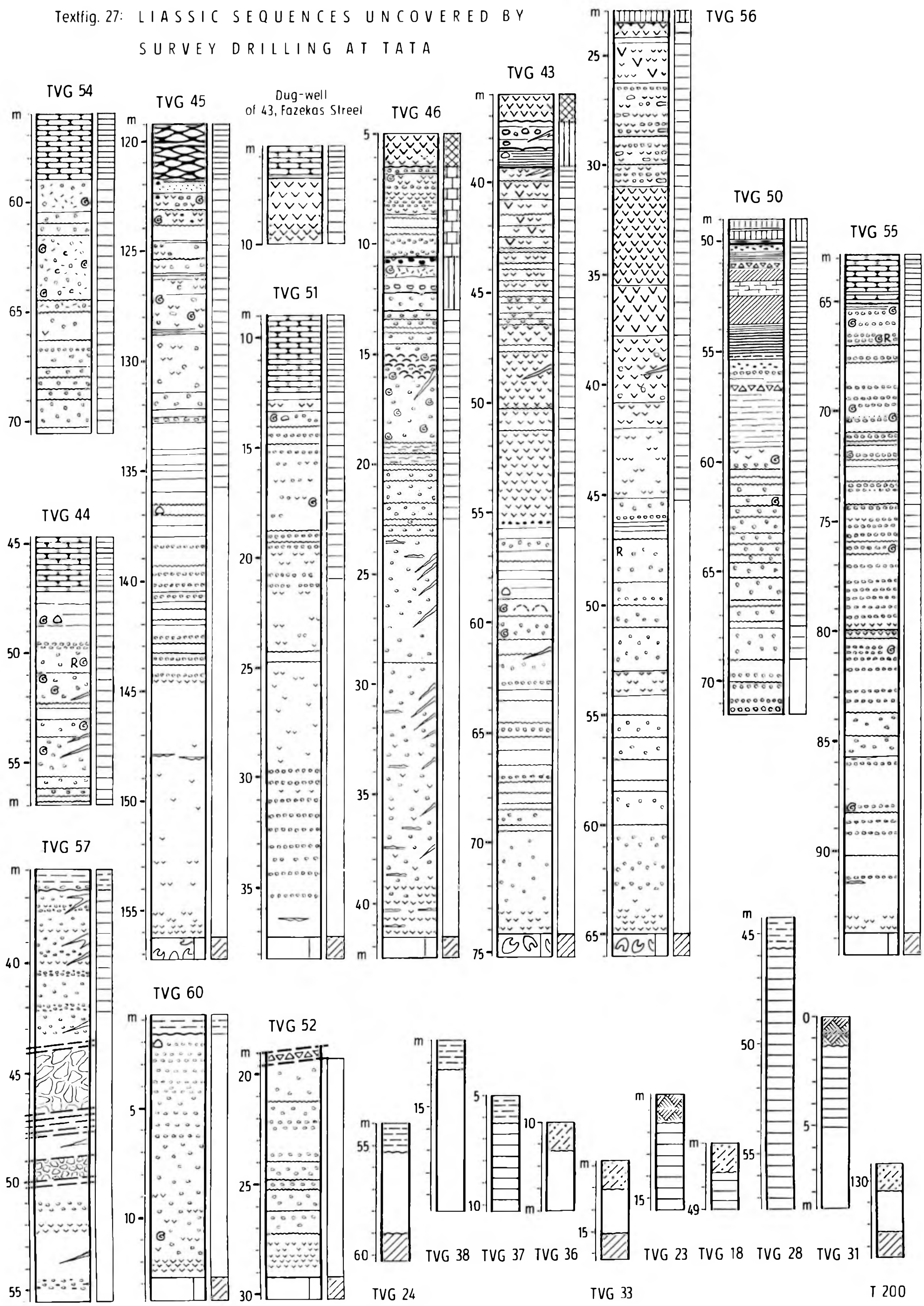
From the red cephalopodal limestone occurring in the upper part of the sequence (the same limestone yielded the earlier ammonite collection of Csurgókút), a fauna suitable for stratigraphic determinations was collected. The material was processed paleontologically and biostratigraphically by B. Géczy who determined the following species: *Calliphylloceras* sp., *Lytoceras* sp., *Dactylioceras* s. l. sp., *Polyplectus* cfr. *pluricostatus* Haas 1913, *Harpoceras?* sp., *Harpoceratoides* sp., *Hildaites serpentiniformis* Buckman 1923, *H.* sp. aff. *borealis* (Seebach 1864) (Plate XXIII, Fig. 1), *H.* sp., *Orthildaites* sp.

Stratigraphy

On account of its specific features of development, the Csurgókút sequence is regarded as an independent formation. It is characterized by the Fe- and MnO-content; the lenticular mode of occurrence; the intraformationally brecciated-nodular development of some limestone strata and beds; the interbedded cephalopodal limestone layer; the abundantly microfossiliferous rock lenses and layers and the Mn-coated hardgrounds. Type locality of the formation is the sequence exposed at Tata's Csurgókút spring. The name proposed for it is Csurgókút Limestone. Its thickness at the type locality is less than 4 m. The biostratigraphic position of the upper part of the formation is indicated by the determined cephalopod fauna to correspond to the middle part of the Lower Toarcian: the *Serpentinus* (= *Falcifer*) Zone. The formation as a whole may include the lower part of the Lower Toarcian as well (*Tenuicostatum* Zone?).

The genetical circumstances of the Csurgókút Limestone are difficult to reconstruct. What can be ascertained is that, together with the Central Mountains Lower Toarcian Mn-containing horizon, its origin was connected with that "break" in evolution which took place at the Middle and Upper Liassic boundary. That "break" stopped the continuous Lower and Middle Liassic limestone sedimentation that was characterized by a rich benthonic fauna; and it was followed by an episodic and ephemeral deposition of limestones and marls with gaps and with higher percentages of nektonic and planktonic fossils and by the development of Mn-oxid-containing sediments. This phenom-

Textfig. 27: LIASSIC SEQUENCES UNCOVERED BY SURVEY DRILLING AT TATA

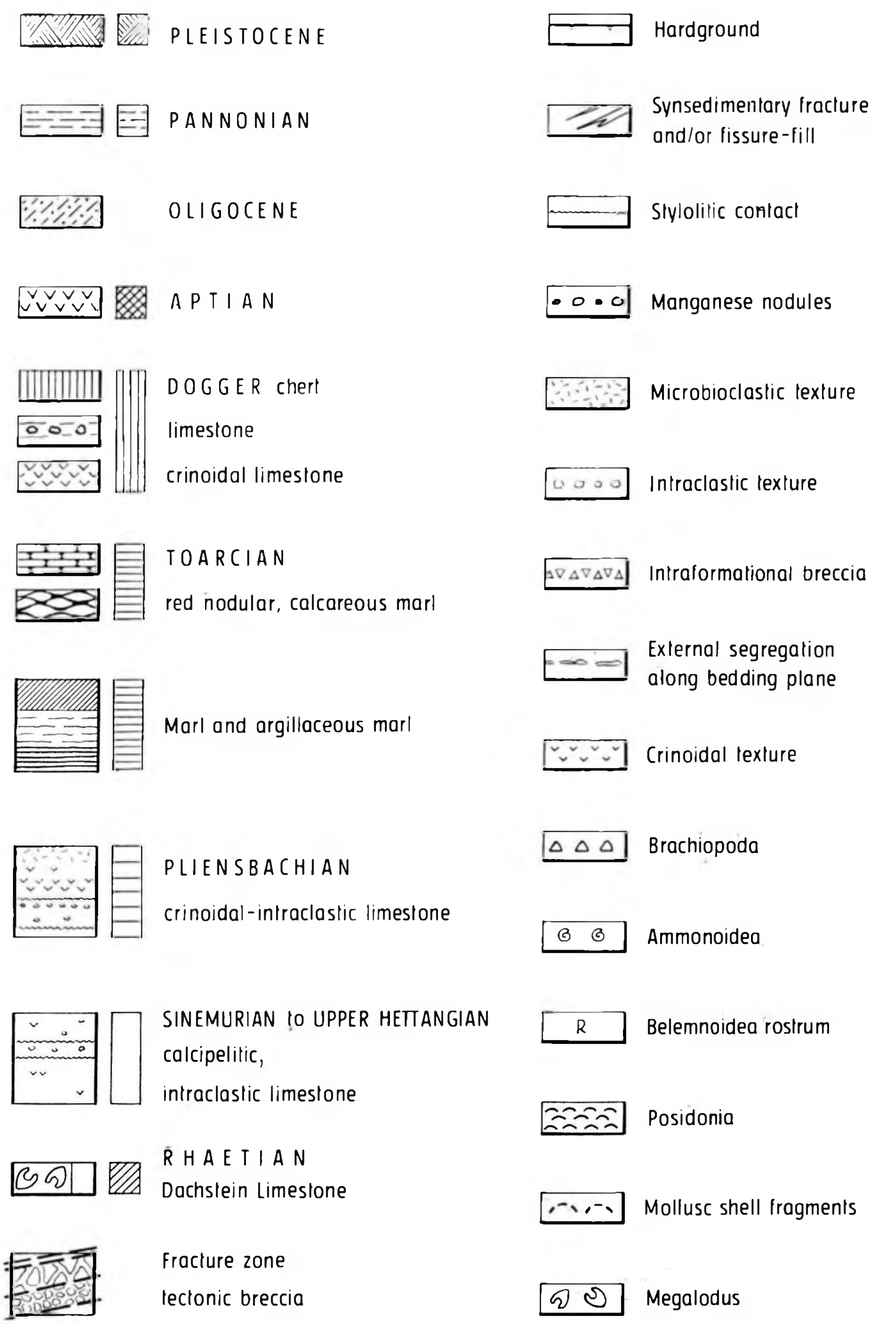


enon cannot be explained satisfactorily by the increasing rate of subsidence or by a pronounced differentiation of sea bottom morphology. As for the hypothesis of volcanic effects suggested by many authors, no direct evidence thereof is available in the area under consideration.

Liassic sequences uncovered by drilling

In the vicinity of Tata many shallow and a few deeper boreholes have intersected Liassic sediments. The lithological logs of six of these comprise the complete sequence of the Liassic (TVG-43, -45, -46, -51, -55, -56). In three additional boreholes (TVG-44, -50, -54) and in the dug-well of

LEGEND to Textfig. 27



a property, 43, Fazekas Street, the whole Upper Liassic and smaller or greater part of the Middle Liassic underneath have been cut. In five more boreholes (TVG-24, -33, -52, -60 and T. 200) a part of the Lower Liassic and below it the Dachstein Limestone of the Rhaetian have been uncovered. Seven boreholes (TVG-18, -23, -28, -31, -36, -38, -57), after crossing Tertiary formations, have penetrated into Middle or Lower Liassic limestones and have stopped within these (Textfig. 27).

Relying on twenty-two Liassic logs, the Liassic standard sections exposed or uncovered on Kálvária Hill and at Csurgókút and a couple of minor outcrops, the present writer has drawn the conclusion that the initial monotony and uniformity of Liassic sedimentation had changed into a progressive and rhythmical differentiation of facies.

The pink to yellowish-pink (skin-coloured) *limestone* exposures and outcrops of the Lower Liassic show the highest degree of similarity. At the very base a fairly crinoidal limestone bed is usually well-recognizable; then an alternation of aphaneritic and microbioclastic members will follow with internal and external segregations. Proceeding up in the vertical section, one observes the intraclastic nature of the texture to become gradually more and more conspicuous. The scarce macrofauna and the microfossils observable in thin section agree in composition (Textfig. 28: in pocket). Synsedimentary fractures, filled with mostly aphaneritic (micritic) limestone, are characteristic. The thickness of the Lower Liassic pink limestones can be estimated to be 19—20 m in five cases and 16—17 m in two cases. The uncertainty is due to difficulties in separating the Lower and Middle Liassic limestones of similar facies.

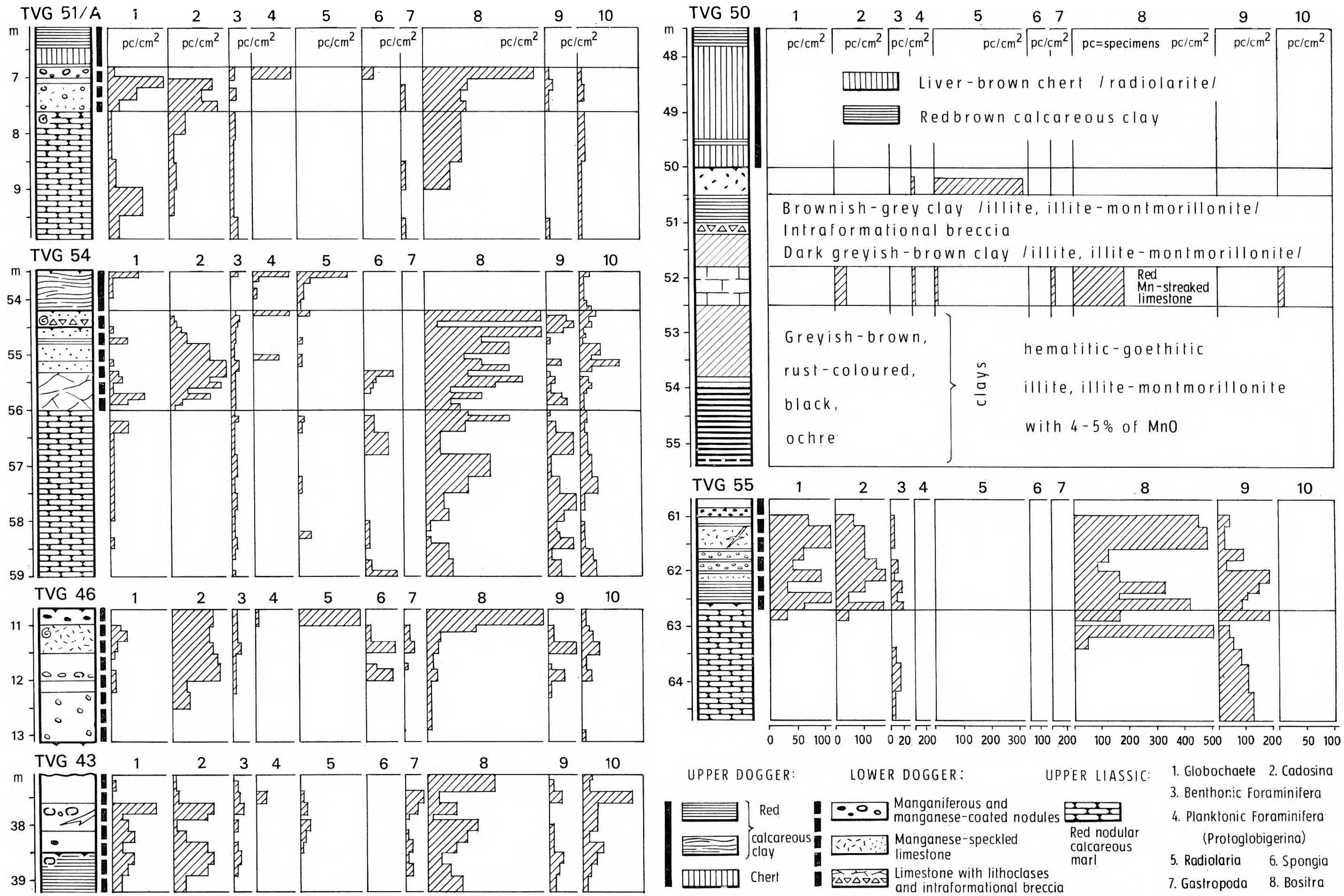
The Middle Liassic can be subdivided basically into two facies areas. In the larger area the formation of Lower Liassic *pink limestones* continued during the Middle Liassic. Gradual changes can be shown to have been manifested by the intensification of intraclasticity, by occasional interbedding of intraformational breccia layers, by the abundance of Fe-Mn-oxide-coated lime lumps and by the higher microbioclast content as well as by the relatively greater number of brachiopods and cephalopods. The thickness of the Middle Liassic pink limestones varies between 9 and 16 m. Most of the uncovered sequences belong to this type of facies. On Kálvária Hill and its immediate vicinity as well as farther north up to Csurgókút and to the abandoned synagogue, the Middle Liassic is represented by *pink crinoidal limestones* (Textfig. 27 and 30). Their thickness is 16 to 20 m.

It is the Upper Liassic formations that show the most remarkable differences in development. The *red nodular calcareous marls* are of comparatively greater and more common distribution. This formation overlies the Middle Liassic limestones with a strikingly different lithological composition, resting on a hardground which is occasionally quite distinct. Its thickness varies between 0.5 and 2.5 m and gradually decreases to the east. The top of the red nodular marl sequences of higher thickness (above 1.5—2 m) (TVG-44, -45, -51, -54 and possibly TVG-55 too) may even represent still the Lower Dogger (Aalenian).

Reduced in extension and showing rapid changes in development, the formation of the Upper Liassic comprises *iron- to manganese-oxidiferous clays, iron-manganese-coated hardgrounds and limestone beds of peculiar development separated by considerable hiatuses.* This N—S trending facies zone extends from Schönherz Street through the foregrounds of the Grammar School and Csurgókút spring up to Tata Castle's Mesozoic basement horst. The relevant results of investigations have been presented in the chapter entitled the Csurgókút Limestone and in Textfig. 29.

The examination of the Liassic sequences uncovered over an area of about 4 km^2 has called the author's attention to the fact that the differentiation of the bedrock must have greatly advanced during the Liassic. This differentiation led in the Middle Liassic to the individualization over some 0.7 km^2 of a facies zone (presently the high shore of Lake Öreg) in which the red crinoidal limestone formation has come into being and above which the Upper Liassic red nodular calcareous marl formation pinches out gradually to the east and passes, on the eastern edge of the facies zone, into the facies of ferruginous-manganiferous clays, very incomplete and rapidly changing in lithology and of limestones of peculiar development. Such a spatial arrangement of the faciological conditions during the Middle and Upper Liassic seems to testify to a relatively high position of the area of the red crinoidal limestone facies, joined in the east by a bottom of yet higher hypsometric position. The roughness of basin bottom topography in Middle Liassic time is supported by the tearing up of calcareous ooze into lumps and nodules and by their movement downslope; in the Upper Liassic the same is indicated by the rapid changes of facies and the strata pinching out within a couple of metres; by the slumping and disintegration of the sediment on the sloped bottom; and by the scour and subsolution of sediments. The N—S orientation of the facies is a testimony to a considerable structural control in the Liassic.

Viewed chronologically, Liassic sedimentation shows two very significant discontinuities (Textfig. 30: in pocket). One is the break in sedimentation and changes in facies between the Rhaetian and the Upper Hettangian, the other is reflected by a change in lithology on the Middle and Upper Liassic boundary. These can be explained essentially by periodical intensifications of the tectonic control involved in the fracturing and faulting of the Triassic limestone and dolomite bedrock and



Textfig. 29: TEST DATA ON UPPER LIASSIC-DOGGER SEQUENCES

the resulting roughness of the paleorelief. The depth of a considerable part of the sedimentary basin on the Middle-Upper Liassic boundary rapidly exceeded the 100—150 m limit representing the optimum of benthonic life and thus the greater part of the basin bottom turned to a lifeless desert. In spite of the effect of deepening tending to eliminate any difference in facies, these did persist as a result of the progress of paleomorphological differentiation; in fact, they became more and more conspicuous. The bottom currents, which grew stronger with the increase of water temperature differences, must have been involved in all these phenomena. The differences in the relative height of the sea bottom over the studied area seem not to have exceeded the 10 m figure in the Early and Middle Liassic and a few tens of metres in Late Liassic time.

Dogger limestones and cherts uncovered on Kálvária Hill

From stratigraphic viewpoint the Lower Dogger red argillaceous limestones and Upper Dogger cherts have been least known of all Jurassic formations on Tata's Kálvária Hill. Their total thickness does not exceed 5 m. Earlier workers knew these formations from a few bad outcrops and exposures.

In the course of the author's investigations, started on the edge of Kálvária Hill's abandoned Bluestone Quarry, the whole Dogger sequence cropping out in this area has been recovered (Textfig. 31 and 32, the latter in pocket). The exposures and outcrops constitute a part of the Geological Conservation Area. Under the present-day conditions, the stratigraphic relations of the strata, their geological development and their lithostratigraphic subdivisions can be readily assessed with high accuracy. In the course of further works it is primarily the cephalopod fauna of the Lower Dogger red argillaceous limestones that would be advisable to sample layer by layer with the purpose of improving the relevant bio- and chronostratigraphic subdivisions.

Red argillaceous limestone (Aalenian-Bajocian)

Review of the relevant literature

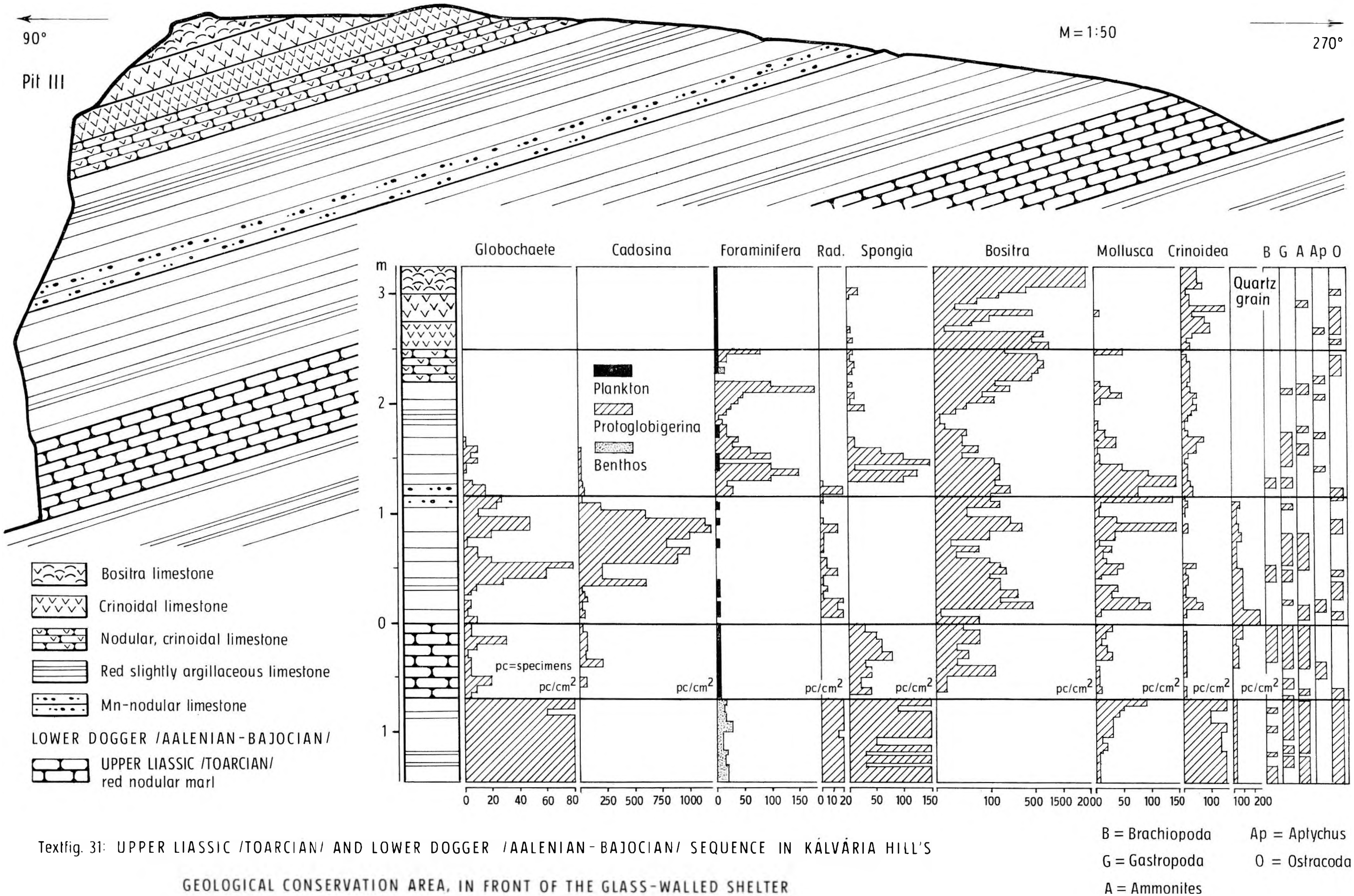
N. Koch (1909) described as "brownish-red nodular cherty limestone" the Lower Dogger of Tata whose outcrops " . . . in the area of the Kálvária Hill can be observed as forming a few small patches above the Middle Liassic crinoidal limestones". On the basis of his determination of the few, poorly preserved fossils available, he published the following list of fauna: "*Phylloceras baconicum* Hantk. et Prinz, *Ph. ultramontanum* Zitt., *Ph.* sp. ind., *Stephanoceras Gervillei* Sow. sp., *St.* sp. ind. (from the group of *St. Gervillei* Sow. sp.), *St.* sp. ind., *Coeloceras longalvum* Vacek, *Nautilus* sp. ind., *Belemnites* sp. (cfr. *B. Didayanus* d'Orb.). In addition, a Brachiopoda still unidentified more exactly and an *Aptychus* sp.". According to his statement, most of the forms listed were typical of the Lower Dogger and only *Stephanoceras Gervillei* Sow. sp. was indicative of a higher Dogger (Dogger γ) horizon.

As far as the paper of I. Szabó is concerned (1961), it was pointed out already in the discussion of the Upper Liassic red nodular calcareous marls, that he had separated richly ammonitic "clayey, nodular, thinly laminated limestones" as belonging to "the Upper Liassic Toarcian-Aalenian Stages", from "the closely adjacent, overlying Dogger beds of similar facies" (dark red thicker-bedded, compact limestones with manganese nodules). He found that the thickness of the Upper Liassic-Dogger limestones was "scarcely more than 5 metres" and that in the Dogger limestone beds "the limestone nodules are accompanied by ferromanganese-coated nodules of limestone and manganese nodules of concentric structure 1 to 2 cm across".

Sedimentological investigations

In the Kálvária Hill's Geological Conservation Area, on the unearthed rock surface of the upper yard, the foresets of Lower Dogger red argillaceous limestone disaggregated, for the most part, into tiny angular fragments can be studied over some 85 m length along the strike. A complete, continuous Lower Dogger sequence is exposed in the rock fissure labelled as Pit III (Textfig. 31) and in the rock wall of the big fault intersecting the Geological Conservation Area (Textfig. 32; Plate XXIV, Fig. 1). Despite the supposable absence of any break in sedimentation, the change of the heavily clayey, nodular facies permits easy distinction from the underlying red argillaceous, nodu-

4*



Textfig. 31: UPPER LIASSIC /TOARCIAN/ AND LOWER DOGGER /AALENIAN-BAJOCIAN/ SEQUENCE IN KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA, IN FRONT OF THE GLASS-WALLED SHELTER

Mineralogical, petrographical and geochemical analyses of a type sample of Lower Dogger red argillaceous limestone

Chemical composition (%):

SiO_2	3.85
TiO_2	0.05
Al_2O_3	0.80
Fe_2O_3	0.52
FeO	0.07
MnO	0.11
MgO	1.88
CaO	50.42
Na_2O	0.06
K_2O	0.44
$+H_2O$	1.59
$-H_2O$	0.11
P_2O_5	0.06
CO_2	39.63
Total:	99.59

Rare elements (ppm): from the lower (I), middle (II) and upper (III) members of the formation

	I	II	III
B	30	30	30
Ba	150	220	220
Co	32	32	100
Cr	8	10	6
Cu	15	26	38
Ga	2	2	2
Mn	220	1200	440
Ni	74	86	140
Pb	10	12	12
Sr	380	400	360
Ti	100	100	100
V	20	15	15

Mineralogical composition (%):

Chemo- and biogenic:	
calcite	89.5
dolomite	1.6
hematite (limonite)	0.6
organic matter	0.1
Total:	91.8
Colloidal:	
illite	3.6
kaolinite	1.0
Total:	4.6
Detrital:	
quartz	0.8
feldspar	0.1
Total:	0.9

Micromineralogical analyses (specimens):

Heavy minerals:	
Magmatic:	
hornblende	3
biotite	1
rutile	2
Metamorphic:	
andalusite	1
garnet	38
epidote	1
tourmaline	1
zoisite	1
chlorite	2
Epigenic:	
pyrite	7
Total:	57

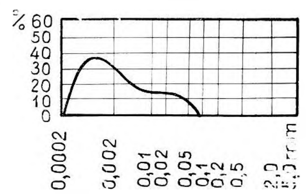
Light minerals:	
Detrital:	
quartz	19
feldspar	12
muscovite	2
Chemogenic:	
glauconite	5
Total:	38

Light mineral fraction represents 99.49 weight % of the insoluble residue.

Grain size composition (%) of insoluble residue (5.76%):

0.06 —0.1 mm	0.5	0.5
0.02 —0.06	12.0	40.7
0.01 —0.02	16.0	
0.005—0.01	12.7	
0.002—0.005	24.1	58.8
0.000—0.002	34.7	

Granulometric curve:



Specific weight:	2.70
Volume weight:	2.50
pH:	8.88
O_{Fe}:	23.60

lar, calcareous marls. The thickness of the Lower Dogger limestones in the rock wall of the big fault is 4.5 m, in Pit III only 3.5 m. This considerable reduction in thickness observable over such a short distance suggests, together with similar observations in lithological logs, the one-time sedimentary basin to have had a very rough bottom topography.

The bulk of the Lower Dogger red argillaceous limestone formation is represented by the lithofacies corresponding to the eponymous notion. In addition, a remarkable feature of the formation is the abundance of Fe-Mn-oxide nodules of 1 to 2 cm size (Plate XXIV, Fig. 4). On the weathered surface of the calcipelitic limestones a plane-ramose netlace of *Chondrites* "*intricatus*" can be observed (Plate XXIV, Fig. 3). In rare cases internal moulds of dissolved ammonite shells can be observed. On the basis of his revision of the cephalopod fauna collected thus far, B. Géczy determined the following species interpretable stratigraphically: *Hammatoceras tenuinsigne* Vacek, *Costileioceras* cf. *opalinoides* (Mayer) (Plate XXV, Fig. 1), *Otoites* cfr. *contractus* (Sowerby) (Plate XXV, Fig. 2), *Teloceras* sp.

The results of the examinations performed in the laboratories of the Hungarian Geological Institute are presented in Table 5.

The topmost strata of the red argillaceous limestone formation are characterized by the presence of crinoids and Bositra visible even to the naked eye. They represent two distinct beds. At the base there is a 50-cm-thick bed of brownish-red, coarse-grained crinoidite. Extremely poor in cement, it weathers very rapidly when exposed to daylight. Beside skeletal elements of crinoids only one belemnite rostrum was found in it. At the edge of Pit III, the coarse-grained crinoidites were observed to form wedge-shaped fissure-fills of a few cm breadth along synsedimentary fractures of 95 to 275° and 110 to 290° trend in the calcipelitic red clayey limestones underlying the formation.

The top of the Lower Dogger red argillaceous limestone formation is made up of 20 to 30 cm of Bositra limestone. This bed is locally characterized by the co-occurrence of both crinoids and Bositra, in other places it consists of a maze of pure Bositra shells. Penecontemporaneous fractures (of 90 to 270° trend) can be observed in this member as well. They have been penetrated, in a few cm width down to a couple of dm depth, by Upper Dogger cherts deriving from the hanging wall. The relatively small size and wedge shape of the above crinoidite and chert fissure-fills seem to be due to the scour and dissolution of the near-surface portion of the faint synsedimentary fractures by bottom currents and wave action. Hardgrounds developed on the surfaces of both the red argillaceous limestone and the Bositra limestone.

Thin section examinations

Viewed in thin sections, the Lower Dogger red argillaceous limestones show up a biomicritic, microsparitic pattern. The crinoidite and Bositra limestone beds are composed of rockforming abundances of accumulated skeletal elements of Crinoidea and Bositra (Plates XXV and XXVI).

Globochaete remnants are characteristic of the lower and middle parts of the sequence.

Skeletal elements of *Cadosina* occur frequently in the lower part. In conformity with the Upper Liassic, they seem to represent new species. Although they stand close to *C. fibrata*, their size is about half that of this species and the disproportionate inner shell also precludes an identification (Plate XXV, Fig. 3—4).

Foraminifera are represented primarily by Protoglobigerina frequent in the upper part of the sequence (Plate XXVI, Fig. 7—9). Benthonic forms are subordinate (Plate XXV, Fig. 5).

Radiolaria tests can be observed to occur, in comparatively not too great number, at the base of the sequence and its upper part, respectively.

Sponge spicules play an important role throughout but the upper part of the sequence, attaining their highest abundance in the middle (Plate XXVI, Fig. 6).

Bositra shell sections are characteristic fossils of the Lower Dogger red argillaceous limestone. They can be found in all samples, being somewhat more abundant in the upper part. In the crinoidites they are absent, being at the same time rockforming in the overlying Bositra limestone bed (Plate XXVI, Fig. 1—3).

Among *mollusc* remnants there are recognizable fragments of *gastropod* and *ammonite* shells. Occurring in medium quantity, these are more frequent at the base of the sequence (Plate XXVI, Fig. 4—5).

The overwhelming majority of *echinoderm* remnants are *crinoid ossicles*. Becoming considerable in amount in the upper part of the sequence, they predominate in the crinoidite bed (Plate XXV, Fig. 7—8).

A few skeletal elements of *brachiopods*, subordinate *Aptychus* sections and, quite sporadically, *Ostracoda* sp. also occur.

Upon the author's request, M. Báldi—Beke examined the nannoplankton in powdered rock samples and she managed to identify *Watznaueria communis* Reinhardt in all samples recovered from the Lower Dogger limestones.

Stratigraphy

The Lower Dogger red argillaceous limestone formation on Kálvária Hill forms a well-individualized lithostratigraphic unit between the underlying Upper Liassic red nodular, calcareous marls and the overlying Upper Dogger cherts. The crinoidite and Bositra limestone beds too can be readily distinguished on the basis of their lithologic characteristics.

The lower part of the Lower Dogger limestones and the Upper Liassic nodular calcareous marls show the same micropaleontological features. The representatives of Cadosina and Globochaete are predominant.

In the upper part of the red argillaceous limestones the Globochaete and Cadosina remnants become subordinate or vanish completely. Bositra and Protoglobigerina are predominant.

Orthostratigraphically, the recovered and identified ammonites prove the presence of the Middle Aalenian *Murchisonae-* and the Bajocian *Sauzei* and *Humphriesianum* Zones. Further samplings may certify the presence of additional Lower Dogger zones in the Lower Dogger limestone sequence, heavily condensed as it is. At the same time latent hardgrounds and associated gaps may also occur which may mean the absence, partial or total, of some zones.

The Lower Dogger sequence of Tölgyháti quarry by Lábatlan is recommended to be the type section of red argillaceous limestone formation and the name Tölgyhát Limestone Formation is considered to be proper for designating it. This Formation is widespread in the northern Transdanubian Central Mountains, being a typical representative of the Lower Dogger deposited in deeper internal sedimentary basin portions.

Chert (Bathonian-Callovian)

Review of the relevant literature

N. Koch (1909) mentioned in his work a "Lower Dogger brownish-red, nodular, cherty limestone". His judgement concerning the chert horizon was erroneous in respect of its geological development, mode of occurrence and stratigraphic position alike. Similarly erroneous was his assigning the Csurgókút Limestone to the Upper Dogger.

As regards the stratigraphic position of the Jurassic chert horizon known from a number of places in the northern Transdanubian Central Mountains, we still rely primarly on the data published by Gy. Vigh (1928) in his "Führer in das Gerecse-Gebirge nach Lábatlan und Piszke". In this work he produced paleontological proofs both concerning the Bajocian age of the underlying limestones and the Oxfordian age of the overlying limestone bed: moreover, he even managed to recover a few ammonite specimens from the limestone intercalations of the chert horizon and thus confirm directly his Bathono-Callovian dating of the chert unit.

I. Szabó (1961) assigned to the "Middle-Upper" Dogger (Bathono-Callovian) the upper part of the "dark red thicker-bedded, compact limestones with manganese nodules" and their final "few centimetres of Posidonia-Crinoidea limestone" whose presence is indicative of the "sudden establishment of a shallow-water regime of deposition". In his stratigraphic tabulation he quoted the species "*Teloceras* sp., *Stephanoceras* sp. and *Chondroceras gervillei*" from the former and *Phylloceras* sp. from the latter. He concluded that "the succession of the Dogger beds ends with 1 metre of red or white-weathered cherts (radiolarites)".

The excursion guide-books of J. Fülöp (1968, 1969) and G. Vigh (1968, 1969) and the author's publication on the chert pits that had been mined by early man on Kálvária Hill (1973) already reflect his standpoint that has materialized in the course of the present work, a standpoint relying, beside the fossil assemblages of the over- and underlying sediments, primarily on Gy. Vigh's stratigraphic evidence and comparative stratigraphic investigations concerning the Gerecse Mountains.

Geological features and stratigraphy

The best exposures and outcrops of Upper Dogger (Bathono-Callovian) cherts can be found in Kálvária Hill's Geological Conservation Area: on the rock surface of the upper yard, at the edge of Pit III (Plate XXIV, Fig. 2) as well as in prehistoric man's Chert Pits I and II. The tops of their beds exposed on the edge of the southern quarry were already described by N. Koch, but because of their being deformed there tectonically it would be no use studying them in those exposures. In the outcrop by Csurgókút spring the Upper Dogger cherts have overlain a hardground on the surface of Lower Toarcian Fe-Mn-oxide-bearing cephalopodal limestones.

In the Geological Conservation Area the chert formation has a sharp contact with both the Bositra limestone bed of the underlying Lower Dogger red argillaceous limestone formation and the Upper Oxfordian intraformational limestone breccia, as evidenced by the hardground probably representing a shorter or longer break in sedimentation. The cherts under consideration were also observed to form wedge-shaped fissure-fills within the Bositra limestones underneath. They are of liver-brown to brownish-grey colour. Their thickness is 0.8 to 1.2 m. Accordingly, these strata are of unsteady thickness, locally pinching out, to grow then unproportionately thick elsewhere. Joints are constituted by $CaCO_3$-containing clays identified, by X-ray and DTA analyses, with illite and illite-montmorillonite, available in equal proportions; more subordinate is the quantity of quartz, hematite and goethite, while feldspar and kaolinite-chlorite are available just in traces. The cherts themselves were determined X-ray analytically to be composed of quartz.

In the thin sections of the cherts and the associated, though subordinate, limestones or siliceous limestones, a rich fossil assemblage was found.

The representatives of *Radiolaria* are predominant elements of the microfauna (Plate XXVII) accounting for about 85% of the fossil assemblage. They show a striking taxonomic diversity. Their paleontological processing merits a separate work to be devoted to. A few genera could even be identified in the frame of the present, large-scale, generalized study (Cenosphaera, Dictyomitra, Saturnalis, Lithocampe).

The smaller part of the microfauna is constituted by *sponge* remnants. Occasionally, a few *Globochaete* and poorly preserved *Foraminifera* can also be observed.

In the course of examinations circular Coccolith remnants, 7 to 20 μ in diametre, showing a cross-shaped extinction at crossed nicols (Plate XXVII, Fig. 12), could be observed on the margins of thin sections. M. Báldi—Beke, on the basis of her examinations of powdered rock samples under the microscope, confirmed this observation and she identified *Watznaueria communis* Reinhardt: a nannoplanktonic species recovered from the Upper Dogger chert formation. "This is the most frequent form both in the Jurassic and elsewhere. This is perhaps the reason for its figuring in the literature under different names (*W. bayacki* Worsley, *Coccolithus deflandrei* Noël?). The systematic position of the species was cleared by Rood, Hay and Barnard (1971). Morphologically, it was described in detail by Noël (1865) and Medd (1971). On the basis of parallel examinations with both optical and electron microscopes, Medd found its variability in size to be 2 to 12 μ. Accordingly, it would be the strikingly most frequent form of the Bathonian, Callovian, Oxfordian and Kimmeridgian Stages".

In thin sections, beside the listed fossils, quartz grains of 10 to 1000 μ diametre, hematite-goethite grains and fossil-fills could be established. Occasionally, calcite rhombohedra of 30 to 300 μ size can also be observed (Plate XXVII, Fig. 13). These are often corroded and frequently carry tiny inclusions, supposedly bulbs of liquids. They seem to have been formed by recrystallization of micrite upon the effect of siliceous colloids*.

From lithostratigraphic viewpoint, the chert sequence can be considered a formation. It is widespread in the northern Transdanubian Central Mountains, the Dorog Basin, the Gerecse, Tata's Mesozoic basement horst blocks, the Tatabánya Basin and the western foothills of the Vértes. Its type section is proposed to be designated in the sequence cropping out by the road between Tölgyhát and Póckő (this whence the only ammonite fauna has so far been recovered from the formation under consideration). The formation name proposed on the basis of the type section is Póckő Chert Formation.

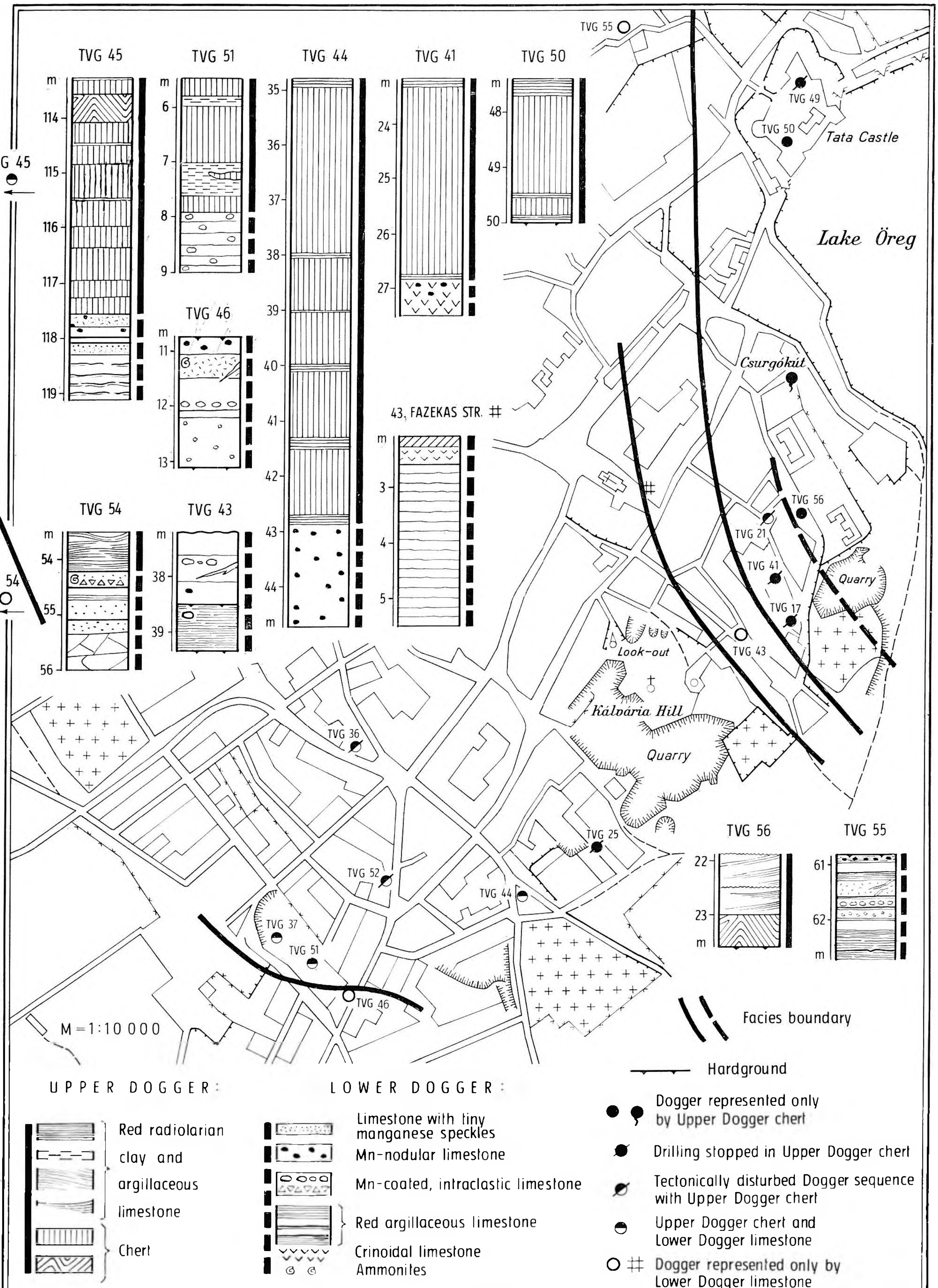
From chronostratigraphic viewpoint, it is advisable to identify the Formation with the Bathono-Callovian span of time, as defined by the overlying Oxfordian and the underlying Bajocian limestones, and to consider it to represent a sequence both markedly condensed and, supposedly, discontinuous.

Dogger formations uncovered by drilling

In the area of the town of Tata and its vicinity Dogger sediments have been uncovered in 16 boreholes and the dug-well of 43, Fazekas Street. In nine of those boreholes the complete sequence of the Dogger was uncovered; seven more boreholes stopped in Upper Dogger cherts or intersected a tectonically disturbed, incomplete sequence.

The Dogger sequences show up great diversity both in thickness and in geological development (Textfig. 33). All these are due to rhythmical rejuvenations of tectonic activities and the resultant gradual differentiation of paleotopography. Beside this high diversity, however, the common features of the Dogger formations are also remarkable. In spite of the relative divergencies in formation thickness, the absolute values are strikingly low. In Tata's vicinity the thickest Dogger sequence is as low as 10 m in thickness. The most essential common feature of the Dogger formations consists in the fact that the Lower Dogger, if any, is represented by limestones, the Upper Dogger by cherts and red clays. Both formations were deposited in the subphotic zone: the limestone at shallower depth as compared to the cherts, these having been deposited in a bathymetric position, the deepest in the course of Jurassic sedimentation. The characteristic fossils of the Dogger are of planktonic and nektonic origin: Globochaete, Nannoplankton, Protoglobigerina, Radiolaria, Bositra, Cephalopoda. The benthos is sparse: Chondrites, sponges and accidental crinoid ossicles introduced by currents supposedly from shallower zones. The limestones are in the majority of cases dotted with

* M. Misik: Structures of the chert concretions from the limestones of Tithonian and Neocomian, West Carpathian Mts. (Geologický Zborník, Geologica Carpathica) Geol. Zborn. Slov. Akad. Vied. XXIV. 1. 1973.



Textfig. 33: DOGGER SEQUENCES AND FACIES AREAS AS REPRESENTED IN TATA'S MESOZOIC BASEMENT HORST BLOCKS

manganese nodules; the phenomena of subsolution, hardgrounds, hiatuses are frequent. All these are typical features of a heavily condensed, episodic and ephemeral sedimentation.

On the basis of comparing the lithofacies of the Dogger sequences facies areas characterized by common features can be distinguished (Textfig. 33). Of greatest extension is the sequence of the so-called pelagic Dogger facies area: Upper Liassic red nodular, calcareous marls overlain by red argillaceous limestones with Mn-nodules, followed by liver-brown, dark-grey cherts at the top. This type of development includes the sequences uncovered by the boreholes TVG-45, -37, -51 and -44. The thickness of the Lower Dogger limestones with Mn-nodules in the afore-listed boreholes does not attain 2 m, whilst the Upper Dogger chert formation is characterized by considerable thicknesses ranging from 2—4 to 8 m. Similarly belonging to the "internal-basinal facies area", Kálvária Hill's Dogger deposits differ from the above boreholes in that the Lower Dogger limestones here are thicker (3.5—4.5 m) and that the Upper Dogger chert formation is less thick (0.8—1.2 m).

NNE of Kálvária Hill there is an alternation of different Dogger facies zones representing the "marginal facies". In the zone of borehole TVG-43; 43, Fazekas Street, and borehole TVG-55 the Upper Dogger cherts are absent in the sections of exposures. The next "facies zone" is delineated by the boreholes TVG-17, -41 and -21 in which there are again considerable Upper Dogger chert sequences supposedly with the availability of Lower Dogger limestones underneath. The manganiferous chert sequences of boreholes TVG-55 and -56 as well as of the exposures and outcrops of Csurgókút spring and the Castle (with lack of the Lower Dogger limestones) exhibit again a distinct divergency opposed to the rest of the developments. The first "stage" of a different facies zone is traceable on the southwestern margin of the "pelagic facies" area, as demonstrated by the different facies of boreholes TVG-54 and TVG-46. The results obtained for some typical Dogger sequences are shown in Textfig. 29.

We cannot ascertain that the outcrops and exposures available do exactly delineate the facies areas of the Dogger sediments. The less so, it is quite sure that the virtual conditions are more complex than implied by the regular zonations of Textfig. 33. But it is no less certain that the so-called "internal-basinal" facies areas develop on a more widely distributed sedimentary basin bottom of more gentle morphology, while the so-called "marginal facies area" includes facies zones of very diversified development, controlled by faults and showing a juxtaposition of more or less distinct belts.

The phenomena of structural evolution of the Jurassic basin bottom bedrock have been faced on several occasions. Progressive subsidence of the basin bottom becoming rhythmically more and more intense; synsedimentary fracturing; bottom differentiation producing facies areas and zones are phenomena that can be ascribed without any doubt to tectonic movements. Let us emphasize once more, that what these movements had produced in the bedrock of the one-time sedimentary basin bottom, as evidenced by the Jurassic sequences, were morphological conditions changing rapidly even within a limited area though showing up comparatively small differences in relative height which did not even exceed a few tens of metres during the Dogger.

Malm-Berriasian group

Extent, mode of occurrence and subdivisions

Upper Jurassic to Berriasian rocks in Tata's Mesozoic basement horst area are known to underlie the Aptian grey crinoidal limestones, uncovered by wells and boreholes, as well as to occur in outcrops or buried below Tertiary formations, in zones adjacent to the line of denudation of Aptian crinoidal limestone. Four separate areas of this kind are available. In the north, the solid rock basement of Tata Castle and its vicinity, where the Upper Jurassic-Berriasian sequence overlain by the Aptian grey crinoidal limestones has been uncovered by drilling. Studied by earlier authors, the next area is situated between Nagytemplom church, the Grammar School and Jewish Cemetery, where Upper Jurassic-Berriasian sediments are exposed or near the surface both in the north, in the zone of pinching out between the Nagytemplom and the Grammar School, and in the south, in Kálvária Hill's Geological Conservation Area, whereas between these two exposures they have been cut by dug-wells and boreholes. The third area is the outcrop of Aptian grey crinoidal limestones southwest of Kálvária Hill, in whose footwall and SW margin, respectively, several boreholes have penetrated into Upper Jurassic-Berriasian formations. At the entrance into Kálvária Hill's southern quarry, a small outcrop of tectonically disturbed Upper Dogger cherts and Upper Jurassic limestones is known. Finally, Upper Jurassic sediments are also known, from boreholes that have penetrated into the footwall of Aptian crinoidal limestones in the territory of Tata West basement horst (Textfig. 3—5).

In the majority of the occurrences, the Upper Jurassic-Berriasian sequence consists of Oxfordian limestone breccias of reduced thickness (1—2 m) overlying Upper Dogger cherts; Kimmeridgian red argillaceous, nodular limestones and Tithonian, or eventually Berriasian limestones. The Kimmeridgian and Tithonian limestones frequently contain debris of earlier Upper Jurassic sediments. In the inner zone of the so-called "marginal" facies area (Textfig. 43), the Dogger limestones are known to be overlain by a crinoid-cephalopod-brachiopod-bearing Upper Jurassic of limited thickness and markedly discontinuous, attaining a considerable thickness in the outer zone (20—25 m).

The unevenly eroded surface of the Upper Jurassic-Berriasian is overlain, supposedly over the whole area, by Aptian grey crinoidal limestones. Pre-Aptian denudation only seldom reached deeper than the Oxfordian limestone level in the areas presently having an Aptian crinoidal limestone overburden.

Genetically, the Upper Jurassic-Berriasian formations are the product of a uniform evolution. The crustal movements, which, in Oxfordian time, turned from subsidence to uplift, led to the development of three successive and more or less clearly distinguishable formations. The dissimilarities of the various sequences are due to differences in sea bottom morphology. Sedimentation must have been more heterogenous than ever before and extremely episodic and ephemeral in nature. This is evidenced by both geological development and thickness data (Textfig. 43).

Research history

The presence of the Upper Jurassic was first suggested by M. HANTKEN (1861) on the basis of the ammonoid species determined by K. PETERS (1859): *Ammonites tatricus* PUSCH, *A. anceps* and *A. triplicatus* SOW.

L. LÓCZY SR. (1906) reported on his observations on Tata's Kálvária Hill at the meeting of the Hungarian Geological Society held on March 7, 1906. In this connection he also referred to the Upper Jurassic cephalopodal limestones ("Acanthicum and Tithonian Stage") from which he had sampled a rich collection of fossils. He believed these to be in secondary position: in the course of the transgression of the "Neocomian sea" the underwashed Upper Jurassic cliffs would have collapsed and the fallen limestone blocks would then be embedded in Lower Cretaceous calcareous ooze containing glauconite grains and skeletal elements of crinoids. (His paleogeographic concept are not confirmed by the digging and drilling carried out under the present writer's direction.)

A. LIFFA (1910) mentioned Tithonian red "cherty limestone" from beside the main entrance to the Piarist Priory (now: Apprentice's Hostel) as well as from the street skirting Kálvária Hill in the west. (His statement seems to concern in the first case, the Upper Dogger cherts, in the second case it makes nonsense, because the rocks occurring in that street are Dachsteinkalk and Middle Liassic crinoidal limestone.)

N. KOCH (1909a), in his work on Tata, made important statements concerning also the Upper Jurassic. As to the mode of occurrence of the Upper Jurassic exposed on the northwestern side of the quarry by Jewish Cemetery (now: Geological Conservation Area), his opinion agreed with that of LÓCZY SR. He described Upper Jurassic limestones with fossils, unearthed in the course of wine-growing in the "Háber" garden by Nagytemplom church. Complementing earlier collections, including that received from L. LÓCZY SR., with his own, he determined the following species:

"*Trochocyatus* cfr. *truncatus* ZITT., *Phyllocrinus* sp. ind., *Eugeniacrinus* sp. ind., *Balanocrinus* sp. (cfr. *subteres* MÜNST.), *Terebratula (Pygope) sima* ZEUSCHN., *T. (P.) diphya* COL. sp., *T. (P.) Bouei* ZEUSCHN., *T. (P.) triangulus* LAM., *T. datensis* FAVRE, *T. himeraensis* GEM., *T. Bilimeki* SUESS, *T.* cfr. *carpathica* ZITT., *Placunopsis tatrica* ZITT., *Pecten cinguliferus* ZITT., *P. polyzonites* GEM., *Modiola punctatostriata* ZITT., *Neaera Picteti* ZITT., *Spinigera?* sp. ind., *Scurria?* sp. ind., *Phylloceras mediterraneum* NEUM., *P. isotypum* BENECKE sp., *P. empedoclis* GEM., *P. silesiacum* OPP. sp., *P. serum* OPP. sp., *P. Kochi* OPP. sp., *P. consanguineum* GEM., *P. ptychoicum* QN. sp., *P.* cfr. *ptychostoma* BENECKE sp., *P. Kudernatschi* HAU. var. nov., *P.* sp. ind., *Lytoceras montanum* OPP. sp., *L. sutile* OPP. sp., *L. quadrisulcatum* D'ORB. sp., *L. Liebigi* OPP. sp., *L.* cfr. *municipiale* OPP. sp., *L.* cfr. *Liebigi* OPP. sp. var. *strambergensis* ZITT., *L.* sp. ind., *Neumayria* cfr. *compsa* OPP. sp., *Oppelia* sp. (from the group of *O. Waageni* ZITT.), *Oppelia* sp. (cfr. *Folgariaca* OPP. sp.), *O.* sp. ind., *Haploceras elimatum* OPP. sp., *H. tithonium* OPP. sp., *H. Staszyczii* ZEUSCHN. sp., *H. carachtheis* ZEUSCHN. sp. var. *subtilior* ZITT., *H.* sp. ind., *Olcostephanus groteanus* OPP. sp., *O.* sp. (cfr. *Negreli* MATH. sp.), *O.* cfr. *pronus* OPP. sp., *Perisphinctes Richteri* OPP. sp., *P. transitorius* OPP. sp., *P. contiguus* CAT. sp., *P.* cfr. *Albertinus* CAT. sp., *P. Colubrinus* REINECKE sp., *P. exornatus* CAT. sp., *P.* cfr. *lictor* FONT. sp., *P. nebrodensis* GEM., *P.* sp. (cfr. *haliarchus* NEUM.), *P.* cfr. *acer* NEUM., *P.* cfr. *serranus* CANAV., *P. Bocconi* GEM., *P. plebejus* NEUM., *P. Pasinii* GEM. var. *balderoides* CANAV., *P.* sp. ind., *Hoplites Calysto* D'ORB. sp., *H. microcanthus* OPP. sp., *H. abscissus* OPP. sp., *H. carpathicus* ZITT. sp., *H.* cfr. *Köllickeri* OPP. sp., *H.* sp. ind., *Simoceras prateres* CANAV., *S. Favarense* GEM., *S.* sp. ind., *Peltoceras transversarius* OPP. sp., *P.* sp. ind., *Aspidoceras acanthicum* OPP. sp., *A. Rogoznicense* ZEUSCHN. sp., *A. avellanum* ZITT., *A. insulanum* GEM., *A. insulanum* GEM. var. nov., *A. cyclotum* OPP. sp., *A. circumspinosum* QN. sp., *A.* cfr. *Wolfi* NEUM., *A. Montisprimi* CANAV., *A. Deáki* HERB., *A.* sp. (cfr. *episum* OPP. sp.), *A.* cfr. *iphiceroides* WAAG., *A. altanense* D'ORB. sp., *A.* cfr. *Helymense* GEM., *A. oegir* OPP. sp., *A. Uhlandi* OPP. sp., *A. Uhlandi* OPP. sp. var. *extuberata* CANAV., *A. Uhlandi* OPP. sp. var. nov., *A. Choffati* P. DE LORIOL, *A.* sp. ind., *Waagenia hybonota* OPP. sp., *Aptychus punctatus* VOLZ, *A.* cfr. *exsculptus* SCHAUR., *A.* cfr. *latus* PARK., *A. Beyrichi* OPP., *Nautilus* cfr. *sexcarinatus* PICT., *Belemnites* cfr. *strangulatus* QN., *B.* cfr. *Zeuschneri* OPP., *B.* cfr. *conophorus* OPP., *B.* cfr. *ensifer* OPP., *B.* cfr. *semisulcatus* MÜNST., *B.* sp. ind."

He believed the limestone horst blocks under consideration to have a "mixed fauna" in which the species characteristic of the "*Acanthicus* Beds" and the Lower Tithonian occurred in strikingly great number, but in which a few species of the "*Transversarius* Beds" and the Upper Tithonian were also represented.

L. Lóczy jr. (1914—15) mentioned, beside the forms cited by N. Koch, the presence of *Phylloceras Zignodianum* d'Orb. as well.

In his first publication on Tata's Mesozoic basement horst (J. Fülöp 1954), the present writer emphasized that Kálvária Hill's Jurassic sequence had been brought about by a continuous sedimentation that lasted from the Early Liassic to the end of the Tithonian. He observed that there was not any larger block of Upper Jurassic limestone embedded in the Cretaceous crinoidal limestone, but what had been believed to be embedded blockes formed in reality a rough Cretaceous paleorelief.

On the writer's request, G. Kolosváry (1954) determined a few corals from Tata's Upper Jurassic-Berriasian sediments.

I. Szabó (1961), in his paper presented at the International Conference on the Mesozoic, in Budapest, characterized the Oxfordian, Kimmeridgian and Lower and Upper Tithonian of Tata's Mesozoic horst as having a rich micro- and macrofauna. He was the first to state the presence of the Berriasian. He listed the following fossils:

"Oxfordian: *Holcophylloceras empedoclis* Gemm., *Taramelliceras* cfr. *costatum* Qu., *T.* cfr. *kobyi* Choffat, *Perisphinctes bocconi* Gemm., *Gregoryceras transversarium* Qu., *G.* aff. *toucasi* d'Orb., *Euaspidoceras oegir* Opp., *E.* cfr. *ovale* Neumann, *E. tietzei* Neumayr, *Aspidoceras choffati* Loriol, *Physodoceras altenense* d'Orb. — Kimmeridgian: *Globochaete alpina* Lombard, *Eothrix alpina* Lombard, *Crinoidea*, *Phylloceras isotypum* Ben. var. *serum* Opp., *Ph. silesiacum* Opp., *Katroliceras acer* Neum., *Ataxioceras* cfr. *lictor* Font., *Aspidoceras longispinum* Sow., *A. acanthicum* Opp., *A. binodum* Opp., *A. iphicerum* Opp., *A. montisprimi* Can., *A. uhlandi* Opp., *A. deaki* Herb., *Holcophylloceras mediterraneum* Neum., *H. empedoclis* Gemm., *Ptychophylloceras ptychoicum* Qu., *Taramelliceras* cfr. *compsum* Opp., *T. pugilis* Neum., *T. trachynotum* Opp., *Physodoceras circumspinosum* Qu., *P. bonatoi* del Campana, *P.* cfr. *raphaeli* Opp., *Pseudowaagenia pressula* Neum., *Ps. monacantha* Waagen, *Ps. microplana* Opp., *Hybonoticeras hybonotum* Opp., *H. harpephorum* Neum., *Simoceras* cfr. *albertinus* Cat. — Lower Tithonian: *Calpionella alpina* Lor., *C. elliptica* Cad., *C. undelloides* Colom, *Lytoceras montanum* Opp., *L. liebigi* Opp., *Thysanolytoceras sutile* Opp., *Protetragonites quadrisulcatum* Opp., *Haploceras elimatum* Opp., *H. staszycii* Zeuschn., *H. tithonicum* Opp., *H. carachteis* var. *subtilior* Zitt., *Phylloceras serum* Opp., *Ph. silesiacum* Opp., *Ptychophylloceras ptychoicum* Qu., *Pt. ptychostoma* Ben., *Subplanites contiguus* Cat., *Lithacoceras geron* Zitt., *Aspidoceras rogoznicense* Zeuschn., *Asp. iphicerum* Opp., *Physodoceras cyclotum* Opp., *Phys. avellanum* Opp., *Simoceras volanense* Opp., *Pygope dyphia* Col., *Py. triangulus* Lam., aptychi, crinoids, pectinids, coral colony. — Upper Tithonian: tintinnids, radiolarians, *Clypeina jurassica* Favre, *Ptychophylloceras ptychoicum* Qu., *Pt. isotypum* Ben., *Virgatosphinctes transitorius* Opp., *Micracanthoceras microcanthus* Opp., *Himalayites köllickeri* Opp., *Spiticeras groteanus* Opp., *Sp. (Proniceras) pronus* Opp., *Lytoceras liebigi* var. *strambergensis* Zitt., *Lytoceras* sp., *Hemilytoceras sutile* Opp., *Berriasella abscissa* Opp., *B. callisto* d'Orb., *B. carpathica* Zitt., *B. moravica* Opp., *B.* cfr. *privasensis* Pict., *B. richteri* Opp. — Berriasian: *Cariophyllia primaeva* Zitt., *Placunopsis tatrica* Zitt., *Pygope triangulus* Lamk., *Berriasella* aff. *boissieri* Pict., *B. privasensis* Pict., *Neocosmoceras euthymi* Pict., *Spiticeras groteanus* Opp., *Sp. (Kilianella) damesi* Steuer, *Negreliceras* cfr. *negreli* Math., tiny *Phylloceras* and *Haploceras* specimens."

The cephalopodal fauna of the Upper Jurassic-Berriasian formations was studied in recent years, as a contribution to the present work already, by G. Vigh, a highly respected member of my research team. On his statements I reported already at the Upper Jurassic Symposium, Moscow-Tbilisi 1967. G. Vigh presented a paper on his relevant results at the International Colloquium on Jurassic Stratigraphy, Budapest 1969. He considered the upper part of the Oxfordian to be evidenced by the presence of *Gregoriceras transversarium* and the two *Euaspidoceras* species. He split up the Kimmeridgian into a lower part (*Tenuilobatus* and *Pseudomutabilis* Zones) and an upper one (*Beckeri* Zone). He considered the *Hybonotum*, *Vimineus* and *Semiforme* Zones to be indentifiable in the Lower Tithonian. Similarly into three parts did he subdivide the Upper Tithonian individualizing itself by sudden changes in the fauna. As for the Berriasian, he considered its cephalopodal fauna to represent a direct and integral continuation of the Upper Tithonian and thus he proposed to include the Berriasian Stage in the Jurassic System.

Malm-Berriasian formations in Kálvária Hill's Geological Conservation Area

On the turn of the century quarrymen uncovered the rough surface of Upper Jurassic-Berriasian limestones in the northeast part of Kálvária Hill, on the margin of the old "bluestone quarry". These circumstances were the reason why L. Lóczy sr. supposed that Upper Jurassic limestone blocks were embedded in the Cretaceous limestone. The overwhelming majority of the Upper Jurassic and Berriasian fossils published by N. Koch and I. Szabó originated from this area, too. During the past two decades a continuous range of Malm-Berriasian sediments has been uncovered in the area of the quarry which had been abandoned as the Aptian grey crinoidal limestone had been stripped off (Textfig. 34: in pocket). The exposure with its diversified geology was threatened by destruction. Therefore, to save it, we urged for the help of the National Nature Conservancy Office and, backed by its favourable decision, we have managed, by several years' work, not only to safeguard the conservation of the exposures, but to create the prerequisites for further studying as well.

The Malm-Berriasian formations are exposed in the upper rock yard of the Geological Conservation Area, along a N—S trending "line of pinching". Small patches of a markedly discontinuous Malm-Berriasian of extremely low thickness can be found in this area (Textfig. 35), which in the Late Jurassic seems to have been an easterly slope and Kálvária Hill as a whole may have represented a swell exposed to submarin erosion (a tectonically uplifted ridge).

On the upper rock surface, close to the large quarry yard, the Upper Dogger cherts are overlain by 30 cm of Oxfordian limestone breccia, followed in turn by 5—30 cm thick limestone patches representing different levels of the Tithonian. The Kimmeridgian is absent and the Tithonian limestone rags represent merely a thin group of strata preserved just accidentally and separated by considerable hiatuses and hardgrounds. Between the limestone beds thin rock lenses of the scree that crept down the slope of sea bottom can also be found. The Tithonian limestones are locally crinoid-bearing.

The Upper Jurassic sequence grows somewhat thicker northwards, on the margin of the prehistoric chert pit (Textfig. 35 and 36). Here the Kimmeridgian red argillaceous and nodular limestone is also available in the stratigraphic column. On the margin of Pit III both a pre-Aptian fault and a slight denudation can be observed.

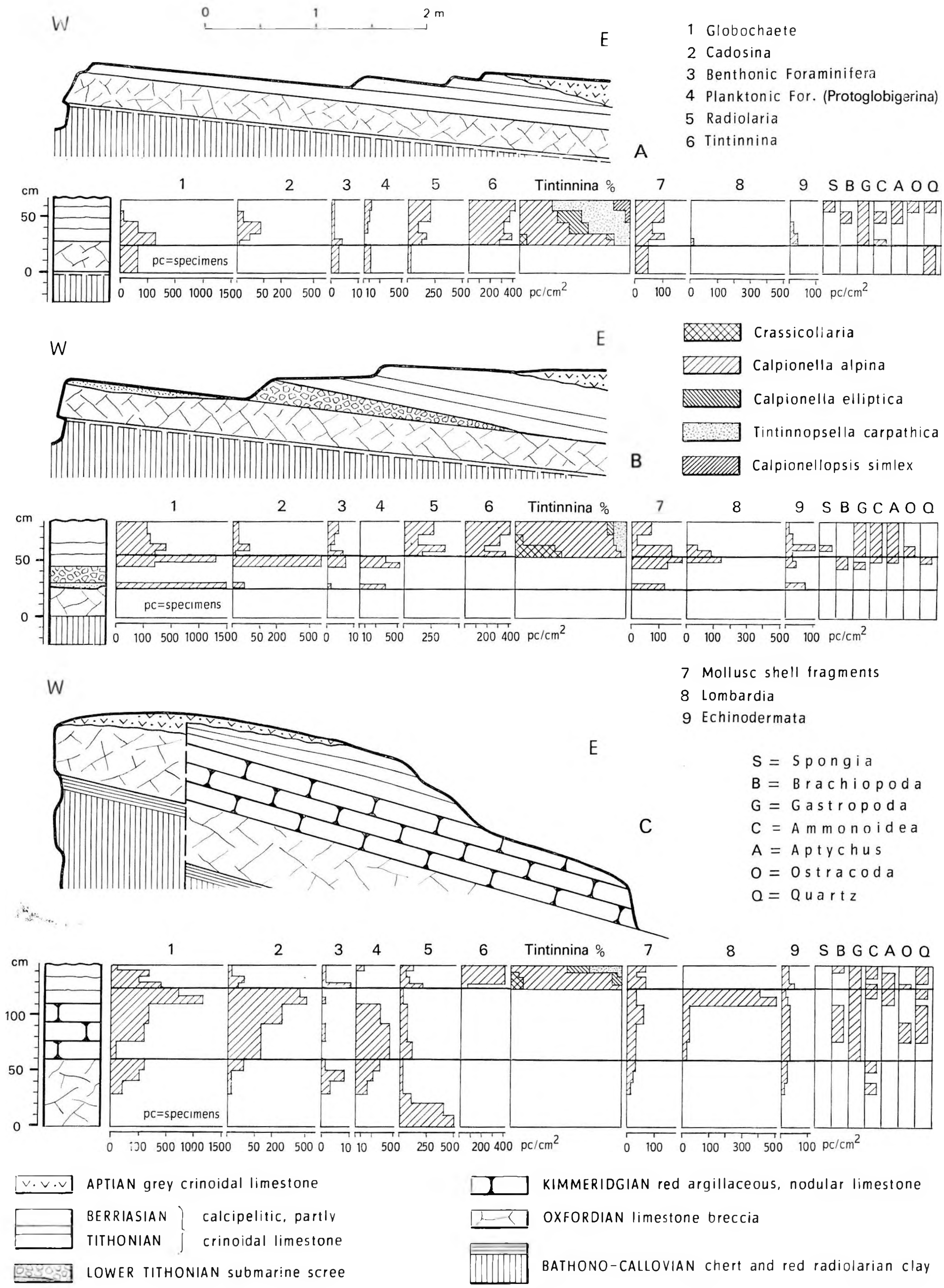
Just a few metres east of the pinching line the Upper Jurassic exposures are already 2 to 3 (3.5) m thick (Textfig. 37 and 40). This increase in thickness is shared almost equally by the Upper Jurassic-Berriasian stages. The Oxfordian is represented by greyish-white intraformational limestone breccia; the Kimmeridgian by red argillaceous, cephalopodal limestones with Mn nodules; the Tithono-Berriasian by purple to light grey cephalopodal limestones. In a direction normal to the strike of the pinching line, relics of east-trending submarine creep can be traced. On the basis of qualitative and quantitative thin section examinations the stratigraphic and sedimentologic features of the Malm-Berriasian formations of the Geological Conservation Area have been summarized in the following chapter.

Greyish-white intraformational limestone breccia (Oxfordian)

Representing the Oxfordian Stage, the intraformational breccia can be studied on what has been referred to as the upper rock surface of the Geological Conservation Area, over a length of 90 m, along topsets exposed in the N—S pinching zone. Its thickness increases from 25 cm in the south to 50 cm in the north. Its colour is greyish-white. The texture is that of a typical intraformational breccia: the rapidly diagenized sediment was fragmented, dissimilarly and, in some cases, even repeatedly, and it was a little transported. It contains sporadical and incomplete Belemnites rostra. Red pelitic sediments typical of the Jurassic sequence, have been almost totally removed by bottom currents. They occur very subordinately as a slightly silicified matrix of disproportionate distribution. Perpendicularly to the pinching zone, the limestone breccia grows gradually thicker in eastward direction; attaining 60 to 80 cm some 15 to 20 m away. In the same direction it gradually loses its remarkably breccious nature; the ratio of the red clayey limestone matrix increases considerably and the texture of the rock becomes rather nodular in character.

The change in megaloscopic features is reflected by the microscopic image of the texture, too. The microscopic texture of the intraformational breccia accumulated in an environment of higher structural position consists of recrystallized micrite with subordinate sparite. Fossils occur just sporadically in it. Deposited in a deeper position and characterized by a richer development of the matrix, the limestone bed of nodular texture can be observed to contain Radiolaria and Protoglobigerina more or less regularly and in varying quantity (5—150 specimens per cm^2). *Cadosina fibrata* may locally become significant (a maximum of 50 specimens per cm^2), *Cadosina parvula* occurs in low number of specimens (5—15). Sporadically, a few sponge spicules, Ostracoda, Aptychus and ammonite embryons as well a few quartz grains can also be encountered. The results of laboratory analyses have been summarized in Table 6.

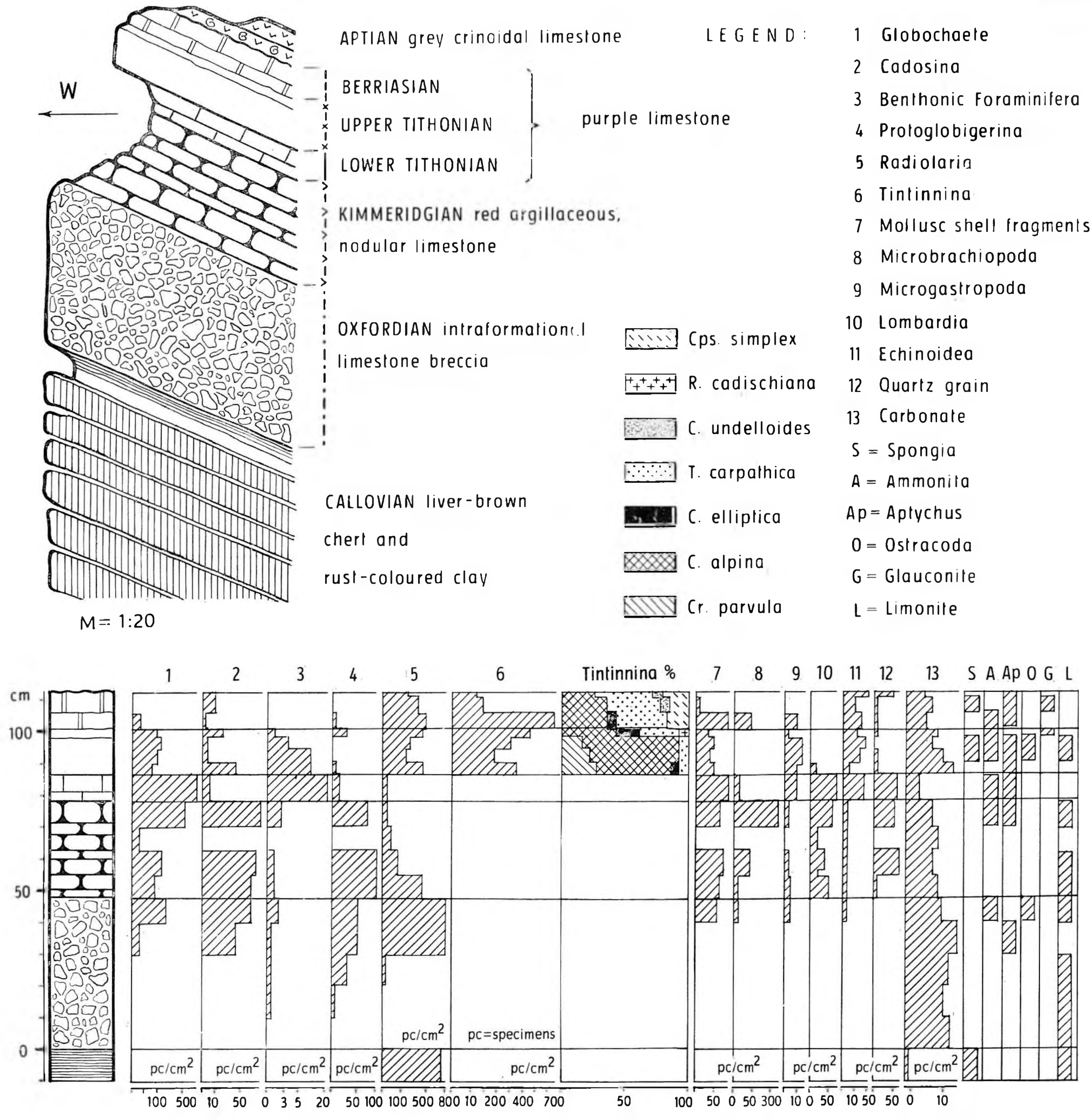
18 ammonite specimens have so far been recovered from the Oxfordian intraformational limestone breccia (15 by N. Koch and 3 by I. Szabó). In this, the zonal index *Gregoryceras transversarium* (Qu.) is represented by 2 specimens, and Perisphinctidae and Euaspidoceras species testify to the presence of the *Bimammatum* Zone as well. As shown by a revision of the fauna by G. Vigh, the following Oxfordian fauna of Kálvária Hill origin is available:



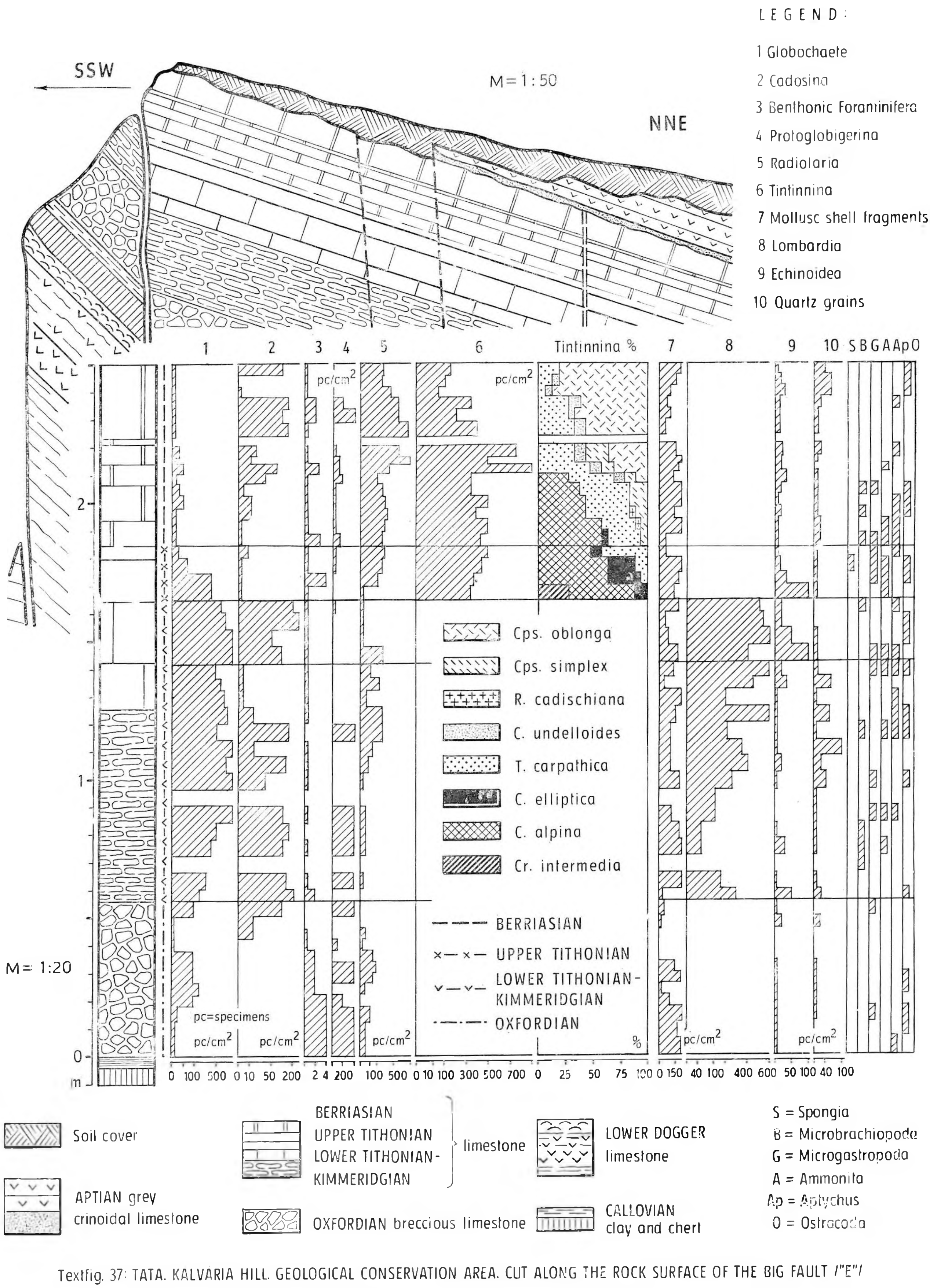
Textfig. 35:

MARKEDLY DISCONTINUOUS MALM SEQUENCES /"A–C"/. KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA. UPPER ROCK SURFACE

	specimens
Taramelliceras (Metahaploceras?) cf. *kobyi* (CHOFF.)	1
Perisphinctes (?Pseudarisphinctes) sp.	1
Perisphinctes sp. [*?Pseudarisphinctes* sp. ex gr. *Ps. subrota* (CHOFF.)]	4
Perisphinctes (Dichotomosphinctes) aff. *bocconii* (GEMM.)	2
Gregoryceras transversarium (QU.)	2
Gregoryceras cf. *transversarium* (QU.)	1
Gregoryceras toucasianum (D'ORB.)	1
Gregoryceras sp. ex gr. *Gr. fouquei* (KIL.)	1
Gregoryceras sp. ind.	1
Euaspidoceras sp. [aff. *E. tietzei* (NEUM.)]	1
Euaspidoceras sp. [ex gr. *E. oegir* (OPP.)]	1
Euaspidoceras helymense (?) (GEMM.)	1
"*Aspidoceras*" *insulanum* GEMM.	1



Textfig. 36: TATA. KÁLVÁRIA HILL. GEOLOGICAL CONSERVATION AREA. EDGE OF CHERT PIT II /"D"/



Textfig. 37: TATA. KALVARIA HILL. GEOLOGICAL CONSERVATION AREA. CUT ALONG THE ROCK SURFACE OF THE BIG FAULT /"E"/

Despite its low thickness, the Oxfordian intraformational limestone breccia is a rock body showing typically independent lithological features: a formation distinguishable on detailed maps. It would be proper to designate Kálvária Hill as its type locality, where the limestone breccia bed yielded the above characteristic Upper Oxfordian ammonite fauna. From chronostratigraphic viewpoint, the intraformational limestone breccia formation is considered to be a heavily condensed and discontinuous representative of the Oxfordian Stage.

Table 6

Mineralogical, petrographical and geochemical analyses of a type sample of Oxfordian intraformational limestone breccia

Chemical composition (%):

SiO_2	21.97
TiO_2	0.01
Al_2O_3	0.33
Fe_2O_3	0.05
FeO	0.08
MnO	0.09
MgO	0.51
CaO	43.01
Na_2O	0.05
K_2O	0.05
$+H_2O$	0.48
P_2O_5	0.02
CO_2	32.87
organic C	0.06
S	0.01
Total:	99.59

Rare elements (ppm):
from the upper rock surface (I) and near the shelter (II), Geological Conservation Area, Kálvária Hill, Tata

	I	II
B	30	30
Ba	20	150
Co	20	35
Cr	1	10
Cu	10	16
Ga	2	2
Mn	520	440
Ni	20	32
Pb	15	26
Sr	180	220
Ti	100	100
V	27	36

Mineralogical composition (%):

Chemo- and biogenic:	
calcite	72.4
dolomite	2.3
chalcedony	21.8
limonite	0.1
Total:	96.6
Colloidal:	
kaolinite	1.0
Detrital:	
quartz	0.1

Micromineralogical analyses (specimens):
(0.06—0.2 mm fraction of insoluble residue)

Heavy minerals:	
Magmatic:	
none	
Metamorphic:	
garnet	4
epidote	1

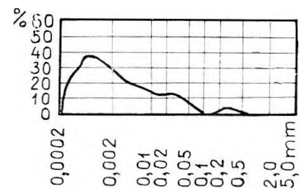
Light minerals:	
Detrital:	
quartz	4
Chemogenic:	
chalcedony	95

Light mineral fraction represents 99.01 weight % of the insoluble residue.
Most of the grains are coated by iron hydroxide. The quartz grains are rounded at the angles.

Grain size composition (%) of insoluble residue (15.1%):

0.5 —1.0 mm	0.2	4.5
0.2 —0.5	1.8	
0.1 —0.2	1.4	
0.06 —0.1	1.1	
0.02 —0.06	10.3	38.6
0.01 —0.02	13.7	
0.005—0.01	14.6	
0.002—0.005	22.3	56.9
0.000—0.002	34.6	

Granulometric curve of insoluble residue:



Specific weight:	2.90
Volume weight:	2.70
Porosity:	7.40%
pH:	8.45
O_{Fe}:	1.25

Red argillaceous cephalopodal limestone with manganese nodules (Kimmeridgian)

The distribution of the Kimmeridgian limestone in Kálvária Hill's Geological Conservation Area has been shown in Textfig. 34. On the basis of its typical — eponymous — lithological features it can be distinguished from the underlying Oxfordian limestone breccia even megaloscopically.

The same features, however, are less diagnostic with regard to drawing the boundary with the overlying Tithonian limestones. The thickness of the formation is 20 to 30 cm in the vicinity of the chert pits (Textfig. 35, 36), increasing to 40 to 60 cm towards the lower quarry yard (Textfig. 38, 39 and 40). The Kimmeridgian bedding plane observable over several square metres area in Exposure "G" (Textfig. 39) represents a hardground. It contains countless ammonites lying on their lateral sides, being halved in the plane of the hardground. The Mn nodules or crusts, respectively, are substantially larger than in the Lower Dogger limestone. Kimmeridgian limestone debris and loaf-size chunks, representing embedded sea bottom scree, occur frequently in the Tithonian limestone, too.

The chemical and spectrographic analyses of the type sample have been presented in Table 7.

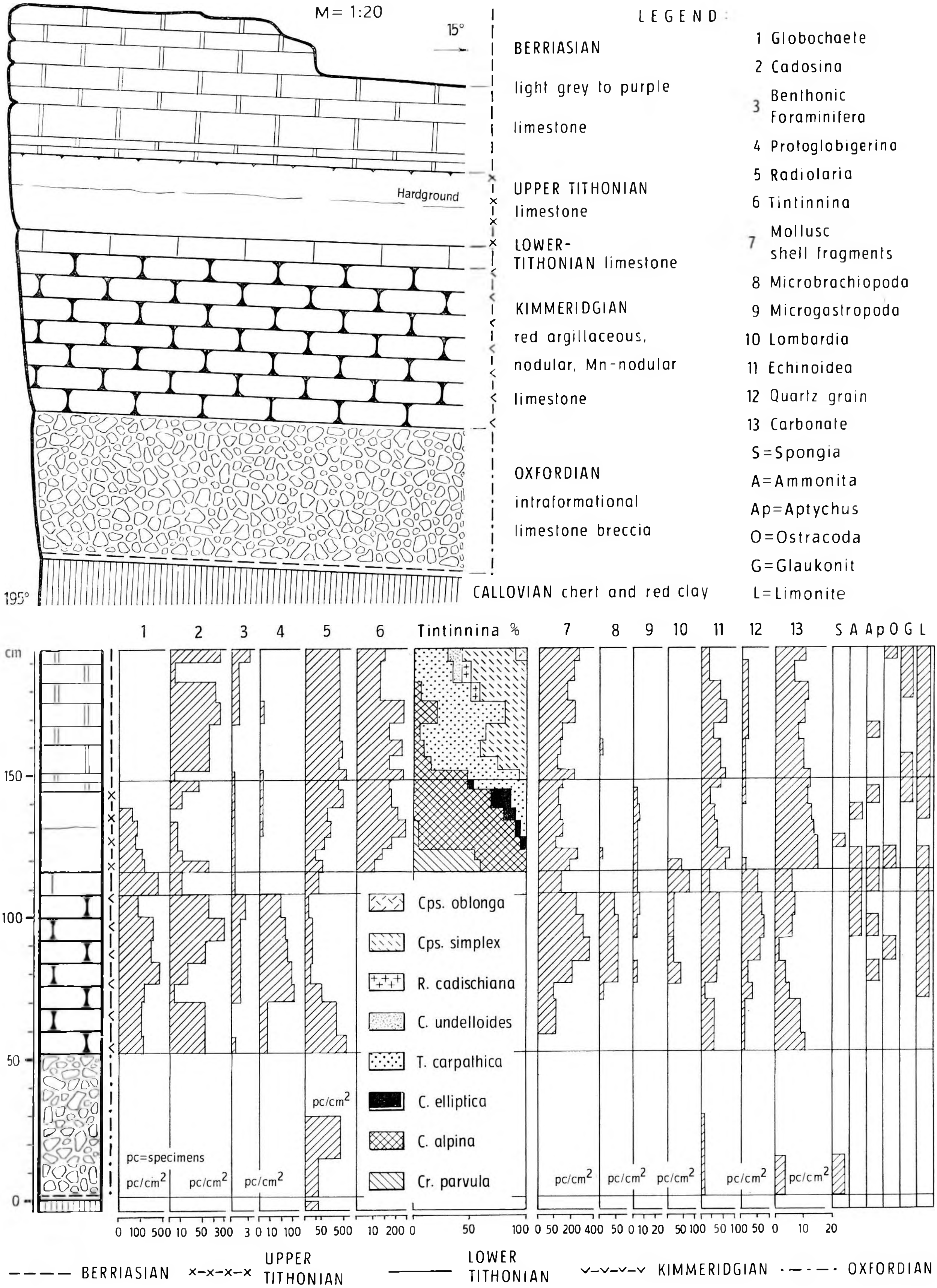
Table 7

SiO_2	7.45%	B	30	ppm
TiO_2	0.16%	Ba	230	ppm
Al_2O_3	1.77%	Co	90	ppm
Fe_2O_3	1.26%	Cr	28	ppm
FeO	0.14%	Cu	38	ppm
MnO	0.18%	Ga	5	ppm
CaO	46.91%	Mn	500	ppm
MgO	2.02%	Ni	280	ppm
K_2O	0.51%	Pb	76	ppm
Na_2O	0.08%	Sr	560	ppm
$+H_2O$	2.03%	Ti	100	ppm
$-H_2O$	0.35%	V	15	ppm
CO_2	36.88%			
P_2O_5	0.13%			
Total:	99.87%			

The Kimmeridgian limestone has a characteristic microfossil assemblage. Notably, it has been the first to yield coccolithophorids: *Watznaueria communis* REINHARDT in larger number of specimens, *Braarudosphaera bigelowi* (GRAN et BRAARUD) in a subordinate number (determinations by M. BÁLDI—BEKE). *Axotrix malmica* NAGY is characteristic of the Lower Kimmeridgian. Frequently rockforming in abundance, Lombardia (planctonic Crinoidea) is an index microfossil of the Kimmeridgian. Up in the sequence the above fossils show an increase in size and in the diversity of forms. Their characteristic frequency is 800 specimens per cm^2. *Cadosina parvula* NAGY available in great number of specimens ($1000/cm^2$) and *Stomiosphaera moluccana* WANNER observable in fewer specimens, though available in a relatively high number of specimens ($5—50/cm^2$) are species of stratigraphic value. Skeletal elements of different molluscs and echinoderms are frequent. Accessory microfossils are *Globochaete alpina* LOMBARD, *Cadosina lapidosa* VOGLER, *Cadosina carpathica* (BORZA), Protoglobigerina, Radiolaria, microbrachiopods, microgastropods, ammonites, Aptychus and Ostracoda.

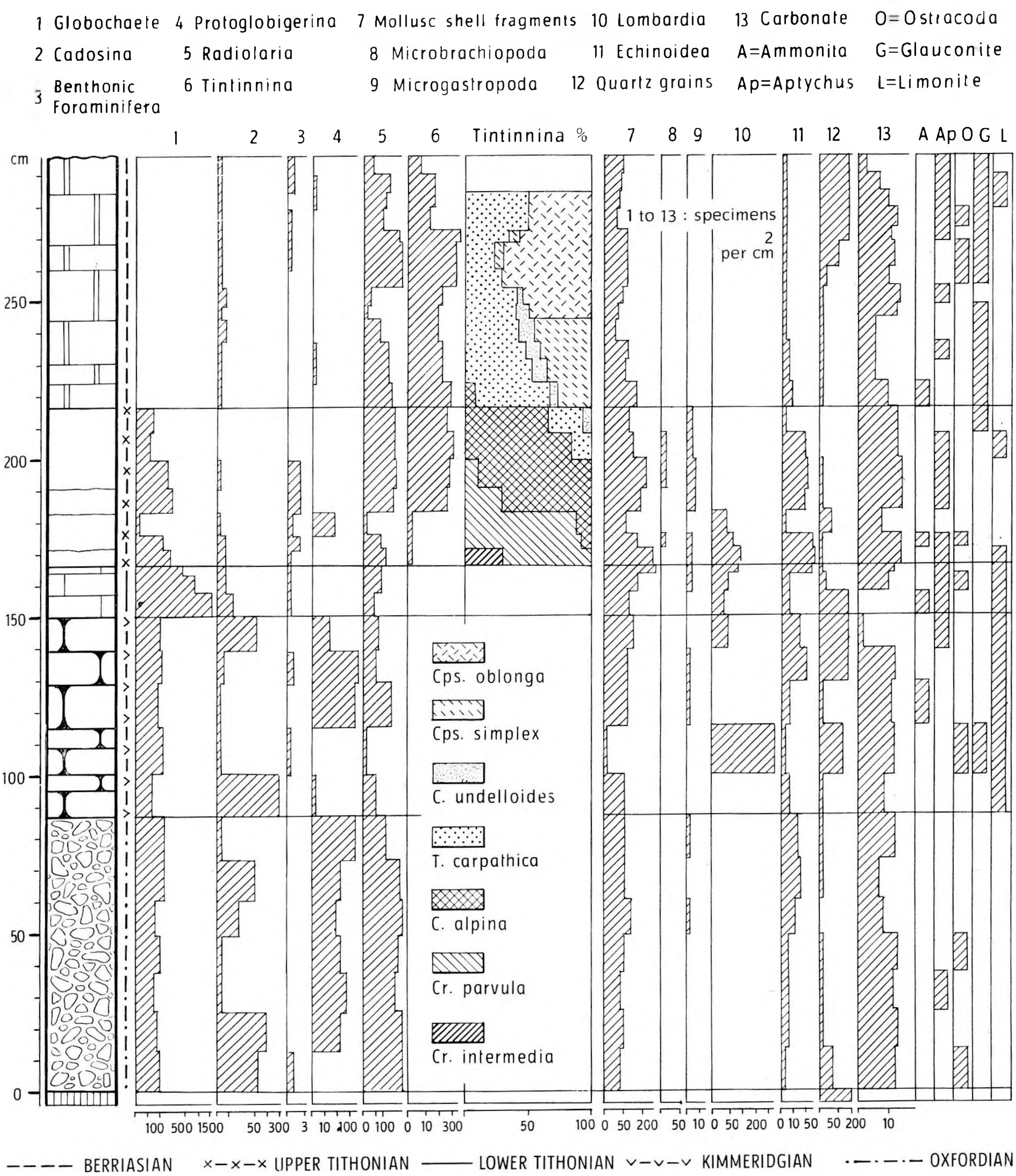
The Kimmeridgian limestones have yielded a rich cephalopodal fauna. On the basis of his revision of earlier collections and of the fossil material sampled from bed to bed by us, G. VIGH established the following faunal list:

	specimens
Microsolena agassiciformis ETALL.	4
Trochocyathus primaeva ZITT.	1
Phylloceras isotypum (BEN.).	3
Phylloceras cf. *isotypum* (BEN.)	2
Phylloceras isotypum apenninicum CAN.	4
Phylloceras consanguineum GEMM.	1
Phylloceras cf. *consanguineum* GEMM.	1
Phylloceras sp. (ex gr. *Ph. consanguineum* GEMM.)	2
Calliphyloceras empedoclis (GEMM.)	3
Calliphylloceras cf. *empedoclis* (GEMM.)	2
Holcophylloceras mediterraneum (NEUM.)	2
Holcophylloceras sp. [ex gr. *H. mediterraneum* (NEUM.)]	1
Holcophylloceras polyolcus (BEN.)	1
Ptychophylloceras semisulcatum (D'ORB.) = *Pt. ptychoicum* (QU.)	4
Lytoceras polycyclus (NEUM.)	1
Lytoceras sp.	2



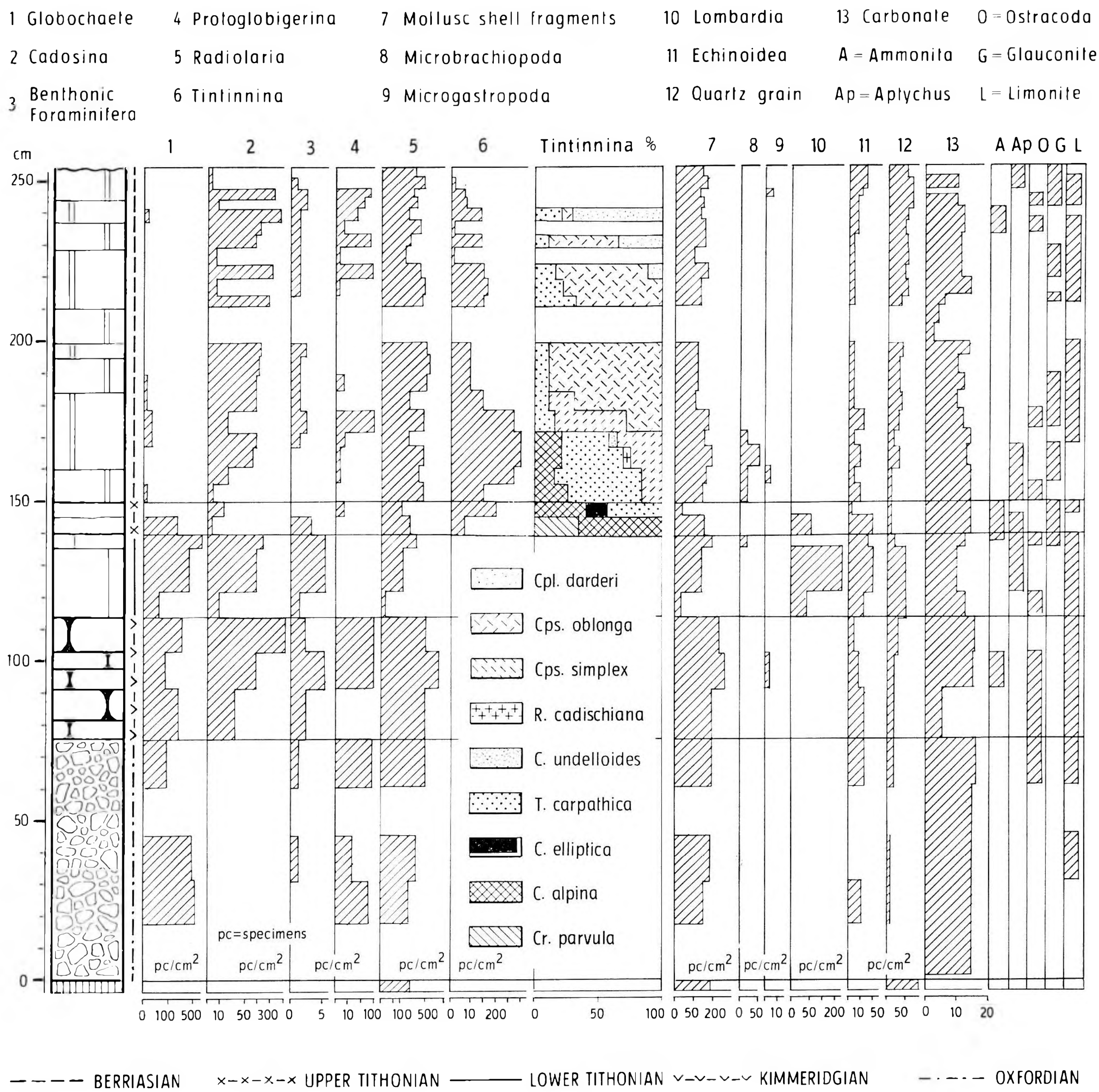
Textfig. 38: TATA. KÁLVÁRIA HILL. GEOLOGICAL CONSERVATION AREA.

THE MALM-BERRIASIAN SEQUENCE AT THE SITE OF DETAILED SAMPLING OF FOSSILS /"F"/ AND ITS TEST DATA



Textfig. 39: TATA. KÁLVÁRIA HILL. GEOLOGICAL CONSERVATION AREA. TEST DATA ON THE MALM-BERRIASIAN SEQUENCE OF THE MIDDLE EXPOSURE /"G"/

	specimens
Pterolytoceras orsinii (GEMM.)	1
Pterolytoceras aff. *orsinii* (GEMM.)	1
Pterolytoceras sp. [ex gr. *Pt. orsinii* (GEMM.)]	2
Pterolytoceras sp. [?aff. *montanum* (OPP.)]	1
Haploceras elimatum (OPP.)	3
Haploceras staszycii (ZEUSCHN.)	1
Taramelliceras (Taramelliceras) cf. *hemipleura* (FONT.)	1



Textfig. 40: TATA. KÁLVÁRIA HILL. GEOLOGICAL CONSERVATION AREA. TEST DATA ON THE MALM-BERRIASIAN SEQUENCE EXPOSED IN THE NORTHERN CORNER /"H"/

	specimens
Taramelliceras (Taramelliceras) aff. *trachinotum* (OPP.)	1
Taramelliceras (Metahaploceras) cf. *semibarbarum* HÖLD.	1
Taramelliceras (s. l.) sp.	3
Lithacoceras (Lithacoceras) cf. *pseudolictor* (CHOFF.)	1
Lithacoceras (Progeronia) sp. [ex gr. *P. unicomptus* (FONT.)]	1
Lithacoceras (Progeronia) sp. ind.	3
Katroliceras (?Garnierisphinctes) sp.	2
Katroliceras (Torquatisphinctes) sp.	1
Katroliceras (s. l.) sp.	1
(?) *Katroliceras* (s. l.) sp.	1
Subplanites sp. [ex gr. *S. contiguus* (CAT.)]	1

	specimens
(?) *Subplanites* sp. ind.	2
"*Planites*" aff. *abadiensis* (CHOFF.)	1
Perisphinctes (s. l.) sp.	3
Aspidoceras acanthicum (OPP.)	2
Aspidoceras cf. *acanthicum* (OPP.)	3
Aspidoceras cf. *acanthicum* (OPP.)*	2
Aspidoceras aff. *acanthicum* (OPP.)	2
Aspidoceras sp. [aff. *A. acanthicum* (OPP.)]	1
Aspidoceras cf. *binodum* (OPP.)	1
Aspidoceras binodiferum WAAG.	3
Aspidoceras cf. *iphiceroides* WAAG.	1
Aspidoceras sp.	8
Orthaspidoceras uhlandi (OPP.)	6
Orthaspidoceras cf. *uhlandi* (OPP.)	3
Orthaspidoceras sp. [ex gr. *O. uhlandi* (OPP.)]	4
Physodoceras avellanum (ZITT.)	2
Physodoceras cf. *avellanum* (ZITT.)	1
Physodoceras circumspinosum (QU.)	4
Physodoceras cf. *circumspinosum* (QU.)	1
Physodoceras circumspinosum ssp.	2
Physodoceras cf. *montisprimi* (CAN.)*	2
Physodoceras (?) *lallerianum liparum* (OPP.)	3
Physodoceras (?) sp. [ex gr. *Ph.* (?) *lallerianum liparum* (OPP.)]	1
Physodoceras sp.	2
"*Aspidoceras*" *choffati* (P. DE LOR.)	1
"*Aspidoceras*" *wolfi* (NEUM.)	1
"*Aspidoceras*" *deáki* (HERB.)	1
"*Aspidoceras*" cf. *deáki* (HERB.)	1
Pseudowaagenia sp. [ex gr. *Ps. micropla* (OPP.)]	1
Nebrodites peltoideus (GEMM.)	1
Nebrodites cafisii (GEMM.)	1
Nebrodites cf. *rhodanensis* ZIEGL.	1
Nebrodites sp.	4
(?) *Nebrodites* sp.	1
Mesosimoceras sp. [ex gr. *M. parateres* (CAN.)]	1
Mesosimoceras sp.	3
Hybonoticeras cf. *beckeri harpephorum* (NEUM.)	1
Hybonoticeras pressulum (NEUM.)	2
Hybonoticeras sp. [ex gr. *H. pressulum* (NEUM.)]	1
Hybonoticeras sp. (ex gr. *H. pressulum-ciliatum*)	1
Hybonoticeras sp. (ex gr. *H. pressulum-verestoicum*)	1
Hybonoticeres cf. *knopi* (NEUM.)	1
Hybonoticeras sp. ind.	2
Laevaptychus latissimus ssp.	1
"*Aptychus*" sp.	1
Sphaerodus sp.	1

At the site of detailed fossil sampling the Kimmeridgian can be split up into two lithologically different beds: considering the South European zonal scale of "Les zones du Jurassique en France 1971" (Compte Rendu Sommaire des Séances de la Soc. Géol. de France 1971. fasc. 2. pp. 76—102), the l o w e r b e d would represent the Lower Kimmeridgian *Platynota*, *Hypselocyclum* and *Divisum* Zones as well as the lower and middle parts of the Upper Kimmeridgian, *Acanthicum* and *Eudoxus (Pseudomutabilis)* Zones, of the same classification, corresponding to the *Tenuilobatus (Uhlandi)* and *Pseudomutabilis (Acanthicum)* Zones in the zonal scale adopted by the Colloque sur le Jurassique in Luxembourg (Zones γ, δ in QUENSTEDT's classification). The u p p e r, thinner b e d, on the basis of the presence in it of *Hybonoticeras beckeri harpephorum* (NEUM.) as well as of the associated fauna [e.g. *Mesosimoceras peltoideus* (GEMM.), *Pysodoceras lallerianum liparum* (OPP.),

*Pathological form

Hybonoticeras pressulum (NEUM.)], can be identified convincingly with the *Beckeri* Zone according to both classifications (Zone ε).

Lithostratigraphically, the red argillaceous, Mn-nodular, cephalopodal limestone is one of the typical representatives of the ammonitico rosso formation group. Represented by red argillaceous, Mn-nodular, cephalopodal limestones, the ammonitico rosso is widespread in the Transdanubian Central Mountains. As for its standard stratigraphic section, it is advisable to postpone its designation until more extensive studies are carried out.

From the bio- and chronostratigraphic viewpoints, all the standard zones of the Kimmeridgian Stage could be recorded to be present, in an extremely condensed and disproportionately discontinuous form though. Chronostratigraphic determination of the Kimmeridgian is possible on the basis of the *Axotrix malmica* Zone and the *Lombardia-* and *Cadosina parvula-Stomiosphaera moluccana* acmezones as well.

The circumstances of the genesis seem to have been similar to those of the Upper Liassic red nodular and calcareous marls which were deposited at the end of the first third of the Jurassic sedimentary cycle when the rich benthonic bios was replaced by the mostly abiotic sea bottom environment of the subphotic zone characterized by lime dissolution. At the middle of the last third of the Jurassic sedimentary cycle the sedimentary basin that had passed the point of inversion from subsidence to uplift witnessed the development of bathymetric and ecologic conditions similar to those of the Upper Liassic.

Purple and light grey cephalopodal limestone (Tithono-Berriasian)

In the middle part of Kálvária Hill's Geological Conservation Area, above the Upper Oxfordian limestone breccia and the Kimmeridgian red argillaceous, nodular, cephalopodal limestone one can study the exposures of the Tithono-Berriasian purple and light-grey cephalopodal-tintinninal limestone over nearly 100 m length (Textfig. 34—40). On the eastern side of the N—S trending, tectonically controlled pinching line the Tithono-Berriasian limestone attains 145 cm in thickness. Poorly bedded, it contains locally Oxfordian and Kimmeridgian limestone debris of varying size. It is subordinately crinoid-bearing. Its poor thickness seems to be due—beside the lack of terrigenous material—to dissolution and winnowing of calcareous ooze and to the formation of hardgrounds. The Tithonian can be separated from the Berriasian by the determination of their cephalopodal fauna or by the examination of the microfossils which are substantially more frequent. The limestone beds closely interconnected can be considered a single formation. The unevenly eroded surface of the formation is overlain by Aptian grey crinoidal limestone.

The laboratory analyses of the Tithono-Berriasian limestone have been shown in Tables 8 and 9.

On the basis of characteristic microfossil assemblages, the Tithono-Berriasian limestone can be subdivided into zones widely identifiable throughout the sedimentation areas of similar character of the Tethyan realm. On the basis of studies by T. LÉNÁRD, member of the author's team, the following conclusions could be drawn:

Most characteristic fossils of the Lower Tithonian are the representatives of Lombardia tending to get gradually thinner and more differentiated ($300/cm^2$). It is here that the greatest number of *Globochaete alpina* LOMB. ($3500/cm^2$) can be found in the Malm sequence. The quantity of *Cadosina parvula* NAGY and *C. lapidosa* VOGLER decreases. Occasionally, hosts of microbrachiopods can also be observed.

In the Upper Tithonian three micropaleontological zones could be distinguished:

— at the base a transition (Middle Tithonian) zone can be distinguished which still contains, though subordinately, the representatives of Lombardia, but in which *Crassicollaria intermedia* (DURAND D.), *Cr. parvula* REMANE and *Calpionella alpina* LORENZ (Zone "A") already occur;

— the next micropaleontological zone is defined by the representative occurrence of *Crassicollaria parvula* REMANE and *Calpionella alpina* LORENZ (Zone "B");

— the topmost Tithonian Tintinnina zone is characterized by a *Calpionella alpina*, *C. elliptica* and *Tintinnopsella carpathica* (MURGH. et FIL.) assemblage (Zone "C").

Fossils associated with the Upper Tithonian Calpionella fauna are *Globochaete alpina* LOMB., *Watznaueria communis* REINHARDT, Protoglobigerina, Radiolaria, microgastropods, microbrachiopods, ammonite shell fragments, aptychi, etc.

The Berriasian Stage is characterized by a specific wealth of Tintinnoidea. On the basis of the distribution of these, three zones can be distinguished:

— in the lowermost Berriasian zone the number of specimens of Tintinnina is still relatively

Table 8

Mineralogical, petrographical and geochemical analyses of the type sample of the Tithonian limestone (Geological Conservation Area, Kálvária Hill, Tata)

Chemical composition (%):

SiO_2	4.77
TiO_2	0.06
Al_2O_3	0.90
Fe_2O_3	0.48
FeO	0.12
MnO	0.06
MgO	0.35
CaO	51.60
Na_2O	0.08
K_2O	0.10
$+H_2O$	1.25
P_2O_5	0.07
CO_2	39.69
organic C	0.05
S	0.05
Total:	99.63
—O	0.02

Rare elements (ppm):

B	30
Ba	72
Co	35
Cr	10
Cu	16
Ga	2
Mn	800
Ni	75
Pb	26
Sr	400
Ti	100
V	20

Mineralogical composition (%):

Chemo- and biogenic:	
calcite	88.6
dolomite	1.6
pyrite	0.2
limonite	0.6
chalcedony	0.3
Total:	91.3
Colloidal:	
illite	1.8
kaolinite	0.5
Total:	2.3
Detrital:	
quartz	2.7
feldspar	1.0
Total:	3.7

Micromineralogical analyses (specimens):
(0.06—0.2 mm fraction of insoluble residue)

Heavy minerals:	
Magmatic:	
magnetite	6
enstatite	6
diopside	1
Metamorphic:	
andalusite	2
actinolite	10
disthene	1
garnet	60
epidote	7
tourmaline	2
Epigenic:	
pyrite	9

The heavy minerals are fresh. Some grains are coated by a siliceous or iron hydroxide crust.

Light minerals:	
Detrital:	
quartz	55
feldspar	17
muscovite	2
Chemogenic:	
chalcedony	23

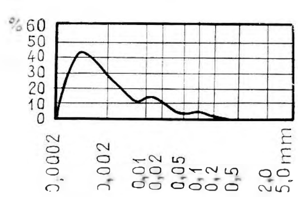
Light mineral fraction represents 98.95 weight % of the insoluble residue.

The quartz grains are in a rather good state of preservation, slightly rounded. Some grains carry a siliceous crust.

Grain size composition (%) of insoluble residue (15.1%):

0.2 —0.5 mm	0.2	1.8
0.1 —0.2	0.9	
0.06 —0.1	0.7	
0.02 —0.06	7.5	34.4
0.01 —0.02	14.2	
0.005—0.01	12.7	
0.002—0.005	21.7	63.8
0.000—0.002	42.1	

Granulometric curve of insoluble residue:



Specific weight:	2.86
Volume weight:	2.60
Porosity:	9.10%
pH:	8.40
O_{Fe}:	8.0

Mineralogical, petrographical and geochemical analyses of the type sample of the Berriasian limestone (Geological Conservation Area, Kálvária Hill, Tata)

Chemical composition (%):

SiO_2	3.28
TiO_2	0.16
Al_2O_3	0.50
Fe_2O_3	0.69
FeO	0.09
MnO	0.07
MgO	0.82
CaO	53.38
Na_2O	0.10
K_2O	0.22
$+H_2O$	0.32
$-H_2O$	0.17
P_2O_5	0.11
CO_2	40.20
organic C	0.08
Total:	100.19

Rare elements (ppm):

B	30
Ba	150
Co	66
Cr	20
Cu	32
Ga	4
Mn	440
Ni	160
Pb	33
Sr	500
Ti	100
V	68

Mineralogical composition (%):

Chemo- and biogenic:	
dolomite	3.2
calcite	88.2
pyrite	0.1
limonite (hematite)	0.4
organic matter	0.1
Total:	92.0
Colloidal:	
montmorillonite	2.2
glauconite	1.8
Total:	4.0
Detrital:	
quartz	0.9
feldspar	0.05
muscovite	0.05
Total:	1.00

Micromineralogical analyses (specimens):
(0.06—0.2 mm fraction of insoluble residue)

Heavy minerals:

Magmatic:	
ilmenite	11
magnetite	12
biotite	4
zircon	5
tourmaline	2
Metamorphic:	
garnet	12
tourmaline	3
chlorite	3
Epigenic:	
pyrite	2
Total:	54
Quantity:	0.66%

Light minerals:

Detrital:	
quartz	88
quartzite	2
glauconite	5
plagioclase	3
muscovite	2
Chemogenic:	
none	
Epigenic:	
none	
Total:	100

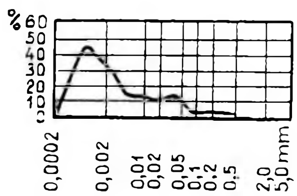
The mineral grains are markedly coated by limonite and well-preserved.

Quantity: 99.34%

Grain size composition (%) of insoluble residue (6.59%):

0.2 —0.5 mm	0.2	4.6
0.1 —0.2	2.2	
0.06 —0.1	2.2	
0.02 —0.06	13.6	35.9
0.01 —0.02	10.0	
0.005—0.01	12.3	
0.002—0.005	17.9	59.5
0.000—0.002	41.6	

Granulometric curve of insoluble residue:



Specific weight:	2.76
Volume weight:	2.53
Porosity:	8.69%
pH:	7.65
O_{Fe}:	15.3

low, but their number of species is already considerable. Listed in the order of frequency, the following species form the assemblage: *Tintinnopsella carpathica* (MURG. et FIL.), *Calpionellopsis simplex* (COLOM), *Calpionella undelloides* COLOM, subordinately *Remaniella cadischiana* COLOM, *Calpionella alpina* (LORENZ), *Calpionellopsis oblonga* (CADISCH) (Zone "D"),

— the next zone is characterized by the predominance of *Calpionellopsis oblonga* in whose frequency order the following forms can also be found: *Tintinnopsella carpathica* (MURG. et FIL.), *Calpionella undelloides* COLOM, a few *Tintinnopsella longa* COLOM, *Lorenziella hungarica* KNAUER et NAGY, *Calpionellites dadayi* KNAUER (Zone "E"),

— the topmost zone is characterized by the predominance of *Calpionellites darderi* and includes, in addition, *Calpionellopsis oblonga* and *Tintinopsella carpathica* as well.

Irregularly varying in quantity though (50—150/cm^2), *Cadosina fusca* is characteristic of all three zones. The quantity of quartz grains becomes significant (300/cm^2). Associated faunal elements are ammonite and echinoderm fragments, aptychi, microgastropods, echinoderms, Radiolaria and Ostracoda. M. BÁLDI—BEKE identified the species *Markalius circumradiatus* (STOVER), *Parhabdolithus embergeri* (NOËL) and *Nannoconus steinmanni* KAMPTNER.

In spite of an extensive examination of Upper Tithonian-Berriasian microfossil assemblages readily utilizable for fine stratigraphic horizonting and of the frequent publication of the results, a convincing solution to the problem, of the Tithono-Berriasian boundary does not yet seem to be feasible. In the present work the beginning of the Berriasian is considered to coincide with the first appearance of the genus Calpionellopsis when the Calpionella species, particularly *C. elliptica*, become subordinate. This boundary is situated a little higher than that drawn in recent years by REMANE, HEGARAT and others (between the frequency peaks of *C. alpina* and *C. elliptica*).

The rich Tithono-Berriasian cephalopodal and brachiopodal faunae as well as the other associated macrofossils were revised by G. VIGH. Old and new samplings have produced the following fossil assemblage:

Summarized lists of the Tithonian fauna:	specimens
Cariophyllia sp.	1
Epismila cf. *laufonensis*	1
Microsolena agassiciformis ETALL.	1
Trochocyathus truncatus ZITT.	5
Trochocyathus primaeva ZITT.	1
Thecocyathus sp.	1
?*Milleporidium* sp.	1
Terebratula cf. *bilimeki* SUESS	2
Terebratula himeraensis GEMM.	1
Terebratula sp. ind.	3
Pygope triangulus (LAM.)	2
Pygope sp. [ex gr. *P. triangulus* (LAM.)]	2
Pygope triangulus angulata (ssp. nov.) VIGH	43
Pygope cf. *triangulus* (LAM.) (ex gr. *P. triangulus angulata*)	3
Pygope aff. *rectangularis* (PICT.)	1
Pygope sp. [cf. *P. rectangularis* (PICT.)]	1
Pygope diphya (COL.)	3
Pygope diphya (COL.)*	1
Pygope cf. *diphya* (COL.)	3
Pygope sp. [ex gr. *P. diphya* (COL.)]	1
Pygope discissa tenuis (ssp. nov.) VIGH	10
Pygope vomer (sp. nov.) VIGH	3
Pygope sima (ZEUSCHN.)	3
Pygope sp. [ex gr. *P. sima* (ZEUSCHN.)]	1
Pygope sima ssp.	1
Pygope sp.	6
Glossothyris sp.	2
"*Rhynchonella*" *tatrica* (ZEUSCHN.)	2
Pecten cinguliferus ZITT.	4
Pecten aff. *cinguliferus* ZITT.	1
Pecten sp. (ex gr. *P. acrorysus* GEMM. et DI BLASS.)	1

*Pathological form

	specimens
Pecten sp.	9
Lima sp.	1
Neaera sp.	1
Placunopsis tatrica Zitt.	1
Lamellibranchiata div. ind.	3
Spinigera sp. (ex gr. *Sp. tatrica* Zitt.)	1
Turbo sp.	1
Phylloceras isotypum (Ben.)	1
Phylloceras aff. *isotypum* (Ben.)	3
Phylloceras serum (Opp.)	2
Phylloceras cf. *serum* (Opp.)	4
Partschiceras ptychostoma (Ben.)	4
Partschiceras cf. *ptychostoma* (Ben.)	1
Partschiceras aff. *ptychostoma* (Ben.)	1
Partschiceras sp.	1
? *Partschiceras* sp.	1
Calliphylloceras kochi (Opp.)	7
Holcophylloceras calypso (d'Orb.) = *H. silesiacum* (Opp.)	14
Holcophylloceras cf. *calypso* (d'Orb.) = *H.* cf. *silesiacum* (Opp.)	2
Holcophylloceras sp. [ex gr. *H. calypso* (d'Orb.)] = *H. silesiacum* (Opp.)	2
Holcophylloceras mediterraneum (Neum.)	1
Holcophylloceras cf. *mediterraneum* (Neum.)	4
Holcophylloceras aff. *mediterraneum* (Neum.)	1
Holcophylloceras sp. [ex gr. *H. mediterraneum* (Neum.)]	1
Holcophylloceras sp.	8
Ptychophylloceras semisulcatum (d'Orb.) = *Pt. ptychoicum* (Qu.)	51
cf. *Ptychophylloceras semisulcatum* (d'Orb.) = *Pt. ptychoicum* (Qu.)	1
Ptychophylloceras semisulcatum inordinatum (Touc.) = *Pt. ptychoicum inordinatum* (Touc.)	1
Sowerbyceras sp. [ex gr. *S. tortisulcatum* (d'Orb.)]	1
Phylloceras (s. l.) sp.	10
? *Phylloceras* (s. l.) sp.	1
Pterolytoceras orsini depressale (ssp. nov.) Vigh	1
Pterolytoceras juilleti (d'Orb.) = *Pt. sutile* (Opp.)	15
Pterolytoceras cf. *juilleti* (d'Orb.) = *Pt.* cf. *sutile* (Opp.)	3
Pterolytoceras aff. *juilleti* (d'Orb.) = *Pt.* aff. *sutile* (Opp.)	5
Pterolytoceras sp. [ex aff. *Pt. juilleti* (d'Orb.)] = *Pt. sutile* (Opp.)	6
Pterolytoceras montanum (Opp.)	17
Pterolytoceras aff. *montanum* (Opp.)	5
Pterolytoceras sp. [aff. *Pt. montanum* (Opp.)]	3
Pterolytoceras sp. (? *Pt. montanum* ssp. nov.)	2
Pterolytoceras liebigi (Opp.)	9
Pterolytoceras cf. *liebigi* (Opp.)	3
Pterolytoceras aff. *liebigi* (Opp.)	2
Pterolytoceras sp. [ex gr. *Pt. liebigi* (Opp.)]	2
Pterolytoceras sp. ind.	3
Lytoceras (s. l.) sp. ind.	19
Protetragonites quadrisulcatus (d'Orb.)	35
Protetragonites cf. *quadrisulcatus* (d'Orb.)	2
Protetragonites aff. *quadrisulcatus* (d'Orb.)	1
? *Protetragonites* cf. *quadrisulcatus* (d'Orb.)	5
Protetragonites sp.	3
Leptotetragonites honnoratianus (d'Orb.) = *L. municipale* (Opp.)	5
Leptotetragonites cf. *honnoratianus* (d'Orb.) = *L.* cf. *municipale* (Opp.)	2
Leptotetragonites aff. *honnoratianus* (d'Orb.) = *L.* aff. *municipale* (d'Orb.)	1
cf. *Leptotetragonites honnoratianus* (d'Orb.) = *L. municipale* (Opp.)	2
Leptotetragonites sp.	3
Bochianites sp.	4
Haploceras elimatum (Opp.)	11
Haploceras cf. *elimatum* (Opp.)	7
Haploceras aff. *elimatum* (Opp.)	2

	specimens
Haploceras staszycii (Zeuschn.)	4
Haploceras cf. *staszycii* (Zeuschn.)	3
Haploceras sp. [ex gr. *H. staszycii* (Zeuschn.)]	1
Haploceras sp. [aff. *H. cristifer* (Zitt.)]	2
Haploceras sp.	27
Pseudolissoceras (?) sp. [ex gr. *Ps.* (?) *rasile planiusculum* (Zitt.)]	1
Neolissoceras (?) *tithonius* (Opp.)	24
Neollissoceras (?) cf. *tithonius* (Opp.)	4
Neolissoceras (?) sp. [ex gr. *N. tithonius* (Opp.)]	1
Neolissoceras aff. *grasianum* (d'Orb.)	2
Neolissoceras sp.	5
Glochiceras (?) *carachtheis* (Zeuschn.)	3
Glochiceras (?) cf. *carachtheis* (Zeuschn.)	2
Glochiceras (?) cf. *carachtheis subtilior* (Zitt.)	1
Taramelliceras (Parastreblites) cf. *waageni* (Zitt.)	1
Streblites folgariacus (Opp.)	3
Substreblites zonarius (Opp.)	1
Taramelliceras (s. l.) sp.	1
? *Taramelliceras* sp. ind.	1
Oppeliidarum gen. et sp. ind.	1
Perisphinctes (s. l.) sp.	10
Lithacoceras (Lithacoceras) cf. *geron* (Zitt.)	1
Lithacoceras (? Progeronia) sp.	2
? *Lithacoceras* (s. l.) sp. ind.	1
? *Katroliceras* (s. l.) sp.	2
? *Katroliceras* (s. l.) sp.*	1
Subplanites pseudocontiguus Donze et Enay	1
Subplanites reisi (Schn.)	1
Subplanites sp.	1
? *Subplanites* sp. ind.	1
Paraulacosphinctes cf. *transitorius* (Opp.)	1
Pseudovirgatites scruposus (Opp.)	1
Pseudovirgatites cf. *seorsus* (Opp.)	2
? *Paraberriasella* sp. ind.	1
Virgatosphinctes cf. *eystettensis* Schn.	1
Virgatosphinctes sp.	1
Pseudosubplanites cf. *lorioli* (Zitt.)	2
Aspidoceras rogoznicense (Zeuschn.)	3
Aspidoceras cf. *rogoznicense* (Zeuschn.)	4
Aspidoceras sp.	2
Physodoceras neoburgense cyclotum (Opp.)	22
Physodoceras cf. *neoburgense cyclotum* (Opp.)	2
Physodoceras aff. *neoburgense cyclotum* (Opp.)	2
Physodoceras sp. [ex gr. *Ph. neoburgense cyclotum* (Opp.)]	2
Physodoceras lallerianum liparum (Opp.)	1
Physodoceras cf. *lallerianum liparum* (Opp.)	1
Physodoceras sp. [ex gr. *Ph. lallerianum liparum* (Opp.)]	1
Physodoceras lallerianum ssp.	1
Physodoceras avellanum (Zitt.)	2
Physodoceras cf. *avellanum* (Zitt.)	1
Physodoceras aff. *avellanum* (Zitt.)	2
Physodoceras sp. ind.	8
? *Orthaspidoceras* sp.	1
Pseudowaagenia sp.	1
"*Aspidoceras*" sp. [ex gr. "*A.*" *episus* (Opp.)]	2
"*Aspidoceras*" sp.	7
? *Nebrodites* sp. ind.	3
Hybonoticeras cf. *hybonotum* (Opp.)	2

*Pathological form

	specimens
Hybonoticeras sp. [ex gr. *H. hybonotum* (OPP.)]	2
Hybonoticeras cf. *mundulum mundulum* (OPP.)	2
Hybonoticeras sp. ind.	4
Simoceras volanense (OPP.)	2
Spiticeras kiliani DJAN.	2
Spiticeras sp. (ex gr. *Sp. kiliani* DJAN.)	3
Spiticeras cf. *bulliforme* UHL.	1
Spiticeras sp. (ex gr. *Sp. bulliforme* UHL.)	2
Spiticeras sp. [ex gr. *Sp. celsum* (OPP.)]	1
Spiticeras sp. (ex gr. *Sp. multiforme* DJAN.)	1
Spiticeras sp. (ex gr. *Sp. mutabile* DJAN.)	2
Spiticeras sp. (ex gr. *Sp. mojsvári* UHL.)	4
Spiticeras sp.	29
Proniceras sp. (aff. *P. jacobi* DJAN.)	1
Proniceras sp.	3
? *Proniceras* sp.	1
Berriasella (Berriasella) privasensis (PICT.)	1
Berriasella (Berriasella) sp. [ex gr. *B. (B.) privasensis-oppeli*]	1
Berriasella (Berriasella) cf. *oppeli* (KIL.)	4
Berriasella (Berriasella) sp. [ex gr. *B. (B.) oppeli* (KIL.)]	1
Berriasella (Berriasella) subcallisto (TOUC.)	1
Berriasella (Berriasella) cf. *subcallisto* (TOUC.)	1
Berriasella (Berriasella) jacobi MAZEN.	1
Berriasella (Berriasella) sp. [? ex gr. *B. (B.) paramacilenta* MAZEN.]	2
Berriasella (Picteticeras) oxycostata (JAC.) in BREISTR.	2
Berriasella (Picteticeras) cf. *oxycostata* (JAC.) in BREISTR.	2
Berriasella (Picteticeras) sp. [ex gr. *B. (P.) oxycostata* (JAC.) in BREISTR.]	1
Berriasella (Picteticeras) chomeracensis (TOUC.)	3
Berriasella (?) *richteri* (OPP.)	3
Berriasella (?) cf. *richteri* (OPP.)	1
Berriasella (?) sp. [ex gr. *B.* (?) *richteri* (OPP.)]	1
Berriasella (?) *subrichteri* (RET.)	1
Berriasella (s. l.) sp. ind.	66
Malbosiceras cf. *chaperi* (PICT.)	1
Malbosiceras sp. (ex gr. *M. chaperi-malbosi*)	1
Malbosiceras cf. *aspera* (MAZEN.)	1
Malbosiceras sp. [aff. *M. aizyensis* (MAZEN.)]	1
Malbosiceras aff. *gignouxi* (MAZEN.)	1
Delphinella cf. *berthei* (TOUC.)	1
Delphinella sp. [ex gr. *D. delphinensis* (KIL.)]	1
Delphinella cf. *obtusenodosa* (RET.)	1
Delphinella subchaperi (RET.)	1
Delphinella aff. *subchaperi* (RET.)	1
Neocosmoceras sp. nov.	2
Neocosmoceras sp.	2
? *Neocosmoceras* sp.	1
Himalayites cortazari ssp.	1
Himalayites cf. *köllickeri* (OPP.)	1
Himalayites aff. *köllickeri* (OPP.)	1
Himalayites (Corongoceras) sp.	1
Himalayites (Micracanthoceras) sp. [ex gr. *H. (M.) microcanthus* (OPP.)]	2
Himalayites sp.	1
? *Himalayites* sp.	3
Fauriella (Strambergella) cf. *carpathica* (ZITT.)	3
Fauriella (Strambergella) aff. *carpathica* (ZITT.)	1
Pseudargentiniceras cf. *abcissa* (OPP.)	2
Pseudargentiniceras aff. *abcissa* (OPP.)	1
Pseudargentiniceras sp. [ex gr. *Ps. abcissa* (OPP.)]	1
Pseudargentiniceras sp.	1
Pseudargentiniceras beneckei (JAC.) in ROM. et MAZEN.	2
Pseudargentiniceras beneckei ssp.	1

	specimens
Tirnovella sp. [ex gr. *T. occitanica* (PICT.)]	1
Jabronella paquieri ssp.	1
Jabronella cf. *isaris* (POMEL)	1
Jabronella sp. [ex gr. *J. isaris* (POMEL)]	1
Jabronella jabronensis (MAZEN.)	1
Dalmasiceras sublaevis MAZEN.	2
Dalmasiceras sp. (ex gr. *D. sublaevis-biplanum*)	1
Dalmasiceras cf. *kiliani* (DJAN.)	1
(?) *Dalmasiceras* sp.	1
Subalpinites aristidis (KIL.)	1
Subalpinites cf. *aristidis* (KIL.)	1
Subalpinites sp. [ex gr. *S. aristidis* (KIL.)]	1
? *Subalpinites aristidis* (KIL.)	1
Neocomites sp.	6
? *Neocomites* sp. ind.	1
? *Kilianella* sp. ind.	1
Punctaptychus punctatus (VOLTZ)	3
Punctaptychus cf. punctatus (VOLTZ)	2
? *Punctaptychus punctatus* (VOLTZ)	5
Punctaptychus sp.	18
Lamellaptychus beyrichi (OPP.)	2
Lamellaptychus sp. [ex gr. *L. beyrichi* (OPP.)]	1
Lamellaptychus beyrichi fractocostata TRAUTH	1
Lamellaptychus exsculptus (SCHAUR.)	1
Lamellaptychus mortilleti ? (PICT. et LOR.)	1
Lamellaptychus cf. *mortilleti?* (PICT. et LOR.)	1
Lamellaptychus sp. [ex gr. *L. seranonis* (COQU.)]	1
Lamellaptychus sp.	12
Laevaptychus sp.	3
"*Aptychus*" sp.	39
Rhyncholites sp.	8
Hibolites aff. *semisulcatus* (MSTR.)	1
Hibolites sp.	32
Duvalia sp. div.	4
"*Belemnites*" sp. (aff. "*B.*" *tithonius* OPP.)	1
"*Belemnites*" sp.	1
Skeletal elements of crinoids	

Summarized lists of the Berriasian fauna:

Trochocyathus truncatus ZITT.	1
Paratrochocyathus cf. *conulus* (PHILLIPS—MICH.)	1
Pygope triangulus (LAM.)	14
Pygope triangulus angulata (nov. sp.) VIGH	27
Pygope euganensis (PICT.)	1
Pygope cf. *vomer* (nov. sp.) VIGH	2
Pygope sima (ZEUSCHN.)	1
Pygope sp.	1
Placunopsis cf. *tatrica* ZITT.	1
Neaera sp.	1
Phylloceras thetys (D'ORB.)	2
Phylloceras aff. *thetys* (D'ORB.)	1
Phylloceras ponticuli (ROUSSEAU)	1
Holcophylloceras calypso (D'ORB.) = *H. silesiacum* (OPP.)	5
Holcophylloceras sp.	2
Ptychophylloceras semisulcatum (D'ORB.) = *Pt. ptychoicum* (QU.)	38
cf. *Ptychophylloceras semisulcatum* (D'ORB.) = *Pt. ptychoicum* (QU.)	1
Phylloceras (s. l.) sp.	5
? *Phylloceras* (s. l.) sp.	1
Pterolytoceras juilleti (D'ORB.) = *Pt. sutile* (OPP.)	24

	specimens
Pterolytoceras cf. *juilleti* (d'Orb.) = *Pt.* cf. *sutile* (Opp.)	1
Pterolytoceras sp.	9
Lytoceras (s. l.) sp.	2
Protetragonites quadrisulcatus (d'Orb.)	22
Protetragonites aff. *quadrisulcatus* (d'Orb.)	1
Leptotetragonites aff. *honnoratianus* (d'Orb.) = *L.* aff. *municipale* (Opp.)	1
? *Leptotetragonites* sp.	2
Neolissoceras grasianum (d'Orb.)	9
Neolissoceras cf. *grasianum* (d'Orb.)	1
Neolissoceras sp. [ex gr. *N. grasianum* (d'Orb.)]	3
Neolissoceras salinarium (Uhl.)	2
Neolissoceras sp.	2
? *Neolissoceras* sp.	1
Spiticeras sp. [ex gr. *Sp. groteanus* (Opp.)]	1
Spiticeras cf. *mojsvári* Uhl.	1
Spiticeras aff. *bulliforme* Uhl.	1
Spiticeras sp. (ex gr. *Sp. bulliforme* Uhl.)	5
Spiticeras cf. *multiforme* Djan.	5
Spiticeras kiliani Djan.	1
Spiticeras sp. (ex gr. *Sp. multiforme* Djan.)	10
Spiticeras cf. *kiliani* Djan.	2
Spiticeras sp. (ex gr. *Sp. kiliani* Djan.)	3
Spiticeras sp. ind.	56
Spiticeras (Negreliceras) sp.	1
Spiticeras (? Negreliceras) sp.	1
Berriasella (Berriasella) privasensis (Pict.)	1
Berriasella (Berriasella) cf. *privasensis* (Pict.)	2
Berriasella (Berriasella) sp. [aff. *B. (B.) paramacilenta* (Mazen.)]	1
Berriasella (Berriasella) sp. [ex gr. *B. (B.) callisto* (d'Orb.)]	1
Berriasella (Picteticeras) picteti (Jac.) in Kil.	1
Berriasella (Picteticeras) oxycostata (Jac.) in Breistr.	2
Berriasella (Picteticeras) sp. [ex gr. *B. (P.) oxycostata* (Jac.) in Breistr.]	1
Berriasella ? cf. *subrichteri* (Ret.)	1
Berriasella sp. ind. div.	26
? *Berriasella* sp. ind.	2
Malbosiceras sp. (ex gr. *M. chaperi-malbosi*)	3
Euthymiceras sp. [ex gr. *E. euthymi* (Pict.)]	1
Neocosmoceras sp.	7
? *Neocosmoceras* sp. ind.	2
Himalayites sp.	1
? *Himalayites (Corongoceras)* sp.	2
Himalayites (Micracanthoceras) sp.	2
? *Himalayites (Micracanthoceras)* sp.	1
Fauriella (Strambergella) cf. *carpathica* (Zitt.)	1
Fauriella (Strambergella) sp.	1
Fauriella boissieri (Pict.)	3
Fauriella cf. *boissieri* (Pict.)	2
Fauriella aff. *boissieri* (Pict.)	1
Fauriella sp. [ex gr. *F. boissieri* (Pict.)]	2
Fauriella gallica (Mazen.)	1
Pseudargentiniceras abcissa (Opp.)	1
Tirnovella occitanica (Pict.)	1
Tirnovella aff. *occitanica* (Pict.)	1
Tirnovella cf. *subalpina* (Mazen.)	2
Tirnovella sp. [ex gr. *T. subalpina* (Mazen.)]	2
Jabronella sp. [ex gr. *J. isaris* (Pomel)]	1
Jabronella sp. [ex gr. *J. subisaris* (Mazen.)]	1
Jabronella angustumbilica (nov. sp.) Vigh	1
Jabronella aff. *discrepans* (Ret.)	1
Dalmasiceras sp.	1
Neocomites sp.	8

	specimens
? *Neocomites* sp.	5
Kilianella sp. [ex gr. *K. pexiptycha* (UHL.)]	1
Kilianella sp.	1
Punctaptychus punctatus (VOLTZ)	3
Punctaptychus sp.	1
? *Punctaptychus* sp.	1
Lamellaptychus didayi (COQU.)	1
Lamellaptychus cf. *seranonis* (COQU.)	1
Lamellaptychus sp.	2
? *Laevilamellaptychus* sp.	1
"*Aptychus*" sp. ind.	13
Rhyncholites sp.	1
Duvalia sp.	1
Belemnites (s. l.) sp. (ex gr. *B. ensifer* OPP.)	1
Belemnites (s. l.) sp.	6
Skeletal elements of crinoids	
Echinoid spines	

On the basis of the rich ammonite fauna the presence of the *Hybonotum* Zone is certified by the zonal index fossil itself; in addition, the presence of the *Vimineus* Zone can be identified on the basis of the associated fauna.

In the Middle Tithonian the fauna showing nest-like enrichments is of lumachelle type. The *Semiforme* Zone is certified by the associated fauna.

In the Upper Tithonian a new faunal wave appears. Beside the representatives of Phylloceras, Lytoceras and Haploceras characteristic of the Mediterranean realm, there appear new genera such as Protetragonites as well as a number of representatives of the families Bochianitidae, Olcostephanidae and Berriasellidae. The fossils are of comparatively small size for the most part. As a rule, they are broken specimens: an indication of intensive agitation of the environment. Their mode of embedding is of irregular, random pattern.

From the biostratigraphic viewpoint, the *Delphinensis* Zone is evidenced by its associated fauna, the *Subcallisto* and *Chaperi* Zones are by the zonal index fossil, too.

The ammonites of the Berriasian Stage are in a close connection with the Upper Tithonian fauna. Of these the Olcostephanidae and Berriasellidae families are most abundant both in specimens and species. The representatives of Pygope are also frequent. Like in the Upper Tithonian, the fossil material is composed mostly of broken specimens and the fossils are embedded as irregularly as in the Upper Tithonian.

Biostratigraphically, the Lower Berriasian *Grandis* Zone is evidenced by the associated fauna, while the Upper Berriasian *Boissieri* Zone is certified by the presence of several specimens of the zonal index as well.

Lithostratigraphically, as already mentioned, the Tithono-Berriasian limestones are considered to represent one single formation. It is advisable to designate also the stratotype of the formation in Kálvária Hill's well-exposed and abundantly fossiliferous sections and to choose the name the of formation from this locality, too. The name Kálvária Hill, however, is a very wide-spread locality name in this country, while a denominantion like Tata's Kálvária Hill would be too awkward and cumbersome. Therefore, recurring to an expedient usage frequently practised in the coinage of stratigraphic names, I propose the earlier geographic name of the locality, "Szentivánhegy" to be used as formation name.

When around 1350 the Hungarian King Louis the Great promoted Tata to the rank of a town, the peripheral district of the town became and independent community. A church for its inhabitants was erected at the top of the "Márványhegy" (Marble Hill) to the honour of St. John the Baptist. Thenceforward both the place and the settlement sprawling around it were to be called Szentivánhegy (St. Ivan's Hill). This situation lasted till 1754 when the church, with exception of the sanctuary developed into a chapel, was pulled down and a Calvary was erected in the vicinity from the material thus recovered. Hence a new name arose in the shade of which the old one was buried in oblivion. This fact, however, cannot hinder us in referring henceforward to the conformable Tithono-Berriasian beds of the Transdanubian Central Mountains as Szentivánhegy Limestone — a locality designation which we should like to make familiar among fellow geologists.

As for its genetic conditions, a sea depth of 150 to 200 m is suggested. Beside planktonic and nektonic forms, the representatives of the benthos play again a considerable role: Foraminifera, Brachiopoda, echinoderms and, subordinately, ahermatypic corals. The mode of embedding of cephalopods is indicative of a heavily agitated environment. The increase of the stilt content indicates the intensification of environmental changes. The post-Berriasian break in sedimentation and denudation accounting for several stratigraphic stages are indications of an emergence. The typically littoral final beds of the Jurassic-Berriasian sedimentary cycle are unknown.

SOME PECULIAR SEDIMENTOLOGICAL PHENOMENA

While studying Kálvária Hill's Kimmeridgian and Tithono-Berriasian formations, the writer observed a few remarkable sedimentological phenomena which are worth of special discussion:

Subsyngenetic diaclases of lobular network pattern, rejuvenated several times and filled with Lower to Upper Tithonian Tintinnina limestone (neptunian dikes)

This phenomenon can be observed best on a Kimmeridgian bedding plane of 20 m^2 size recovered in the central part of the Geological Conservation Area (Textfig. 41: in pocket). The surface of the Kimmeridgian bed containing a rich cephalopodal fauna and a characteristic microfossil assemblage is a typical hardground. Lying on their sides, the ammonites are cut "asunder" (their upper part being affected by subsolution); ferromanganese crusts and nodules are abundant. The width of the diaclases is up to 15 cm. The fissure-filling material consists of heavily limonitized limestone matrix with a very low amount of corroded bioclasts and of corroded Kimmeridgian and Lower to Upper Tithonian limestone grains. The formation of diaclases can be explained by minor crustal movements that recurred in Tithonian time. Differential distribution of the Lower and Upper Tithonian limestone grains in the fissure-filling matrix allowed the writer to distinguish between Lower and Upper Tithonian diaclases. Debris of Berriasian limestone were absent in the extraclastic material of fissure-fills.

Submarine scree

A remarkable discovery is the fact that in the Malm-Berriasian sequence of Kálvária Hill's Geological Conservation Area lithified remnants of scree can be found which crept down the contemporaneous submarine slope. It is the western side of the tectonically controlled, N—S trending "pinching line", referred to in several instances already, that was perched (in conformity with Kálvária Hill's present-day surface). The brecciated material of the Oxfordo-Kimmeridgian and Lower Tithonian limestone that was already diagenized for the most part crept down the slopes of submarine ridges in form of scree flows of several metres width (Plate XXX, Fig. 1). In additon, Kimmeridgian limestone "inclusions" attaining even 30 to 50 cm size can also be found embedded in the Tithonian limestone on the one-time sedimentary slope [Textfig. 42 (in pocket) Plate XXX, Fig. 2]. The presence of slope-deposited sediments is evidenced both by the eastward increase of thickness of the Malm sequences uncovered in the Geological Conservation Area, and their pinching out in opposite direction.

Submarine diaclases and submarine scree may have been closely interconnected. Tectonic stresses resulted in fractures, diaclases and neptunian dikes, while the roughness of sea bottom morphology provoked slope-generated sedimentation. It can be concluded firmly that all these phenomena may have occurred within a few tens of metres and at a few metres of height difference and that one need not necessarily suppose the existence of large seamounts of considerable height to account for them.

Hardgrounds

Typical features of the Malm-Berriasian sequences of 50 cm to 3.5 m thickness, hardgrounds are the regular consequences of their genetical conditions and provide one of the explanation for their reduced thickness. In the "starving" seas little sediment could be accumulated and the calcareous ooze that had settled on the bottom of the sea was frequently reduced by subsolution. This phenomenon was often coupled with a washing away of the sediment. Most characteristic features of hardgrounds are: halved ammonites (reduced by subsolution) along bedding planes (Textfig. 43: in pocket) and coating by ferromanganese oxide. They do not always form easily recognizable bedding planes, and bedding planes, in turn, do not always represent hardgrounds.

Malm-Berriasian sequences recovered by drilling

Beside Kálvária Hill, the Malm-Berriasian at Tata has been uncovered by 17 boreholes (and the dug-well of the property of 43, Fazekas Street). A few of these have penetrated into a fault zone, therefore their lithological log is obscure; some boreholes have not completely uncovered the Malm-Berriasian sequence. The uncovered rocks show an extremely rich variety of geological characteristics and largely vary in exact stratigraphic position, being difficult to assign to definite types or units. In spite of this, the available material offers good possibilities for the deduction of sedimentological and geohistorical conclusions.

The studied Malm-Berriasian sequences can be assigned to two different types of development:

(1) sequences of reduced thickness, discontinuous, with hardgrounds, resulting from condensed sedimentation, like those of Kálvária Hill;

(2) sequences "of horst margin position", of greater thickness, more continuously sedimented and, consequently, more complete.

1. The Malm-Berriasian sequences of low thickness (boreholes TVG-17, -21, -25, -41, -44, -45, -46, -51, -52, -54, -55 and dug-well of 43, Fazekas Street) are more generally distributed (Textfig. 44: in pocket). Their thickness varies between 0.5 and 4 m (1—2 m in most of the cases). They occur above the Upper Dogger cherts in all but a few boreholes (TVG-54, -46, -55). In the case of boreholes TVG-46 and -55 the Upper Jurassic sequence overlies with a hiatus the Lower Dogger limestones, in borehole TVG-54, supposedly, the Upper Dogger red calcareous argillite.

At the base of the Upper Jurassic sequence the Oxfordian intraformational limestone breccia is a formation of overall distribution. Its thickness varies between 0.15 and 1 m (most frequently about 0.5 m). Lithologically, it is characterized by the presence of greyish-white limestone debris of obscure origin. In the red-brown clayey limestone of the interstices of the breccia grains hosts of Protoglobigerina and Radiolaria occur; in addition, the presence of *Cadosina parvula* is characteristic. Less frequently, thin-valved Ostracoda, tiny echinoderm skeletal debris and small benthonic Foraminifera can also be observed.

Difficult to distinguish microbiostratigraphically, the Kimmeridgian-Lower Tithonian limestone is of overall distribution. Its thickness varies between 0.4 and 1.8 m. Rather low even originally, the thickness of the formation was occasionally reduced, inter alia, by denudation that preceded the deposition of the Aptian grey crinoidal limestone, which locally led to the complete denudation of the Malm-Berriasian limestones (TVG-52, -43). Lithologically, it is represented by red argillaceous limestones, nodular and homogeneous limestones, locally with submarine scree which may be intraformational as well as may derive from the Oxfordian limestone breccia. In borehole TVG-46 the formation is constituted predominantly by Liassic limestone debris. Mn-coated nodules and hardgrounds can also be observed. Ammonites are typical. Crinoidal limestone layers are also available. The texture is of biomicritic nature. Lombardia (skeletal elements of Saccocoma) and Globochaete, occasionally (e.g. borehole TVG-44) even rockforming, are of overall distribution. In some sections Protoglobigerina and Radiolaria are abundant (dug-well of 43, Fazekas Street). A peculiar microfossil assemblage is contained in borehole TVG-46 in which the Kimmeridgian-Lower Tithonian sequence begins with an Axotrix microfacies, followed by a bed consisting of rockforming skeletal elements of echinoderms and finally, by Protoglobigerina-Radiolaria limestone at the top. The Kimmeridgian and Lower Tithonian could be separated in some cases only. Associated with a considerable quantity of *Stomiosphaera moluccana*, the species *Cadosina parvula* suggests the presence of the Kimmeridgian, while the abundant representatives of Globochaete are indicative of the Lower Tithonian.

Upper Tithonian-Berriasian limestones have been intersected only by a few boreholes (TVG-17, -21, -44). The reason for this was the terrestrial denudation that preceded the formation of the Aptian grey crinoidal limestone. The thickness of the Upper Tithonian and Berriasian limestones combined is as low as 1—2 m. The rock is of aphaneritic texture, locally with synsedimentary breccias, in the Upper Tithonian with Mn-coated nodules and a microbioklastic rock texture. Here again, microscopic quartz grains become comparatively frequent. Of the microfossils, skeletal elements of Crinoidea and benthonic Foraminifera are usually available, though in a low quantity as a rule. In some beds Protoglobigerina and Radiolaria are abundant. Generally present in great quantities, Tintinnina are of biostratigraphic value. Their thanatocoenoses are representative of coenological and frequency conditions similar to those of Kálvária Hill (Textfig. 45).

After the above review of the geological setting, let us quote briefly some peculiarities of the genetic conditions as well.

The low formation thickness is basically due to a break in sedimentation that had been lasting here for long after Late Liassic time ("starving basins" blocked from terrigenous supplies) and to frequent dissolution of lime and to removal of sediment by currents. The condensed nature of the sequences of low thickness is also indicated by the observation that the frequency of planctonic microfossils is substancially higher than in the case of thick sequences.

Syngenetic fault tectonics is indicated by the occurrence of neptunian dikes, submarine scree (synsedimentary breccias) and the heterogeny of lithology testifying to a sea bottom of rough morphology.

2. The Malm-Berriasian limestone formation, of greater thickness, more complete, "of horst margin position" is exposed on the eastern border of Tata's Mesozoic basement horst block, in the rocky basement of Tata Castle, in the footwall of Aptian grey crinoidal limestones (boreholes TVG-16, -49, -50), and, to the north of it, in front of the Apprentice's Hostel and the Grammar School both on the surface and in boreholes TVG-56 and T-1047 as well as in borehole TVG-59 in the NW part of the town (Textfig. 44).

The thickness of the Malm-Berriasian sequences exposed on the eastern border of the basement horst varies between 16.5 and 28 m. In borehole TVG-59 the thickness of the Berriasian and Upper Tithonian (where the bore stopped) combined is 22.5 m. The considerable difference in thickness is due to the higher thickness of the Kimmeridgian-Lower Tithonian and the Upper Tithonian-Berriasian. Development and thickness of the Oxfordian limestone breccia do not differ from those of the low-thickness sequences.

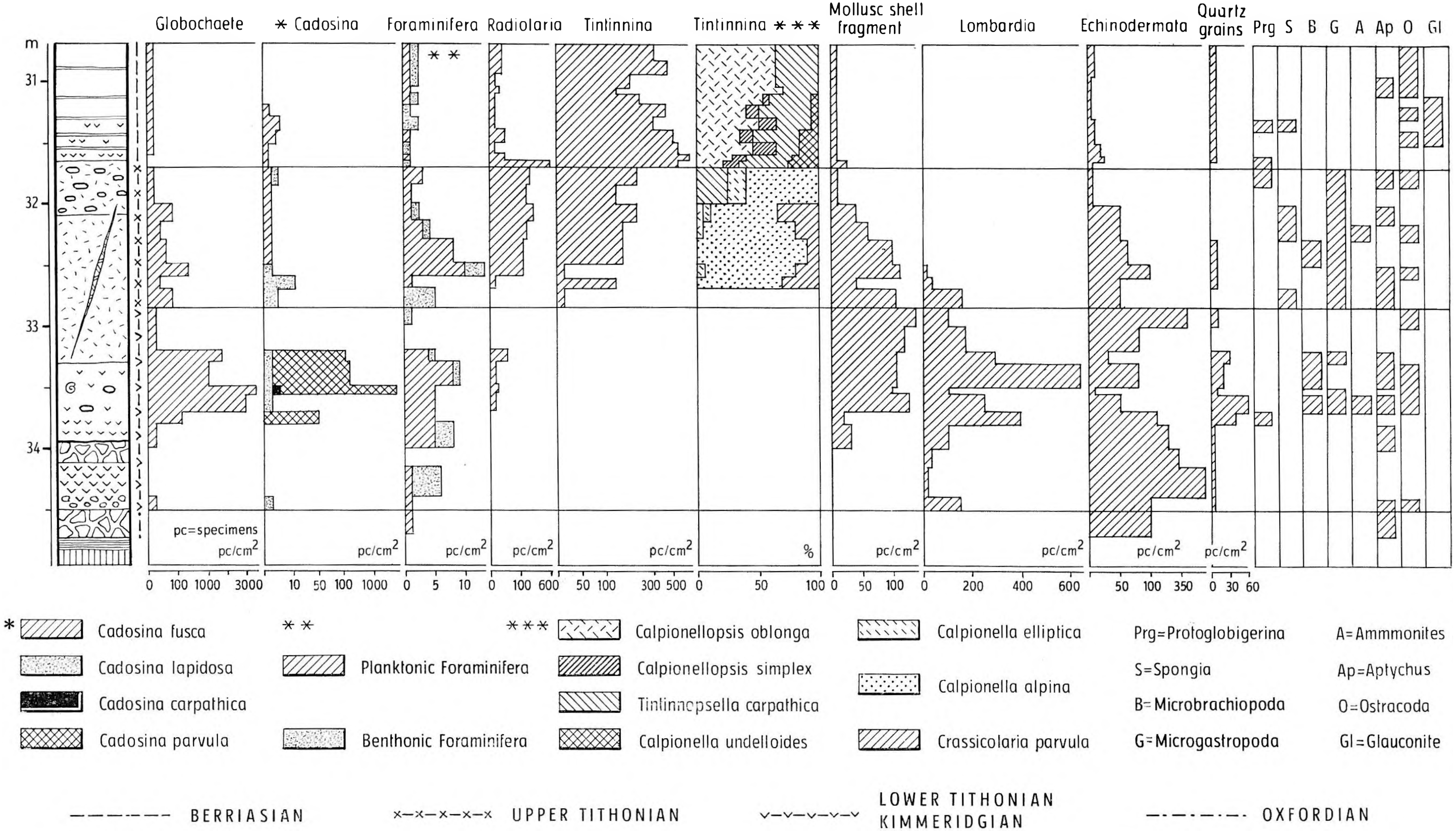
The individual sequences show differences in facies even within a small distance. This holds true both of differences in lithology and the thicknesses of single stratigraphic units. Marked divergency of lithofacies is observable in the case of the Kimmeridgian-Lower Tithonian limestone, and rather considerable difference in thickness is in that of the Upper Tithonian limestone. The former is crinoidal, ammonitic and homogeneously aphaneritic in texture, being in some cases represented by synsedimentary breccias. Characteristic texture of the Upper Jurassic of horst margin position is that consisting of ammonite skeletal elements of lumachell nature with voids filled with sparry matter. Fissures filled with penecontemporaneous sediment are widespread. Upper Tithonian fissure-fills are particularly frequent. Gaps and beds produced by slow (condensed) sedimentation occur in these sequences, too. The detailed analyses of the Malm-Berriasian sequence of borehole TVG-50 have been presented in Textfig. 46 (in pocket).

Variety is manifested in the distribution of the microfacies of the sequences. In the Kimmeridgian-Lower Tithonian limestone it is the Lombardia (Saccocoma)-Crinoidea microfacies that predominates, though a Protoglobigerina-Radiolaria assemblage is also present. The Upper Tithonian-Berriasian limestones are characterized by a microfacies with ammonite embryons, Crinoidea and Tintinnina, though interbedded layers of Protoglobigerina-Radiolaria microfacies are also frequent.

In the uppermost 2.2- to 1-m-thick part of the Malm-Berriasian sequence of borehole TVG-49 and -50 it is *Calpionellites darderi* and *C. dadayi* that are predominant. This portion may represent the topmost part of the Berriasian Stage or, with a view to standpoints expounded in literature, it may so the beginning of the Valanginian Stage as well. Below it, beside a predominant *Calpionellopsis oblonga*, a Berriasian microfossil assemblage of *Tintinnopsella carpathica*, *Calpionellopsis simplex* and *Remaniella cadischiana* can be found. In the sequences under discussion a Protoglobigerina-Radiolaria microfacies can be found in the middle part of the Berriasian limestones. The Tintinnina assemblages of the strata lying deeper underneath may represent Tithono-Berriasian transitional members and three Tintinnina zones of the Upper Tithonian.

The sequences under consideration are supposed to have been formed in fault-troughs between basement horst blocks. On the basis of the available data the presence of N—S trending syngenetic fractures can be located firmly on the eastern side of the Tata horst and the eastern sides of these can be shown to have been subsided. Part of the sediment has been drifted from the slightly elevated submarine ridges — like Kálvária Hill's — into depressions on their margins where, deposited together with a richer crinoidal, foraminiferal and brachiopodal benthos, it has built up sequences of greater thickness. The topographic difference between ridge surface and fault-trough bottom seems not to have been too high, as suggested by the geological features of the uncovered formations. The width of the Jurassic facies area of block margin position is not explored, nor is its connection with the facies of the other side of the through. In connection with the nearby exposures of Dachstein Limestone, it is not known whether these may have carried any Jurassic sediment on their surface or the Jurassic was absent above the Upper Triassic limestone from the very beginning? If this is admitted as plausible for vast areas in Hettangian time, why might it not be supposed in certain areas for the entire Jurassic period as well?

On the basis of their geological development the Upper Jurassic-Berriasian sequences of block margin position may be considered to represent an independent formation. Provisionally, let us call them Tata's Upper Jurassic-Berriasian limestones of block margin position and consider this an informal designation. Final definition of the formation has to be delayed until it is studied over a larger area.



Textfig. 45: MALM SEQUENCE OF BOREHOLE TVG-44

THE LEGEND IS ON THE SUMMARY FIGURE OF THE MALM SEQUENCES / Texfig. 44. /

Review of the geological development, genesis and geohistory of Tata's Jurassic-Berriasian sequence

With a view to details of geological development, Tata's Jurassic-Berriasian sequence would belong to the northern facies area of the Transdanubian Central Mountains, extending from Mór to the Danube; as far as its main characteristics are concerned, it belongs to the "Red Jurassic" geofacies of the Mediterranean. This is a sequence of unsteady sedimentation, heavily condensed except for the Lower to Middle Liassic, bounded by breaks in sedimentation of the magnitude of a stratigraphic stage and reduced in thickness by frequent subsolutions and removal of sediment by currents. (The term "Red Jurassic" may be used as an analogy to BUCH's Black, Brown and White Jurassic.)

The genetic conditions of the "Red Jurassic" have been a vexed question for decades. The conceptual roots of the divergencies in opinions can be traced back to the dissimilar application of the principle of actualism. There are people who believe that present-day seas may provide an entirely satisfactory model and identifiable parametres accounting for the sedimentation conditions of the Red Jurassic. Others consider, and the present writer is adherent to this opinion, that concrete forms of sedimentation, their characteristic features reflect a number of irreversible realizations in the course of Earth's history. They believe that in the course of these processes not only the distribution of sea and land, their structure, the forms of life, their extension and quantitative conditions, and some cosmic effects, hardly perceivable today, changed irreversibly, but in interaction with the former, the physical and geochemical parametres of sedimentation displayed, an ample spectrum of manifestations. While interpreting the genetical conditions of the Red Jurassic, some authors applied the principle of actualism, without any reason for it, to phenomena of convergency in several connections.

The main point of controversy has been the question of the depth and costal distance of deposition of the Red Jurassic. The views concerning the environment of deposition diverge widely: neritic to shallow bathyal, archipelagic to pelagic, shallow-water to deap sea (oceanic). Despite never precedented achievements in oceanography and a considerable progress in the study of the Red Jurassic, the divergencies of opinions have not disappeared, the less so, the problem has been further complicated by the implications of plate tectonic.

The first paleogeographic interpretations concerning the Red Jurassic in the Hungarian geological literature appeared after the turn of the century, between 1906 and 1913:

GY. PRINZ 1906: "In Liassic time the territory of Hungary was an archipelago around the northern end of an island called 'orientalis' by POMPECKJ (originally, by MOJSISOVICS)".

H. TAEGER 1912: "Real deep-sea sediments, however, could not have been formed *a priori* in the Mesozoic, nor in the Cenozoic, because in these eras the territory under consideration never carried the features of an ocean, but was akin to the present-day Mediterranean that time already". "Although the sea of the Jurassic was deeper than that of the Triassic, all Jurassic deposits of the Bakony area were formed close to the shoreline."

N. KOCH 1912: "Where the sequences of the Jurassic are interrupted by considerable hiatuses, a regression of the sea is more acceptable to account for it than NEUMAYR's theory according to which the discontinuity of the Jurassic in the Eastern Alps would have been caused by sea currents prohibiting the deposition of zoogenic sediments".

E. VADÁSZ 1913: "Local unconformities and, in some places, traces of denudation in the Bakony, erosional unconformity in the Vértes, apparent conformity in the Gerecse and Pilis and, as suggested by the lack of the Liassic, a contemporaneous land in the Buda Mountains. The only conclusion that can be drawn from these geohistorical facts is to suppose a shifting of the coastline. . . the land may have lain rather near, and the puzzling impossibility for terrigenous supplies into the Jurassic sea was due to the predominantly dolomitic-calcareous composition of the nearby land with a rocky coast and without any river entering the sea. Accordingly, the ammonitic clayey facies of the Mediterranean zone cannot be called a pelagic sediment, but a fossil hemipelagic sediment that has no analogy among recent sediments".

In the interwar period it was primarily studies by GY. VIGH that ensured the continuity in the interpretation of the Red Jurassic as a shallow-water, hemipelagic formation: 1925: "with the end of the Triassic the sea regressed — maybe for a short time though — and the Dachsteinkalk emerged adry. The Liassic sea transgressed then upon the rough Dachsteinkalk surface". 1928: ". . . das ganze Gerecse-Gebirge während der Jurazeit ein — ständigen Schwankungen unterworfener, im Allgemeinen aber der hemipelagischen Tiefe entsprechender — Archipel war, wie das für die Nordalpen PIA voraussetzte".

K. TELEGDI ROTH 1934 took a not entirely clear-cut position which E. VADÁSZ (1953) interpreted as a hint at the deep-sea origin of the cherts and the red ammonitic limestones: "The formation of cherts and the comparatively thin sequences of the associated ammonitic sediments are indications, as suggested by present-day deep-sea analogies, of a long process of sedimentation". As for the suggestion of nearby coastlines, he advocated an unambiguously refusing standpoint: "It would be uncorrect to trace any paleo-coastline across the Central Mountains' body within the continuous sequence extending up to the Lower Cretaceous and showing the predominance of cephalopodal and siliceous facies: irrefutable proofs of deep-sea sedimentation."

K. Telegdi Roth's suggestion of a "deep-sea environment" and "the absence of coastlines" was left, still for a long time on, without any favourable response (except for Gy. Wein's opinion published in 1934 with regard to the second). In the meantime, J. Noszky jr. and, concerning the depth of sedimentation, L. Kovács advocated again the conventional standpoint.

J. Noszky jr. 1953: "Comparing the Jurassic sequences thus far explored in the course of field surveying, one can deduce more and more distinctly the paleogeographic conclusion that the Jurassic sea must have been very diversified and dynamic in the basin where the strata making up the Bakony were deposited. There were areas that had been continuously covered by the sea since Late Triassic time (e.g. the vicinity of Kávháshegy and Büdöskútpuszta), while other areas were only temporarily inundated, as the sea bottom subsided only in those cases to such an extent that sedimentation could take place. Hence the discontinuity of the sequences there, as e.g. at Kisnyergesárok, near Törkü or the hills Hajaghegyek."

L. Kovács 1956: "The nature of the Jurassic sedimentary facies in the Bakony testifies to a slow, gradual, but not too significant, deepening of the Jurassic sea, a process that remained within the confines of the neritic realm till Mid-Dogger time. It reached its culmination with the beginning of Late Dogger time, but did not overstep the limits of the shallow-bathyal environment even then." "The Jurassic sedimentary sequence of the Bakony is the product of marine sedimentation which took place in an uniform sea basin and which was not interrupted anywhere by temporary emergence."

The assumption of a shallow-water (to shallow-bathyal) archipelago connected with the "open sea" was invariably advocated by E. Vadász, J. Noszky and G. Vigh at the International Conference on the Mesozoic, Budapest 1959, by J. Konda in his work on the Bakony Liassic published n 1970 and by J. Fülöp at the Colloquium on Jurassic Stratigraphy, Budapest 1969.

E. Vadász 1961: "Les conditions de la formation des couches jurassiques de facies alpin de la Montagne Central Hongroise . . . peuvent être considérées pour la plupart comme des sédiments de mer peu profonde, tout-au-plus bathyales, y compris aussi le silex à Radiolaires et les diverses couches à Ammonites. Il y a aussi des couches littorales, travaillées par les vagues, à Brachiopodes (Hierlatz), à brèches et à lumachelles (Posidonia), sans qu'on puisse démontrer de la matière terrigène et des lignes de rivage."

J. Noszky 1961: "En ce qui concerne les conditions paléogéographiques des terrains jurassiques de la Hongrie, il est bien clair que les formations jurassiques de la Montagne Centrale de Transdanubie se sont accumulées dans un bras de mer mésozoïque, de SW—NE. . . . l'évolution de la vie organique du Jurassique s'est déroulée, au territoire de la Montagne Centrale de Transdanubie, dans un milieu de mer peu profonde mais ouverte. Ce ne sont que les couches de 'marne siliceuse' à Radiolaires et de silex qui peuvent être considérées comme des sédiments bathyaux."

G. Vigh 1961: ". . . le territoire de la partie occidentale de la Montagne Gerecse fut . . . un archipel, ou les petites îles émergeaient à peine."

J. Konda 1970: ". . . bildete der Sedimentationsbeckenteil einen relativ engen, in NO—SW-Richtung laufenden Meereszweig innerhalb der durch submarine Rücken zerteilten grossen Synklinale der Alp-Karpaten."

J. Fülöp 1971: ". . . un système de bassins sédimentaires, de caractère archipélagique, séparés l'un de l'autre par des rides peu surélevées, développait . . . Le caractère autochtone des montagnes traitées, et le fait qu'elles sont peu déformées par le tectonisme, ainsi que les régularités du développement du Jurassique, permettent la réconstruction des zones marginales, des rides, et du bassin central de l'aire de sédimentation du Jurassique. Les séries des zones marginales sont toujours interrompues par des lacunes, leurs sédiments sont non ou bien légèrement stratifiés; ils comprennent une faune benthique, avec des éléments du necton et du plancton y emportés, et les calcaires renferment bien souvent des fragments de falaises de la rive . . . En ce qui concerne les conditions bathymétriques de la sédimentation jurassique, moi je partage l'avis de ceux, qui cherchent l'explication des traits caractéristiques mentionnés dans les différences fondamentales de la paléogéographie, en comparaison aux conditions actuelles, et non dans la profondeur exagérée de la mer jurassique . . . La variabilité des faciès dans ces séries, même au dedans de quelques dizaines de mètres, est un trait bien frappant (Eperkéshegy). En mettant en considération la circonstance, que dans le voisinage des formations jurassiques on connaît des gisements de bauxite crétacé inférieur, dans le mur desquels le Jurassique manque complètement, et n'y a jamais existé, on reçoit un image réel d'une mer peu profonde, encadrée par des rives calcaires, au Jurassique."

The idea of the deep-water (oceanic) origin of the Ammonitico Rosso and the radiolarites and of the total absence of any nearby land in Jurassic time was suggested by B. GÉCZY, A. GALÁCZ and A. VÖRÖS. Beside his own results, GÉCZY invoked the large-scale crustal movements of plate tectonics. A. GALÁCZ and A. VÖRÖS adapted statements published on seamount-type sedimentation to account for the origin of the Jurassic sediments.

B. GÉCZY 1961: "Die Kalksteine des mittleren Lias sind in die tiefste Zone der neritischen Region, die knolligen Kalksteine des oberen Lias, des unteren und mittleren Doggers in die höhere Zone der bathyalen (zwischen —200 m und —4000 m) Region und die Radiolarite des Oberdogger-Untermalms in die tiefere Zone der bathyalen Region einzureihen." 1973: ". . . the Hungarian Central Mountains belonged originally to the . . . southern margin of the Tethys; the Mecsek and Villány Mountains, now situated to the south of the former, were parts of the northern marginal complex. The inversion of the two paleogeographic units . . . was provoked by large-scale post-genetic plate-tectonic movements."

A. GALÁCZ — A. VÖRÖS 1972: "The Jurassic sediments of the Bakony Mountains are of pelagic nature, without any manifestation of the proximity of coasts or islands. If the large Late Triassic to Early Cretaceous sedimentation cycle be regarded in unity: the succession shallow-water—deep-water—shallow-water can be visualized. At the beginning of the Jurassic the carbonate platform was fractured by steep faults. The result was the development of submarine highs that preserved their perched position (seamounts) on one hand and deep-subsided basin portions between them (interseamounts) on the other. From that time to about Early Cretaceous time it was that bathymetric disposition that defined the character of sedimentary processes."

If the arguments of the above standpoints be scrutinized, no decisive proof can be found on either side.

Strikingly enough, the breaks in sedimentation, on one hand, were regarded unscrupulously as an "evidence" of emergence, on the other hand, they were declared, again unanimously, to be of exclusively submarine origin. This meant at the same time a chronological consecutiveness, as first only the most striking hiatuses were recognized while later, with the development of the fine-stratigraphic methods of biostratigraphy and sedimentary geology in the last decades, a number of "internal" hiatuses could be detected.

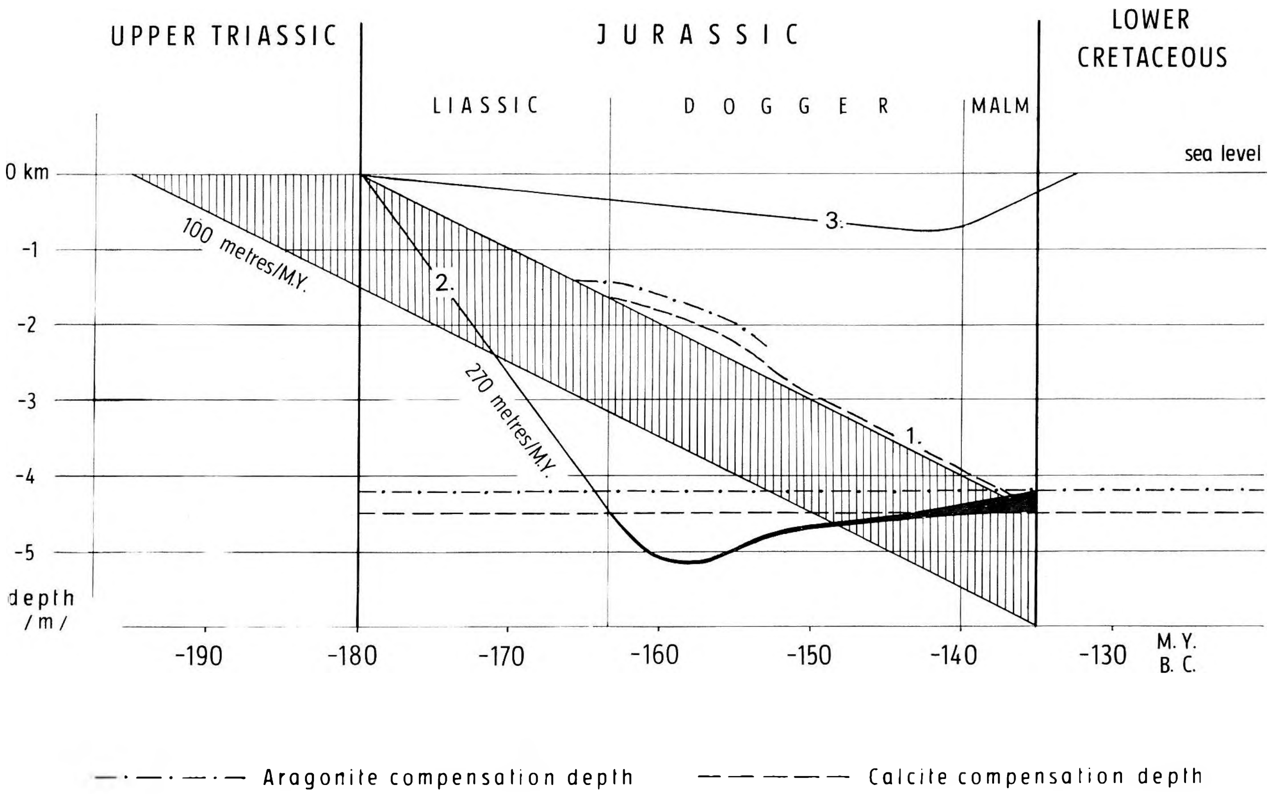
Emergent lands accounting for the substantially different conditions of large facies areas (Central Mountains—Mecsek—Villány) were supposed to have existed, on the basis of extrapolation of synchronous, intercommunicating facies zones of varying depth, with a view to breccias of littoral nature and to the hypothesis of Triassic carbonate land sources of red clay sedimentation. Opponents consider the facies areas of dissimilar characteristics of development to be in an "inverse" position due to subsequent large-scale plate tectonic movements; they explain the dissimilarity of the facies zones by seamount and interseamount sedimentation, considering the breccias to be of submarine origin and emphasizing the total absence of terrigenous material. The absence of Jurassic sediments due to denudation, syn- or postgenetic, over large areas above Upper Triassic formations makes it impossible to verify unambiguously either the assumption of overall coverage by sea or the existence of an archipelago.

To support the deep-water origin of the Ammonitico Rosso, some authors pointed out the frequency of Phylloceras and Lytoceras and the absence of benthonic fauna as well as the presence of Mn-nodules and coatings and that of hardground produced by subsolution. They consider the radiolarites to have been deposited in deep-bathyal to abyssal environments below calcite compensation depths. As regards the assumption of a comparatively deeper origin, the opinions do not diverge, but they do so concerning the necessity of assuming the presence of pelagic-oceanic conditions with depths of several thousand metres to account for all the above phenomena. It was particularly A. HALLAM (1971)* who expounded convincingly the relevant counter-arguments. His

*A. HALLAM: Evaluation of Bathymetric Criteria for the Mediterranean Jurassic. — Ann. Inst. Geol. Publ. Hung. Vol. LIV. Fasc. 2. 1971.

summarizing conclusion reads: "Actualistic comparisons have generally suffered from an inadequate understanding of the fundamental factors controlling sedimentation and organic activity and I see no compelling reasons for invoking depths at any time more than a few hundred metres."

Supposing the Latest Triassic subsidence of the basin floor down to several thousand metres to have continued in the Jurassic and the rate of subsidence to have increased, some authors have concluded on abyssal depths. On the contrary, if on the basis of the rich benthonic fossils and sedimentary phenomena of the Lower to Middle Liassic the sea floor is considered to have subsided down to 200—250 m by the end of the Middle Liassic and this value is extrapolated to the end of the Dogger, the final result will not exceed 600 to 800 m (Textfig. 47).

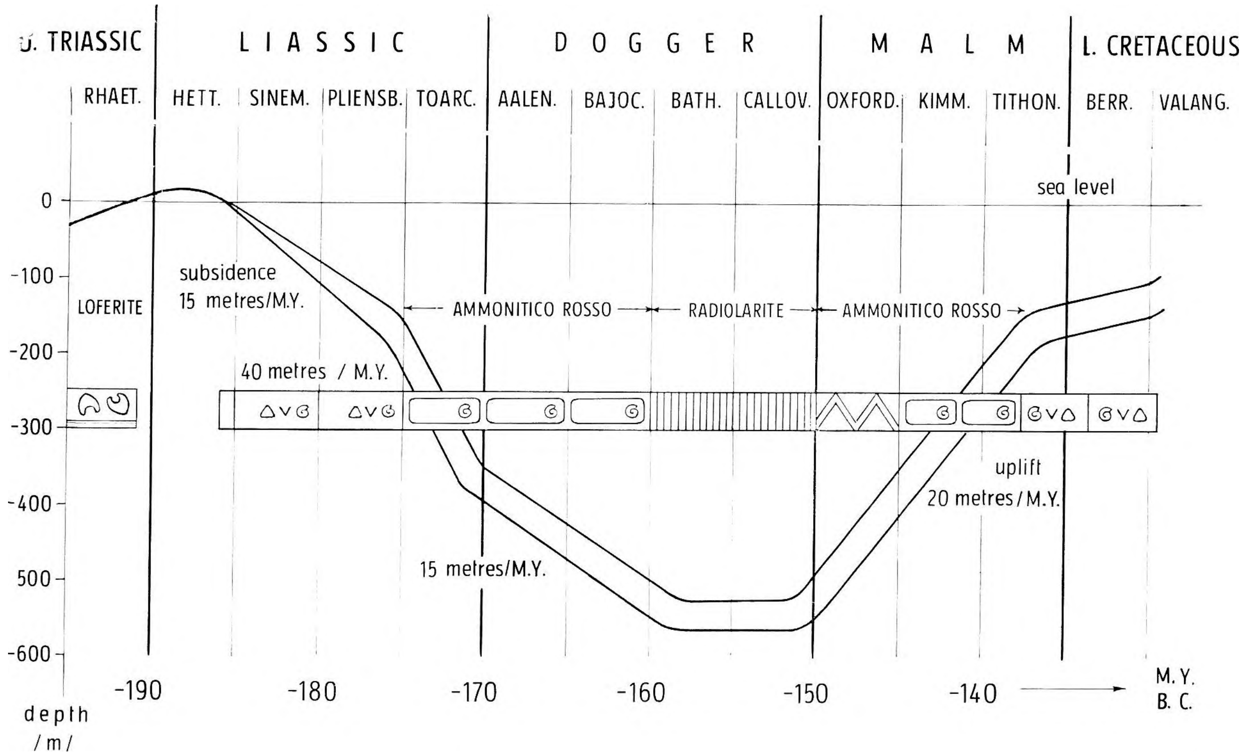


1. Bubnoff oscillogram. The rate of Late Triassic subsidence is extrapolated to the Jurassic Period. In the Jurassic the compensation depths of aragonite and calcite considerably increased.
2. Bubnoff diagram. The basic assumption is that the compensation depths of aragonite and calcite have remained unchanged since the Jurassic Period up to the present.
3. Depth of deposition of Tata's Jurassic-Berriasian sequence as extrapolated from Early to Middle Liassic subsidence trends

Textfig. 47: JURASSIC DEPTH DIAGRAMS PLOTTED ON THE BASIS OF SUBSIDENCE TRENDS

Finally, the present writer believes the post-Variscan geohistorical evolution which resulted in a peculiar paleogeographic situation in the Jurassic period to have been crucial for the development of the Red Jurassic. Ranges formed by the block-faulting of the Triassic carbonate platform adjacent to denuded land areas were responsible for the formation of "starving basin areas" blocked from the inflow of any organic or inorganic terrigenous material in which the sediments of the Red Jurassic were laid down in hemipelagic, neritic and shallow-bathyal environments.

On the basis of the above, the genetic conditions of Tata's Jurassic-Berriasian sequence of 40 to 60 m thickness can be summarized as follows (Textfig. 48):



Textfig. 48: SEDIMENTATION DIAGRAM OF TATA'S JURASSIC-BERRIASIAN SEQUENCE

The latest Triassic, Jurassic and Berriasian evolution can be subdivided into four basically distinct phases:

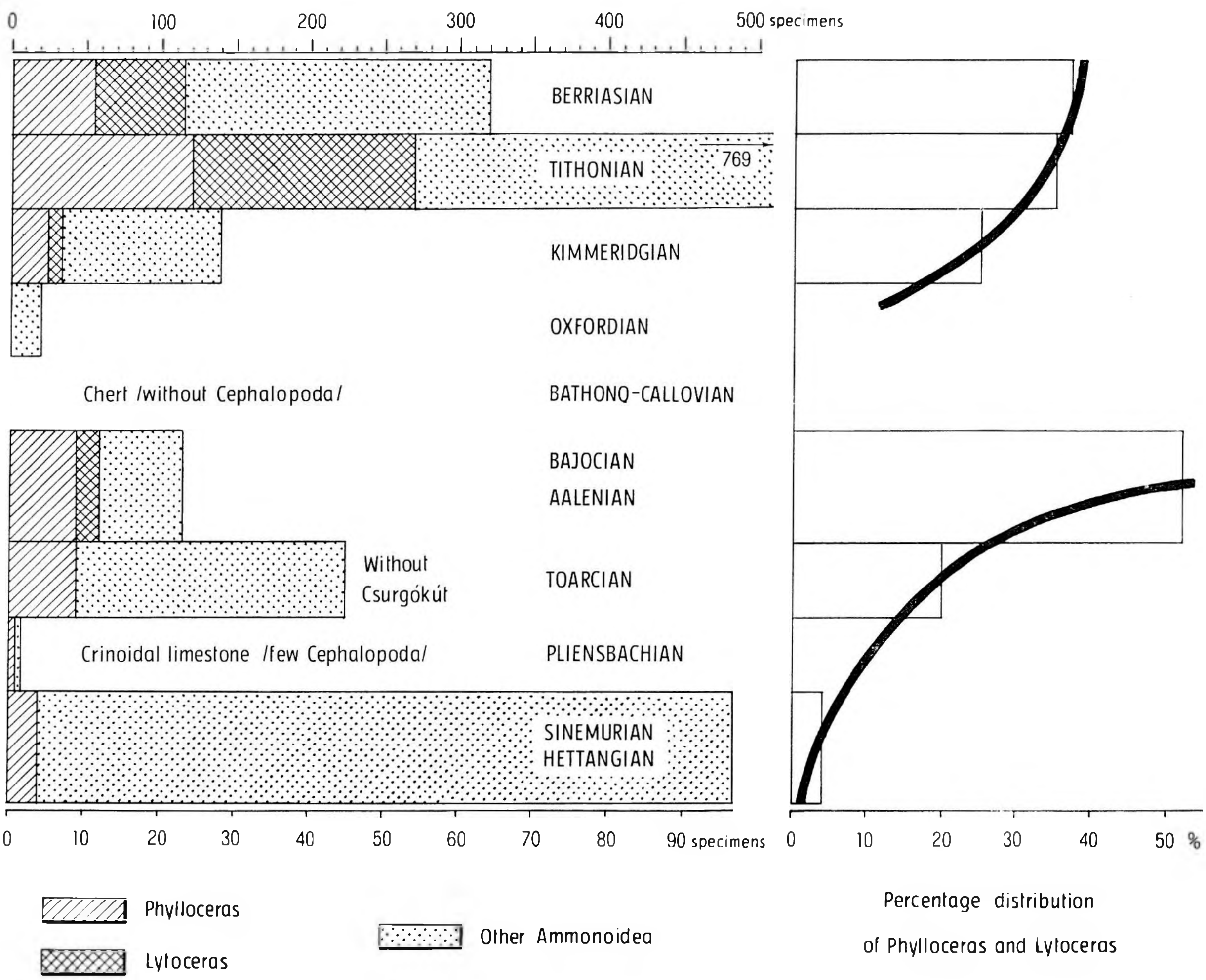
The first phase is a hiatus of about 5 million years embracing the top of the Rhaetian and the larger part of the Hettangian. Its interpretation is still open. From the span of time that lasted from the Triassic-Jurassic boundary to the upper part of the Hettangian, no sediment can be evinced to have been left over either at Tata or on the whole nothern area of the Transdanubian Central Mountains. On the other hand, the Jurassic sequence beginning with the Upper Hettangian overlies, in the same area, different horizons of the Rhaetian Dachstein Limestone. [In her monograph on Gerecse's Upper Triassic (1960), E. VÉGH—NEUBRANDT stated the presence of a hiatus of 60 m at Tata after comparing the Dachstein Limestone sequences underlying the Lower Liassic at Tata and Asszony-hegy (Western Gerecse)]*. The Hettangian hiatus as well as the missing members of the Dachstein Limestone and the occurrence of halved megalodontids on the Triassic-Jurassic boundary (on the shorn surface of the topmost Dachstein Limestone member) might be explained more simply by latest Triassic emergence and Late Hettangian (Sinemurian) transgression as well as by a break in sedimentation and corrosion (subsolution and removal by currents) of sediments at permanent sea-water coverage: explanation which may seem "more up-to-date", but which remains less acceptable to me even today.

The second phase of Jurassic history lasts from Late Hettangian to latest Pliensbachian time, being characterized by sedimentation in a steadily deepening shallow-water sea environment. The initial, entirely shallow-water conditions are indicated by the formation of oncolites and pseudo-oölites as well as by internal and external segregations under the effect of wave action. The presence of the photic zone is suggested by the wealth of benthonic organisms: diversified bottom-dwelling foraminiferal assemblages, abundance of Brachiopoda and deposition of crinoidal limestones. It is the block-faulting of the Triassic carbonate basement that was responsible for the development of sediment-filled syngenetic fractures, for the progressive differentiation of facies and for intraformational brecciation and for the development of slumps on a sloping bottom. Tata's Lower Liassic is represented by pink limestones of overall distribution above the Dachstein Limestone, the Pliensbachian is, beside the pink limestone, by crinoidal limestone which was deposited on the slopes of

* E. VÉGH—NEUBRANDT: Petrologische Untersuchungen der Obertrias-Bildungen des Gerecsegebirges in Ungarn. — Geol. Hung. Ser. Geol. Tom. 12. pp. 1—132.

a contemporaneous submarine mound formed in the area of Felső-Tata (Kálvária Hill and its broader vicinity).

The third geohistorical phase lasted from the Late Liassic to the end of the Dogger. Fundamental feature of sedimentation is the low thickness of the formation owing to lack of sediment material. The average rate of sedimentation was as low as 10 to 20 cm per million years. The reason for this was the fact that the Triassic carbonate platforms, involved in zoned blockfaulting and situated like dams, were screening the continental influences, i.e. the "starving" of the Red Jurassic sedimentary basins. The extremely slow sedimentation rendered possible the setting in of subsolution already at a depth of a few hundred metres; hence the development of "internal" hiatuses and hardgrounds. Principal constituents of the contemporaneous bios were planktonic Globochaete, Bositra, Protoglobigerina, Radiolaria; typical macrofossils are the cephalopods of which the representatives of Phylloceras and Lytoceras, forms indicative of comparatively greater depths, occur more frequently (Textfig. 49). The presence of a subphotic basin floor is evidenced by the lack or poverty of benthonic fossils. The aphaneritic layers of Lower Dogger limestones are characterized by the occurrence of small Chondrites. The crinoidal limestone bed underlying the Dogger chert sequence of Kálvária Hill seems to have been brought about by the inflow of skeletal elements from a nearby shallow-water environment. The formation of cherts may indicate the maximum of relative deepening of the basin floor within the afore-mentioned depth limits. It indicates both the maximum of subsolution and the large-scale proliferation, specific abundance, of Radiolaria. The geohistorical phase under discussion is represented basically by three consecutive formations: the Upper Liassic is by red-nodular calcareous marls, the Lower Dogger by red argillaceous, Mn-nodular, cephalopodal limestones, the Upper Dogger by a chert formation. The differ-



Textfig. 49: THE SHARE OF PHYLLOCERAS AND LYTOCERAS IN TATA'S JURASSIC AMMONOIDEA FAUNA

entiation of the topography of the basin floor continued and this is reflected by the thicknesses of the formations and the details of their developmental features.

The final phase of Jurassic-Berriasian evolution embraces the span of time from the Oxfordian to the beginning of the Valanginian. Sedimentation on a basin floor of uplifting trend is indicated by the occurrence of condensed sequences (of reduced thickness and discontinuous) and by the continued differentiation of facies. The problem of the origin of the greyish-white, greasy limestone matter of the Oxfordian limestone breccia representing a considerable sedimentological change, remains open. The red argillaceous, Mn-nodular, cephalopodal limestones of the Kimmeridgian seem to be a formation faciologically similar to the Upper Liassic. The Tithono-Berriasian limestone formations contain again a considerable amount of benthonic fossils, primarily Foraminifera, Brachiopoda and skeletal elements of crinoids. That was the time when submarine scree was being accumulated most intensively on a sea floor of diversified morphology. Synsedimentary cracks and neptunian dikes are common. On the higher-perched blocks of the basement (i.e. "seamounts") markedly discontinuous, hardgrounded Upper Jurassic-Berriasian sequences of low thickness were formed, while in the troughs between them — at Tata and on the margin of the Mesozoic basement horst block — stratigraphically more continuous formations of greater thickness and of bioclastitic type (Crinoidea, Cephalopoda, Brachiopoda) were accumulated. Littoral formations that would have preceded the Valanginian emergence are absent.

BIBLIOGRAPHY OF REFERENCES TO TATA'S JURASSIC-BERRIASIAN FORMATIONS

Beudant, F. S. 1925: Voyage minéralogique et géologique en Hongrie, pendant l'année 1818. II. — Paris.

Blind, W. 1963: Die Ammoniten des Lias Alpha aus Schwäben, vom Fonsjoch und Breitenberg (Alpen) und ihre Entwicklung. — Palaeontogr. 121. Stuttgart. pp. 38—131.

Csiba, T. 1714: Dissertation historicophysica de montibus Hungariae. — Tyrnava.

Dean, W. T. — Donovan, D. T. — Howarth, M. K. 1961: The Liassic ammonite zones and subzones of the North-West European province. — Bull. British Mus. Nat. Hist. Geol. 4. London. pp. 437—506.

Donovan, D. T. 1952: The ammonites of the Blue Lias of the Bristol district. — Ann. Mag. Nat. Hist. 12. London. pp. 629—655.

Donovan, D. T. 1954: Synoptic supplement to Wright's "Monographs on the Lias Ammonites of the British Islands". — Palaeontogr. Soc. London. pp. 1—54.

Donovan, D. T. 1958: The Lower Liassic ammonite fauna from the fossil bed at Langeneckgrat, near Thun. — Schweiz. Palaeont. Abhandl. 74. Basel. pp. 1—58.

Fischer, A. G. 1964: The lofer cyclothems of the Alpine Triassic. — Symposium on Cyclic Sedimentation. Kansas. Geol. Surv. Bull. 169. pp. 107—149.

Fucini, A. 1901—1905: Cefalopodi liassici del Monte di Cetona. — Palaeont. Ital. 7—11. Pisa. pp. 1—318.

Fülöp, J. 1954: Examen géologique de la motte mésozoïque de Tata. (Summary). — Földt. Közl. 84. 4.

Fülöp, J. 1968: Geology of the Transdanubian Central Mountains. — Excursion guide, International Geological Congres 23rd session, Prague—Budapest.

Fülöp, J. 1969: Excursion géologique dans les Montagnes Centrale de Transdanubie, Mecsek et de Villány. — Coll. Jurass. Médit. Budapest 1969.

Fülöp, J. 1971: Les formations jurassiques de la Hongrie. — Coll. Jurass. Médit. Budapest 1969. Ann. Inst. Geol. Publ. Hung. 54. 2.

Fülöp, J. 1973: Funde des prähistorischen Silexgrubenbaues am Kálvária-Hügel von Tata. — Acta Arch. Acad. Sci. Hung. 25.

Galácz, A. — Vörös, A. 1972: Jurassic history of the Bakony Mountains and interpretation of principal lithological phenomena. (res.) — Földt. Közl. 102. pp. 122—135.

Géczy, B. 1961: Die jurassische Schichtreihe des Tűzköves-Grabens von Bakonycsernye. — Ann. Inst. Geol. Publ. Hung. 49. 2. pp. 507—567.

Géczy B. 1973: Lemeztektonika és paleogeográfia a Kelet-Mediterrán mezozóos térségben. — Geonómia és Bányászat 6. 1—4. pp. 219—225.

Grossinger I. 1794: Ichtyológia.

Guérin-Franiatte, S. 1966: Ammonites du Lias inférieur de France. Psilocerataceae: Arietitidae. — Édit. Centre Nat. Rech. Sci. Paris. pp. 1—455.

Hantken M. 1861: Geológiai tanulmányok Buda és Tata között. — Math. és Term. tud. Közl. 1.

Hauer, F. 1853: Über die Gliederung der Trias-, Lias- und Juragebilde in den nordöstlichen Alpen. — Jahrb. Geol. Reichsanst. 4.

Hauer, F. 1854: Beiträge zur Kenntniss der Capricornier der österreichischen Alpen. — Sitzungsber. Math. Nat. Cl. Akad. Wiss. 13.

Hauer, F. 1865: Über die Cephalopoden aus dem Lias der nordöstlichen Alpen. — Denkschr. Akad. Wiss. Math. Nat. Cl. 11.

Horusitzky, H. 1923: Hydrogeologie und nationalökonomische Zukunft der Thermen von Tata und Tóváros. — Ann. Inst. Geol. Publ. Hung. 25. 3.

Koch, N. 1909a: Die geologischen Verhältnisse des Kalvarienhügels von Tata. (res.) — Földt. Közl. 39. 5.

Koch, N. 1909b: Beiträge zur Kenntnis der Gattung Tmaegoceras. (res.) — Földt. Közl. 39. 5.

Koch N. 1912: A Magyar Középhegység jura fáciesei. — Koch Emlékkönyv.

Kolosváry, G. 1954: Beiträge zur Kenntnis der fossilen Korallen der Jurazeit in Ungarn. (res.) — Földt. Közl. 84.

Konda, J. 1970: Lithologische und Fazies-Untersuchung der Jura-Ablagerungen des Bakony-Gebirges. — Földt. Int. Évk. 50. 2. pp. 227—260.

Kovács L. 1956: A bakonyi juratenger Kávásbegy-Lókúti részének bionómiai vonatkozásai a fáciesváltozások tükrében. — Sopron. Manuscript.

Kulcsár, K. 1914: Die mittelliassischen Bildungen des Gerecsegebirges. (res.) — Föld. Közl. 44.

Liffa, A. 1910: Geologische Notizen aus der Umgebung von Tata und Szőny. — Jahresber. Ung. Geol. Reichsanst. 1908.

Lóczy L. sen. 1906: Geológiai megfigyelések a tatai Kálvária-hegyen. — Földt. Közl. 36.

Lóczy, L. jun. 1914—1915: Monographie der Villányer Callovien-Ammoniten. — Geol. Hung. Ser. Geol. 1. 3—4.

Mouterde, R. et *al.* 1971: Les zones du Jurassique en France. — Compt. Rend. Soc. Géol. France. Paris. 1—27.

Noszky, J. jun. 1953: Le levé géologique des terrains jurassiques des environs de Szentgál, Herend, Márkó, Városlőd. (res.) — Földt. Int. Évi Jel. 1941—42-ről.

Noszky, J. jun. 1961: Formations jurassiques de la Hongrie. — Ann. Inst. Geol. Publ. Hung. 49. 2. pp. 481—501.

Peters, K. 1859: Geologische Studien aus Ungarn. II. Die Umgebung von Visegrád, Gran, Totis und Zsámbék. — Jahrb. Geol. Reichsanst. 10. 4.

Prinz Gy. 1906: A magyarországi liász partvonalának helyzetéről. — Földr. Közl. 34.

Staff, J. 1904: Beiträge zur Stratigraphie und Tektonik des Gerecse-Gebirges. — Jahrb. Ung. Geol. Reichsanst. 15. 3.

Szabó, I. 1961: Die Ausbildungen der mesozoischen Scholle von Tata aus der Jurazeit. — Ann. Inst. Geol. Publ. Hung. 49. 2.

Taeger, H. 1909: Die geologischen Verhältnisse des Vértesgebirges. — Jahrb. Ung. Geol. Reichsanst. 17. 1.

Taeger, H. 1912: Daten zum Bau und erdgeschichtlichen Bild des eigentlichen Bakony. — Jahresber. Ung. Geol. Anst. 1910.

Telegdi Róth K. 1934: Adatok az Északi Bakonyból a magyar közbenső tömeg fiatal mezozóos fejlődéstörténetéhez. — Mat. és Term. tud. Ért. 52. p. 245.

Townson, R. 1797: Travels in Hungary, with a short account of Vienna in the year 1793. — London.

Vadász E. 1913: Üledékképződési viszonyok a Magyar Középhegységben a jura időszak alatt. — Mat. és Term. tud. Ért. 31.

Vadász E. 1953: Magyarország földtana. — I. kiadás Budapest.

Vadász E. 1956: Magyarország földtana. — II. kiadás Budapest.

Vadász, E. 1961: Questions fundamentales du mésozoïque hongrois. — Ann. Inst. Geol. Publ. Hung. 49. 1. pp. 55—61.

Vigh, G. 1961: Problèmes de faciès des sédiments jurassiques de la Montagne Gerecse. — Ann. Inst. Geol. Publ. Hung. 49. 2. pp. 591—597.

Vigh G. 1968: Kirándulásvezető. 3. Tata, 4. Vértes. *in:* XIII. Geofizikai Szimpozium. — METESZ Geofiz. Egyes. kiadv.

Vigh G. 1969: UNESCO kirándulásvezető. Tata. — Manuscript.

Vigh, G. 1971: Oberjurassische—berriasische Ammonoideen-Faunen aus dem Nordteil des Transdanubischen Mittelgebirges. — Coll. Jurass. Médit. Budapest 1969. Ann. Inst. Geol. Publ. Hung. 54. 2.

Vigh, Gy. 1928: Führer in das Gerecse-Gebirge nach Lábatlan und Piske. — Führer Studienreise. Pal. Ges.

Vigh, Gy. 1934 (1925): Geologische Notizen aus dem Gerecse-Gebirge. — Jahresber. Ung. Geol. Anst. 1917—24.

Walliser, O. H. 1956: Chronologie des Lias α_3 zwischen Fildern und Klettgau. — Neues Jahrb. Geol. Pal. Abhandl. 103. Stuttgart. pp. 181—222.

Wein, Gy. 1934: Tithonschichten der Umgebung von Zirc. (res.) — Földt. Közl. 64.

Winkler B. 1883: A Gerecse- és Vérteshegység földtani viszonyai. — Földt. Közl. 13.

Wissner, U. 1958: Ammonitenfauna und Stratigraphie der Lias-Fleckenmergel (Sinemurian bis Domerian) in den Bayerischen Alpen. — Diss. Univ. Tübingen. pp. 1—150.

Upper Aptian grey crinoidal limestone

History of geological research

L. LÓCZY SR., was the first to recognize, in 1905, the presence of the grey crinoidal limestone as an independent formation exposed on Tata's Kálvária Hill and to determine its Cretaceous age. He supposed a steep, rocky coast to have existed here at the time of deposition of the Cretaceous crinoidal limestone unconformably overlying the Jurassic, a coast where the underwashed Upper Jurassic limestone cliffs were braking off in huge slabs that would be embedded in the Cretaceous sediment. He even collected fossils from the grey crinoidal limestone. He reported on his observations on a special meeting of the Geological Society on 7 March, 1906. His conclusions, however, have not been recorded in his own works, but were cited by N. KOCH (1909) and H. TAEGER (1909).

A. LIFFA (1910) mentioned the Cretaceous limestone exposed on Kálvária Hill and beneath the Tata castle under the name of Neocomian crinoidal limestone.

N. KOCH (1909), in his fundamental work on Kálvária Hill's geology, characterized, beside the Triassic and Jurassic formations, the geological features of the Cretaceous "greenish-grey crinoidal limestone" as well; he described its extent, estimated its thickness (40—50 m) and determined the Cretaceous fossils collected by L. LÓCZY SR., F. BALOGH and himself. Here they are:

Terebratula cfr. *dyphioides* D'ORB., *T.* cfr. *hippopus* RÖMER, *T.* cfr. *Moutoniana* D'ORB., *T.* cfr. *carnea* SOW., *T.* cfr. *depressa* LAM., *T.* cfr. *Dutempleana* D'ORB., *T.* cfr. *semiglobosa* SOW., *T.* cfr. *capillata* D'ARCHIAC, *T.* sp. (cfr. *sulcifera* MORRIS), *T.* sp. ind., *Waldheimia* cfr. *faba* D'ORB. sp., *W.* cfr. *celtica* MORRIS, *W.* cfr. *tamarindus* SOW. sp., *W.* sp. ind., *Rhynchonella* cfr. *plicatilis* SOW., *Phylloceras Calypso* D'ORB. sp., *Ph. semisulcatum* D'ORB. sp., *Ph.* sp. (from the group of *Ph. tortisulcatum* D'ORB. sp.), *Ph.* sp. ind., *Lytoceras (Tetragonites)* sp. (from the group of *L. Duvalianum* D'ORB. sp.), *Hoplites (Parahoplites)* sp. (cfr. *H. angulicostatus* D'ORB. sp.), *H.* sp. ind., *Nautilus* sp. (from the group of *N. neocomiensis* D'ORB.), *N.* sp. (from the group of *N. triangularis* MOUTH), *Belemnites* sp. ind.

On the basis of the fauna available, he thought the greenish-grey crinoidal limestone to be of "Lower Neocomian" age.

K. SOMOGYI (1914) did no field work on Tata's Kálvária Hill, he only studied fossils collected by others. When determining the poorly preserved fossils, he was markedly influenced by the stratigraphic subdivisions that had earlier been distinguished as well as by the rich and well-preserved Valanginian-Hauterivian fossils of the Gerecse Mountains which he was processing at the same time. Under the influence of these circumstances he took many fossils from Tata to agree with forms from the Gerecse. This was how he could "certify" the presence of the Valanginian and Hauterivian Stages on Tata's Kálvária Hill. His conclusion as to the presence of the Barremian Stage relied on a single ammonite specimen which he identified with "*Hoplites (Parahoplites) angulicostatus*". As a contrast to his afore-mentioned errors, it is a lasting result of his research work that he showed the presence of the Aptian by relying on *Lytoceras (Tetragonites) duvalianus* and on Brachiopoda characteristic of the Aptian Stage: *Terebratula depressa* LAM., *T. biplicata* BROAC and *T. dutempleana* D'ORB.

After a long pause it was the present writer who engaged himself in the study of Kálvária Hill's Cretaceous formations. Searching for the southward continuation of Gerecse's Cretaceous formations, he got to Tata in 1952. In his work on the geological structure of Tata's Mesozoic basement horst block (1954), he pointed out the basically different geological features of the Cretaceous of Gerecse on one hand and Tata on the other; the erroneous stratigraphic conclusions drawn by earlier workers on account of the poor preservation of the fossils; the uniformity of the greenish-grey crinoidal limestone representing an independent formation of the Aptian Stage and the identical stratigraphic position and geological features of the grey crinoidal limestones of the Vértes and the Bakony Mountains and of Tata.

K. RÁSKY (1954) determined and described as *Striaestrobus* sp. the pine cone remnant recovered by the author from the base of Kálvária Hill's Aptian grey crinoidal limestone.

E. Szörényi (1959, 1961, 1965) contributed to an up-to-date understanding of the fauna of the Aptian grey crinoidal limestone by her scientific examination of the Crinoidea (Torynocrinus) and Echinoidea remnants collected by the author.

P. Greguss (1956) carried out the xylotomical determination and evaluation of vegetal remnants collected by the author on Kálvária Hill.

Tata Limestone Formation

The Upper Aptian grey crinoidal limestone has not had any standard lithostratigraphic name as yet. In the second edition, now in press, of *Lexique Stratigraphic*, J. Knauer proposed to use the name "calcaire de Várhegy" with a view to the sequence of the Várhegy (Castle Hill) of Sümeg. However, "Várhegy" is not a concrete geographic name and another consideration is that, at that locality neither the hanging-, nor the footwall of the grey crinoidal limestone can be studied at the surface. Megafossils cannot be recovered therefrom either. Therefore I consider it more reasonable and desirable to use the name Tata Limestone Formation as a term designating the grey crinoidal limestone formation. It is at Tata that the stratigraphic position of the formation was first defined in an acceptable way (J. Fülöp 1954). As a further development, the grey crinoidal limestone localities of the Bakony Mountains were critically analyzed from the viewpoint of their stratigraphic position and were united in one formation (J. Fülöp 1964). The richest cephalopodal fauna, of stratigraphic value, was sampled at Tata. This can still be complemented in the course of further research work. The contact with the underlying formations can be studied in good exposures. The overlying beds are known from deep drilling, being rather easy to uncover in the near-surface zone as well. Tata Limestone Formation was quarried for centuries and houses and stone-walls have been built of the extracted material. The Castle of Tata stands, itself, on grey crinoidal limestones and has been built of them.

Geological features

In my paper published in 1954 I gave a detailed description of the Aptian grey crinoidal limestones exposed in the territory of Tata's Mesozoic basement horst block. Recent research has allowed me to refine the geological portrayal I had made earlier.

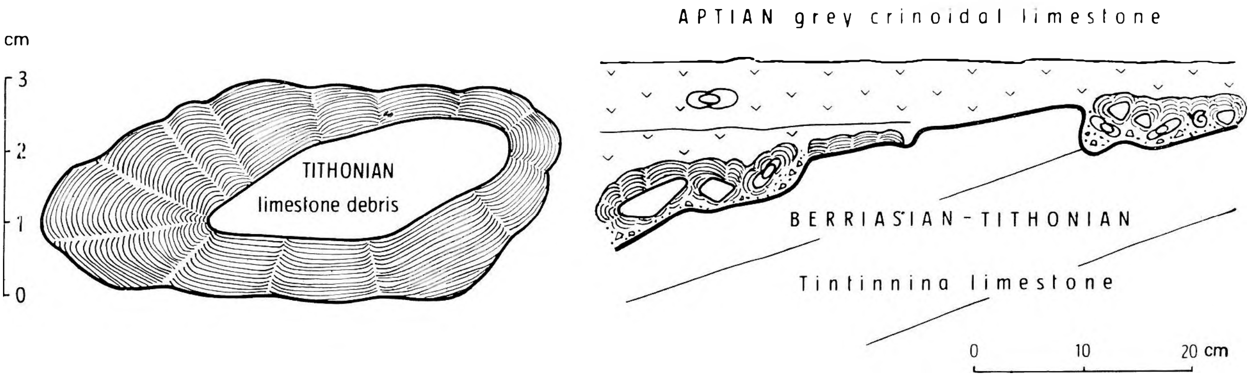
A) Basal beds

Prior to investigating in detail the fossils of the Upper Jurassic limestone sequence underlying, in an unconformable way, the Upper Jurassic limestone, I was still emphasizing that the Aptian grey crinoidal limestone lay throughout the investigated area upon the rough paleorelief of Tithonian limestones. According to I. Szabó's results indicating the presence of the Berriasian Stage and to recent results of detailed micropaleontological research, the Aptian crinoidal limestone can overlie any member of the Malm-Berriasian sequence, being superimposed to its unevenly eroded surface. In the exposures studied so far, we observed the detrital basal beds of the Aptian grey crinoidal limestone to occur mostly above Berriasian and Tithonian, subordinately above Kimmeridgian and Oxfordian, limestones (for the profiles of the Malm-Berriasian sequence, see Textfig. 44, for the sequences of the Aptian grey crinoidal limestones, see Textfig. 55).

In my earlier work I analyzed in detail the geological features of the basal beds of the Upper Aptian grey crinoidal limestone. These littoral sediments deposited on the one-time shoreline or not far off-shore are important proofs for a terrestrial emergence that had preceded the Aptian transgression.

The rough, eroded surface of the Malm-Berriasian group in the area of Tata's Mesozoic basement horst block represented, at the time of the transgression of the Aptian sea, a rocky coast, sloped, though not particularly steep (Plate XLII, Fig. 1—2, Plate XLIII, Fig. 3).

At the time of tidal sedimentation the contemporaneous rocky bottom was coated by a stromatolitic crust, a few cm or, occasionally, 1 to 2 dm thick, which surrounded the terrigenous detrital material introduced into the sea and a considerable part of the organic remnants washed together along the shoreline. This coating consists of thin (a few tenths of mm to one mm), overlapping calcareous, microdetritic, glauconitic and limonitic laminae varying in a banded pattern. Its surface is studded with fingerlike protrusions (Textfig. 50; Plate XLV, Fig. 1—4). Chemical composition: Fe_2O_3 5.83%, FeO 0.28%, MnO 0.13%, P_2O_5 0.87%, TiO_2 0.16%, Na_2O 0.08%, K_2O 0.88%, SiO_2 46.11%, Al_2O_3 1.96%, CaO 23.38%, H_2O 1.13%, loss on ignition 19.36%.



Textfig. 50: STROMATOLITIC COATING AT THE BASE OF THE APTIAN GREY CRINOIDAL LIMESTONE

Rock detritus of local origin deriving from the coastal zone and sands and gravels coming from the more distant terrestrial hinterland are frequent in the sediments of the basal beds. The terrigenous material shows the following distribution:

a) The overwhelming majority of the very poorly rounded detrital material of local origin is represented by Malm-Berriasian limestone and, subordinately, by chert, a few mm to cm in diameter. Occasionally, larger (20—30 cm in diameter) limestone boulders can also be found. As shown by examinations of thin sections, the limestone detritus consists mostly of Berriasian and Tithonian limestones. Less frequently, Kimmeridgian, Oxfordian and Upper Triassic limestone debris can also be observed.

b) Minute, coalified and silicified skeletal fragments of plants (occasionally, cones and needles of conifers, more frequently, fragments of stems) brought in from the near-by land occur frequently.

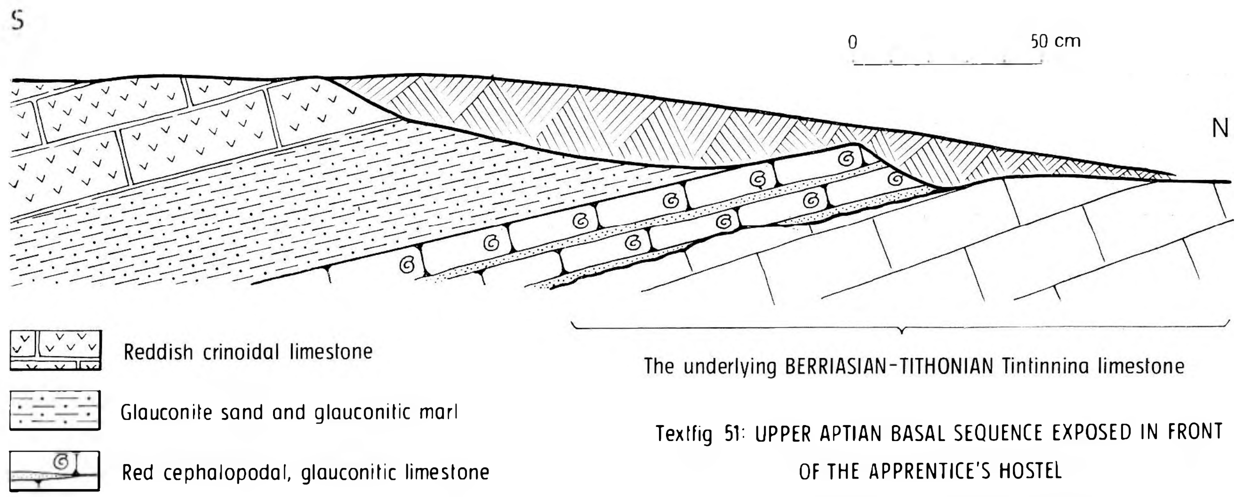
c) The pebbles deriving from the more distant terrestrial hinterland have the size of hazelnuts or nuts. Consisting mostly of cherts, they include subordinate quartz and diabase pebbles as well. (Despite their high-grade roundness, the chert pebbles may originate from the near-by Upper Dogger beds as well and their rounding could have been produced by the surfs that were keeping in motion the detrital material of the littoral zone. In my earlier work on Tata the symbols P-V of the CPV diagram are, erroneously, transposed.)

d) The overwhelming majority of the terrigenous detrital material of sand to coarse silt size consists predominantly of mineral grains of magmatic and metamorphic origin that have undergone a long-distance transportation. Its share is, as a rule, 1 to 2%. According to micromineralogical results, sharp-edged, angular quartz grains, 20 to 80 μ in diameter, are predominant. The comparatively significant amount of magnetite and ilmenite is indicative of basic source rocks. This hypothesis is confirmed by the co-occurrence (in a low percentage though) of augite and enstatite. Epimetamorphic epidote and zoisite are subordinate. The mineralogical spectrum includes, beside the minerals listed above, garnet, tourmaline and chlorite as well. The lack or extremely low quantity of feldspar and the frequency of limonitic-quartzose incrustations are indicative of a low rate of denudation associated with heavy chemical weathering.

In the basal layers of the grey crinoidal limestone, especially in the hollows of the one-time rocky shore, a rich and diversified evidence of the Late Aptian (shallow-water) bios has been preserved:

Beside algae producing stromatolitic incrustations, colonies of tubular worms were living adhered to the rocky bottom (Plate XLIII, Fig. 2). Under the effect of water movement, skeletal fragments of Cephalopoda, Brachiopoda, Echinodermata, Bivalvia and Gastropoda have been drifted together (Plate XLIV, Fig. 2). As a result of surf action and of the motion of the detrital material the larger fossils were crushed and then deformed under the weight of the overburden. In the course of diagenesis the calcareous shells and tests were dissolved so that nowadays, except for rostra of Belemnoidea and skeletal fragments of Crinoidea, it is mostly ornamented internal moulds that are available to the collector. The skeletal fragments of Crinoidea are rockforming in the lowermost beds of the grey crinoidal limestone (just like in the whole formation), remnants of Echinoidea, Brachiopoda and Foraminifera occur frequently. In addition, sponge skeletons and bryozoan fragments as well as a comparatively low amount of spores and pollen grains can also be found.

The basal beds of the Upper Aptian Tata Limestone and their connection with the underlying, Malm-Berriasian, sediments can be studied in excellent exposures in the area of the old, abandoned "Bluestone quarry" now declared a Geological Conservation Area, adjacent to Jewish Cemetery (Textfig. 60). When the town's tapwater tubes were being laid, I discovered in that horizon a rich fossiliferous site in front of the property 21, Fazekas Street. In the course of the geological mapping



Textfig 51: UPPER APTIAN BASAL SEQUENCE EXPOSED IN FRONT OF THE APPRENTICE'S HOSTEL OF THE INSTITUTE OF VOCATIONAL TRAINING

of Kálvária Hill, we have uncovered, in front of the Apprentice's Hostel of the Institute of Vocational Training (Textfig. 51), basal beds of sublittoral origin, heavily glauconitiferous, rather abundant in macrofossils.

In the profile in front of the Apprentice's Hostel, glauconite has a very significant share in the composition of the basal beds of the Aptian crinoidal limestone, being present in flakes or aggregates from 1/2 to 2 mm in diameter. Very frequently, it has filled in chambers of Foraminifera and has entered into the composition of the skeletons of echinoderms or siliceous sponges, forming cavity fills and incrustations. In thin sections the dia- to epigenetic transformations of glauconite can be observed. Upon diagenetic effects, the individual glauconite grains are often cracked, being altered into limonite by subsequent oxidation (Plate XLVI). Glauconite seems to have been formed in a shallow sea water under reductive conditions and decaying organic matter was largely involved in its formation. According to J. V. NIKOLAEVA (1972)*, the formation of glauconite is connected with the sedimentation of zones of arid, tropical and humid temperate climates.

The fossils found in the glauconitic limestones are less crushed and deformed than the fossils drifted together along the shoreline. In the bed they lie on their flat side, being unshelled, ornamented internal moulds.

The laboratory analyses of the rock sample taken in front of the Apprentice's Hostel of the Institute of Vocational Training are shown in Table 10.

B) Tata Limestone sequences examinable at the surface

In the Geological Conservation Area (the one-time "Bluestone quarry") both the basal and the somewhat higher-seated beds of the grey crinoidal limestone (at the wall of Jewish Cemetery) can be studied. The most essential exposures were in the quarries that had been operated for centuries in the large outcrop area between the Grammar School and Kálvária Hill. The sequence shown in Textfig. 52 was surveyed here, too. Unfortunately, this area has now been almost completely invaded by the sprawling city. A grey crinoidal limestone bedrock can be studied in the rocky basement of the Castle of Tata as well. It crops out in the western foreland of Kálvária Hill, too. In the town a number of ground-water wells were earlier sunk into this formation.

As far as its megaloscopic features are concerned, this formation is a greenish-grey well-stratified, subordinately cross-bedded, bio- to extraclastic calcarenite. Its fracture face is crystallo-granular mainly on account of the calcite laminae of the skeletal elements of echinoderms, mainly crinoids, or is dotted with very tiny terrigenous limestone detritus and more or less glauconitic.

Viewed in thin section, the pattern of the rock is predominantly bioclastic (primarily crinoidal, foraminiferal, brachiopodal) with an abundance of limestone debris a few tenths of mm in diameter (mostly Upper Jurassic to Berriasian, though older Jurassic limestone grains and a considerable amount of Dachstein Limestone debris can also be found in the rock), with a great number of quartz and quartzite grains and varying quantities of glauconite; mafic minerals are subordinate. This rock type is a characteristic representative of the most widely distributed glauconitic rock variety: "the organo-detrital quartz sand mingled with carbonate and terrigenous, silty-argillaceous matter" (NIKOLAEVA, 1972).

*J. V. NIKOLAEVA 1972: Glauconite in the paleogeographical systems (in Russian). — Geologiya-Geofizika. No. 6.

Rock name: **glauconitic sandy limestone**

Rock of medium hardness, of uneven fracture and nodular structure. Nodules 4 to 6 cm in diameter and constituted by pink limestone. Internodular matrix greenish to brownish-red, argillaceous. Considerable amount of glauconite in both the nodules and the matrix.

Geological features: a sediment deposited in the sublittoral zone during transgression.

Chemical composition (%):

SiO_2	18.32
TiO_2	0.34
Al_2O_3	2.55
Fe_2O_3	2.37
FeO	0.36
MnO	0.17
MgO	0.92
CaO	41.14
Na_2O	0.12
K_2O	1.03
$+H_2O$	1.89
P_2O_5	0.42
CO_2	29.89
organic C	0.03
Total:	99.55

Chemical composition of insoluble residue (%):

SiO_2	66.86
Al_2O_3	8.95
Fe_2O_3	10.40
MgO	2.38
CaO	0.16
Na_2O	0.10
K_2O	3.14
$-H_2O$	2.21
loss on ignition	5.95
Total:	100.15

Petrographic composition (%):
(according to origin and size)

chemo- and biogenic	73.2
sand	9.3
silt	9.9
pelite	7.6

Mineralogical composition (%):

Chemo- and biogenic:	
calcite	66.6
dolomite	1.8
limonite (hematite)	0.4
pyrite	0.3
apatite	1.0
Total:	70.1
Colloidal:	
montmorillonite	6.0
glauconite	11.7
Total:	17.7
Detrital:	
quartz	8.8
feldspar	0.2
muscovite	0.1
Total:	9.1

Micromineralogical analyses (specimens):
(0.1—0.2 mm fraction of insoluble residue)

Heavy minerals:

Magmatic:	
ilmenite	10
magnetite	13
tourmaline	5
Metamorphic:	
garnet	9
tourmaline	8
corundum	1
chlorite	3
Epigenic:	
pyrite	7
Total:	56

Quantity: 0.08%

Light minerals:

Detrital:	
quartz	69
quartzite	2
glauconite	26
plagioclase	2
muscovite	1
Chemical:	
none	
Epigenic:	
none	
Total:	100

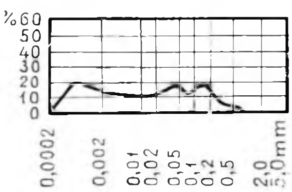
Quantity: 99.92%

Most of the mineral grains are markedly coated by limonite. Quartz grains are angular.

Grain size composition (%) of insoluble residue (17.32%):

0.5 —0.7 mm	0.6	34.7
0.2 —0.5	5.0	
0.1 —0.2	20.4	
0.06 —0.1	8.7	
0.02 —0.06	15.6	36.9
0.01 —0.02	11.4	
0.005—0.01	9.9	
0.002—0.005	10.2	28.4
0.000—0.002	18.2	

Granulometric curve:



Specific weight:	2.78
Volume weight:	2.49
Porosity:	10.43%
pH:	8.0
O_{Fe}:	13.1

Textfig. 52: UPPER APTIAN GREY LIMESTONE SEQUENCE EXPOSED IN THE SOUTHERN PART OF THE ABANDONED QUARRY LINE ON THE WEST SIDE OF EÖTVÖS STREET

C) Tata Limestone sequences uncovered by drilling

At Tata and its immediate neighbourhood the Upper Aptian grey crinoidal limestone has been uncovered in 20 boreholes. Beneath the overlying Albian dark grey siltstone, the Tata Limestone sequence has been cut through its whole vertical range, varying between 26 and 38 m in thickness, in 5 boreholes. The mode of occurrence and geological features of the borehole profiles, examined both megalo- and microscopically, have been illustrated in Textfig. 53 to 57. During megaloscopic examinations, the colour, structure and texture of the rock, its fossils visible to the naked eye, the layers of siliceous cement and particularly abounding in glauconite have been recorded. In the course of semi-quantitative examinations under the microscope by J. Haas and E. Edelényi, primarily the textural characteristics of the rock varieties being examined were paid attention, though the quantity of fossils were also evaluated.

During the examinations no lithologically or paleontologically characterizable horizon, regularly traceable and consistent throughout the sequences studied, could be found. A characteristic uniformity was displayed however, by some, territorially linkable, sequences which could be defined on the basis of the constituent microfacies combinations or their abundances, respectively.

The microfacies combinations characteristic of the sequences as a whole are made up of the following basic types:

Bioextrasparite—extrabiosparite (Plate XLVII, Fig. 8)

This rock texture is characterized, as a rule, by extraclasts consisting of Jurassic and Upper Triassic rock debris, well-sorted and rounded, of coarse sand grain size, and by skeletal fragments of echinoderms of similar size and roundness. The cement is sparite composed of large, limpid calcite crystals. The occurrence of sparry rims produced by the continued growth of skeletal fragments of echinoderms is common. Red algae, bryozoan, brachiopod and mollusc shell fragments are also frequent. The quantity of Foraminifera is rather poor. Benthonic forms, of which the large and thick-walled Lenticulinae are particularly characteristic, are predominant. Quartz sand is subordinate, often completely absent. Glauconite is unevenly distributed.

Bioextramicrosparite with a poor matrix

The texture is characterized by unsorted bio- and extraclasts of small to medium grain size, angular or very poorly rounded (Plate XLVII, Fig. 9). The cement is mostly microsparite, eventually micrite; frequently limonitic. Foraminifera occur in medium quantity, of which the benthonic forms are rather frequent, being accompanied by sponge spicules. The quantity of quartz debris is usually subordinate, with occasional enrichments in lenses. Glauconite is poor.

Bioextra(mosaic)sparite

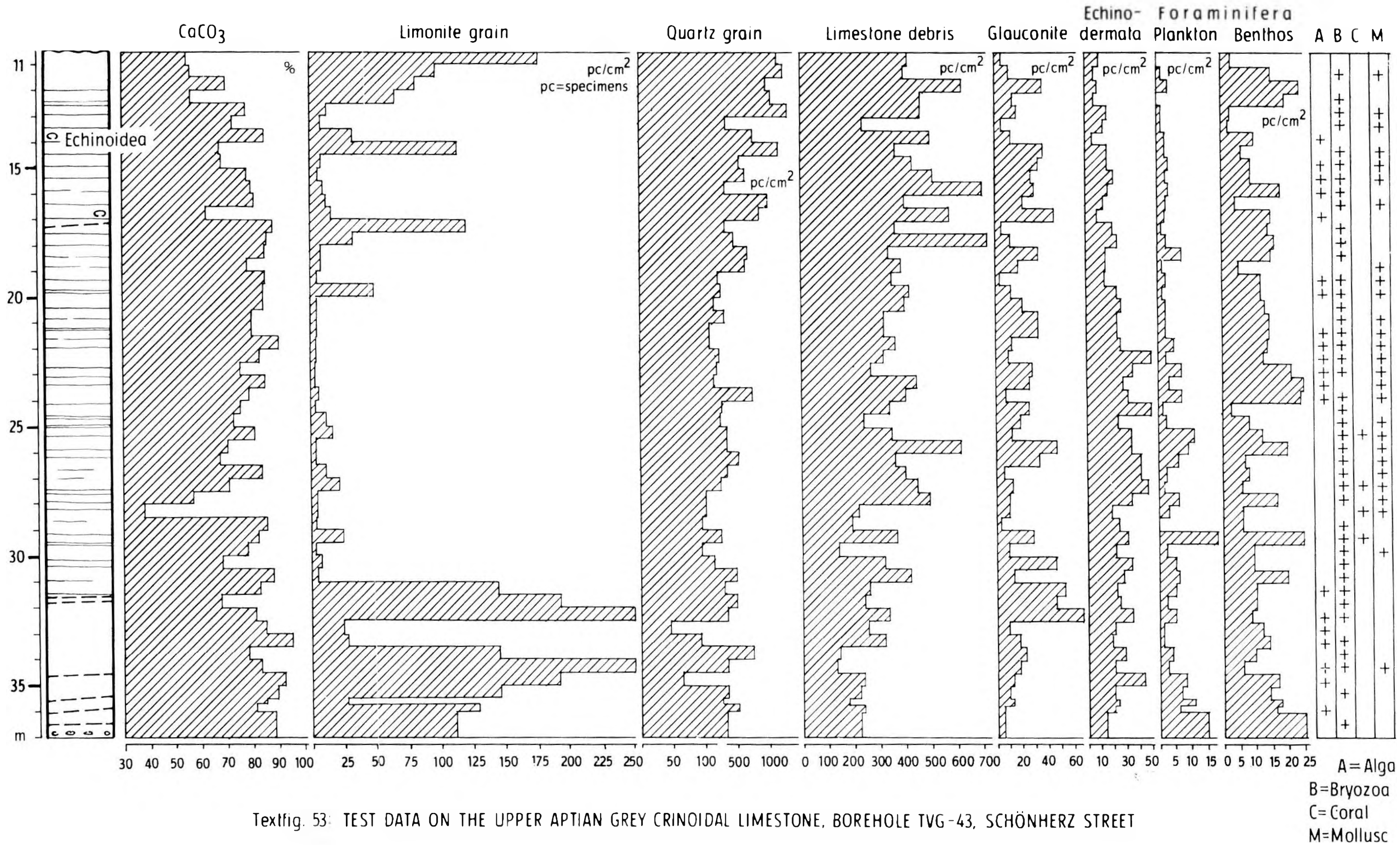
Bioextra(mosaic)sparite is not a frequent type of microfacies characterized by a matrix recrystallized in a mosaic pattern making up the bulk of the texture. The clasts are of minute to medium size and usually poorly rounded. The abundance of benthonic Foraminifera is typical (Plate XLVII, Fig. 2). Quartz and glauconite grains vary in quantity.

Foraminiferal, slightly sandy bioextramicrosparite (Plate XLVII, Fig. 6)

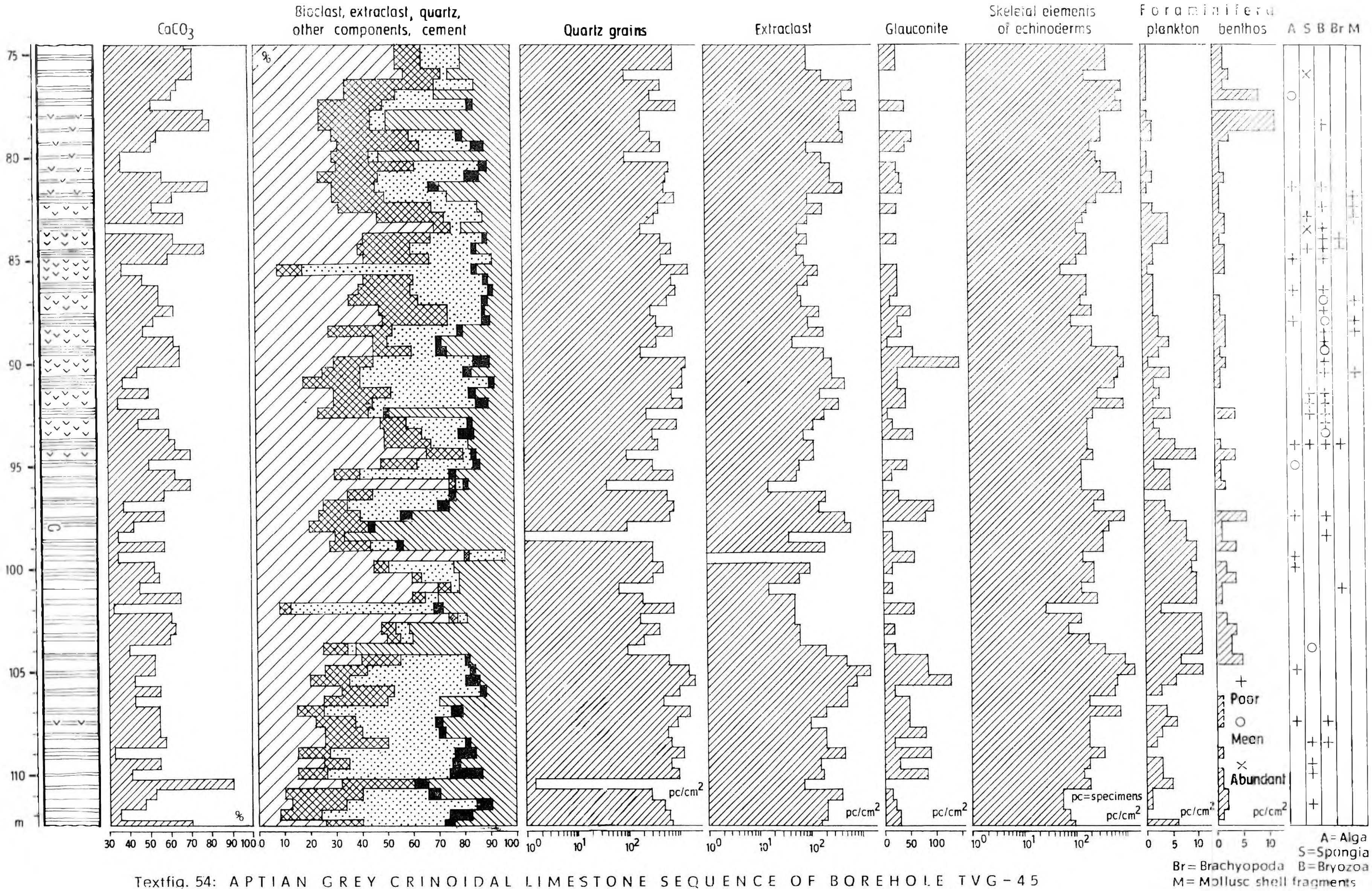
The grains are ungraded, varying from small to coarse grain size, very poorly rounded. Extraclasts are of usually smaller size, bioclasts often attaining several millimetres in diameter. Carbonate detritus is abundant, quartz of medium quantity, glauconite poor. Foraminifera, both benthonic and planktonic, are frequent, though usually the quantity of the benthos is higher. Hosts of other bioclasts are also present, primarily Bryozoa, accompanied by red algae and mollusc fragments. The share of the matrix (microsparite and micrite) is usually subordinate. Limonitic bands and limonite-coated surfaces occur frequently.

Sandstone of micritic matrix with bio- and extraclasts (Plate XLVII, Fig. 3, 4, 5)

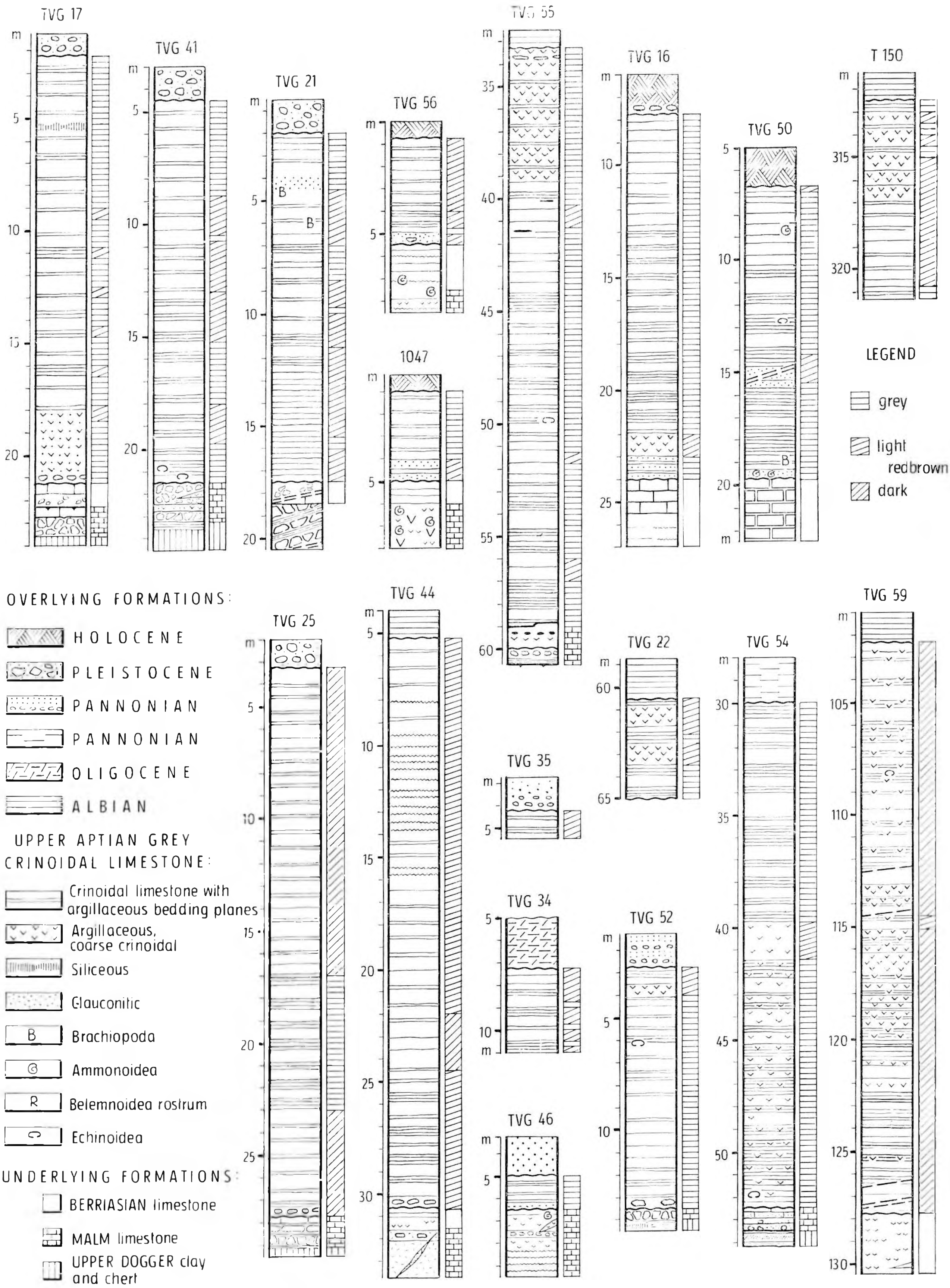
This type of rock is composed predominantly of small (0.05—0.15 mm in diameter), angular quartz grains. Carbonate extraclasts vary in quantity. The bioclasts are ungraded, of usually small size, though sporadical 5 mm fragments of echinoderms can also be observed. The detrital material



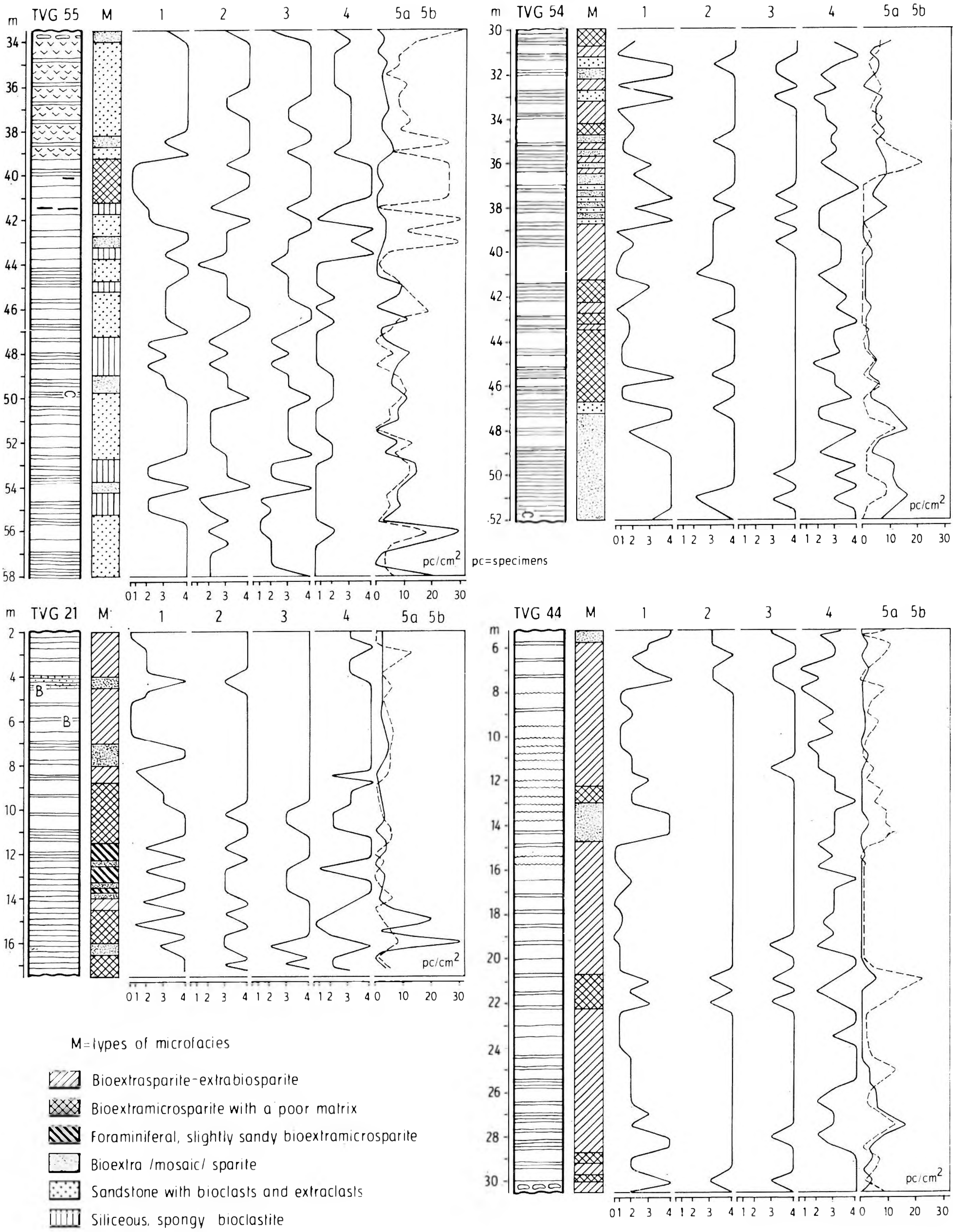
Textfig. 53: TEST DATA ON THE UPPER APTIAN GREY CRINOIDAL LIMESTONE, BOREHOLE TVG-43, SCHÖNHERZ STREET



Textfig. 54: APTIAN GREY CRINOIDAL LIMESTONE SEQUENCE OF BOREHOLE TVG-45



Textfig. 55: UPPER APTIAN GREY CRINOIDAL LIMESTONE SEQUENCES IN THE VICINITY OF TATA



1 Quartz grains
2 Limestone extraclasts
3 Crinoidal detritus
4 Other bioclasts
5a Plankton } FORAMINIFERA
5b Benthos

0 1 Poor
1 2 Fair
2 3 Mean
3 4 Abundant

Textfig. 56:

TATA LIMESTONE SEQUENCES SHOWING PECULIAR MICROFACIOLOGICAL FEATURES is very poorly rounded. Glauconite is usually available in medium quantity and small grain size. It may be partly allochtonous. Foraminifera are of medium quantity, planktonic forms predominate as a rule; in rare cases, they are abundant. Benthonic Foraminifera and sporadical sponge spicules can also be found.

Siliceous, spongy bioclastite

In some sequences siliceous, spongy bioclastites occur as repeatedly interbedded layers. Their most typical form of occurrence is that of a resilicified matrix dotted with hosts of Silicispongia spicules and scarce representatives of Radiolaria. The resilicification of the matrix was also observed, subordinately though, in a rock texture devoid of sponge spicules. The rock is poor in bio- and extraclasts which are of usually small size. Foraminifera are sporadical, glauconite grains only occasional.

Relying on test data, we have calculated the percentage distribution of the microfacies types discussed above as referred to the thickness of the individual exposures. The results have been plotted in form of circular diagrams in Textfig. 57 (in pocket). On the map, two areas of different facies can be definitely distinguished:

The southern facies area is characterized (as shown by the boreholes TVG-21, -41, -43, -17, Ta-1047, TVG-25, -44, -46) by the predominance of bioextrasparite and foraminiferal, slightly sandy bioextramicrosparite microfacies. The sandstone type is totally absent. In the southernmost profiles (TVG-17, -25, -44, -46) bioextrasparite is the predominant type (more than 50%). In these sequences, no sponge spicule facies was found.

In the northern part of the southern area (TVG-21, -41, -43, Ta-1047) it is the slightly sandy foraminiferal extrabiomicrosparite that predominates. The share of bioextrasparite can attain 30%. Interbedded layers of siliceous, spongy bioclastite microfacies can also be found.

In the sequences of the northern facies area (TVG-16, -50, -55, -29, -45) the quartz sandstone facies is predominant; its share exceeds even 50%. Bioextrasparite is of subordinate quantity. Siliceous, spongy bioclastite microfacies occur in almost all boreholes.

The sequence of borehole TVG-54 is of transitional character in many respect, though standing closer to the sequences of the southern facies area. Bioextrasparite and foraminiferal, slightly sandy extrabiomicrosparite microfacies have equal shares. In addition, the quartz sandstone microfacies is also present.

Beside the laterally different characteristics of the sequences, we have examined the relationships of the components of the individual microfacies types. It seems to be a general relationship, that the curve of the quartz grains runs parallel to that of glauconite and the curve of carbonate extraclasts to that of the echinoderm detritus. The behaviour of bioclasts and carbonate extraclasts is usually opposed to that of the quartz detritus and glauconite curves; they seem to represent something like each other's reflections in a mirror. (In Textfig. 56 the semi-quantitative test data of a few characteristic sequences are shown.)

The determination of the micrite-sparite (Folk) and clasts-matrix ratios (Leighton-Pendexter) is crucial for the genetic interpretation of clastic carbonate rock varieties. In addition, the sorting, roundness, size, etc. of the clastic material is important. Considering all these facts, it seems very probable that bioextrasparite and extrabiosparite are indices of the most intensely agitated depositional environment. This type of rock is considered to have been formed in a near-shore environment subject to wave action. On the other hand, the rock varieties formed at the lowest environmental energy are: bio- and extraclastite of micritic (microsparitic) matrix, unsorted and very poorly rounded as well as sandstone having an argillaceous micrite (microsparite) matrix. Since quartz grains are present in all facies types, their enrichment in the definitely sandy facies seems to have been provoked rather by a marked decrease of the quantity of carbonate clasts; this phenomenon can be traced back to the different paleogeographic patterns of the two facies areas: a relatively elevated, island-like area with a slight slope southwards and a steeper one northwards, at the time of deposition of the Upper Aptian grey crinoidal limestone.

The fossils of the Tata Limestone

Macrofossils have been recovered — all but a few — from the lowermost beds of the Tata Limestone in Kálvária Hill's Geological Conservation Area, in front of the property 21, Fazekas Street and before the Apprentice's Hostel of the Institute of Vocational Training. The data on microfossils have been obtained from the regular examination of samples recovered primarily from deep drilling.

Vegetal remnants are scant. The sedimentation conditions were unfavourable for their preservation. Despite this fact, we have managed to recover from the base of the sequence a poor spore-pollen assemblage, small coalified and/or silicified plant stem remnants and, a by freak of chance, the casts of a pine cone and needles as well.

In the glauconitiferous limestone of the profile facing the Apprentice's Hostel, M. H. DEÁK has found the following spore-pollen remnants:

Appendicisporites sp.
Cicatricosisporites sp.
Gleichenia nigra BOLCH.
Caytonathus oncodens HARRIS
Podocarpus sp.
Pinus haploxylon RUDOLPH

The spore of *Gleichenia nigra* BOLCH. was described by BOLKHOVITINA from Kazakhstan's Albian and from the Aptian of Moscow's neighbourhood.

P. GREGUSS, who examined xylotomically the fragments of plant stems, identified them as belonging to

Araucarioxylon,
Podocarpoxylon and
Keteleeria.

These are extinct relatives of Conifera living presently in the forests of Southeast Asia. They seem to be indicative of a warm, maritime climate, Keteleeria may even indicate the proximity of a mountain. The annual rings observed in cross sections of Podocarpoxylon and Keteleeria are indices of varying climatic conditions.

The luckily found pine cone was described by K. RÁSKY as *Striaestrobus* sp.

On the basis of literature data we sought intentionally to find potential remnants of Coccolithophoridae. M. BÁLDI—BEKE has recovered from the Tata Limestone the following assemblage:

Prediscosphaera cretacea (ARKHANGELSKIJ) (frequent)
Glaukolithus bochotnicae (GÓRKA)
Cyclolithus sp.
Zygodiscus sp. (frequent)
Rhabdolithus sp.
Watznaueria barnesae (BLACK) (frequent)
Markalius cf. *circumradiatus* (STOVER)
Tetralithus sp.
Braarudosphaera bigelowi (GRAN et BRAARUD)
Braarudosphaera sp.
Peritrachinella sp. (?)

The representatives of Foraminifera occur in the Tata Limestone in a considerable number of specimens and species. They were examined in thin sections made of samples recovered from outcrops and boreholes. As for the species *Ticinella roberti* (GAND.), I had noticed its presence already earlier (FÜLÖP 1961, 1964).

M. SIDÓ, in her paper now in press, summarized the results of foraminiferological examinations of some sequences of the Upper Aptian grey crinoidal limestone in the Transdanubian Central Mountains. She determined 36 genera and 57 species. She separated within the sequence the *Globigerinelloides algerianus* Zone characteristic of the Gargasian Substage and a "Ticinella assemblage" indicative of the Clansayan Substage.

E. EDELÉNYI and J. HAAS have given the following evaluation of the foraminiferal fauna of Tata's Upper Aptian grey crinoidal limestone sequences:

Planktonic Foraminifera are common, being most abundant in the sandstone type. Here they are:

Hedbergella infracretacea (GLAESSNER)
Ticinella roberti (GAND.)
Ticinella sp. div.
Globigerinelloides algerianus CUSHMAN et TEN DAM
Globigerinelloides sp. div.

Since the characteristically Gargasian *Globigerinelloides algerianus* species could be observed only in the basal part of the Tata Limestone sequence, thicker than the Upper Aptian sequences of Kálvária Hill's vicinity, uncovered by the borehole TVG-45 drilled into the basement horst block Tata II, the conclusion which we could draw was that Kálvária Hill's area must have been relatively more elevated even in Gargasian time and that it had not been buried by sediment until the advent of Clansayan time.

Benthonic Foraminifera too are common, but their quantity is the highest in rock types showing bioextra(mosaic)sparite- and slightly sandy bioextramicrosparite textures. Their majority are arenaceous:

Dorothia (Marssonella) trochus (D'ORBIGNY)
Dorothia (Marssonella) oxycona (REUSS)
Dorothia praeoxycona (MOULLADE)
Dorothia filiformis (BERTHELIN)
Dorothia sp.
Arenobulimina sp.
Cuneolina sp.
Spiroplectinata robusta MOULLADE
Spiroplectinata sp.
Bigenerina loeblichae CRESPIN
Bigenerina sp.
Textularia anglica LALICHER
Textularia sp.

Among the forms listed, it is the genera Dorothia, Spiroplectinata and Textularia that can be found in highest quantities.

Of the calcareous Foraminifera those of Lenticulina, usually large and thick-walled, are characteristic and frequent. These are characteristic of the texture types termed bioextrasparite and extrabiosparite. Of the other, sporadical, calcareous Foraminifera, the following have been identified:

Meandrospira washitensis LOEBLICH et TAPPAN
Spiroloculina sp.
Triloculina sp.
Quinqueloculina sp.
Nodosaria sp.
Dentalina sp.
Marginulina sp.
Bulimina sp.
Anomalina sp.

The highest abundance of the large, thick-walled Lenticulina can be observed in the calcarenite (crinoidite) rock type agreeing in grain size with the foraminiferal specimens, whereas the smaller, arenaceous, forms are frequent in extrabioclastic and slightly sandy rock varieties of low grain size. The diversity of Lenticulina is low, whereas the arenaceous genera, particularly the representatives of Dorothia and Spiroplectammina, exhibit a very high diversity: not even two individuals of the same type seem to be available.

The plankton to benthos ratio is, in terms of average per single sequences, close to 1:1, but when considered in the individual strata, this ratio is dependent on the microfacies type:

1. In beds of bioextrasparite—extrabiosparite microfacies, a marked preponderance of benthonic forms can be recorded.

2. In the bioextramicrosparite type the benthonic forms are somewhat more frequent than the planktonic ones.

3. The bioextra(mosaic)sparite microfacies is characterized by a striking predominance of the benthos.

4. In the slightly sandy extrabiosparite type the share of the benthos is somewhat higher.

5. In sandstone of micritic matrix with bio- and extraclast a marked predominance of plankton can be observed.

6. In the siliceous, spongy bioclastite microfacies the abundaces of the plankton and the benthos are more or less the same.

R a d i o l a r i a n s occur very subordinately in the thin sections of the Tata Limestone.

Skeletal fragments of S p o n g i a are relatively abundant, being characteristic of single facies zones. The silicification of the Tata Limestone is connected, as a rule, with the presence of Silicispongia. In the basal layers uncovered on Kálvária Hill, complete skeletons can even be found.

C o r a l remnants are rare elements of the fossil assemblage. Just a few solitary corals have been recovered from the basal part of the formation.

B r y o z o a n cross-sections are rather frequent in thin sections. A well-preserved Bryozoan colony was found on a damaged specimen of Brachiopoda. E. DUDICH determined this as *Flustrellaria* sp. PICTET and RENEVIER described a similar form under the name of *Flustrella rhodani* recovered from the Aptian of Perte du Rhône.

B r a c h i o p o d a are typical constituents of Tata's Upper Aptian faunal assemblage. It is particularly at the base of the grey crinoidal limestone that Brachiopoda remnants, mostly rounded off, flattened or deformed otherwise, can be found in great quantities. Their paleontological elaboration is being done by A. HORVÁTH carrying out a revision of earlier samplings and processing newly sampled materials. The species thus far determined and number of specimens are as follows:

	specimens
Rhynchonella decipiens Orb.	1
Rhynchonella nova Kar.	1
Rhynchonella rugosa Horv.	96
Rhynchonella tripartita Pict. var.	2
Rhynchonella sp.	1
Monticlarella lineolata (Phill.)	3
Terebratula depressa Lam. var. *Cyrta* Walker	1
Terebratula dutempleana Orb.	1
Terebratula cfr. *dutempleana* Orb.	2
Terebratula moutoniana Orb.	333
Terebratula cfr. *moutoniana* Orb.	12
Terebratulina sp. indet.	25
Waldheimia sp.	16
Nucleata hippopus (Römer)	18

A list of species figuring, for the most part still under old names, includes both persistent forms transient from the Tithonian and ranging throughout the Lower Cretaceous such as *Nucleata hippopus*, and *Terebratula moutoniana* which was first described by d'Orbigny from the Berriasian of France, but which had lived up to the end of the Aptian. As evidenced by foreign fossiliferous localities, it had its acme in the Barremian. In our country this species is yet unknown at other localities, but it is that which forms the overwhelming majority of Brachiopoda at the base of the Tata sequence, coupled with a new Rhynchonella species *(Rhynchonella rugosa)* whose relations to other species are still obscure.

There are sporadical, but stratigraphically significant, forms such as *Rhynchonella decipiens* and *Terebratula dutempleana*, characteristic representatives of the Aptian Stage, or the forerunners of the Albian: *Monticlarella lineolata* and *Rhynchonella tripartita*.

Because of the predominance and wide variability of *Terebratula moutoniana*, this species furnished an adequate material for detailed paleontological studies. A. Horváth had polished sections of brachial valves made of specimens of this species and concluded that though the shell had externally preserved its basic features, a comparison with the brachial valves of Berriasian specimens showed a considerable phylogenetical change which was the result of a long-time evolution.

At the base of the Tata Limestone, on top of the Upper Malm-Berriasian limestone, colonies of Serpula can be locally found. The coiled and curved tube tests form a crust of 1 to 2 cm thickness. The ornamentation of the dwelling tubes consists of very fine longitudinal and yet finer transversal ribs. Their diameter is usually 1 mm, subordinately 1/2 and 2 mm.

B i v a l v i a are relatively scarce in the grey crinoidal limestone. A total of two species has been found thus far: *Pecten alpinus* Orb. and *Alectryonia rectangularis* Roem.

The basal layers of the Tata Limestone have yielded a rich g a s t r o p o d a l fauna. In my first work on Tata's Kálvária Hill (1954), I had already pointed out the marked conformity of this fauna with regard to the Upper Neocomian gastropodal fauna of Escragnolles, France (Orbigny: Types du Prodrôme Pl. LXXXI., Ann. Pal. T. XXVI. Pl. VII.). At present the following gastropodal fauna is available to us:

	specimens
Turritella moutoniana Orb.	1
Scalaria ellatior Orb.	1
Scalaria sp.	7
Turbo alceae Orb.	12
Turbo sp.	7
Chemnitzia varusensis Orb.	4
Natica sp.	11
Varigera rochatiana Orb.	1
Neritopsis moutoniana Orb.	22
Neritopsis laevigata Orb.	45
Neritopsis sublaevigata Orb.	1
Solarium sp.	45
Pleurotomaria varusensis Orb.	25
Pleurotomaria cassiana Orb.	4
Rostellaria provincialis Orb.	1
Rostellaria varusensis Orb.	10

These are, for the most part, phytophagous, shallow-water benthonic forms.

Stratigraphically most significant fossils of the Tata Limestone are C e p h a l o p o d a (Plates XLIX and L). Thank to repeated samplings, now we have a rich collection thereof: a total of about 2000 representatives of Ammonoidea, 25 of Nautiloidea and 160 of Belemnoidea. The cephalopodal fauna has been recovered from three localities: from the base of the Aptian grey crinoidal limestone in Kálvária Hill's Geological Conservation Area, from the same stratigraphic position in front of 21, Fazekas Street and, finally, from the lowermost reddish-glauconitic-sandy limestone beds in front of the Apprentice's Hostel of the Institute of Vocational Training. The fossils are ornamented internal moulds. Except for the locality in front of the Apprentice's Hostel, these are usually more or less flattened, deformed and often broken specimens brought together by wave action into the more protected hollows of the one-time rocky coast.

The distribution of the fossils by localities has been shown in Table 11.

The determined Ammonoidea fauna represents the Clansayan Substage: the *Diadochoceras nodosocostatum* Zone. Considering the detailed zonal scale developed by Soviet geologists, we can

Table 11

	Kálvária Hill's Conservation Area	21, Fazekas Street	Apprentice's Hostel
	specimen		
Phyllopachyceras rouyanum (ORB.)	13	5	1
Calliphylloceras cfr. *aptiense* (SAYN)	20	22	—
Calliphylloceras sp.	19	—	3
Holcophylloceras (Salfeldiella) guettardi (RASPAIL)	99	41	8
Lytoceras sp.	11	1	1
Eotetragonites duvalianus (ORB.)	71	22	26
Eotetragonites heterosulcatus (ANTH.)	17	—	4
Eotetragonites sp.	59	11	8
Gabbioceras (Jauberticeras) latericarinatum (ANTH.)	—	2	—
Gabbioceras micheliana (ORB.)	1	—	—
Ammonitoceras pavlovi WASS.	—	—	1
Ptychoceras minimum ROUCHADZE	40	28	14
Hamites div. sp.	47	30	4
Valdedorsella getulina (COQ.)	127	49	8
Valdedorsella planulata (JEGOJAN)	1	—	2
Puzosiella minuta JEGOJAN	69	31	15
Puzosiella n. sp. 1.	5	8	7
Puzosiella n. sp. 2.	16	—	2
Puzosiella sp. indet	22	11	—
Melchiorites melchioris (TIETZE)	14	18	9
Zurcherella zurcheri (JACOB)	2	—	—
Uhligella sp.	21	6	—
Desmoceras falcistriatum ATHULA	3	1	8
Desmoceras sp.	12	—	—
Epicheloniceras aphanasievi URM.	17	5	1
Epicheloniceras sp.	2	—	—
Diadochoceras nodosocostatum (ORB.)	58	86	3
Diadochoceras spinosum MIHAJLOVA	10	7	—
Diadochoceras sp.	18	4	—
Parahoplites sp.	4	1	3
Acanthohoplites bigoureti SEUNES	52	24	4
Acanthohoplites nolani (SEUNES)	28	22	7
Acanthohoplites aschiltaensis ANTH.	10	6	8
Acanthohoplites abichi ANTH.	21	14	3
Acanthohoplites uhligi ANTH.	35	—	5
Acanthohoplites sp.	37	3	—
Hypacanthoplites sp.	30	6	1
Colombiceras sp.	1	4	6
?*Dufrenoyia* sp.	17	—	—

state the presence of the lower part, the *Acanthohoplites nolani* Zone, of the Clansayan Substage. This is supported by the fact that representatives of several Ammonoidea genera predominant in the Gargasian Substage can still be found in the Tata fauna: Melchiorites, Colombiceras and Dufrenoyia. Species characteristic of the Upper Clansayan *Hypacanthoplites jacobi* Zone are subordinate, if any. With a view to the faunal relationship interlocking the Clansayan with the Gargasian, and to he striking difference from the Lower Albian *Leymeriella tardefurcata* Zone, we consider the Tata Limestone to represent the final portion of the Aptian Stage.

C r i n o i d ossicles and skeletal fragments are typical rockforming faunal elements of E c h i n o i d e a in the Tata Limestone. E. SZÖRÉNYI determined and described the following fauna from the material given to her:

	specimens
Sterocidaris malum (A. GRAS) — (Hauterivian—Aptian)	1
Salenia prestensis DESOR — (Barremian—Aptian)	2
Pseudocidaris clunifera (AGASSIS) COTTEAU (Neocomian)	14
Plymosoma loryi (A. GRAS) — (Neocomian)	2
Holectypus cfr. *neokomiensis* A. GRAS — (Neocomian)	3
Conulus soubellensis (GAUTHIER) LAMB. — THIERI	1
Conulus tatensis SZÖRÉNYI	1
Discoidea decorata DESOR — (Aptian)	13
Pyrina div. sp.	5
Collyropsis cfr. *ovulum* (DESOR) — (Neocomian)	16
Collyropsis jaccardi (DESOR) — (Valanginian)	1
Collyropsis globulus SZÖRÉNYI	6

Thin radioles and coprolites of Echinoidea are frequent in the residues of washing and thin section.

Since typical representatives of Discoidea are known only from the Aptian on and since the specimens from Tata are typical Discoidea provided with internal supporting pillars, the Echinoidea fauna itself does confirm the conclusion that a pre-Aptian stratigraphic position of the Tata Limestone is inconceivable. If we take into consideration the shares of regular and irregular sea urchins, again a higher stratigraphic position appears to be reasonable, because the irregular sea urchins are represented by a richer variety of forms in the Tata Limestone. The fauna can be neritic at the most, being rather sublittoral.

E. SZÖRÉNYI even determined a new crinoid species, *Torynocrinus (Collarocrinus) phialaeformis* SZÖRÉNYI (Plate XLIII, Fig. 1), originating from the Tata Limestone.

V e r t e b r a t e s are represented only by a couple of fish teeth, one minute fragment of vertebra and a reptile bone fragment, not yielding to closer determination.

REFERENCES

FÜLÖP, J. 1954: Examen géologique de la motte mésozoïque de Tata. (Summary) — Földt. Közl. 84. 4.

FÜLÖP, J. 1961: Formations crétacées de la Hongrie. — Ann. Inst. Geol. Publ. Hung. 49. 3.

FÜLÖP, J. 1964: Unterkreide-Bildungen (Berrias—Apt) des Bakonygebirges. — Geol. Hung. Ser. Geol. 13.

GREGUSS, P. 1956: Pflanzenreste aus der Kreidezeit von Tata. — Acta Biol. nov. ser. 2. 1—4. Szeged.

KOCH, N. 1909: Die geologischen Verhältnisse des Kalvarienhügels von Tata. (Summary) — Földt. Közl. 39.

LIFFA, A. 1910: Geologische Notizen aus der Umgebung von Tata und Szőny. — Jahresber. Ung. Geol. Reichsanst. 1908.

ID. LÓCZY L. 1906: Geológiai megfigyelések a tatai Kálvária-hegyen. — Földt. Közl. 36.

RÁSKY, K. 1954: Lower Cretaceous plants from Hungary. (Summary) — Földt. Közl. 84. 1—2.

SOMOGYI, K. 1914—1916: Das Neokom des Gerecsegebirges. — Jahrb. Ung. Geol. Reichsanst. 22. 5.

SZABÓ, I. 1961: Die Ausbildungen der mesozoischen Scholle von Tata aus der Jurazeit. — Ann. Inst. Geol. Publ. Hung. 49. 2.

SZÖRÉNYI, E. 1961: Echinodermes mésozoïques de la Hongrie. — Ann. Inst. Geol. Publ. Hung. 49. 1.

SZÖRÉNYI, E. 1962: Les Torynocrinus (Crinoides) du Crétacé inférieur de la Hongrie. — Acta Geol. 6. 1—2.

SZÖRÉNYI, E. 1965: Échinides du Crétacé inférieur de la Hongrie. — Geol. Hung. Ser. Pal. 29—32.

TAEGER, H. 1909: Die geologischen Verhältnisse des Vértesgebirges. — Jahrb. Ung. Geol. Reichsanst. 17. 1.

Lower Albian dark grey siltstone

Possibilities for describing any new geological formation of significance in this country are constantly waning. Tata's vicinity now offers an opportunity even in that respect:

Survey drills T-150, TVG-22, -29, -40, -43 and -45 have uncovered a poorly consolidated, dark grey sandy marl—siltstone formation unconformably (with a sharp boundary and different geological features) overlying the Aptian grey crinoidal limestone (Textfig. 58: in pocket). At its base, some detritus of the Aptian grey crinoidal limestone and calcareous, glauconitic sandstones can be found. In a few metres thickness the quartz-, glauconite- and the lime content is usually high and this feature locally reappears even higher in the vertical sequence of the formation. Macrofossils are scarce: rostra of Belemnoidea and internal moulds of predominantly smaller Ammonoidea; in addition, poorly preserved remnants of Gastropoda, Bivalvia and, sporadically, also Echinoidea can be encountered. Microfossils, especially spore-pollen remnants, Coccolithophoridae and Foraminifera, are present in relatively great quantities. Histrichosphaeridae, "Microforaminifera", Radiolaria, skeletal elements of Spongia, skeletons of Octocorallia and remnants of Ostracoda are subordinate.

The sequences uncovered are residues of obviously postsedimentary denudation. They are overlain, with a considerable hiatus, by Oligocene and/or Pannonian sediments. In the vicinity of borehole TVG-43 — in the southern part of Schönherz Street (at a single point known thus far) — the formation occurs close to the ground surface.

To quote a bibliographic reference, I should like to refer to that part of my study published in 1954, in which I wrote the following: "When studying the rocks uncovered in trenches excavated for the tap-water pipe of Tata's Old Town, I discovered such marls and calcareous sandstones as those overlying the crinoidal limestone. They are less resistant than this latter, so that Tertiary denudation has not left hardly any of them preserved. Only at the southern extremity of Kálvária Street* was it possible to trace these formations in greater thickness (7—10 m). I could not find any fauna in them. That they belong to the Cretaceous sequence cannot be doubted, for they have evolved by a gradual transition from the crinoidal limestone." This last statement too had contributed to my not recognizing then the presence of an independent formation.

The Lower Albian dark grey siltstones extend, across the western foreland of the Tatabánya Basin, up to the Vértessomlyó "bay".

This same formation had been uncovered by that coal-exploratory drift, from the spoil-heap of which H. Taeger had sampled and determined the "Barremian" cephalopodal fauna published in his monograph on the Vértes Mountains (Ann. Inst. Geol. Publ. Hung. 17. 1.): the misterious "black stone of Kabah" in our geological literature. I intend to devote a monograph to the Cretaceous formations of the Vértes foreland in which a detailed geological description of this fauna and of the formation enclosing it — which I propose to name the "Vértessomlyó Beds" — is to be given.

Summarization of the mineralogical and petrographical results

The formation is characterized by the determinant ratio of the fine sand to silt content (0.2—0.063 and 0.063—0.005 mm ∅) as well as by a considerable clay and $CaCO_3$ content (Textfig. 58 and 59). Poor sorting and high-grade reductivity, abundance of organic matter and pyrite and, finally, poor stratification are indicative of sheetwash on a flat land surface and rapid accumulation of sediment without any considerable factor of fractioning. Oxidation-reduction conditions testify to a closed, bay-like sedimentary basin with plenty of detritus. The glauconite is a characteristic autigenic mineral of the similar Albian shallow-water facies.

The micromineralogical analyses of the Lower Albian siltstones of borehole TVG-59 were carried out by K. Vaskó—Dávid. She examined the 0.1 to 0.2 mm fraction of the insoluble residue (10% solution of HCl) of samples taken at 1 m spacing. The analyses are shown in Table 12. At the fractioning of the constituents the microcrystalline detritus got separated completely with the light fraction, excepting leucoxene grains which we have indicated separately in the annexed table. Because of the small number of the heavy minerals separated, the individual percentage values, in some cases (indicated by asterisks), cannot be considered to be real.

The weight percentage of heavy minerals is scarcely more than 1 to 2%. Considering the qualitative composition of the heavy mineral fraction, the predominance, beside pyrite, of minerals of basic to ultrabasic origin (chromite, leucoxene) is characteristic. Minerals suggestive of a slight metamorphism and of a mixed origin are present in subordinate quantities.

The light fraction is dominated by a microcrystalline and vitroclastic detrital material. In addition, there is a very low amount of weathered K-feldspar and a somewhat higher amount of basic plagioclase which, in spite of its being less resistant to weathering, is relatively fresh. Quartz and quartzite are less abundant than the magmatic rock detritus (Textfig. 60).

As shown by the micromineralogical analyses, the source area must have been made up of chromite-containing intrusive ultrabasic rocks, quite probably, of subvolcanic, volcanic moreover and epimetamorphic formations.

---

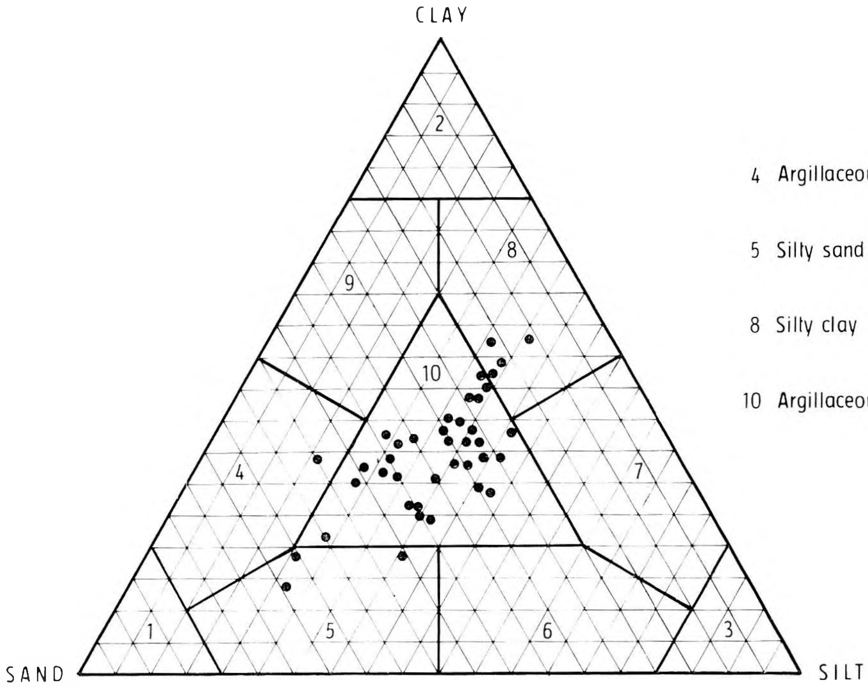
*Now: Schönherz Street

Depth m	Heavy minerals														
	epidote	zoisite	actinolite	chlorite	tourmaline	garnet	hornblende	zircon	rutile	anatase	magnetite	hypersthene	biotite	chromite	chromite in rock detritus
67.0	—	—	1	1	—	1	—	—	—	—	1	—	—	3	—
68.0	—	—	—	1	—	1	—	—	—	tr	1	—	—	2	2
69.0	—	—	—	4	1	—	1	—	—	—	—	—	—	1	4
70.0	—	—	—	4	1	—	tr	1	—	—	1	1	1	3	1
71.0	—	—	—	4	—	—	—	1	—	—	—	—	—	—	4
72.0	—	—	—	1	—	1	1	—	—	—	—	—	—	1	3
73.0*	—	—	—	18	—	—	—	—	—	—	—	—	19	5	—
74.0	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
75.0	2	—	—	7	—	1	—	—	—	—	—	—	4	1	2
76.0***															
77.0	—	—	—	1	2	1	—	—	—	—	—	—	—	9	1
78.0	—	—	tr	—	—	tr	—	—	tr	—	—	—	—	1	1
79.0	—	—	—	—	—	—	—	—	—	—	—	—	—	tr	—
80.0*	—	—	—	—	—	—	—	—	—	—	—	—	—	9	—
81.0	—	—	—	—	3	tr	tr	—	—	—	—	tr	—	7	—
82.0**	—	—	—	—	—	—	—	—	—	—	—	—	—	27	—
82.8**	—	—	—	—	6	—	5	—	—	—	—	6	—	22	—
83.0**	—	—	—	—	—	—	—	—	—	—	—	—	—	9	9
84.0	—	—	—	—	1	—	—	1	—	—	—	—	—	—	2
85.0**	—	—	—	—	—	—	—	—	—	—	—	—	5	18	5
86.0**	—	—	—	—	—	—	—	—	—	—	—	—	—	29	—
87.0**	—	—	—	—	tr	—	—	—	—	—	—	—	—	tr	—
88.0**	—	—	—	—	—	—	—	—	—	—	—	—	—	5	8
89.0	—	—	—	—	—	—	—	—	—	—	—	—	—	2	5
90.0**	—	—	—	—	—	—	—	—	—	—	3	—	—	12	22
91.0**	—	—	—	11	—	3	—	—	—	—	—	—	—	18	11
92.0	—	—	—	9	—	2	—	—	—	—	—	—	—	34	2
93.0	—	tr	—	5	1	—	—	tr	—	—	1	—	—	7	2
93.6*	—	—	—	5	10	—	—	—	—	—	1	—	—	13	30
93.8**	—	—	—	6	6	3	—	—	—	—	—	—	3	19	16
94.0	—	—	—	—	2	1	—	—	—	—	—	—	—	62	—
95.0	—	—	—	—	3	—	1	—	—	—	—	—	—	15	1
95.7**	—	—	—	—	12	—	—	—	—	—	8	—	—	21	21
96.0**	—	—	—	—	—	5	—	—	—	—	—	—	—	16	26
97.0	—	—	—	—	3	1	—	—	—	—	—	—	—	9	3
98.0*	—	—	—	—	2	—	—	7	—	—	4	—	—	20	9
99.0	—	—	—	—	5	2	—	1	—	—	3	—	—	32	7
100.0	—	—	—	6	2	—	—	—	—	—	—	—	—	20	4
101.0	—	—	—	11	—	—	—	—	—	—	—	—	—	11	9
102.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
103.0	—	—	—	—	—	—	—	—	—	—	—	—	—	2	5

* Individual percentage values have been calculated on the basis of 50 to 100 grain specimens available in the heavy fraction
** Individual percentage values have been calculated on the basis of 10 to 50 grains available in the heavy fraction
*** 10 grains were present in the heavy fraction separated
tr = in traces

Albian siltstone of the borehole TVG-59

						Light minerals									
leucoxene	limonitic and hematitic debris	pyrite – chalcopyrite	pyrite	pyritiferous coalified remnant	heavy minerals, weight %	microcrystalline rock detritus	quartz	quartzite	weathered rock detritus	albite	K-feldspar	plagioclase	coalified remnants	muscovite	chert
—	3	—	74	9	1.20	20	20	8	44	—	2	3	3		tr
3	—	—	88	2	0.97	12	14	9	46	—	tr	17	1		tr
9	15	—	65	—	0.97	14	11	8	43	1	1	20	2	tr	
4	—	—	82	—	0.98	16	7	6	53	tr	2	14	tr	tr	
8	—	—	61	4	0.78	10	5	5	60	1	2	12	3	tr	
9	3	—	77	4	0.89	11	13	5	60	—	—	10	—		tr
—	—	—	27	4	1.78	23	12	7	47	1	2	8	—	tr	tr
—	—	—	99	—	4.07	6	17	7	55	—	1	5	1		8
2	—	—	77	4	1.69	11	15	5	56	1	1	6	—	tr	5
						10	17	9	56	—	1	3	1		3
6	2	—	71	1	0.94	20	16	7	50	2	—	3	1		1
2	—	96	—	—	1.12	22	11	5	54	1	1	6	—		
—	—	100	—	—	2.63	27	9	5	49	—	—	10	—		
42	—	46	—	3	0.84	20	15	8	49	—	1	7	—		
—	—	90	—	—	1.16	25	7	2	56	1	1	8	—		
—	—	73	—	—	0.78	21	9	10	44	2	2	12	—		
22	—	39	—	—	0.93	28	10	8	38	1	2	11	2		tr
45	—	37	—	—	0.88	14	14	8	51	5	1	7	—		
6	—	90	—	—	0.93	18	8	6	52	1	2	13	—		
27	—	45	—	—	0.54	17	15	7	47	2	2	9	1		
—	—	71	—	—	0.35	23	14	10	44	1	3	5	—		
—	—	100	—	—	0.31	16	9	7	58	1	1	8	—		
10	—	77	—	—	0.38	15	14	8	54	2	1	6	—		
5	—	88	—	—	0.52	18	12	3	62	—	—	5	—		
16	—	47	—	—	0.44	12	11	8	67	—	—	2	—		
14	—	43	—	—	0.51	22	2	6	61	—	—	9	—		
32	—	21	—	—	0.51	10	9	4	63	—	1	13	—		
13	—	71	—	—	0.63	12	11	7	59	—	—	11	—		
25	—	16	—	—	0.63	7	9	8	67	1	—	8	tr		
16	—	31	—	—	0.49	26	14	3	45	—	—	12	—		tr
14	1	1	18	—	0.52	20	13	8	52	—	—	7	—		
5	1	3	71	—	1.33	12	16	7	53	1	1	10	—		
21	—	—	14	—	0.50	12	14	11	52	2	1	5	3		
16	—	—	37	—	1.26	9	15	11	59	tr	1	5	—		
12	—	—	72	—	1.31	24	11	9	39	—	—	17	—		
49	—	—	5	—	1.06	14	16	10	47	2	1	10	—		
32	7	—	11	—	1.32	19	17	5	46	2	1	10	—		
40	—	—	28	—	1.19	11	14	11	52	—	—	12	—	tr	
37	—	—	32	—	1.21	17	21	6	47	—	—	9	—		
tr	100	—	—	—	1.76	9	17	5	63	—	—	6	—		
7	86	—	—	—	1.44	8	25	6	47	—	1	13	—		

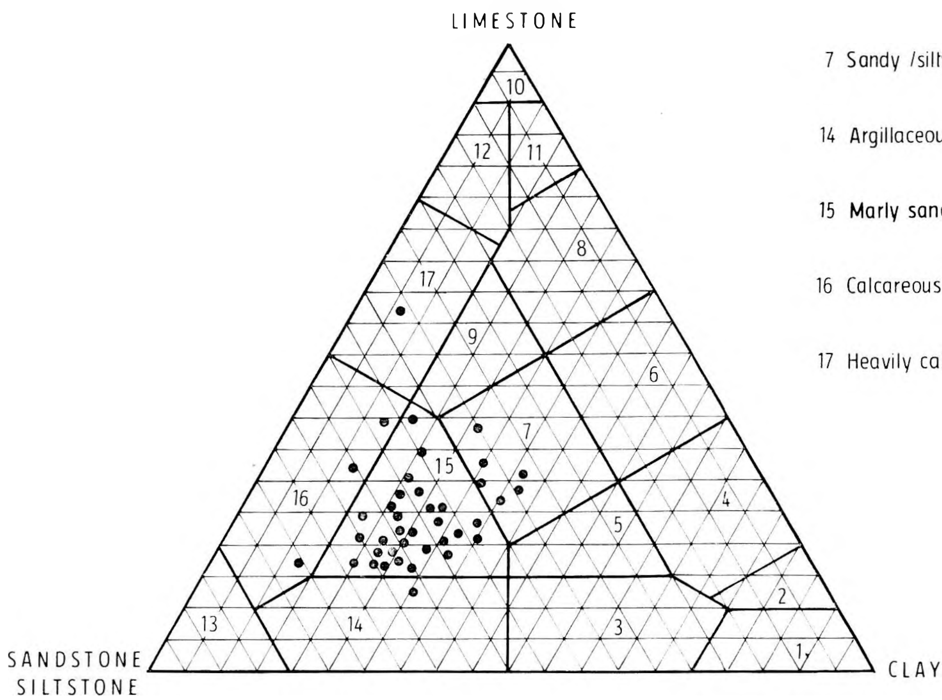


4 Argillaceous sand

5 Silty sand

8 Silty clay

10 Argillaceous, silty, sandy sediment



7 Sandy /silty/ marl

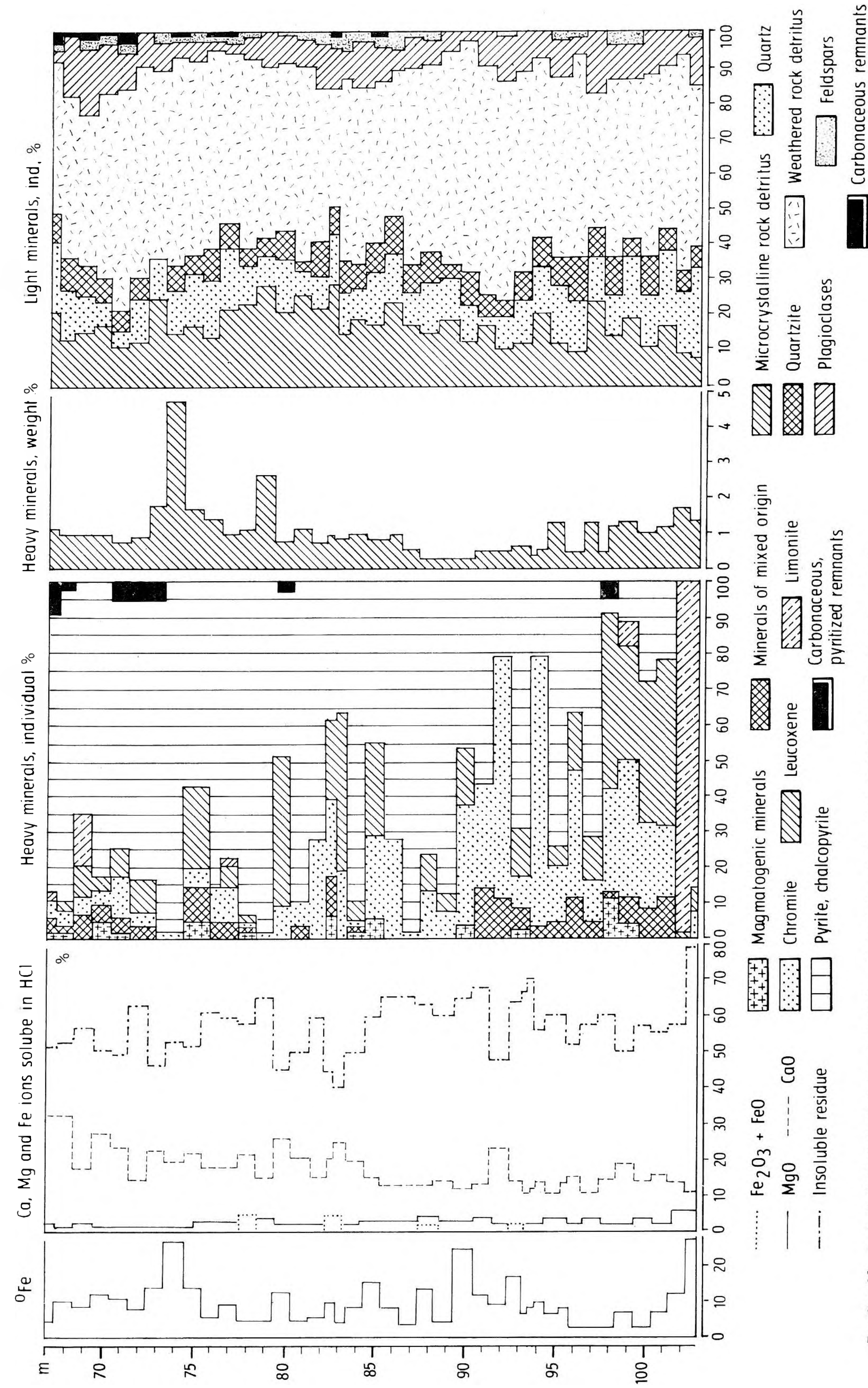
14 Argillaceous sandstone, siltstone

15 Marly sandstone, siltstone

16 Calcareous sandstone, siltstone

17 Heavily calcareous sandstone, siltstone

Textfig. 59: PETROGRAPHIC DIAGRAM OF LOWER ALBIAN SILTSTONE from the 67.0 to 102.3 m INTERVAL OF BOREHOLE TVG-59



Textfig. 60: L A B O R A T O R Y   T E S T   D A T A   O N   B O R E H O L E   T V G - 5 9

Fossils

The Lower Albian dark grey siltstones contain a prolific fossil assemblage of varied composition. I invited specialists to examine them and they contributed with new, significant results to an up-to-date understanding of the formation under discussion.

M. JUHÁSZ and J. BÓNA conducted palynological studies, J. BÓNA examined the representatives of Coccolithophoridae, I. KOVÁCS—BODROGI determined the foraminiferal fauna, A. ORAVECZ—SCHEFFER, L. MÓRA—CZABALAY and G. SCHOLZ were very helpful by examining Ostracoda, Gastropoda and Ammonoidea, respectively.

The palynological study of the Lower Albian dark grey siltstones of Tata's vicinity was carried out by M. JUHÁSZ and J. BÓNA. From the Lower Albian dark grey siltstones of boreholes TVG-22, -40, -43, -45 and -59 they have recovered and determined, on the basis of the botanical relations known thus far, the following fossil assemblage:

Phyllum: P T E R I D O P H Y T A

Classis: PTEROPSIDA

Ordo: *F i l i c a l e s*

Familia: S c h i z a e a c e a e

Trilites (Bikolisporites) toratus (WEYL. et GR.) JUHÁSZ 1972
Trilites (Trilites) triangulatus KDS. 1964
Trilites (Pereisporites) minor JUHÁSZ 1972
Cicatricosisporites potomacensis BRENNER 1963
Cicatricosisporites pseudotripartitus (BOLCH.) DETT. 1963
Cicatricosisporites hughesi DETT. 1963
Cicatricosisporites venustus DEÁK 1964
Cicatricosisporites baconicus DEÁK 1964
Appendicisporites parviangulatus DÖRING 1966
Appendicisporites stylosus (THIERG.) DEÁK 1964
Appendicisporites crimensis (BOLCH.) POCOCK 1964
Appendicisporites crenimurus SRIVASTAVA 1972
Concavissimisporites verrucosus (DEL. et SPR.) DEL., DETT. et HUGH. 1963
Concavissimisporites asper (BOLCH.) POCOCK 1964
Ischyosporites pseudoreticulatus (COUPER) DÖR. 1966
Corniculatisporites (al. *Welwitschiapites*) *alekhini* (BOLCH.) KUVAEVA 1971

Familia: G l e i c h e n i a c e a e

Plicifera delicata (BOLCH.) BOLCH. 1966
Gleicheniidites senonicus ROSS. 1949
Gleicheniidites laetus (BOLCH.) BOLCH. 1966
Gleicheniidites umbonatus (BOLCH.) BOLCH. 1966
Clavifera triplex (BOLCH.) BOLCH. 1966

Familia: M a t o n i a c e a e

Matonisporites major DEÁK 1964
Matonisporites minor DEÁK 1964

Familia: O s m u n d a c e a e

Osmundacidites wellmannii COUPER 1953
Todisporites minor COUPER 1958

Familia: C h e i r o p l e u r i a c e a e

Dictyophyllitides harrisii COUPER 1958

Classis: LYCOPSIDA

Ordo: *L y c o p o d i a l e s*

Familia: L y c o p o d i a c e a e

Retitriletes austroclavatidites (COOKSON) D.K.M.SCH. 1963
Foveosporites canalis BALME 1957
Densoisporites velatus WEYL. et KRIEG. 1953
Densoisporites microrugulatus BRENNER 1963

Sporae Incertae Sedis:

Pilosisporites brevibaculatus DÖRING 1965
Rotverrusporites obscurilaesuratus (POCOCK) DÖRING 1965
Leptolepidites major COUPER 1953
Cyathidites australis COUPER 1953
Cyathidites minor COUPER 1953
Neoraistrickia truncatus (COOKSON) DETT. 1958
Ceratosporites equalis COOKSON et DETT. 1958
Staplinisporites caminus (BALME) POCOCK 1962

Phyllum: G Y M N O S P E R M A T O P H Y T A

Classis: PTERIDOSPERMATOPSIDA

Ordo: *C a y t o n i a l e s*

Vitreisporites palladius (REISS. 1938) NILSSON 1958

Classis: CYCADOPSIDA

Ordo: *C y c a d a l e s*

Monosulcites minimus COOKSON 1947

Classis: GINKOPSIDA

Monosulcites sp.

Classis: CONIFEROPSIDA

Ordo: *C o n i f e r a l e s*

Familia: P i n a c e a e

Alisporites grandis (COOKSON) DETT. 1963
Abietineaepollenites minimus COUPER 1958
Podocarpidites multesimus POCOCK 1962
Parvisaccites radiatus COUPER 1958
Cedripites sp.

Familia: A r a u c a r i a c e a e

Araucariacites australis COOKSON 1947
Araucariacites hungaricus DEÁK 1963

Familia: C h e i r o l e p i d a c e a e

Classopollis torosus (REISS.) COUPER 1958

Planktonic organisms:

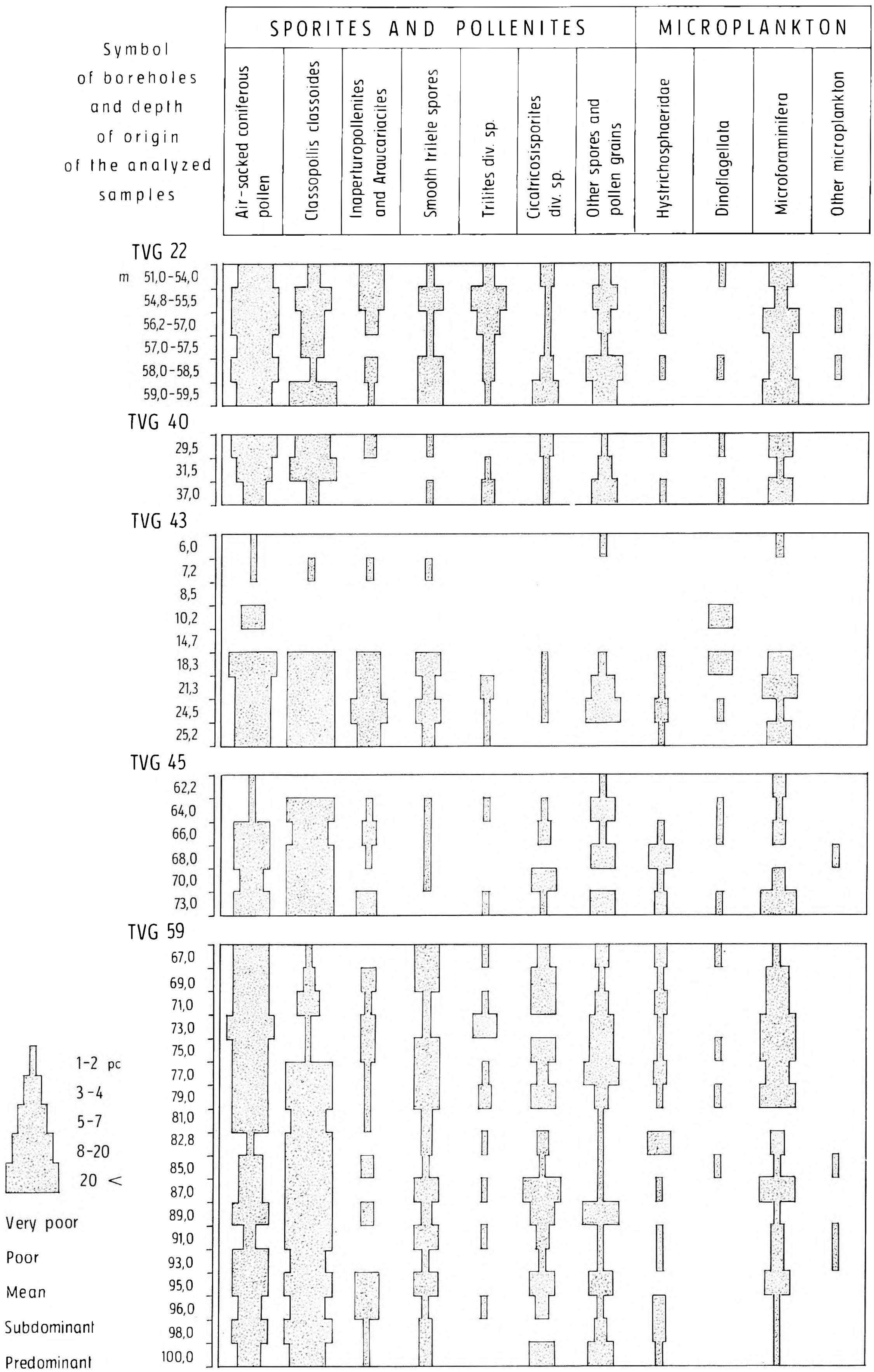
Algae:

Cribroperidinium (al. *Gonyaulax*) DAVEY 1969
Cribroperidinium orthoceras EIS. — type
Cribroperidinium serrata COOKSON et EIS. — type
Cribroperidinium cassidata COOKSON et EIS. — type
Cribroperidinium edwardsi COOKSON et EIS. — type
Tenua hystrix EIS.
Baltisphaeridium ferox (DEFL.) DOVNIE et SARJ.
Baltisphaeridium hirsutum (EIS.) DOVNIE et SARJ.
Hystrichosphaeridium coniodes EIS.
Hystrichosphaeridium astergerum GOCHT
Hystrichosphaera cf. *furcata* (EHRT.) O. WETZEL
Micrhystridium sp.
Wetzeliella sp.
Cymatiosphaera sp.
Leiosphaeridia sp.

Fossil fauna:

Microforaminifera
Scolecodonta

(See Plate LI)



Textfig. 61: SPORE-POLLEN AND MICROPLANKTON DIAGRAM OF BOREHOLES INTERSECTING LOWER ALBIAN DARK GREY SILTSTONES

Well-preserved spores, pollen grains and microplanktonic skeletons can be recovered from the dark grey siltstones. The sporomorphs recoverable upon maceration of 30 grams of pre-sieved rock can be considered to be of mean quantity. This means that, as a rule, 30 to 40 forms can be determined in one slide. The spore—pollen remnants are accompanied by hosts of tiny fragments of coalified vegetal tissue, hence probably the dark grey colour of the rock.

After summarizing the numerical test data, we have plotted the palynological diagrams of the examined boreholes in which we have distinguished faciologically and paleobotanically important groups (Textfig. 61). The diagrams testify to the homogeneity (uniformity) of the flora. Each bore profile shows the predominance of one and the same forms: coniferous air-sacked pollen grains and coniferous pollen of *Classopollis torosus*. Inaperturate coniferous pollen grains are less abundant in each profile.

Beside the pollen grains of Conifera, fern spores are also represented in similar percentage ratio in the bore profiles. Of these, it is smooth trilete spores (Laevigati), the genera Cicatricosisporites and Trilites that represent the most important group. The group of Trilites ferns is predominant among these. Parallel to its increasing frequency in the upper parts of the profiles, the share of the pollen grains of the conifer Classopollis decreases. The spore—pollen assemblage is accompanied in every profile by marine microplanktonic and foraminiferal remnants. Among these, the tests of Foraminifera are represented, as a rule, in mean quantity; the representatives of Hystrichosphaeridea and Dinoflagellata algae are usually rare and small in number.

As evidenced by the pollen assemblage, Conifera in coastal maritime forests must have been represented by types which had evolved still in Mid-Jurassic time. However, the representatives of Cycas and Ginkgo occur only sporadically. Most striking compared to the Jurassic is the great number of markedly sculptured (Murornati) fern spores (Cicatricosisporites, Trilites, Appendicisporites). Their mother plant belongs to the tropical fern family Schizeaceae (Anemia). Representatives of Matoniaceae and Gleicheniaceae and the spores of Matonisporites and Gleicheniidites similarly belonging to tropical fern families are already less frequent. It should be pointed out, that no pollen grain of certainly angiospermous origin could be detected. The presence of Classopollis is indicative of an arid climate. Among fern spores too, forms of a ribbed sculpture, again the result of adaptation to aridity, are frequent.

The marine character of the sediment is evidenced by the marine microplankton always associated with the spores and pollen grains. In the planktonic assemblage the representatives of Dinoflagellata tolerant of turbulent water are also frequent. Leiosphaeridia planktonic forms enduring a marked shortage of oxygen can be shown to occur, too. Judging by these circumstances and the good preservation state of the spore—pollen material, we can conclude that the sedimentary environment was unaerated, reductive.

On the basis of comparisons with Hungarian pollen florae the most probable age of the formation is Lower Albian. The sporomorph assemblage seems to be somewhat older than that of the variegated clay formation. The assemblage is very akin to the Middle Albian microflora of Vokány studied by F. Góczán and presented in my monograph on the Cretaceous of the Villány Mountains (1966), but the marked abundance and diversity of Cicatricosisporites suggest that the first of the two should be slightly older. The microplanktonic forms, too, allow us to declare it older. *Hystrichosphaeridium syphoniphorum* and *H. trumcigerum*, forms typical of the Turrilites marl, could not be identified here. The very small number of Cycadophytous and Ginkgophytous pollen grains, however, suggests the assemblage to be of post-Aptian age.

J. Bóna carried out a study of the nannoplankton of the dark grey siltstone sequence uncovered in borehole TVG-59. The forms determined and their frequencies can be listed as follows:

Watznaueria barnesae (Black) — predominant
Discolithina embergeri (Noël) — subordinate
Discolithina div. sp. — subordinate
Zygolithus sp. — subordinate
Biscutum sp. — scarce
Rhabdolithus sp. — very subordinate
Ahmuellerella sp. — very subordinate
Staurolithites bochotnicae (Górka) — scarce
Stephanolithion laffittei Noël — scarce
Braarudosphaera bigelowi (Gran et Braarud) — very subordinate
Braarudosphaera hoschulzi Reinhardt — subodinate
Braarudosphaera cf. *discula* Braml. et Ried. — subordinate
Micrantholithus sp. — very subordinate
Nannoconus steinmanni Kamptner — frequent
Nannoconus elongatus Brönnimann — fair
Nannoconus truitti Brönnimann — frequent
Nannocunus globulus Brönnimann — subordinate
Nannoconus colomi (de Lapp.) — subordinate
Nannoconus div. sp. — frequent

According to the opinion of M. BÁLDI—BEKE, the nannoplanktonic assemblage is characteristic of the Lower Cretaceous, *Watznaueria barnesae* being the predominant form. The species *Nannoconus truitti*, the youngest in the assemblage, is indicative of the Aptian-Lower Albian already. *Discolithina embergeri* and Nannoconus, as a rule, are characteristic of the Lower Cretaceous. From the Middle Albian on, it is already a substantially more diversified assemblage, richer in species, that is known to us.

I. KOVÁCS—BODROGI carried out the foraminiferological study of the residue of washing of a total of 34 rock samples recovered from boreholes TVG-22, -40, -43, 45 and T-150 in Tata's vicinity (Plate LII). Most of the samples contained a rich microfauna; beside Foraminifera, a relatively great number of skeletal elements of Echinoidea, a smaller number of Ostracoda, spicules, oögonia of sponges, one or two specimens of Radiolaria, sclerites of Octocorallia and fish teeth could be observed.

The foraminiferal remnants are for the most part in a good to fair preservation state, for a smaller part recrystallized. Most of the samples are rich both in species and specimens, the assemblages are mainly shallow-water associations of benthonic character. In the middle and upper parts of the dark grey siltstone sequence of borehole T-150 there are many tiny planktonic forms as well.

With a view to the relevant international and national literature and to the results of microfaunal studies carried out in the Tatabánya Basin, the species recovered and determined from exploratory boreholes at Tata, notably *Hedbergella washitensis* (CARSEY), *H. planispira* (TAPPAN), *H. portsdownensis* (WILL. — MITCH.), *H. delrioensis* (CARSEY), *Eoguttulina anglica* CUSHM. et OZAWA, *Gavelinella rudis* (RSS.), *Pleurostomella obtusa* BERTH., *Planulina schloenbachi* (RSS.), *Spiroplectinata annectens* (JON. et PARKER), *Dorothia gradata* (BERTH.), *Verneuilinoides schizeus* (CUSHM. et ALEX.) and their characteristic associates, testify to the presence of the Albian Stage.

Out of the 91 species of the 49 genera determined, 59 belong to the calcareous benthos, 23 to the arenaceous benthos and 9 to the planktonic association. 41.6% of the species are characteristic of the Albian, 29.7% of the Lower Cretaceous, 26.5% of the Cretaceous System and 2.2% are cosmopolitan forms.

Within the benthonic group it is the calcareous forms that predominate, including the index-fossils *Eoguttulina anglica* CUSHM. et OZAWA, *Gavelinella rudis* (RSS.), *Planulina schloenbachi* (RSS.), *Pleurostomella obtusa* BERTH., as well as the very abundant representatives of *Gavelinella intermedia* (BERTH.) and *Valvulineria gracillima* TEN DAM.

Calcareous benthonic forms of the associated assemblage are *Bifarina calcarata* (BERTH.), *Enantiomorphina* sp., *Epistomina* sp., *Frondicularia loryi* BERTH., *Globulina prisca* RSS., *G. lacrima* RSS., *Lagena oxystoma* RSS., *L. hispida* RSS., *Lingulina semiornata* RSS., *L. lamellata* TAPPAN, *Lenticulina macrodisca* (RSS.), *L. bronni* (ROEMER), *L. bononiensis* (BERTH.), *L. sulcifera* (RSS.), *Patellina subcretacea* CUSHM. et ALEX., *Patellina* sp., *Siphogenerina* sp., *Sigmomorphina neocomiensis* SZTEJN., *Spirillina minima* SCHACKO, *Turrispirillina subconica* TAPPAN, *Tristix excavata* (RSS.), *Globorotalites aptiensis* (BETTENSTAEDT).

The less significant assemblage of arenaceous benthonic forms is represented by species belonging to the genera Ammodiscus, Ammobaculites, Dorothia, Gaudryina, Haplophragmoides, Marssonella, Proteonina, Reophax, Spiroplectammina, Spiroplectinata, Tritaxia, Verneuilinoides of which *Spiroplectinata annectens* (JON. et PARKER), *Dorothia gradata* (BERTH.), *Verneuilinoides schizeus* (CUSHM. et ALEX.) are index-fossils. In terms of the number of specimens it is *Dorothia gradata* (BERTH.), *Proteonina* sp., *Tritaxia tricarinata* RSS. that are richest (frequent to mean number of specimens) within this group.

The planktonic assemblage consists of the species *Hedbergella infracretacea* (GLAESSNER), *H. cretacea* (D'ORB.), *H. portsdownensis* (WILL. — MITCH.), *H. planispira* (TAPPAN) and *Ticinella* sp. belonging to the genera Hedbergella and Ticinella.

Noteworthy from the viewpoint of stratigraphy and frequency are the Hedbergella species most of which make their first appearance in the Albian. *Hedbergella planispira* (TAPPAN) is frequent to abundant in the middle and upper parts of borehole T-150, the other species are sparse or occur in a low number of specimens throughout the lithological column. This foraminiferal fauna, characterized by a Hedbergella-Ticinella plankton, an Eoguttulina-Epistomina-Gavelinella-Planulina-Pleurostomella-Valvulineria-Patellina association of calcareous benthonic fossils and an Ammodiscus-Ammobaculites-Dorothia-Proteonina-Verneuilinoides-Tritaxia-Spiroplectinata association of arenaceous forms, can be readily distinguished from the younger, Upper Albian (Vraconian), Rotalipora-*Planomalina buxtorfi* assemblage and from the Lower Albian Orbitolina-Foraminifera associations of different facies.

A. ORAVECZ—SCHEFFER has determined, from 8 samples of borehole T-150, the following ostracod fauna:

Cytherella ovata ROEMER
Paracypris cf. *acuta* (COURNEL)
Paracypris cf. *jonesi* BONNEMANN
Triebelocythere triebeli GRÜNDEL
Pontocyprella maynoci OERTLI
Habrocythere cf. *labda* GRÜNDEL
Habrocythere cf. *fragilis* TRIEBEL
Dolocytheridea bosquetiana (JONES — HINDE)
Conchoecia? sp. (n. sp. ?)
Dicrorygma (?) *minuta* GRÜNDEL

L. MÓRA—CZABALAY has identified a few representatives of Gastropoda recovered from borehole TVG-40. Here they are:

Straparollus pellati COSMANN
Fusus sp.
Metacerithium albensis D'ORB.
Metacerithium sp.

G. SCHOLZ determined the following representatives of Cephalopoda:

from borehole TVG-45:
Leymeriella (Proleymeriella) revili JACOB (from 65.0 m)
Kossmatella jacobi WIDMANN (from 65.1 m)
Leymeriella (Proleymeriella) revili JACOB } (from 65.2 m)
Leymeriella (Proleymeriella) romani JACOB } (from 65.2 m)
Puzosia sp. (from 65.3 m)

from borehole TVG-55:
Puzosia sp. (from 16.0 m)
Hamites sp. } (from 17.4 m)
Puzosia sp. } (from 17.4 m)
Puzosia sp. (from 26.3 m)
Leymeriella (Proleymeriella) revili JACOB (from 28.6 m)

from borehole TVG-59:
Hamites sp. (from 79.0 m)
Leymeriella (Proleymeriella) sp. (from 94.0 m)

from borehole T-150:
Protanisoceras sp. (from 266.0 m)

The Ammonoidea fauna determined represents the *Leymeriella tardefurcata* Zone.

Beside the representatives of Ammonoidea, rostra of Belemnoidea, unidentifiable fragments of Echinodermata and worm traces can be found. Fragments of a few solitary corals and one Brachiopoda were also recovered.

Out of the results of paleontologists and their chronostratigraphic statements, the dating based on the examination of ammonites should be pointed out as particularly important. Notably, the specimens of the typical *Leymeriella (Proleymeriella)* subgenus testify to the presence of the Lower Albian *Leymeriella tardefurcata* Zone. This corresponds to the stratigraphic position admitted on the basis of the analysis of the geological features. The results obtained for the other fossil groups do not contradict this assignment either. Another important consideration is the fact that both in the development of the spore—pollen assemblages and in the evolution of the nannoplankton, typically Lower Cretaceous forms accompanied by some new elements can be found last, in a diagnostic measure, in the Lower Albian: an observation confirmed by the study of the dark grey siltstones under discussion.

Cretaceous paleogeography and geohistorical evolution

The remarkable fact that the present-day geological structure of Kálvária Hill and its neighbourhood has preserved hosts of ancient, original features was pointed out already in the discussion of the paleogeography and geohistory of the Jurassic Period. Features of this kind are: the distribution of Middle Liassic crinoidal limestones like a collar around Kálvária Hill; the preservation of lithified remnants of a submarine downslope creep of detrital material in the same position as it had in the Late Jurassic seas; the fact that Tata's Mesozoic fault block is surrounded by Tithono—Berriasian sediments of great thickness and of block-marginal position.

In respect of the preservation of ancient characters, similar properties are characteristic of the Transdanubian Central Mountains as a whole. This mountain range acted incessantly, together with its Paleozoic basement, as a uniform, coherent fragment of a Triassic carbonate platform which, despite the large-scale under- and overthrusts and considerable folding deformations that were taking place around it, underwent practically only deformations of disjunctive nature throughout the Mesozoic Era. No nappe was in motion above it, and it did not play itself the role of a nappe either. Paleogeographically and geohistorically, the Triassic, Jurassic and Cretaceous represented three substantially different stages of evolution. The Triassic is characterized by a large uniform shallow-water carbonate platform, the Jurassic by a peculiar marine sedimentation on fragments of that platform that had been disintegrated in the meantime, the Cretaceous by an alternation of transgressions and regressions and by marine and terrestrial sequences mutually replacing each other. To be able to review the Cretaceous history of Tata's Mesozoic basement horst block, we must be familiar with this geological environment taken in a little wider perspective.

At the beginning of the Cretaceous Period, in the Berriasian, the Late Jurassic sedimentation continued without any break or change. The Tintinnina-Cephalopoda- and Crinoidea-Brachiopoda-bearing Berriasian limestones do not show practically any difference from the Upper Tithonian limestones of similar facies. These are shallow-water, hemipelagic sediments. From the end of the Berriasian to the Late Aptian transgression, however, neither marine, nor terrestrial formation is known to have been accum ulated in the area of Tata's Mesozoic fault blocks. The area is supposed to have emerged in that period. Two negative features, however, are conspicuous: the Jurassic-Berriasian sedimentary cycle has no characteristic final regressive member and the long terrestrial period brought only a verymeagre denudation.

In the Valanginian the area of Tata's Mesozoic fault blocks (as part of the area between Dunaalmás and Zirc) emerged and remained a land up to the onset of Late Aptian transgression; the northern part of the adjacent Gerecse Mountains and the northern margin of the Tatabánya Basin formed a shallow sea bay from the Valanginian to the beginning of the Aptian. During the Aptian this paleogeographic setting interchanged: the Gerecse area emerged, while the western foreland, together with the depression that extended throughout the Central Mountains zone, was inundated by the sea. In the Cretaceous Period, movements of opposite direction of mountain-size areas (subsidence versus uplift) were characteristic features of the Transdanubian Central Mountains (just like of the connection between the Mecsek and Villány Mountains).

The Late Aptian transgression reached Tata's Mesozoic basement horst blocks in a relatively elevated position. This is the reason for the occurrence of *Globigerinelloides algerianus*, a species of somewhat lower stratigraphic position, in the crinoidal limestones deposited in deeper, and thus earlier inundated, subareas between the emergent fault blocks. On Kálvária Hill already the fossil assemblage of the somewhat younger zonal index-species *Diadochoceras nodosocostatus* can be sampled. The mineralogical, petrographical and paleontological examination of the Tata Limestone even enabled us to give a detailed interpretation of the paleogeographic conditions. In Kálvária Hill's Geological Conservation Area we have recovered a part of the one-time rocky coast and developed it to a permanent exposure. The rugged limestone shoreline shaped by littoral wave action; the terrigenous rock and vegetal detritus drifted together in the depressions and the mostly broken skeletal elements of the marine bios, can be readily observed here. The presence of a stromatolitic incrustation is also an evidence of the one-time tidal environment here. In the lithological composition it is the sand-size Triassic and Jurassic limestone detrital material of the littoral areas and the magmatic and metamorphic mineral detritus of more distant terrestrial areas that indicate the paleogeological conditions. The large quantity of chromite-leucoxene grains indicative of basic to ultrabasic igneous rocks is particularly noteworthy.

The diversified geological structure of the Aptian and Albian Stages and the rapidly changing transgressions and regressions are synorogenic manifestations of the Austrian orogenic phase. The first significant orogeny in the evolution of the post-Hercynian Mesogea took place in the Cretaceous Period which, undoubtedly, corresponds to the first marked relative approach of the continental platforms of Eurasia and Africa. Of the orogenic phases of the Cretaceous, each of the Austro-Alpine (Hauterivian-Barremian), Austrian (Aptian-Albian), Mediterranean or pre-Gosau (Turonian), sub-Hercynian (Coniacian-Santonian) and Laramian phases was involved in the development of the geological conditions under consideration, but in the paleogeographic and structural evolution of the Tata region the primary role was played by the Austrian synorogenic movements.

The Middle Cretaceous synorogenic movements were manifested by rapidly alternating transgressions and regressions. The formation of the Upper Aptian grey crinoidal limestone was one (the first) stage in this development, a stage still characterized by a remarkable uniformity of the structural and geological features. The ephemeral emergence at the end of the Aptian was folowed by an Early Albian transgression which, came from northern direction and extended up to the line of Oroszlány—Vértessomlyó and which, as a new stage of evolution overwhelmed in the Middle Albian a considerable part of what is now the Transdanubian Central Mountains and led to the formation of the well-known Middle Cretaceous sequence.

The Lower Albian dark grey siltstones need not necessarily have marked the end of the Cretaceous sedimentation in the Tata region. The fact is, however, that no tangible evidence of this kind has been recorded thus far. Even if the Albian to Early Cenomanian sedimentary cycle did persist in this region in full, its seemingly soft, unconsolidated, sedimentary product could well have fallen prey, partly or, for that matter, completely, to subsequent erosion. From the Late Cretaceous — when the Central Mountains platform fragment submerged, again with its southern part — no tangible record is available to us.

APPENDIX

KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA

When carrying out geological studies on Kálvária Hill in 1952 and 1953, I was surprised by the diversified geological structure of the locality in general and of the Redstone and Bluestone quarries in particular. The peculiar formations of the Red Jurassic, the pretty examples of disjunctive tectonics and the grey crinoidal limestone with a rich fossil assemblage at its base, stimulated me to further digging and research work. Another couple of years of research convinced me of the necessity to save exposures and diggings of outstanding scientific value, very favourable to visit and study, from being buried by the unstoppably sprawling city. The *National Council of Nature Conservancy* of which Professor E. VADÁSZ was chairman, became aware of the urging need for protective measures and issued the following decree:

"Decree No. 1225/1958 of the National Council of Nature Conservancy.

Authorized by legislative order 4.235/1949 M.T., 2.§, the National Council of Nature Conservancy declares the property Kálvária Hill, situated in the central municipal area of the town of Tata, to be a Geological Conservation area protected by law, as of 1935: IV. tc. 212.§, in order to save its geohistorical values having no like nor equal in this country as well as to conserve the environment of prime-order architectural monuments there.

The site put under conservancy includes the municipal properties registered under topographical lot numbers 1230, 1231, 1232 and 1233/1 covering a total area of 6.3 ha.

At the same time, the National Council of Nature Conservancy designates a 19.2 ha area of the town of Tata, surrounded by the SE side of Stalin Square, Csurgókút, Törökvár, by the NW and W sides of Csurgó-föld Cemetery and the NW side of Jewish Cemetery and by Kálvária Hill and Fazekas Street, as outer conservation zone and declares it to be conserved.

Budapest, 16 December 1958.

DR. ELEMÉR VADÁSZ

academician, twice winner of Kossuth Prize, chairman of the National Council of Nature Conservancy."

On the basis of declaration No 12/1971 of the *Executive Committee of Tata's Municipal Council*, the Office of Land Registry has enacted, by order No 2255/1971, the cadastral separation of the Geological Conservation Area and, reserving the Hungarian State's ownership, it has registered tenancy rights by the *Hungarian Geological Institute*. (Textfig. 62: in pocket).

The city government of Tata has kept on supporting the geological study of the municipal area and the development of geological conservation areas, i.a. by having an asphalt road constructed to enable an access by motor car. The *National Nature Conservancy Office* had a fence constructed in order to protect digging and trenching works in full development. Thus, the prerequisites for developing the Geological Conservation Area into a scientific research, technical training and public education centre were granted. Because of the shortage of both labour force and funds these objectives could be approached step by step only. By 1969, however, the work had so greatly progressed that both Hungarian and foreign visitors could be regularly received in the Area. Geology students of the Budapest and Miskolc universities pay visits every year; the *Hungarian Geological Society* conducts excursions to the Area, and this is an important station of excursions organized for geologists coming from abroad to Hungary. From among the most prominent visitors to Kálvária Hill, let us recall the name of academician A. V. SIDORENKO, minister of geology of the U.S.S.R. and Professor DR. S. VAN DER HEIDE, Secretary General of *International Union* of *Geological Sciences*.

Out of the meetings held at the Geological Conservation Area, I should like to quote the consultation on the results and future tasks of geological conservancy at a special meeting held here by the Commission on Geology of the Hungarian Academy of Sciences on 22 May, 1967. The *Commission on Archeology and Excavations of the Hungarian Academy of Sciences* discussed, here on the spot, on

15 October 1971, a report on the evidence of prehistorical flint mining as recovered on Kálvária Hill. (Reference: J. Fülöp: Funde des prähistorischen Silexgrubenbaues am Kálvária-Hügel von Tata. Acta Arch. Acad. Sci. Hung. 25. 1973).

In the research-bungalow built in 1972, a collection of geological literature on the formations exposed on Kálvária Hill has been deposited. In front of the bungalow a millstone table has been set up. It used to stand at Balatonarács in the cottage garden of Lajos Lóczy — university professor and then director of the Geological Institute and discoverer of Kálvária Hill's Cretaceous beds and author of the famous geological monograph on the Balaton Highland.

A large quarry yard leased by the *city government* has allowed us to enlarge the Geological Conservation Area. At present, thermal karst galleries are being explored there by enthusiastic amateur speleologists. We have envisaged to exhibit there an outdoor lapidary of Hungary's geological formations and mineral resources. Neither a support from governmental authorities, nor the devotion of scientists are enough for an efficient exploitation of the natural resources. None of us can achieve this goal, unless being encouraged by people's awaken interest. Prerequisites for such a progress are: to encourage publicity on earth science matters; to understand the unity of origin and harmony of human existence and natural environment and to make the best possible use of Nature's endowments. Beside a just and righteous system of social conditions, those requirements are basical for the welfare of every nation.

PLATES

PLATE I

KÁLVÁRIA HILL

Dachstein Limestone

1. Southwestern quarry face below the Calvary. Rhaetian Dachstein Limestone with Lower Liassic limestone overlying it (apparent conformity).
2. Intertidal (B) and subtidal (C) beds alternating in the Dachstein Limestone sequence.
3. Dachstein Limestone with Megalodus remnants.

I.

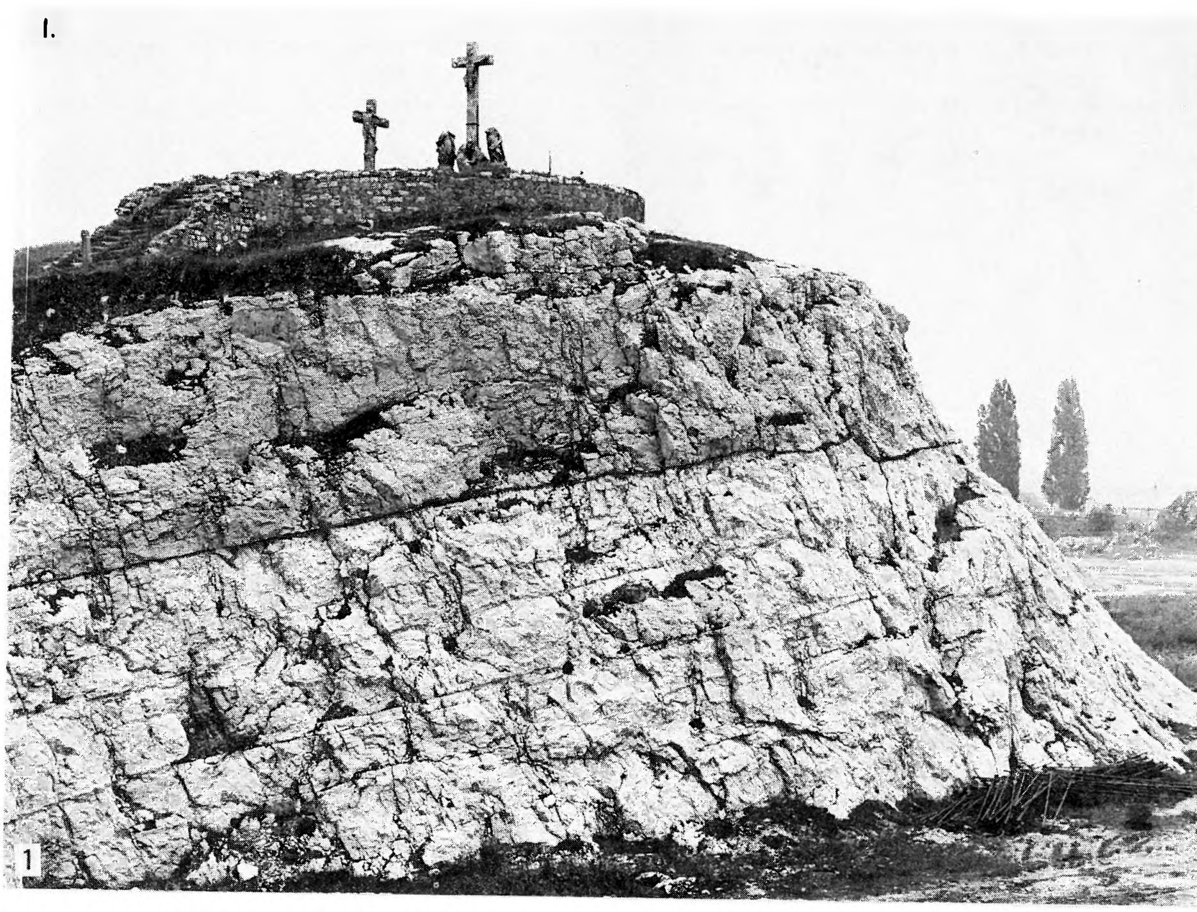


PLATE II

KÁLVÁRIA HILL

Megalodus remnants

1a, b, c. *Rhaetomegalodon incisus cornutus* (FRECH.) 1/1
Internal mould of a juvenile specimen.
2. *Neomegalodon mojsvári* (HOERNES) 1/2
3a, b. *Rhaetomegalodon incisus cornutus* (FRECH.) 2/3
4. Postsedimentary filling of Megalodus shell. 2/3
K = calcite crust of inward growth. M = pink calcilutite.

1—3: Photo by PELLÉRDY

II.

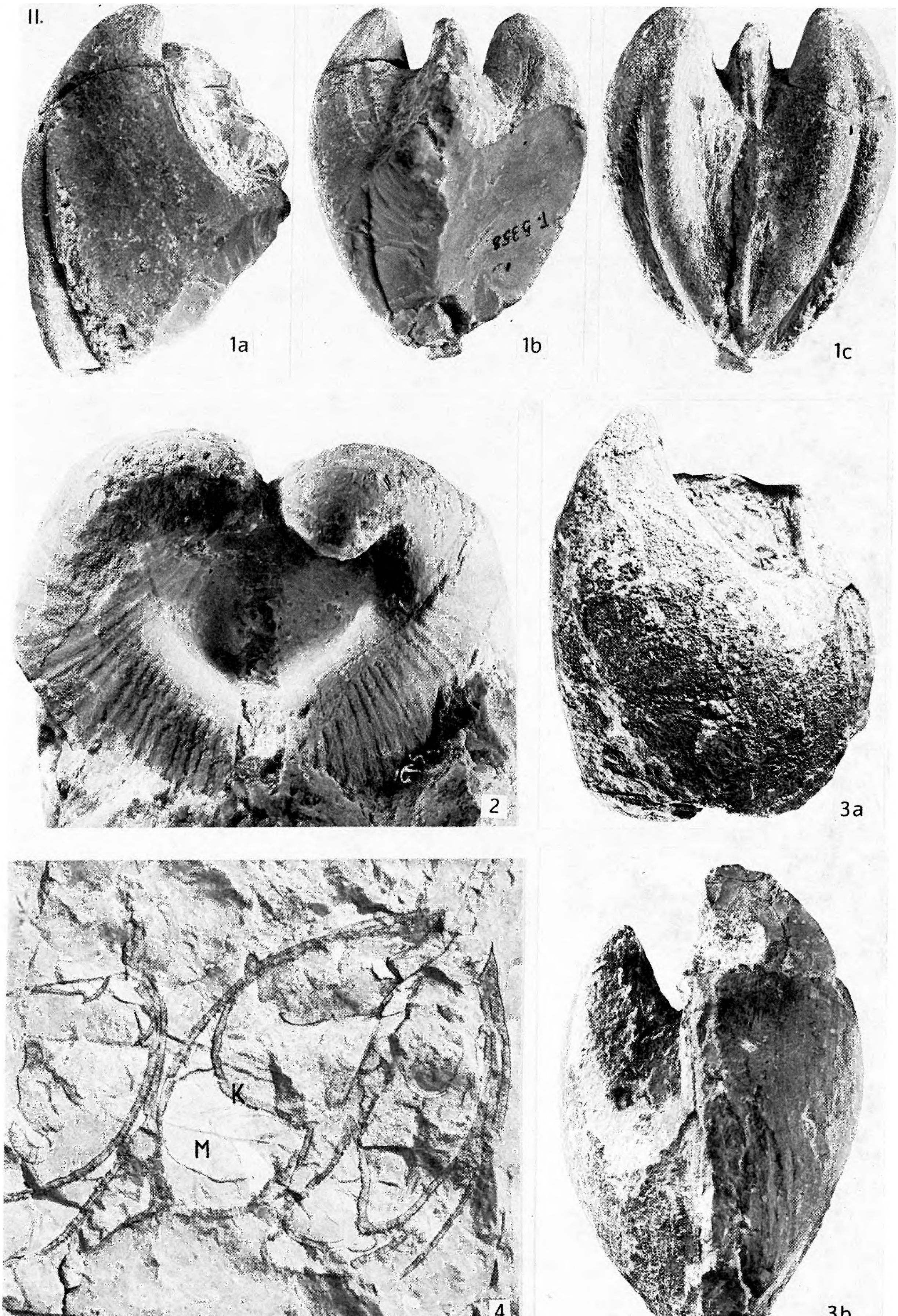


PLATE III

KÁLVÁRIA HILL

Dachstein Limestone, intertidal sediments

1. Algal mat facies. 1/1
2. Intraformational breccia. 1/1
3. Shrinkage pores. 1/1
4. Sheet cracks along bedding planes, coated by calcite and filled with pink calcilutite. 1/1

Photo by Pellérdy

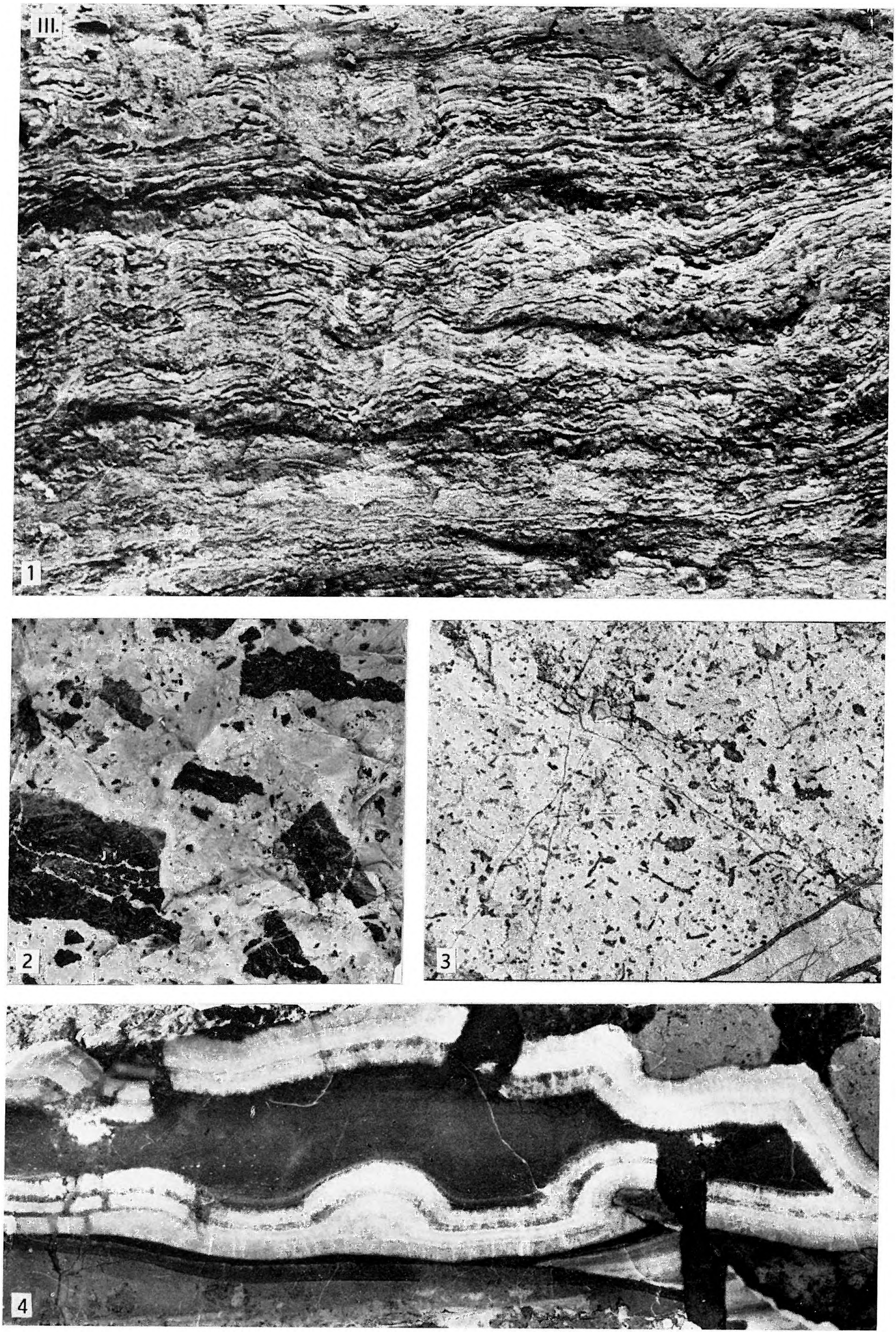

III.
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PLATE IV

KÁLVÁRIA HILL

Dachstein Limestone, neptunian dikes

1. Fissure-filling calcipelite and crinoidal limestone, red, banded perpendicularly to the fissure wall.
2—3. Pink calcipelitic fissure-fill with Dachstein Limestone debris.

IV.

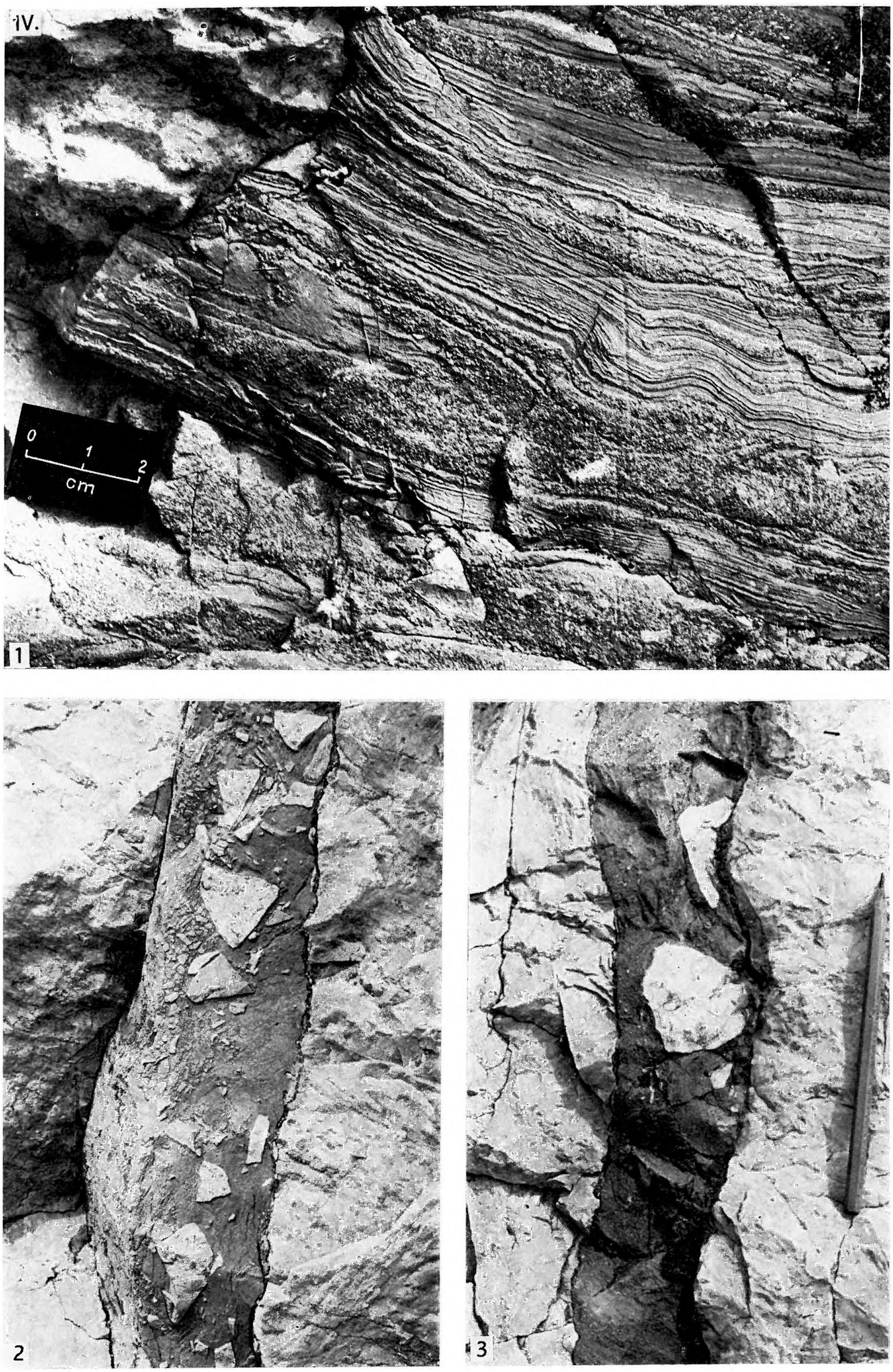

PLATE V

KÁLVÁRIA HILL

Dachstein Limestone. Borehole T-5. Intertidal sediments

1. D = cavities due to dissolution, filled with calcite and calcilutite, R = intraformational breccia, P = shrinkage pores. 1/1
   Depth: 133 m.
2. Algal mat facies with shrinkage pores and cracks and clastic grains. 1/1
   Depth: 102 m.
3. Shrinkage cracks with postsedimentary calcilutite fill. 1/1
   Depth: 107.5 m.
4. A = altered soil with limestone debris. P = calcilutite with shrinkage pores. 1/1
   Depth: 174 m.

Photo by Pellérdy

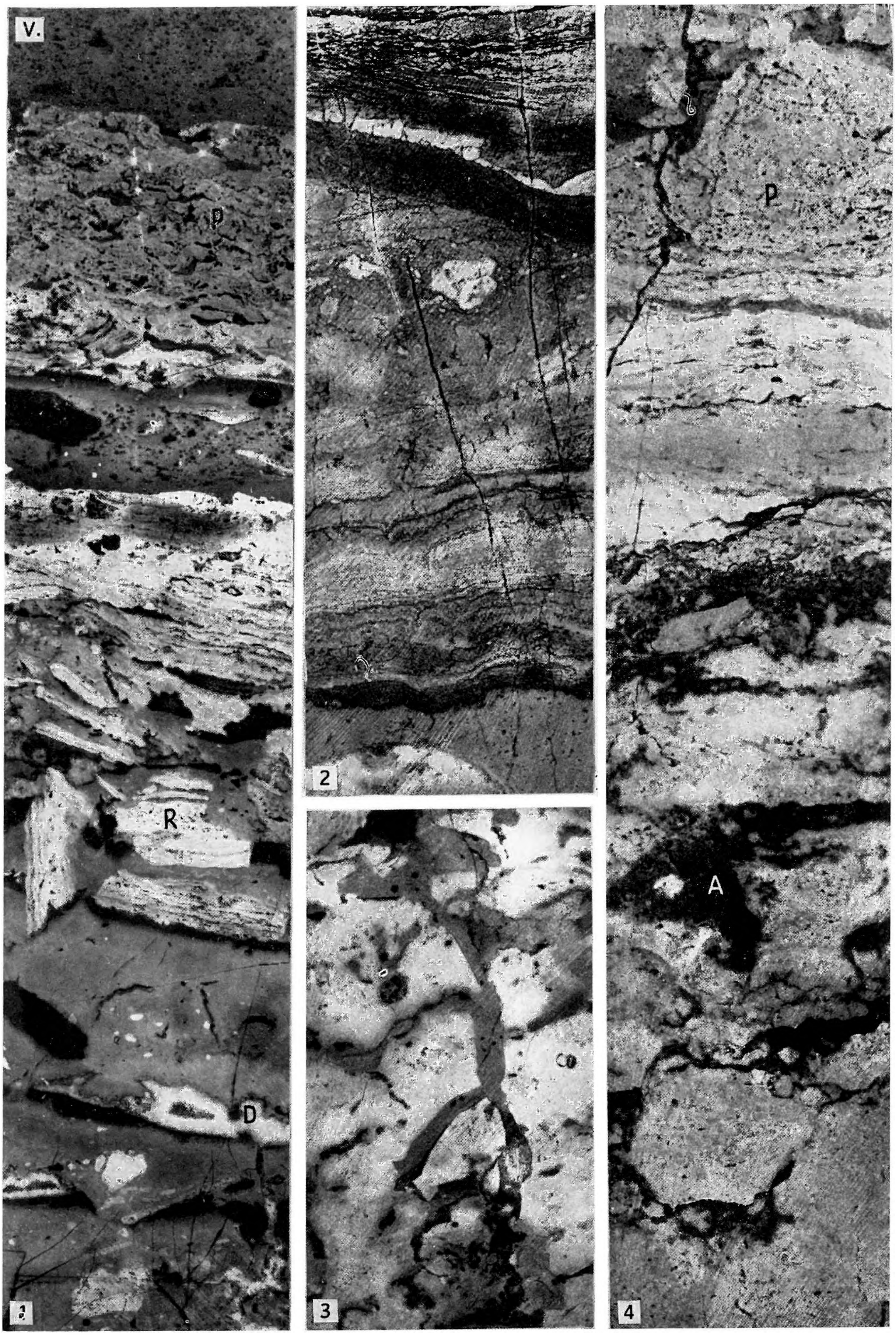
V.
P
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PLATE VI

KÁLVÁRIA HILL

Dachstein Limestone

Microscopic image of texture types from borehole T-5

1—3. Calcarenite with *Triasina hantkeni* (biomicrite showing increasing grade of recrystallization).
1. Depth: 12.0 m. 27×
2. Depth: 7.0 m. 27×
3. Depth: 2.7 m. 68×

4. Glomospirella-bearing calcarenite (intrabiosparite). 27×
Depth: 2.7 m.

5. Triasina-Involutina-bearing calcarenite with crystalline cement. 27×
Depth: 2.7 m.

6. Involutina-bearing biomicrite. Western face of the western quarry. 27×
Depth: 1.15 m.

7—9. Calcarenite with pseudo-oöids, pellets and oöids.
7. Depth: 15.5 m. 27×
8. Depth: 15.5 m. 27×
9. Depth: 15.5 m. 35×

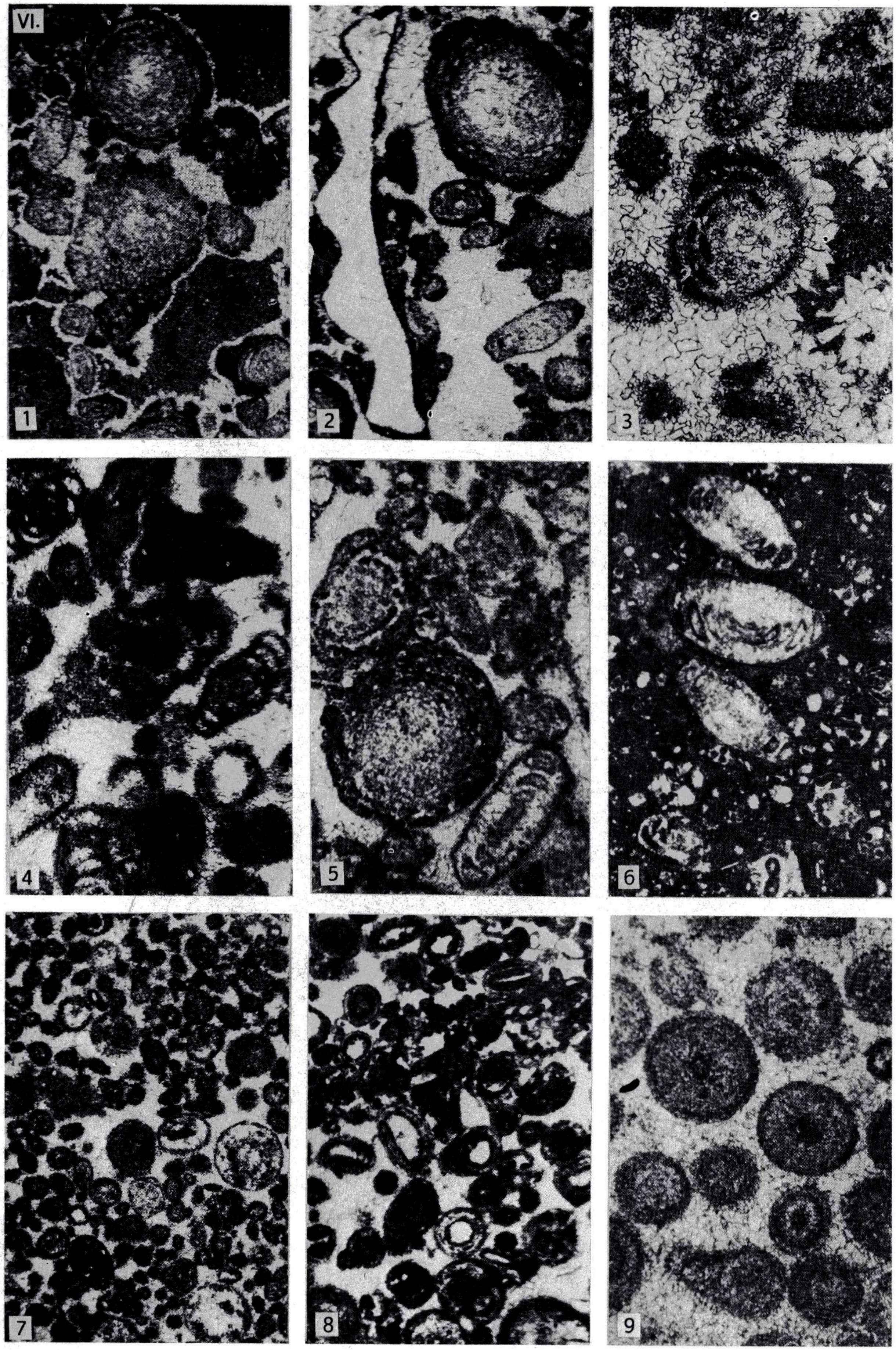
VI.
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PLATE VII

KÁLVÁRIA HILL

Dachstein Limestone

Types of microfacies from borehole T-5

1. Micritic microfacies with Turrispirillina. 27×
Depth: 134.5 m.
2. Micritic microfacies with Frondicularia. 35×
Depth: 144.9 m.
3. Intertidal sediments with gastropods. 30×
Depth: 27.5 m.
4. Shrinkage pores ("Moon crater" texture). 30×
Depth: 7.0 m.
5. Shrinkage pores. 30×
Depth: 15.60 m.
6. Ostracod microfacies. 70×
Depth: 125.15 m.
7. Shrinkage pores filled with sparite. 70×
Depth: 142.2 m.

— 9. Microscopic image of algal mat facies. 70×
Depth: 184.15 and 38.9 m.

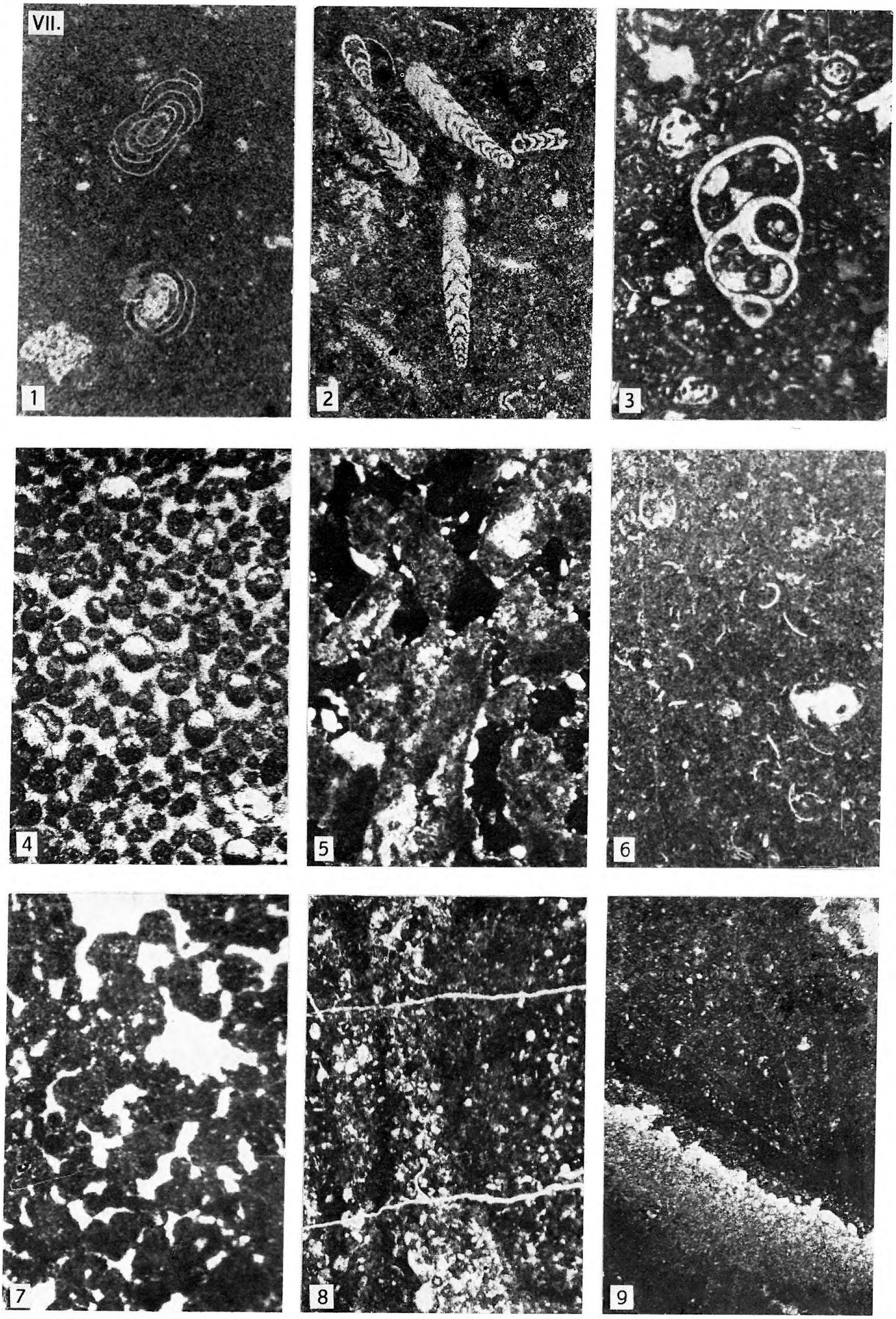
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PLATE VIII

KÁLVÁRIA HILL

Dachstein Limestone

Foraminiferal fauna from borehole T-5

1—2. *Nodosaria* sp. 70×
1. Depth: 15.0 m.
2. Depth: 21.5 m.

3. *Dentalina* sp. 70×
Depth: 118.9 m.

4—5. *Frondicularia wooduardi* HOWCH. 170×
4. Depth: 156.5 m.
5. Depth: 20.0 m.

6. *Pseudotextularia* sp. 70×
Depth: 15.0 m.

7. *Spiroplectammina* sp. 70×
Depth: 21.5 m.

8. *Planulina* sp. 27×
Depth: 120.0 m.

9. *Turrispirillina minima* (PANTIČ) 27×
Depth: 134.5 m.

10. *Glomospirella* sp. 70×
Depth: 14.5 m.

11. *Glomospira* sp. 70×
Depth: 14.5 m.

12. *Involutina tumida* (KRISTAN) 70×
Depth: 1.15 m.

13. *Triasina hantkeni* MAJZON. 27×
Depth: 2.7 m.

14. *Triasina hantkeni* MAJZON. 70×
Depth: 2.7 m.

15. *Triasina hantkeni* MAJZON. 70×
Depth: 12.0 m.

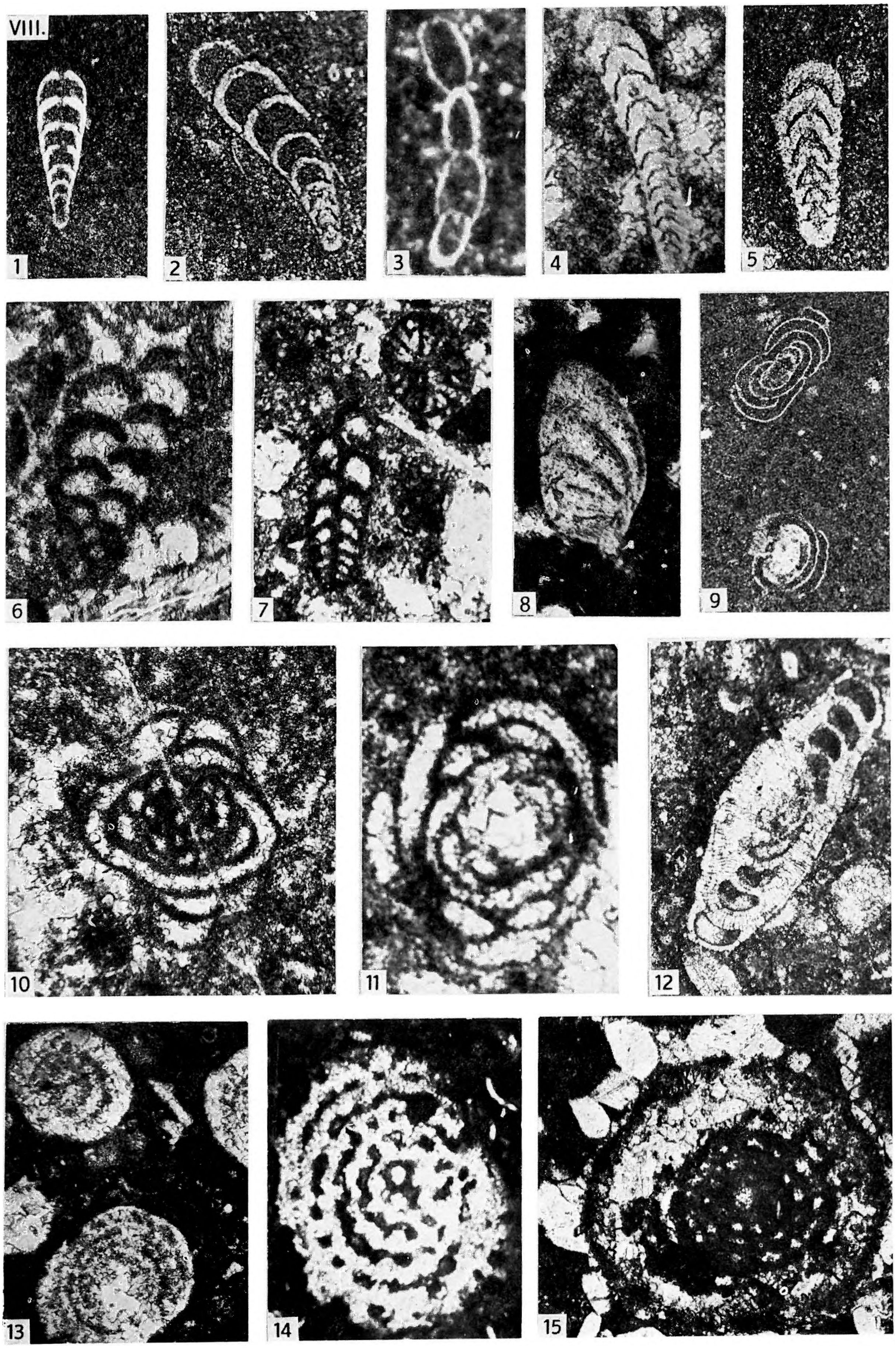
VIII.
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PLATE IX

KÁLVÁRIA HILL

Dachstein Limestone

Microscopic fossils and traces of bioactivity from borehole T-5

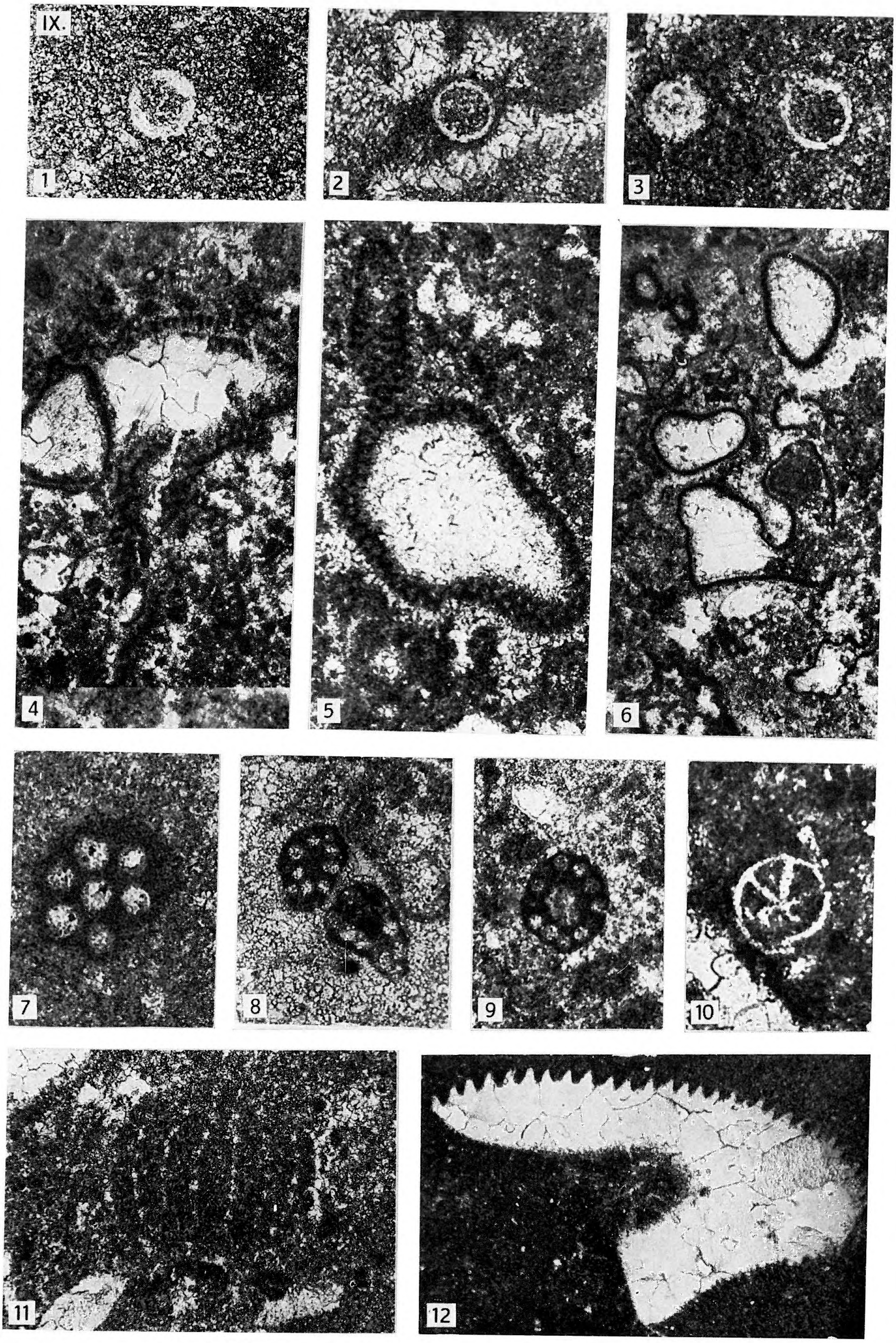
1—3. *Stomiosphaera sphaerica* KAUFMANN. 170×
Depth: 10.10 m.

4—6. *Thautomoporella* sp. 70×
Depth: 69.00 m.

7—10. Skeletal elements of Holothurioidea. 70×
Depth: 184.10 m.

11. Coprolites of Crustacea. 70×
Depth: 184.30 m.

12. Crinoid ossicles. 27×
Depth: 56.0 m.


IX.
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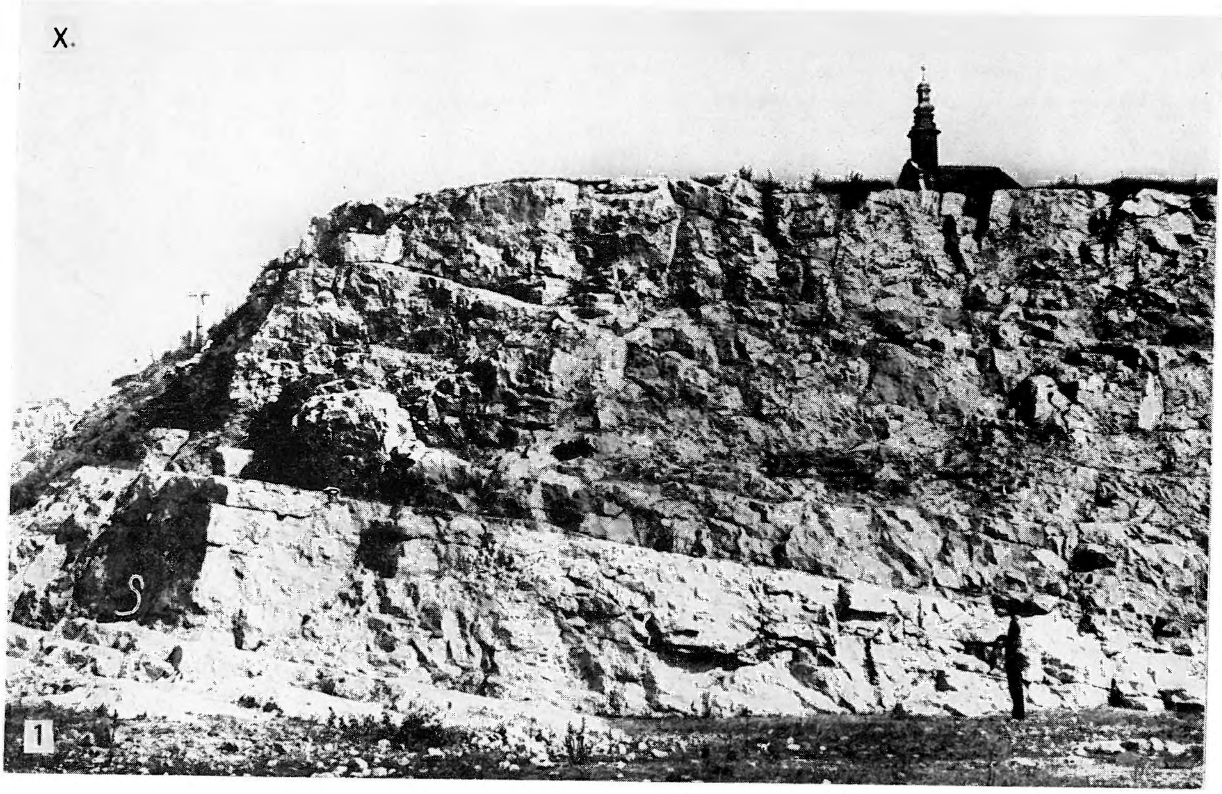
12

PLATE X

KÁLVÁRIA HILL

Triassic-Jurassic boundary

1. Lower, poorly stratified, sequence of the Liassic limestone.
2. Lower Liassic red crinoidal limestone overlying Dachstein Limestone with megalodontids. Megalodontids filled with Lower Liassic sediment.



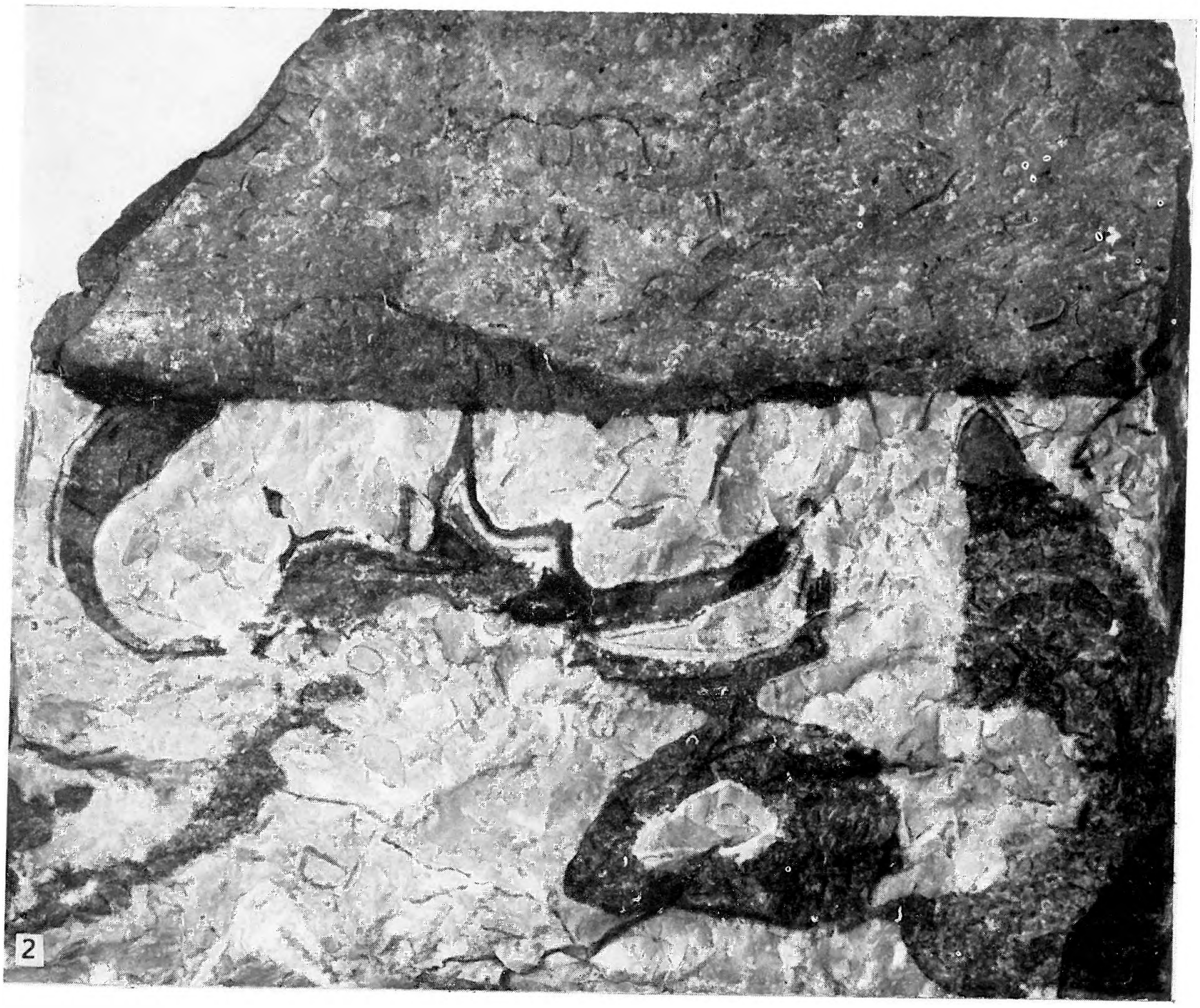


PLATE XI

KÁLVÁRIA HILL

Liassic Formations

1. Lower Liassic (Upper Hettangian-Sinemurian) pink limestone.
   A = lower part of Member I (poorly stratified, light pink, skin-coloured limestone)
   B = Member II (well-stratified, pink, skin-coloured limestone)
   C = Member III (pink limestone with small nodules of manganese)
2. Boundary of the Lower and Middle Liassic.
   C = pink limestone with small nodules of manganese (Sinemurian)
   D = red crinoidal limestone (Pliensbachian)
3. Middle Liassic (Pliensbachian) red crinoidal limestone.
4. Upper Liassic (Toarcian) red nodular marl underlain by Middle Liassic limestone (F) and overlain by Lower Dogger red argillaceous limestone (FE).

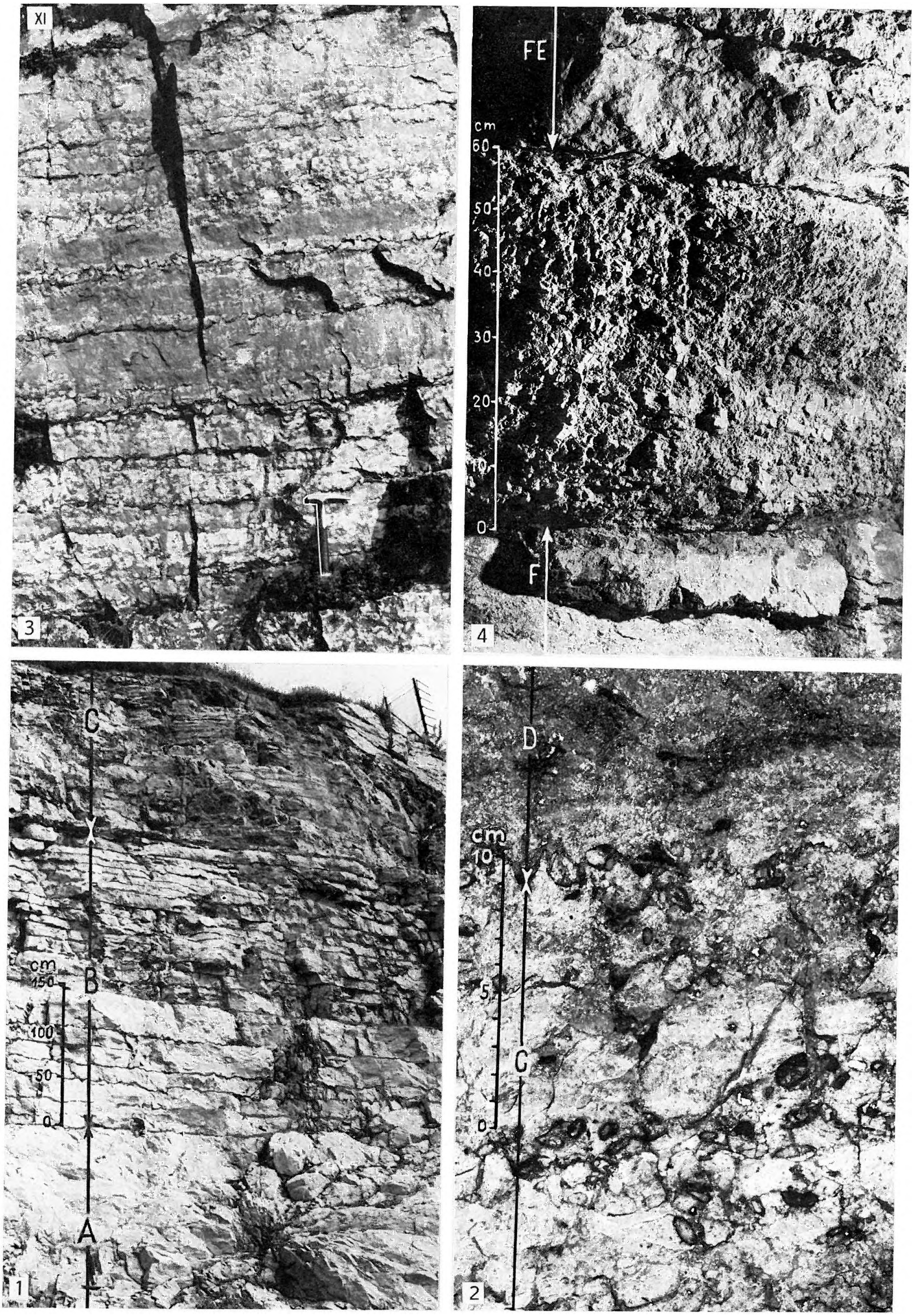

XI
3
FE
cm
60
50
40
30
20
10
0
F
4
C
cm
150
B
100
50
0
A
1
D
cm
10
5
C
0
2

PLATE XII

Lower Liassic pink intraclastic limestone

1. Onkoidal limestone at the base of the Lower Liassic pink limestone. Kálvária Hill, standard profile of the Liassic.
2. Intraclastic plastite. Lower Liassic limestone. 1/1
   Borehole TVG-46, 25.3 to 25.5 m.
3. Intra-breccia from the top of the Lower Liassic pink limestone. Kálvária Hill, standard profile of the Liassic.
4. Intraclastic calcilutite. Lower Liassic limestone. 1/1

2, 4: Photo by PELLÉRDY

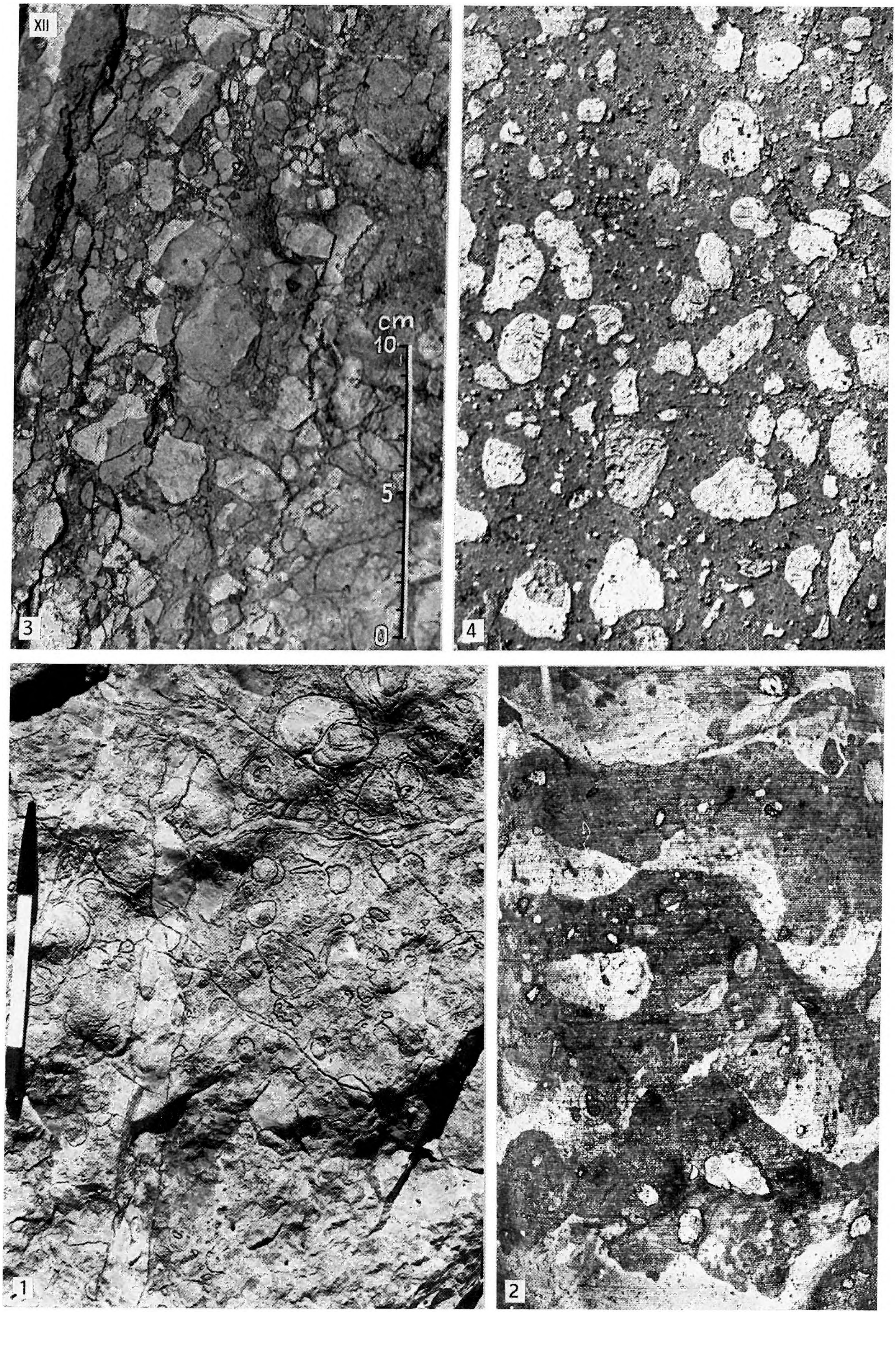

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PLATE XIII

KÁLVÁRIA HILL

Standard profile of the Liassic

Internal segregation in Member 1 of the Lower Liassic (Upper Hettangian—Sinemurian) pink limestone formation. 1/1

A = microbioclastic Lower Liassic limestone matrix
B = radiaxial calcite coating
C = calcilutite cavity-fill

Photo by Pellérdy


XIII
A
B
C
B
A

PLATE XIV

Scheck and neptunian dikes in the Lower Liassic pink limestone formation

1. Red argillaceous limestone fissure-fill in the Lower Liassic limestone. 1/1
   Borehole TVG-46, 31.4—31.6 m.
2. Red argillaceous limestone fissure-fill in the lower part of the Lower Liassic pink limestone formation.
   Kálvária Hill.
3. Texture of scheck type in the Lower Liassic pink limestone. 1/1
   Borehole TVG-51/A, 28.3 m.
4. Internal, transversal fissure-fills.
   Kálvária Hill, standard profile of the Liassic.

1, 3: Photo by PELLÉRDY

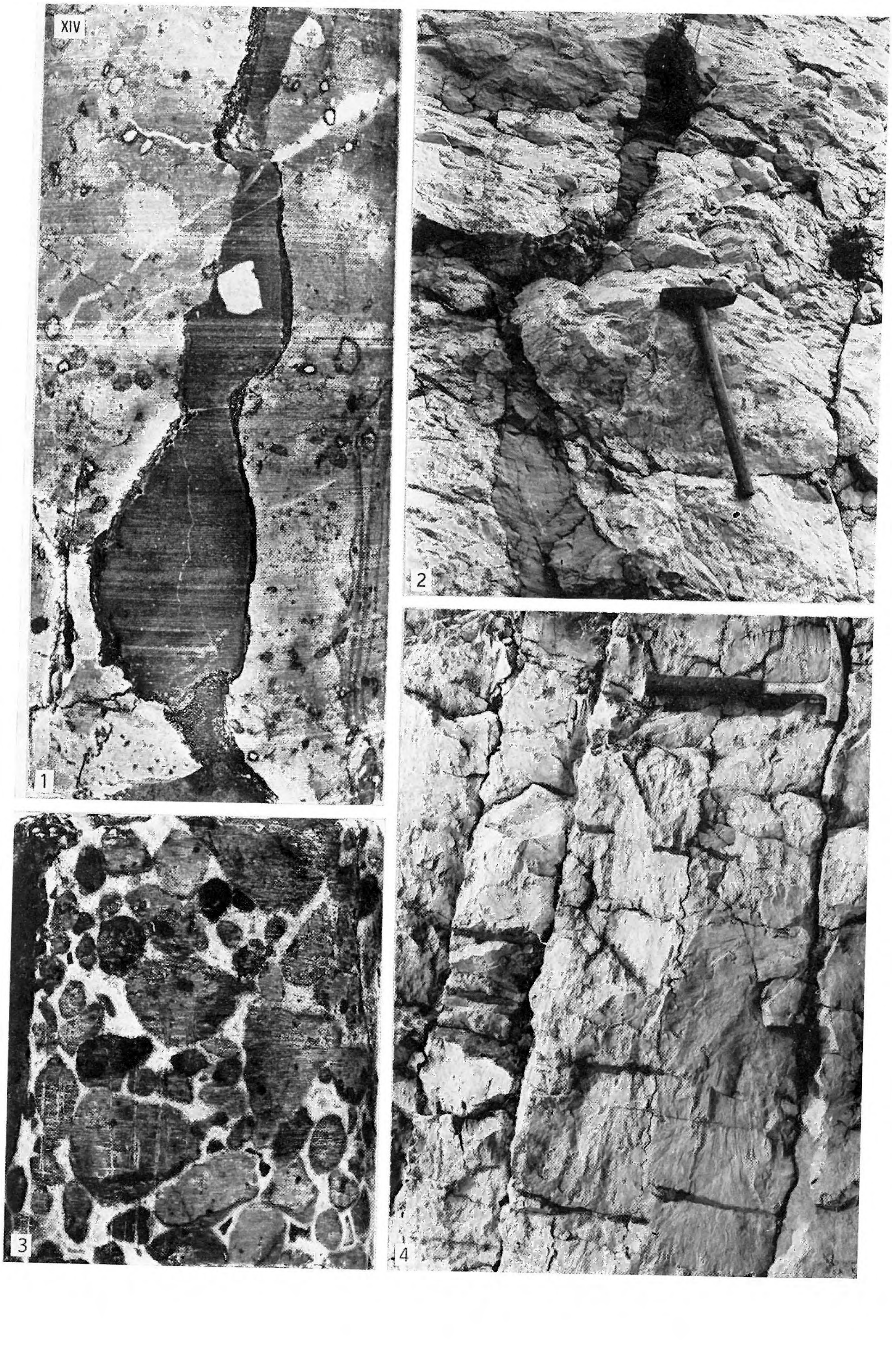
XIV
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PLATE XV

KÁLVÁRIA HILL

Lower Liassic (Upper Hettangian-Sinemurian) fauna

1. Biomicrite with Ostracoda. 50×
2. Biomicrite with gastropods and sparry mottles. 50×
3. Biomicrite with crinoids and echinoids. 50×
4. *Paracaloceras coregonensis* (Sowerby in de la Beche)

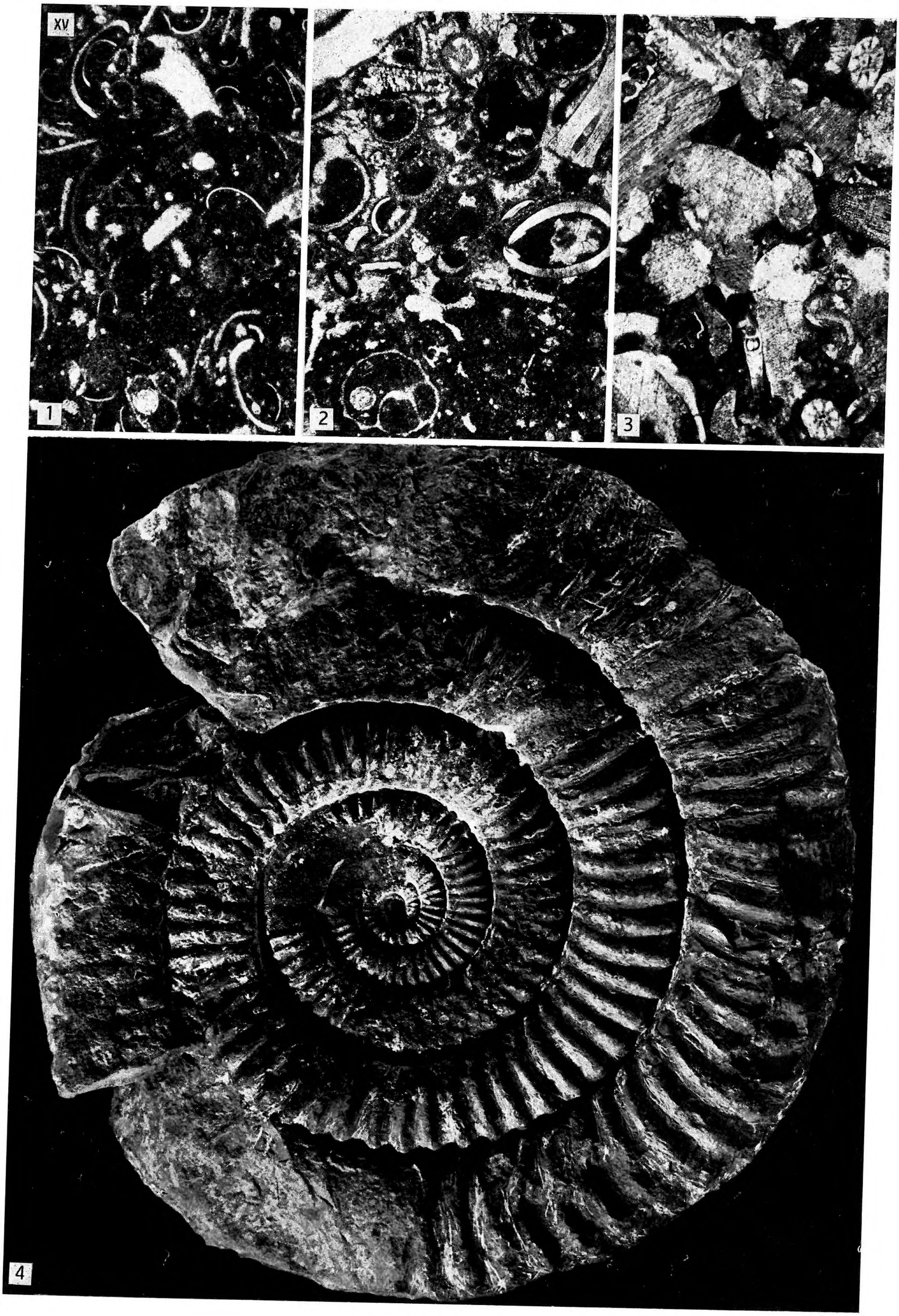
XV
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PLATE XVI

KÁLVÁRIA HILL

Lower Sinemurian cephalopods

1. *Tmaegoceras crassiceps* Pompeckj. 1/1
   (*T. lacordieri* Mich. as determined by N. Koch)
   a) side view, b) back view.
2. *Coroniceras (Metophioceras) gracile* Spath. 1/1

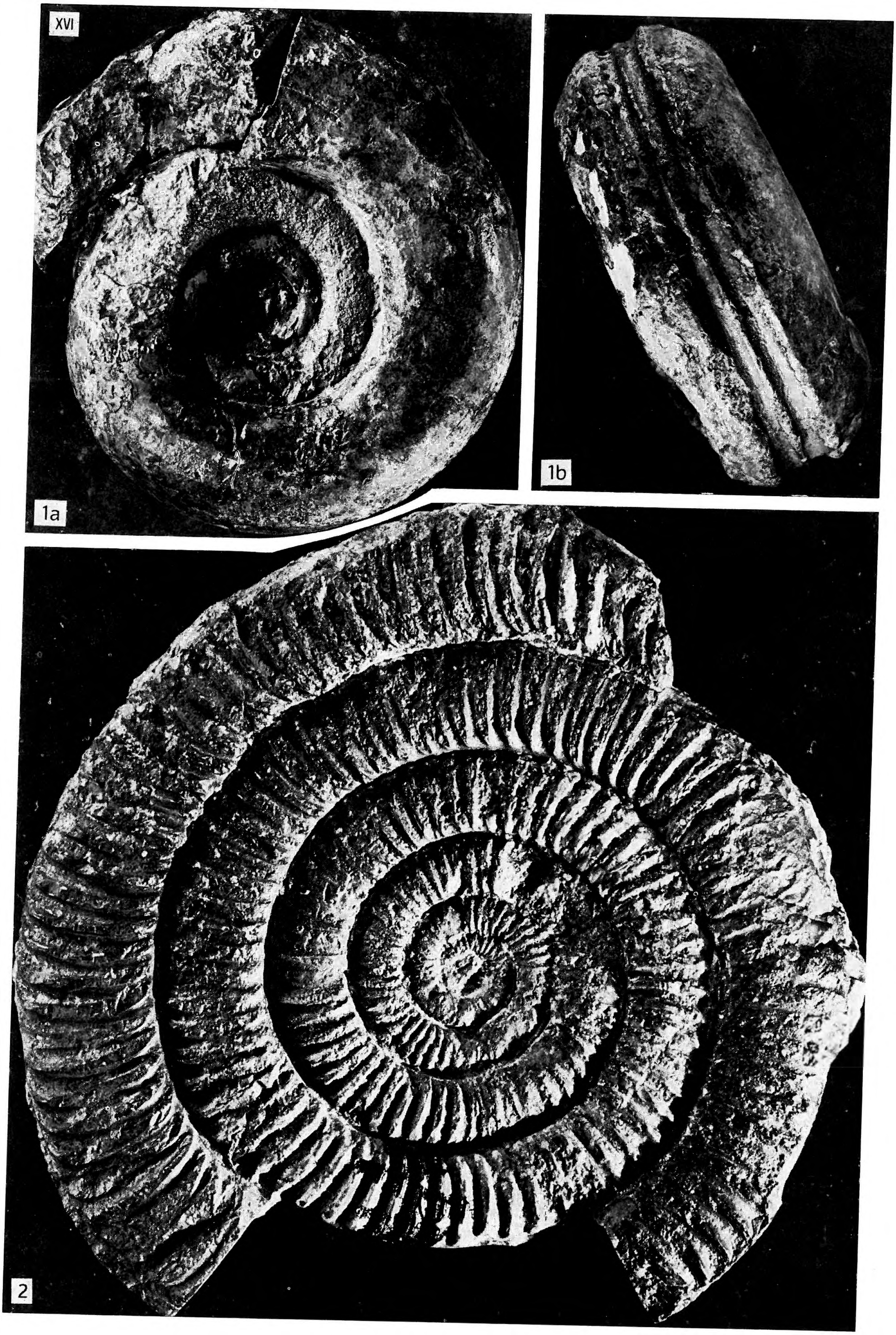
XVI
1a
1b
2

PLATE XVII

KÁLVÁRIA HILL

Lower Liassic pink limestone

Photomicrographs

1. *Involutina liassica* (JONES), *Ostracoda* sp. 50×
2. *Trocholina* sp. 80×
3. *Ophthalmidium* sp. 50×
4. Globochaete-dotted texture. 50×
5. Texture with sponge spicules. 50×
6. Thin Bivalvia shells (Bositra?). 50×
7. Intraclastic texture (with lumps). 50×
8. Pseudo-oölite. 50×
9. Crystalline micrite. 50×

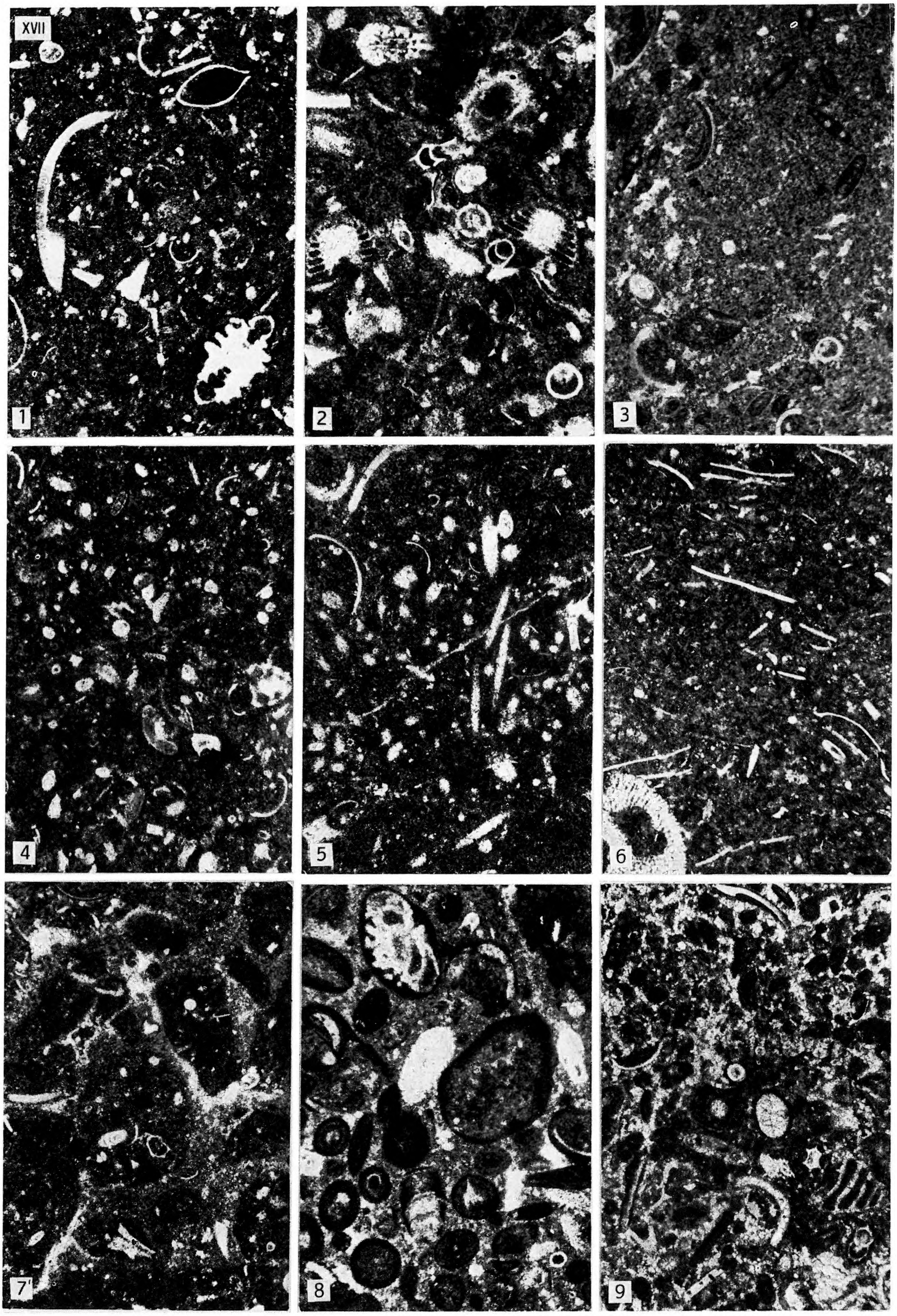
XVII
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PLATE XVIII

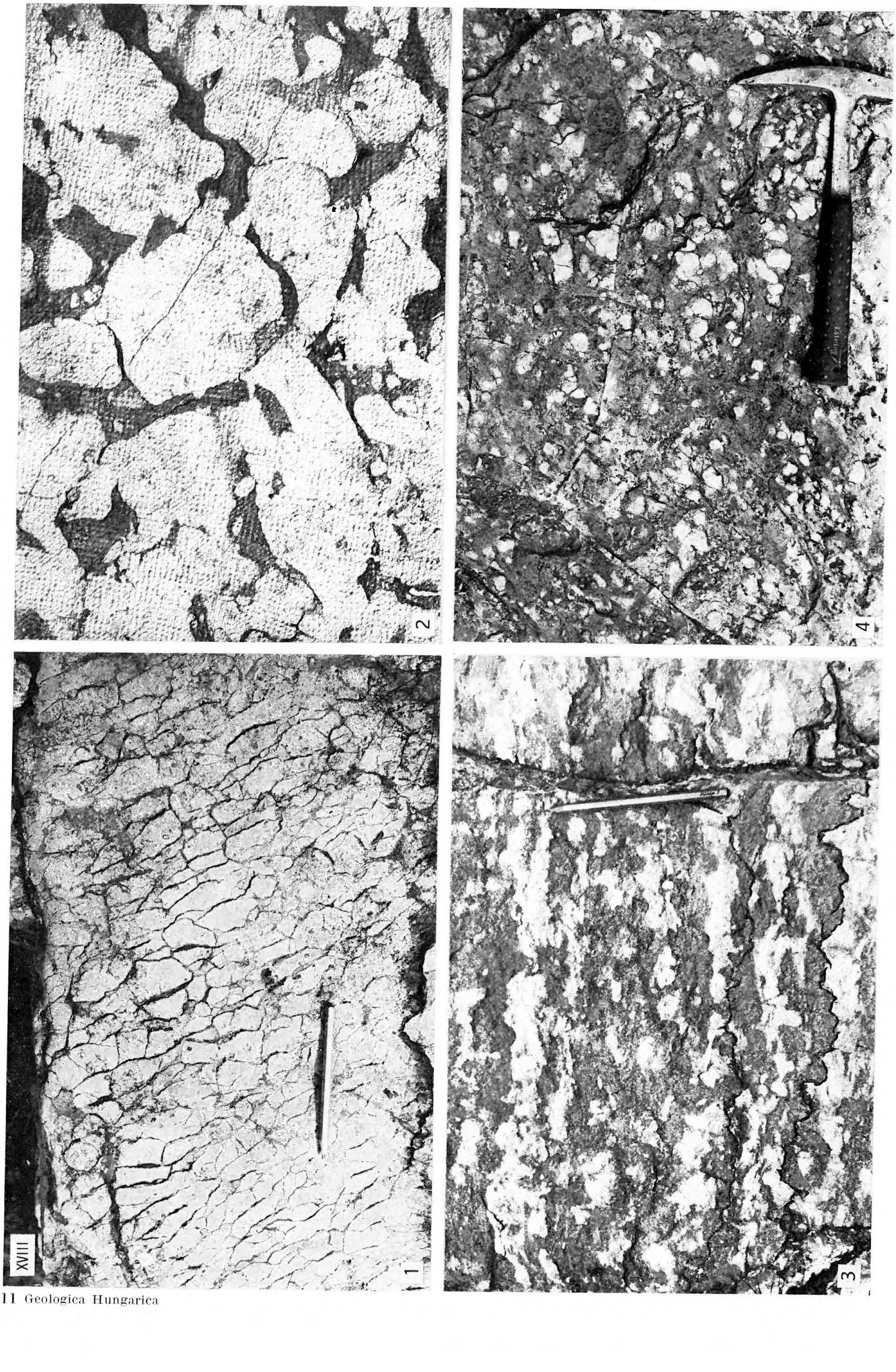
KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA

Middle Liassic red crinoidal limestone

Texture types

1. First stage of disintegration of lime mud sheet. Top view.
2. The lime lumps are still contiguous for a considerable part. Second stage. Top view. 1/1
3. Series of lime lumps as viewed from aside.
4. Independent lime lumps. Third stage. Top view.

2: Photo by Pellérdy



XVIII

PLATE XIX

KÁLVÁRIA HILL

Middle Liassic red crinoidal limestone

1. Crinoidite with poorly rounded skeletal elements of medium sorting. 30×
2. Crinoidite with skeletal elements of medium roundness and sorting. 30×
3. Biosparite, coarse-grained, crinoidal, with rounded, sorted skeletal elements showing postsedimentary overgrowths. 30×
4. Crinoidal biomicrite with corroded crinoid ossicles. 30×
5. Crinoidal biomicrite with rounded and well-sorted skeletal elements showing postsedimentary overgrowths. Cross-sections of Ostracoda. 30×
6. Biomicrite, fine-grained, rounded, sorted. 30×
7. Intrabiomicrite with fine-grained bioclasts and rounded intraclasts. 30×
8. Biomicrite with disintegration of the micritic matrix into lime lumps. 30×
9. Biopelmicrite showing patches due to recrystallization. 30×

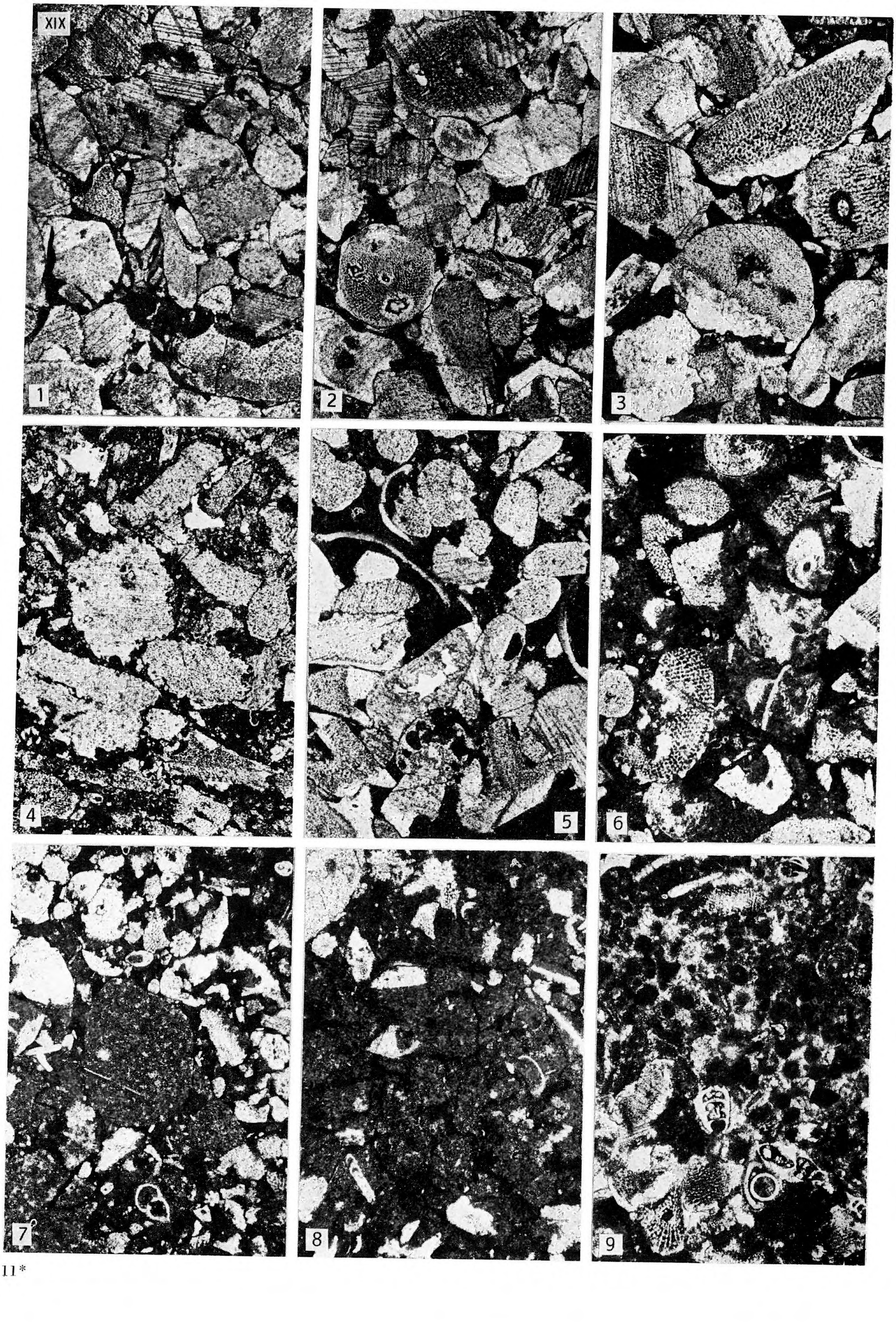

XIX
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PLATE XX

KÁLVÁRIA HILL

Middle Liassic red crinoidal limestone

1. Biomicrite, coarse-grained, rounded, sorted, spar-rimmed with skeletal elements of Crinoidea, Gastropoda and ammonite embryons. 30 ×
2. Crinoidal biomicrite with an ammonite shell whose chamber walls are overgrown by calcite crystals. 30 ×
3. Crinoidal, foraminiferal biomicrite with fragments of mollusc shells. 30 ×
4. Crinoidal biomicrite. The fine-grained calcite grains of supposedly biodetrital origin are typical rockforming components. 30 ×
5. Biopelmicrosparite-mosaicsparite with Ostracoda and crinoids. 30 ×
6. Biomicrite with radiaxial calcite coating on mollusc shells. The fine-grained calcite grains of supposedly biodetrital origin are typical rockforming components. 30 ×
7. Biopelmicrite-microsparite. 30 ×
8. Biopelmicrite-microsparite with ammonite embryons. The rock contains skeletal elements and shell fragments of Globochaete, sponge spicules, Crinoidea and Gastropoda. 30 ×
9. Echinoderm-Bositra biomicrite with a calcite coating, sparry around echinoderm skeletons and radiaxial around Bositra shells. 30 ×

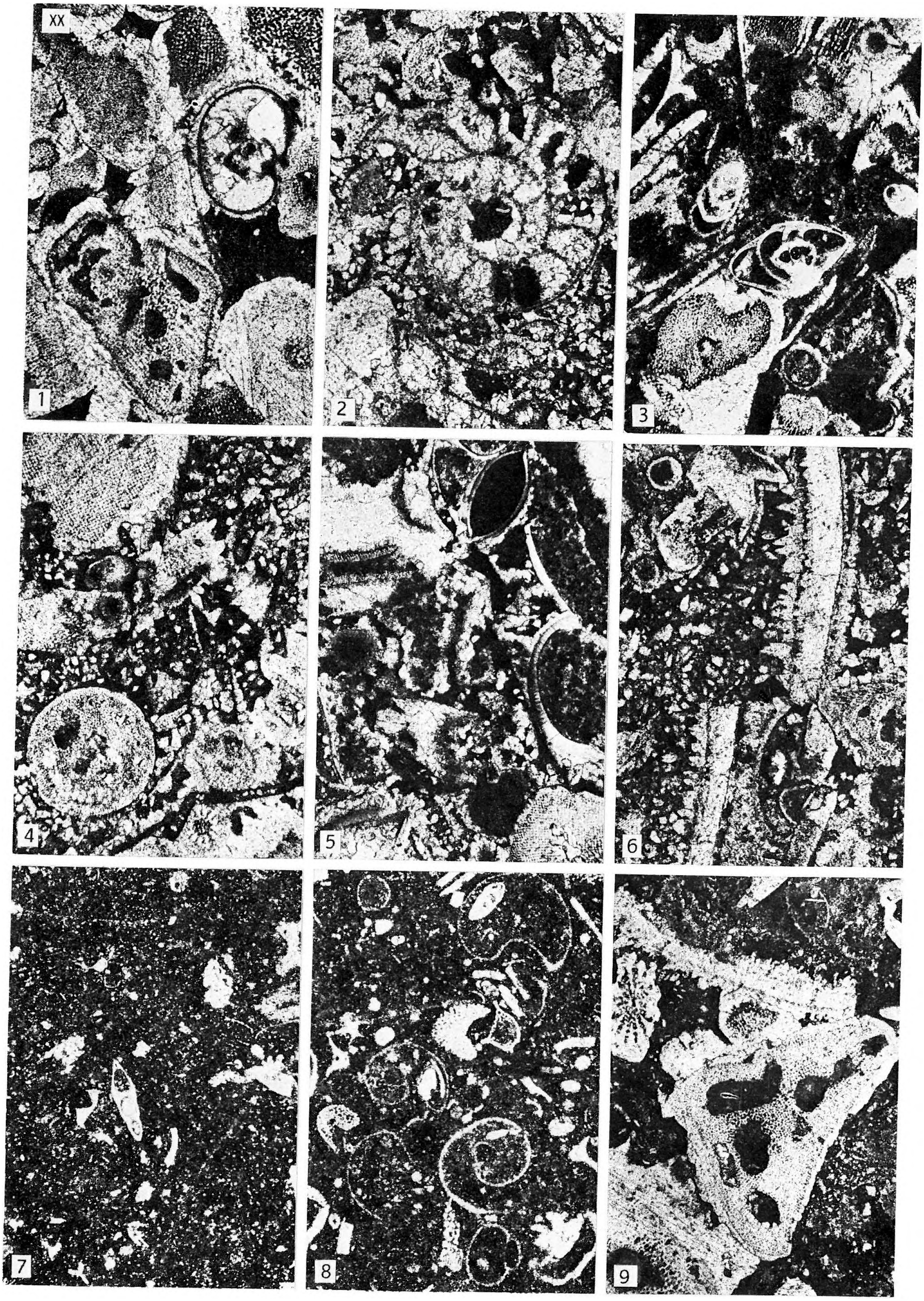
XX
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PLATE XXI

TATA

Top of the Upper Liassic (Upper Toarcian) red argillaceous, nodular, calcareous marl

1—2. Upper Liassic (Upper Toarcian) red argillaceous, nodular, calcareous marl. 1/1
Borehole TVG-45, 112.55—112.75 m.

3. *Cadosina* sp. (new species, form 1) 950×
4. Micritic, subordinately microsparitic texture with ammonite embryons and quartz grains. 43×
5. Biomicrite, Posidonia—Bositra? 27×
6. Bositra, ammonite embryons, mollusc shell fragments. 20×
7. Biomicrite, mollusc shell fragments, ammonite embryons and *Ostracoda* sp. Cross-sections of sponge spicules. 27×
8. Biomicrite with mollusc shell fragments, *Gastropoda* sp. (*Spongia*, *Ostracoda*, *Bositra* sp.) 27×
9. Biomicrite, mollusc shell fragments, ammonite embryons. 27×

1, 2: Photo by Fördős

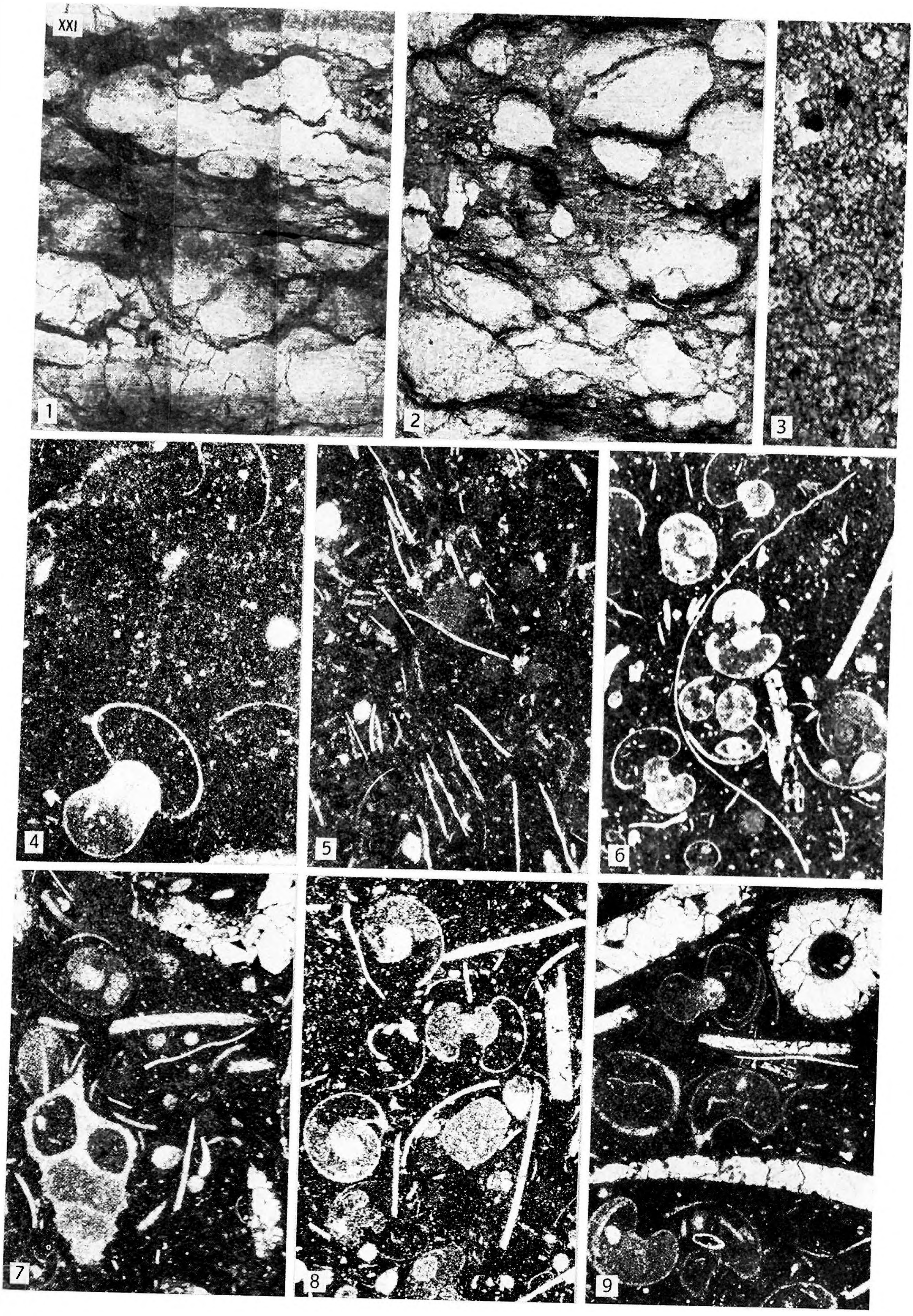
XXI
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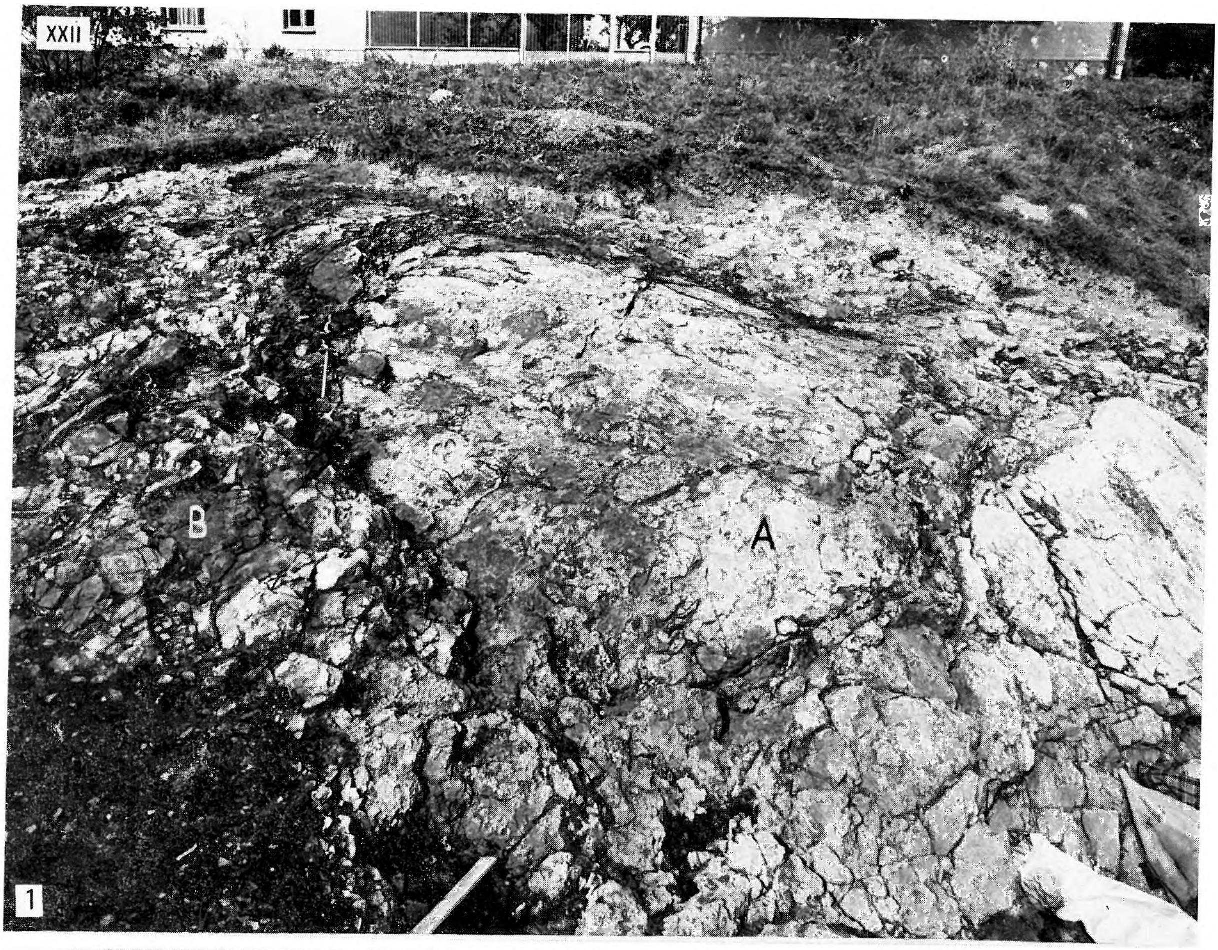
PLATE XXII

TATA, CSURGÓKÚT

Lower Toarcian

1. Domed Upper Liassic (Toarcian) sequence (A) overlain by Upper Dogger (Bathono-Callovian) cherts (B) resting on a manganese-coated hardground.
2. The Upper Liassic sequence of Csurgókút.


XXII
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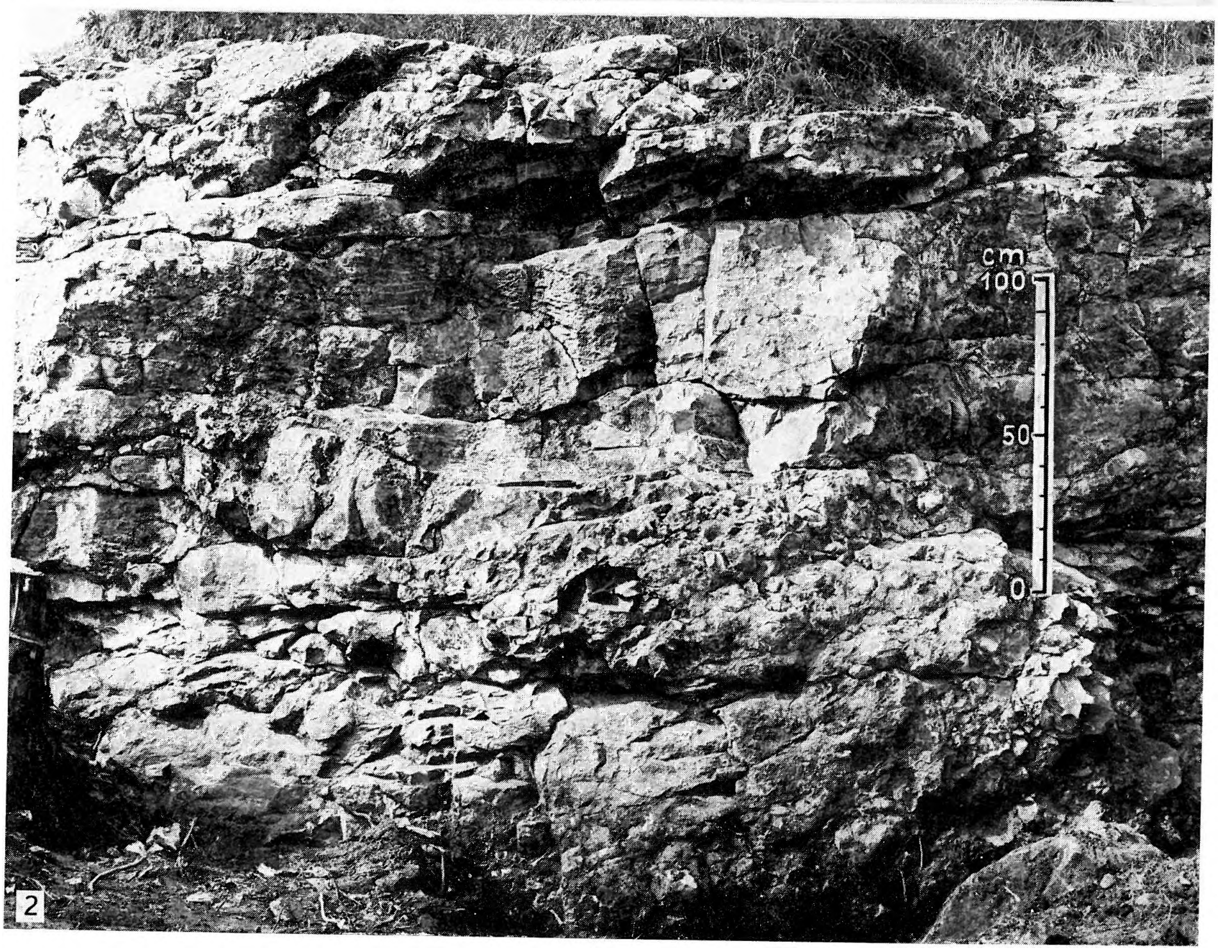
cm
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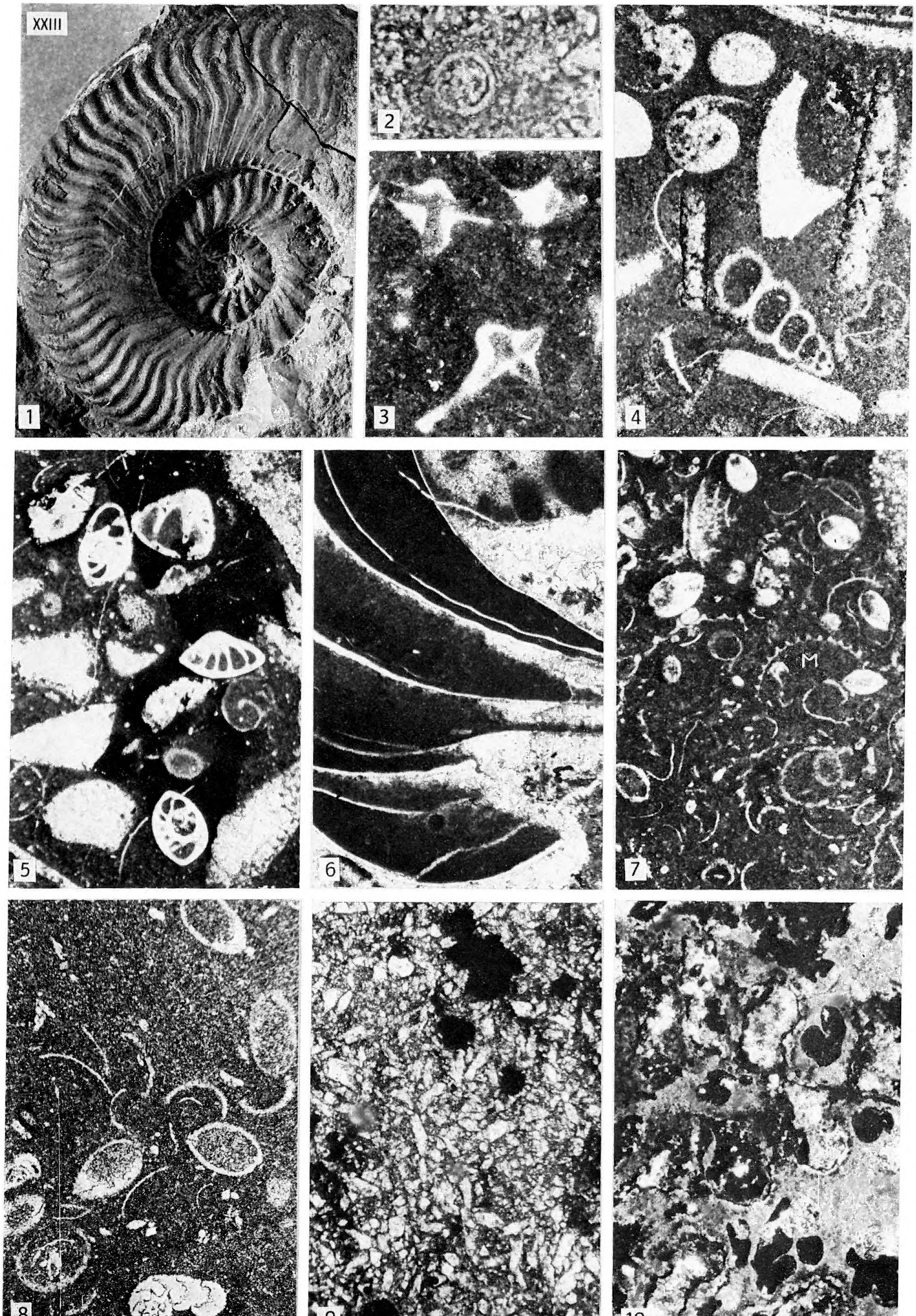
PLATE XXIII

TATA, CSURGÓKÚT

Lower Toarcian

1. *Hildaites* sp. aff. *borealis* (SEEBACH) 1/1
2. *Cadosina* sp. (form 1) 700×
3. Skeletal elements of sponges. 43×
4. Biomicrite-microsparite. Ammonite embryons, gastropods, mollusc fragments, Ostracoda. 27×
5. Foraminiferal biomicrite. *Lenticulina* sp. 27×
6. Bositra micrite with sparite coating it and filling its cavities. 27×
7. Ostracodal biomicrite, *Microcalamoides* sp. (M) 27×
8. Ostracodal biomicrite with *Marginulina* sp. 68×
9. Biomicrite with Mn-Fe oxide. 68×
10. Micrite with Mn-Fe oxide and spar-mottled. 35×


XXIII
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M
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PLATE XXIV

KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA

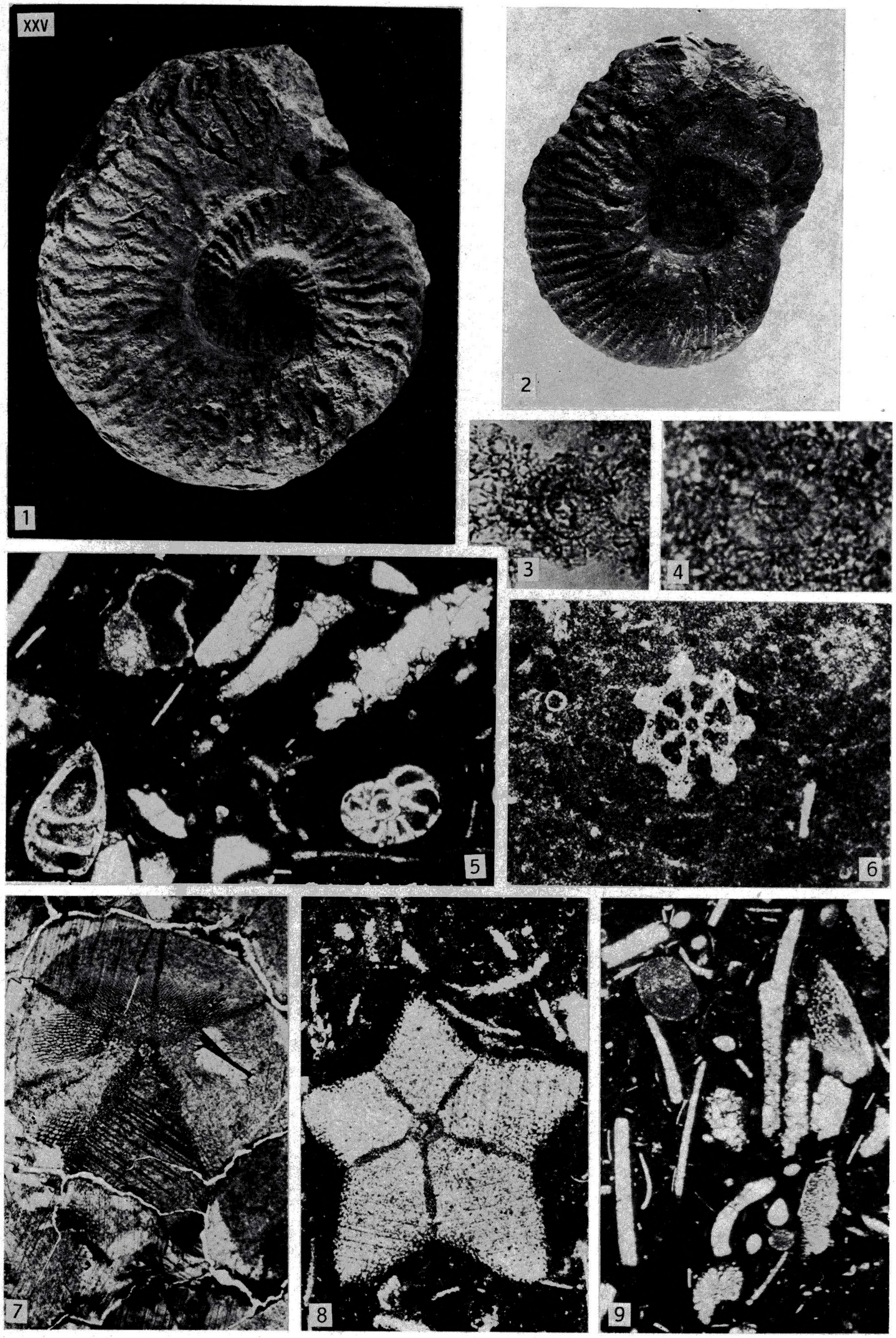
Dogger limestone and chert

1. Lower Dogger (Aalenian-Bajocian) red argillaceous limestone in the plane of the large fault crossing the Geological Conservation Area.
2. Upper Dogger (Bathono-Callovian) chert (T) and Oxfordian intraformational breccia bed (O). Upper edge of Pit III.
3. Lower Dogger red argillaceous limestone with Chondrites. 2×
4. Lower Dogger red argillaceous limestone with manganese nodules.

KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA

Lower Dogger (Aalenian-Bajocian) fossils

1. *Costileioceras* cf. *opalinoides* (MAYER) 1/1
2. *Otoites* cf. *contractus* (SOW.) 1/1
3. *Cadosina* sp. (form 2) 642 ×
4. *Cadosina* sp. 642 ×
5. Foraminiferal-molluscan biomicrite. 105 ×
6. Holothurioidea sclerite. 43 ×
7. Crinoidite. 37 ×
8. Crinoid skeletal elements. 27 ×
9. Biomicrite with sponge spicules, echinoderms and molluscs. 27 ×


XXV
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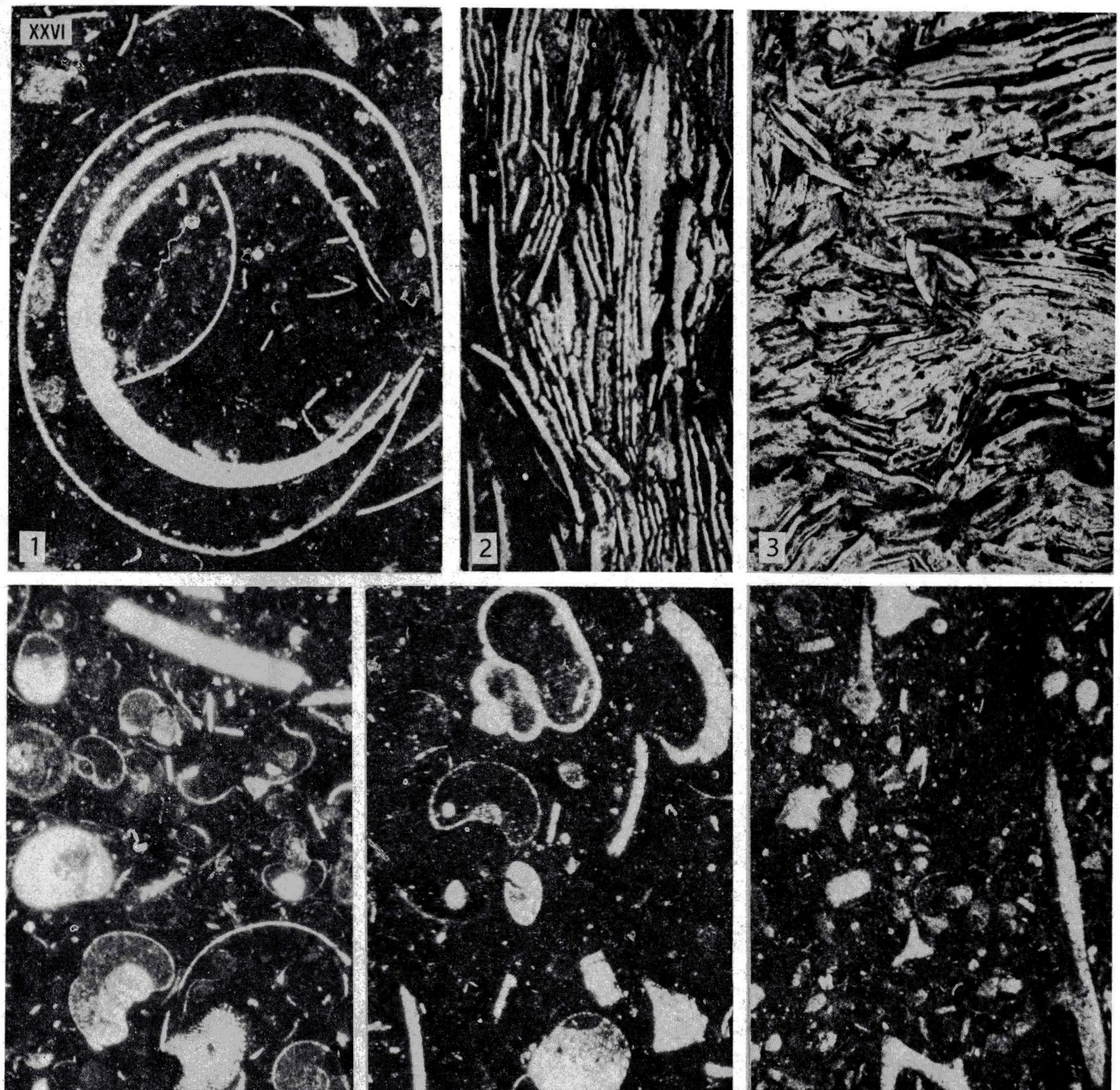
KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA

The microfauna of the Lower Dogger (Aalenian-Bajocian) red argillaceous limestone

1. *Bositra buchi* (RÖMER) 22×
2. Bositra biomicrite. 27×
3. Bositra biomicrite with spar-coated skeletal elements. 27×
4. Ammonite-embryoned biomicrite. 27×
5. Biomicrite with gastropods and ammonite embryons. 27×
6. Biomicrite with sponge spicules. 27×

7—9. Protoglobigerina biomicrite. 27×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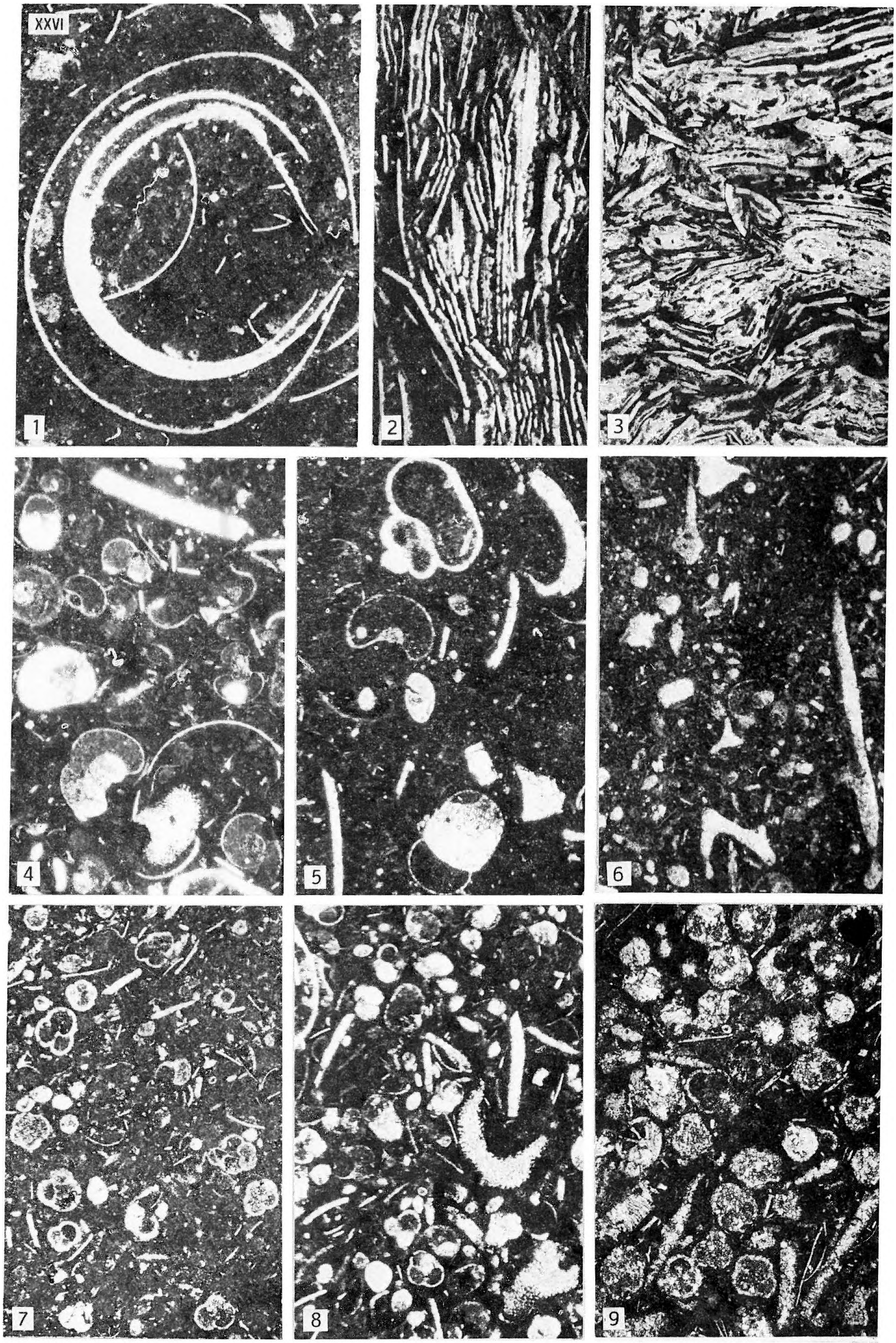
XXVI
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PLATE XXVII

KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA

The microfauna of the Upper Dogger (Bathono-Callovian) chert

1. Radiolarian biomicrite. 37 ×
2. Radiolarian biomicrite. 68 ×
3. Radiolerian biomicrite, *Trisphaera* sp., sponge spicules. 43 ×
4. *Flustrellinae*, *Theocosphaera* sp. 170 ×
5. *Radiolaria* sp. 170 ×
6. *Tricolocapsa* sp. 170 ×
7. *Saturnalis* sp. 68 ×
8. *Saturnalis* sp. 105 ×
9. *Lithocampe* sp. 170 ×
10. *Dictyomitra* sp. 170 ×
11. Biomicrite with sponges and radiolarians. 37 ×
12. Nannofossils. 418 ×
13. Spar crystals of rhombohedral cross-section in radiolarian biomicrite. 105 ×

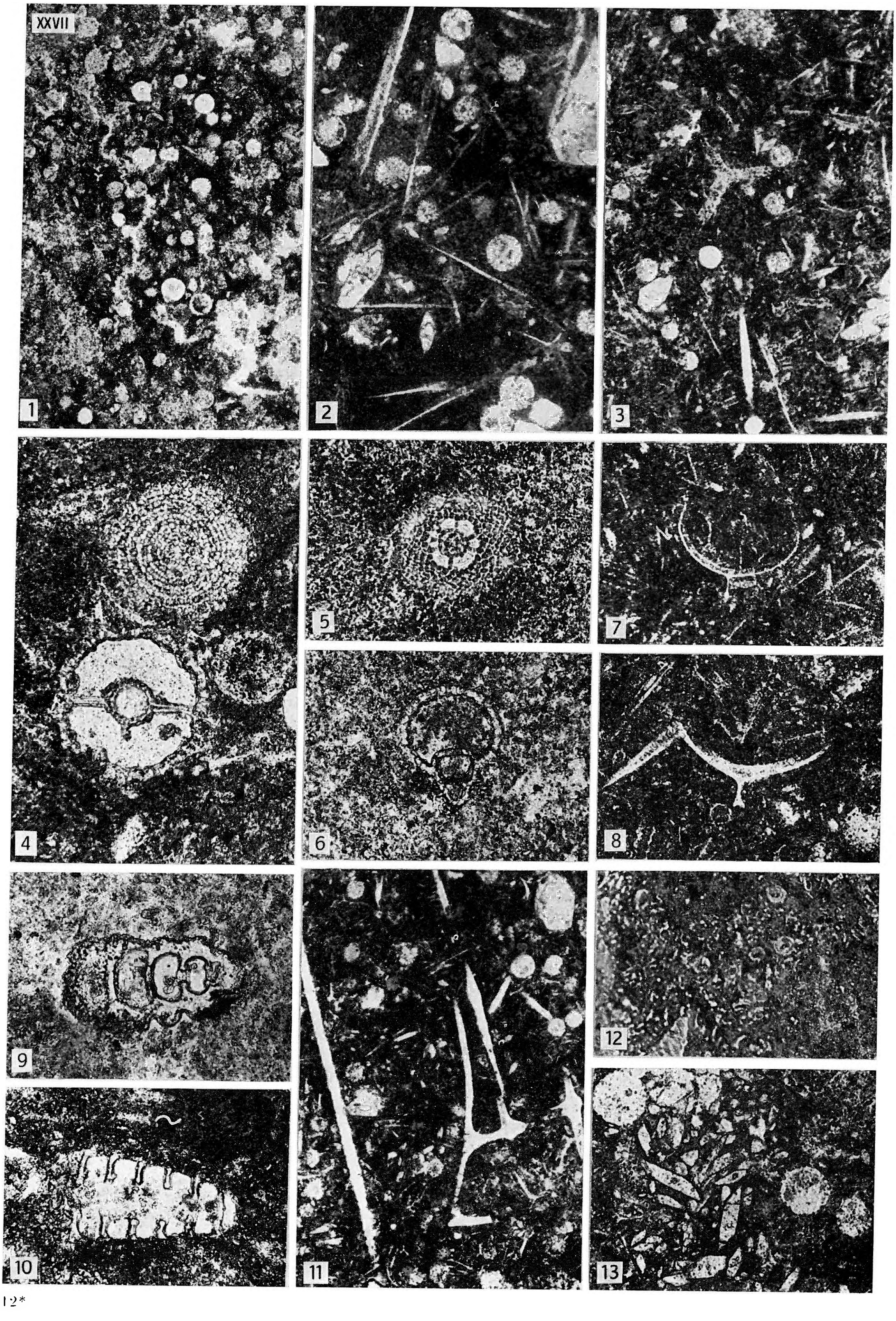
XXVII
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PLATE XXVIII

KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA

Malm-Berriasian formations

Site of detailed, layer-by-layer sampling

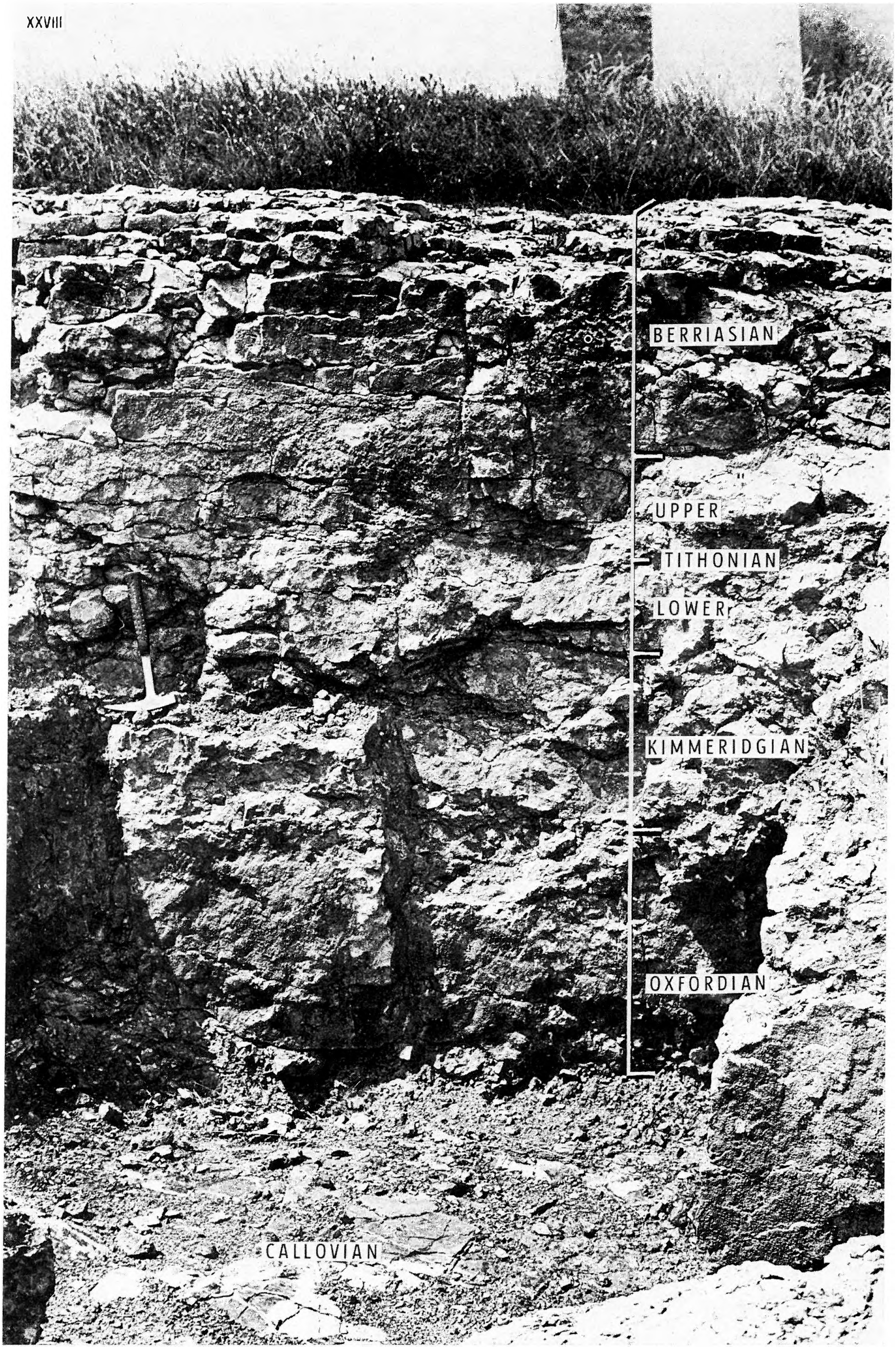

BERRIASIAN
UPPER
TITHONIAN
LOWER
KIMMERIDGIAN
OXFORDIAN
CALLOVIAN

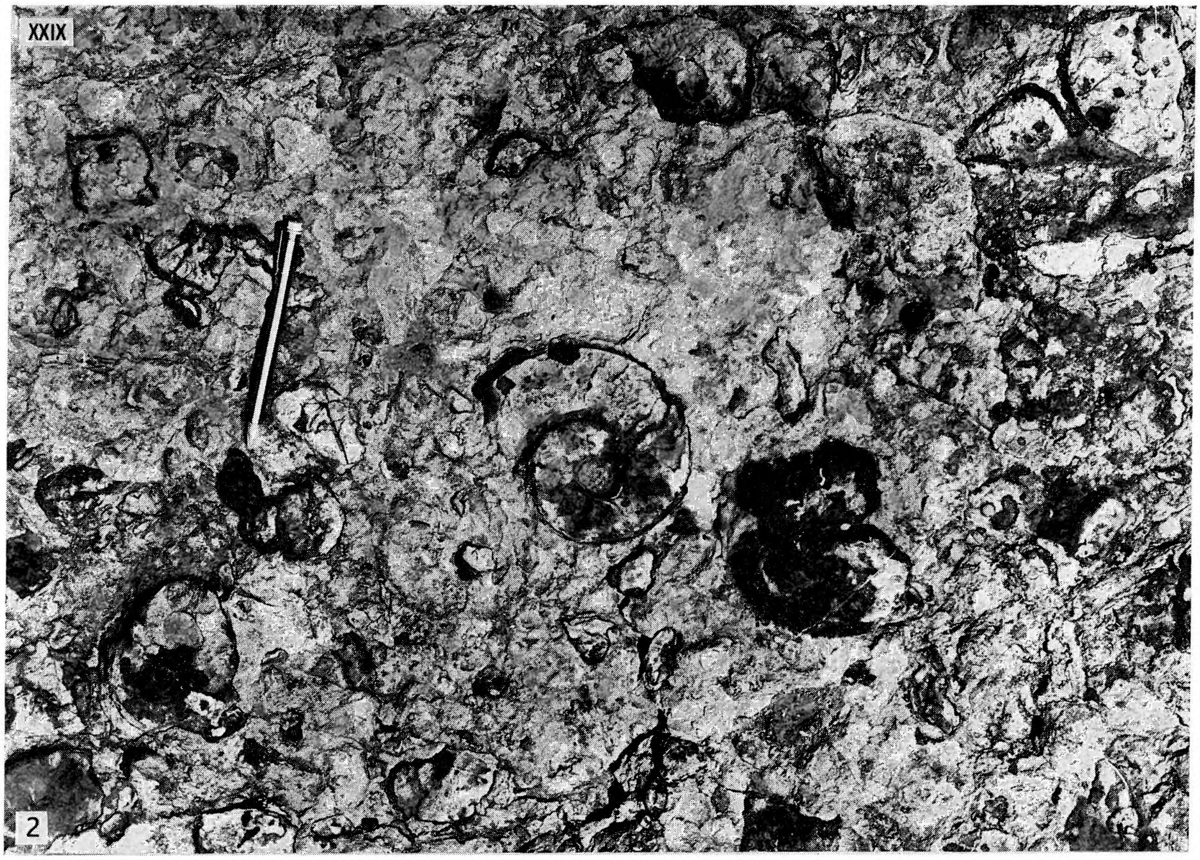
PLATE XXIX

KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA

Oxfordian and Kimmeridgian limestone

1. Oxfordian intraformational limestone breccia. 1/1
2. Kimmeridgian cephalopodal limestone with manganese nodules.

XXIX



2

1

PLATE XXX

KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA

Submarine scree

1. Kimmeridgian scree flow on a submarine slope.
2. Fe-Mn-oxidized Kimmeridgian limestone rubble enclosed in Lower Tithonian limestone.

XXX

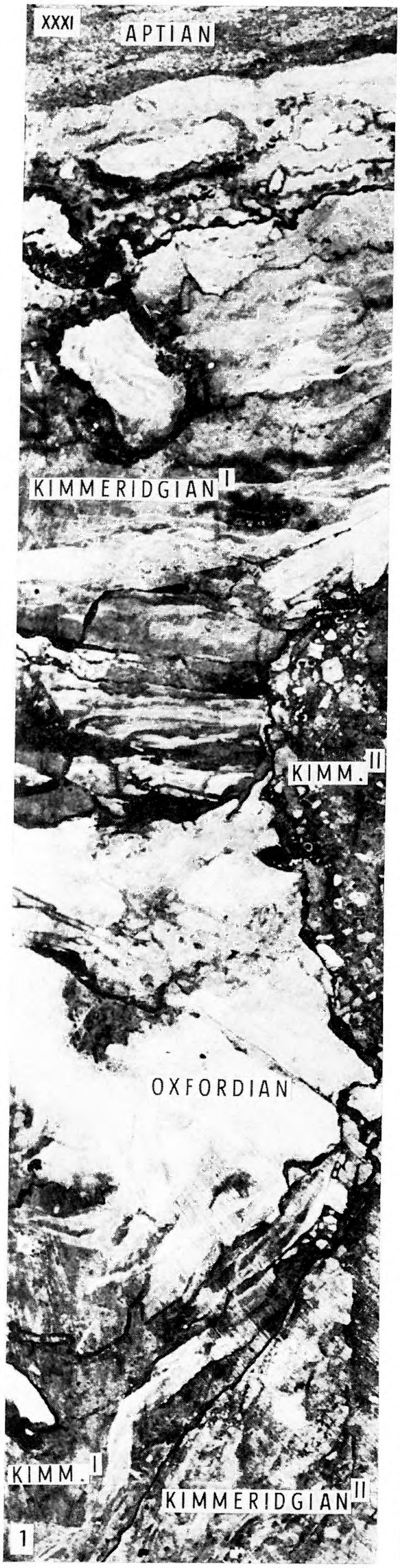
2

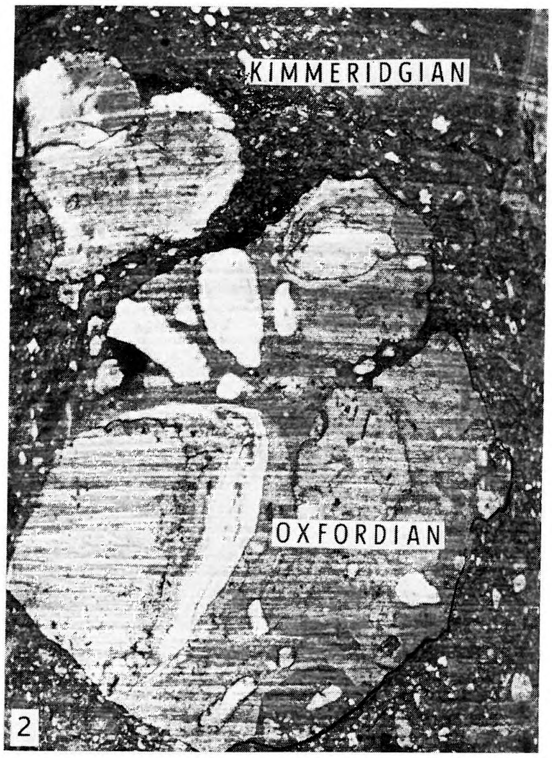
1

PLATE XXXI

Submarine scree

1. Lower Kimmeridgian brecciated limestone with Oxfordian limestone debris, Upper Kimmeridgian fissure-fills overlain by Aptian limestone. 1/1
   Borehole TVG-52, 13.5—13.8 m.
2. Kimmeridgian limestone with Oxfordian limestone breccia debris. 1/1
   Borehole TVG-46, 7.9—8.0 m.
3. Oxfordian limestone debris coated by Mn-oxide in Lower Tithonian limestone overlain, above a hardground, by Berriasian limestone. 1/1
   Borehole TVG-17, 2.2—2.3 m.


XXXI
APTIAN
KIMMERIDGIAN I
KIMM. II
OXFORDIAN
KIMM. I
KIMMERIDGIAN II
1


KIMMERIDGIAN
OXFORDIAN
2

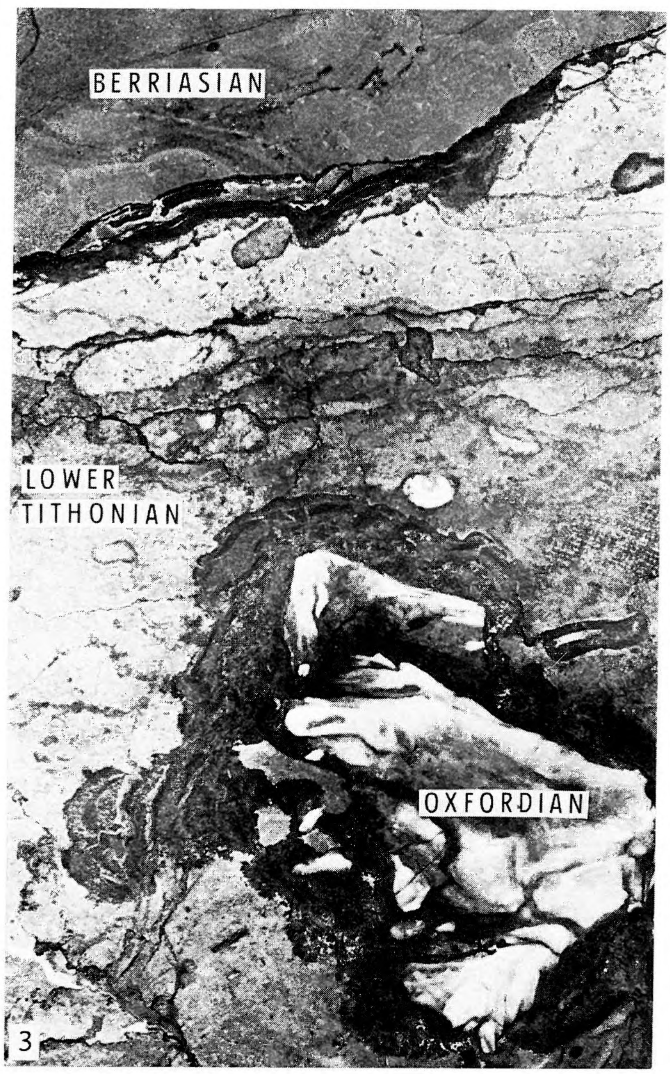

BERRIASIAN
LOWER
TITHONIAN
OXFORDIAN
3

PLATE XXXII

TATA

Upper Oxfordian ammonites, photographs of thin sections of Bathono-Callovian and Oxfordian sediments

1. *Gregoryceras transversarium* (Qu.) 1/1
   Fazekas Street "Vineyard of rope-maker Háber".
2. *Gregoryceras toucasianum* (d'Orb.) 1/1
   Kálvária Hill.
3. Protoglobigerina micrite from Oxfordian limestone breccia. 27.5×
   Kálvária Hill's Geological Conservation Area.

4—6. Typical microscopic texture of Oxfordian limestone breccia. 27.5×
Kálvária Hill's Geological Conservation Area.

7—8. Radiolarian biomicrite (radiolarite). 105×
Borehole TVG-44, 40 m.

9. Calcitized tests of Radiolaria in silicified matrix (radiolarite). 90×
   Borehole TVG-44, 39 m.

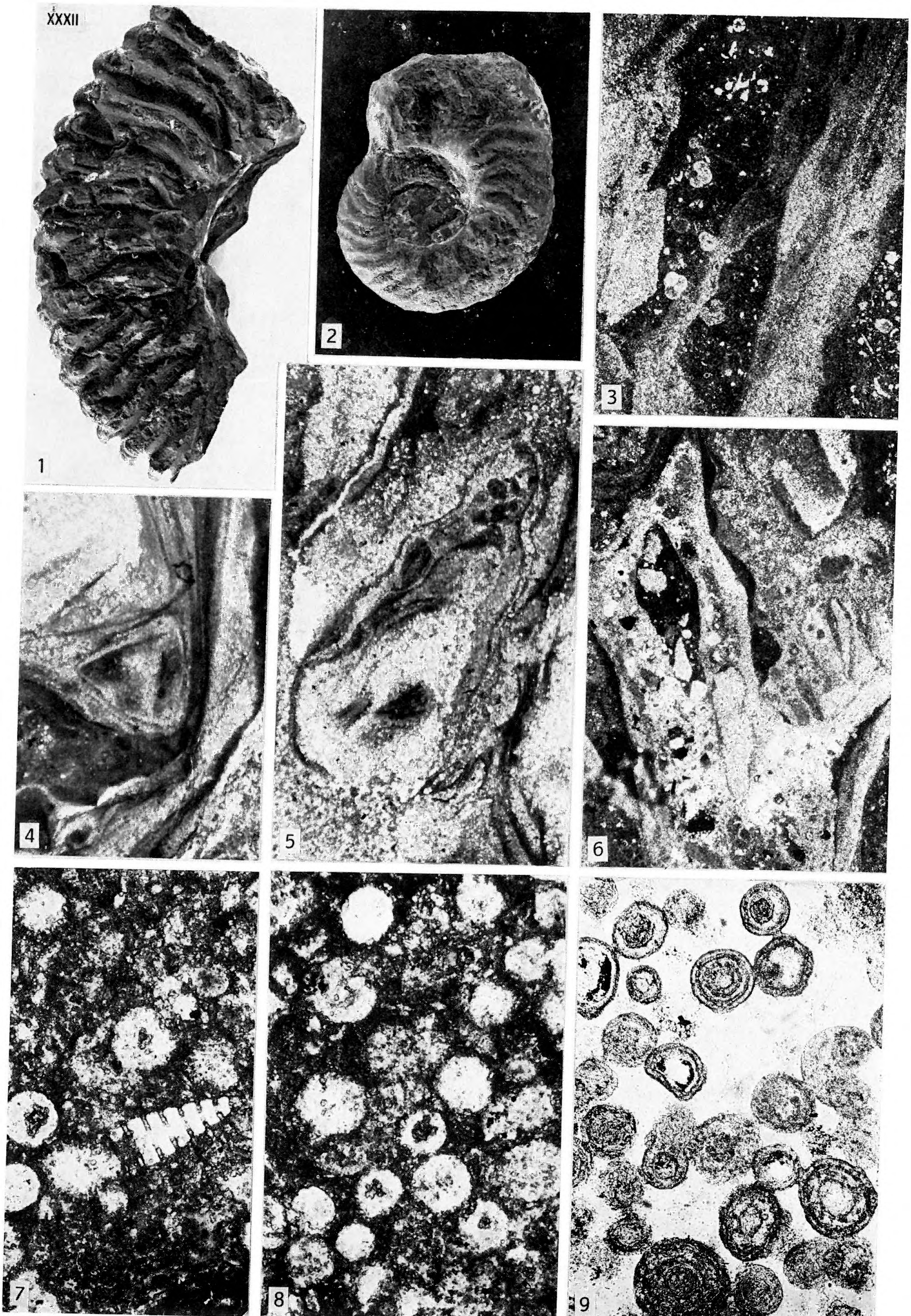

XXXII
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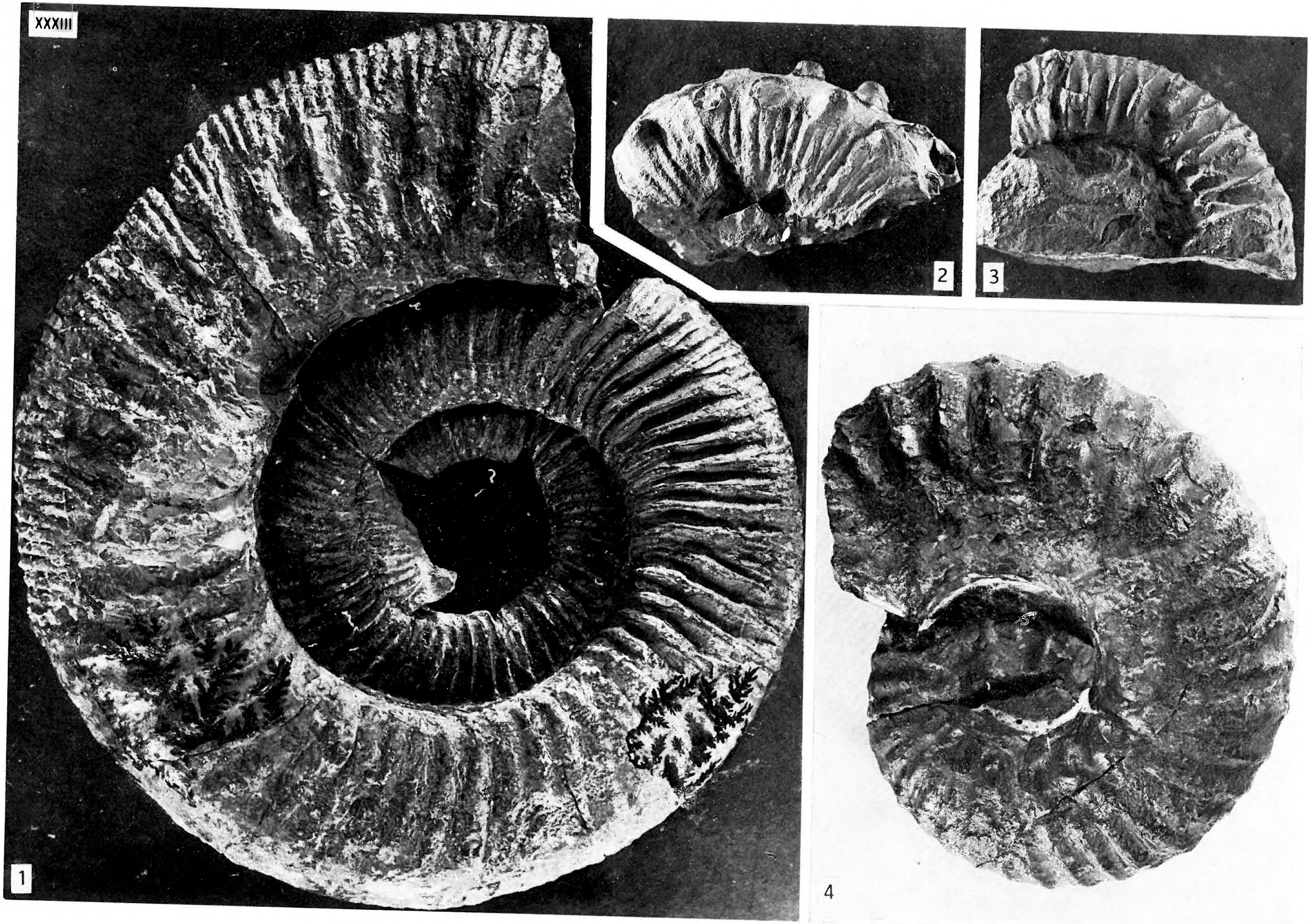
PLATE XXXIII

KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA

Kimmeridgian ammonites

1. *Lithacoceras (Lithacoceras)* cf. *pseudolictor* (Choff.) 1/1
2. *Taramelliceras* aff. *trachinotum* (Opp.) 1/1
3. *Katroliceras* sp. 1/1
4. *Aspidoceras (Orthaspidoceras) uhlandi* (Opp.) 1/1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Photomicrographs of thin sections of Kimmeridgian limestone

1. Lombardia biomicrite. 43×
   Borehole TVG-50, 42.25 m.
2. Axotrix biomicrite. 68×
   Borehole TVG-46, 9.7 m.
3. Biomicrite with mollusc shell fragments and Globochaete. 43×
   Borehole TVG-50, 40.25 m.
4. Lombardia biomicrite with Globochaete, Foraminifera, Aptychus, microgastropods and detritus of molluscs. 55×
   Kálvária Hill's Geological Conservation Area. Pit III.
5. Globochaete biomicrite with ammonite embryons, Lombardia, mollusc detritus, Crinoidea. 35×
   Kálvária Hill's Geological Conservation Area. Pit III.

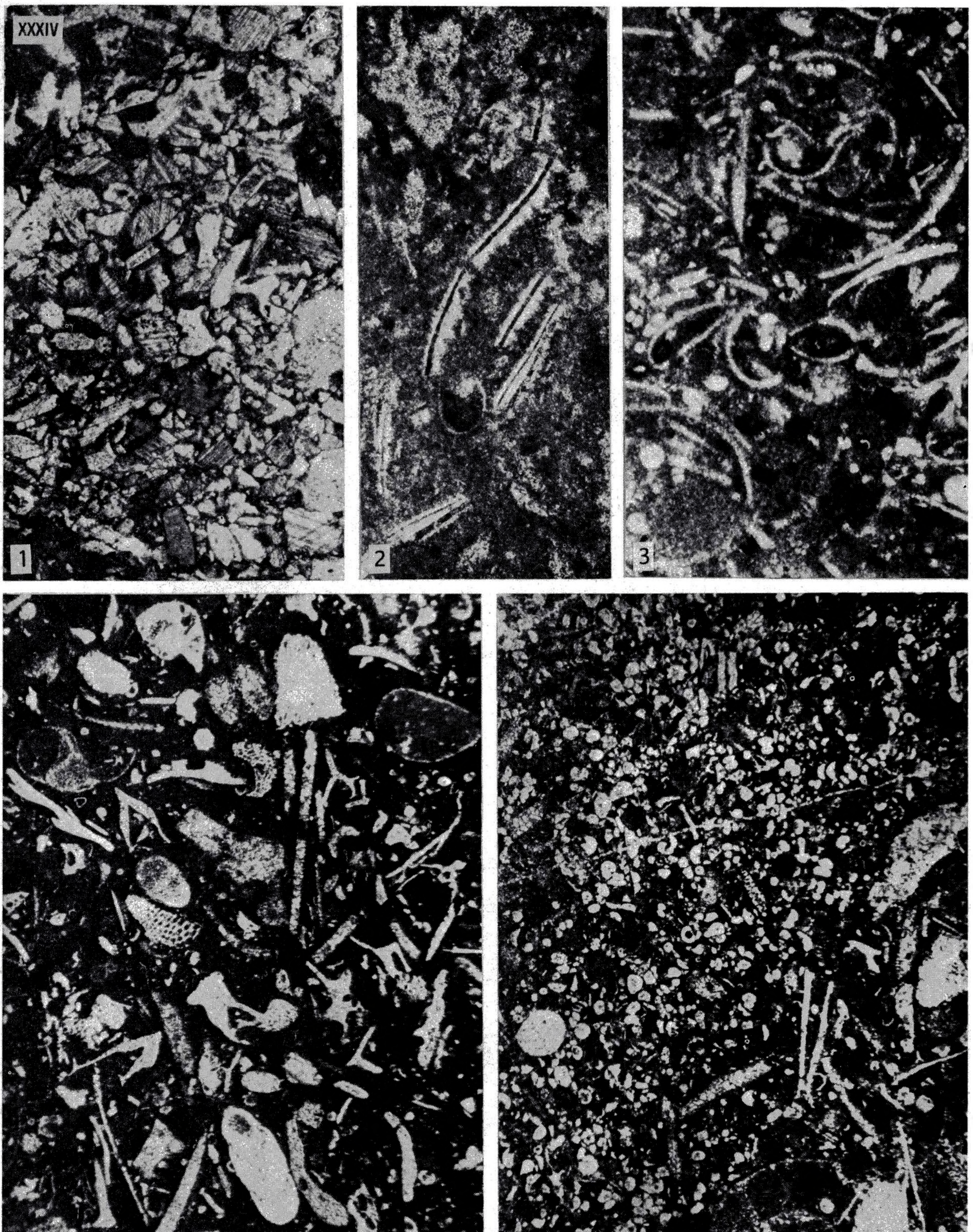
XXXIV
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PLATE XXXV

KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA

Tithonian ammonite fauna

1. *Pseudargentiniceras beneckei* (JAC.) in ROM. et MAZEN. 1.5×
2. *Berriasella (Picteticeras) chomeracensis* (TOUC.) 1/1
3. *Berriasella (Berriasella) subcallisto* (TOUC.) 1/1
4. *Haploceras elimatum* (OPP.) 1/1
5. *Neolissoceras (?) tithonius* (OPP.) 1.5×
6. *Subalpinites aristidis* (KIL.) 1/1
7. *Aspidoceras rogoznicense* (ZEUSCHN.) 1/1
8. *Phylloceras serum* (OPP.) 1/1
9. *Jabronella jabronensis* (MAZEN.) 1/1

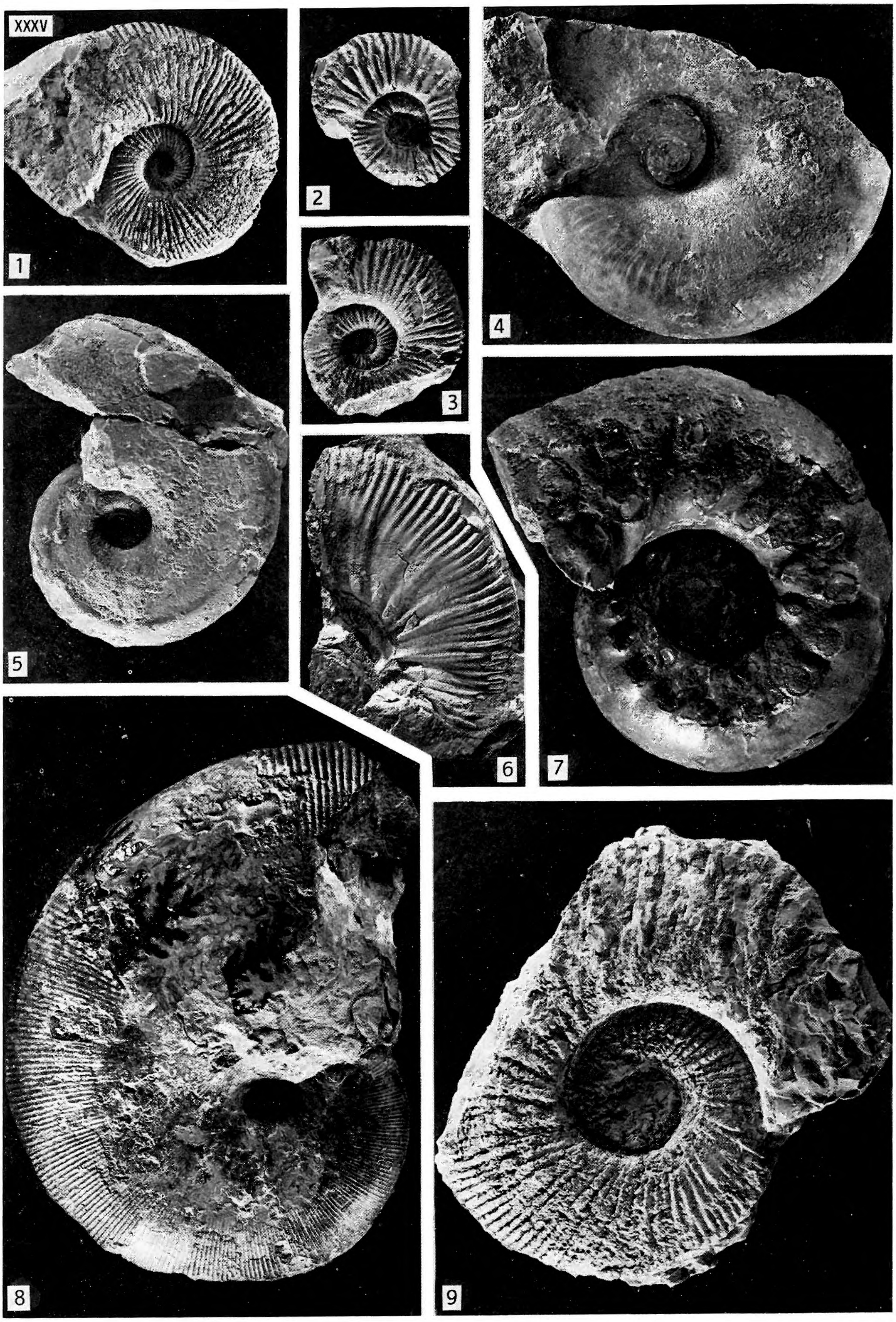
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PLATE XXXVI

Tithonian microfossils

1. *Globochaete alpina* (*Calpionella alpina*, mollusc shell fragments, Radiolaria) 105 ×
   Borehole TVG-50, 28.5 m.
2. *Globochaete alpina* (Lombardia) 170 ×
   Borehole TVG-50, 31.0 m.
3. *Cadosina borzai (C. parvula)* 262 ×
   Borehole TVG-44, 33.7 m.
4. *Cadosina lapidosa*. 262 ×
   Borehole TVG-50, 22.8 m.
5. *Cadosina parvula*. 262 ×
   Borehole TVG-50, 33.5 m.
6. *Crassicollaria parvula* (*Microcalamoides* sp.) 105 ×
   Borehole TVG-56, 8.5 m.
7. *Crassicollaria brevis*. 170 ×
   Borehole TVG-56, 8.25 m.
8. *Calpionella alpina*. 170 ×
   Borehole TVG-44, 31.7 m.
9. *Calpionella elliptica (C. alpina)* 170 ×
   Borehole TVG-44, 31.85 m.
10. *Lenticulina* sp. 68 ×
    Borehole TVG-50, 29.75 m.
11. *Lenticulina* sp. 68 ×
    Borehole TVG-50, 28.75 m.
12. Textularidae. 68 ×
    Borehole TVG-50, 28.75 m.
13. Textularidae. 43 ×
    Borehole TVG-50, 27.75 m.
14. Lombardia, Crinoidea, mollusc shell fragments. 68 ×
    Kálvária Hill.
15. Aptychus, Crinoidea, Calpionella, Ostracoda, mollusc shell fragments. 27 ×
    Borehole TVG-56, 8.0 m.

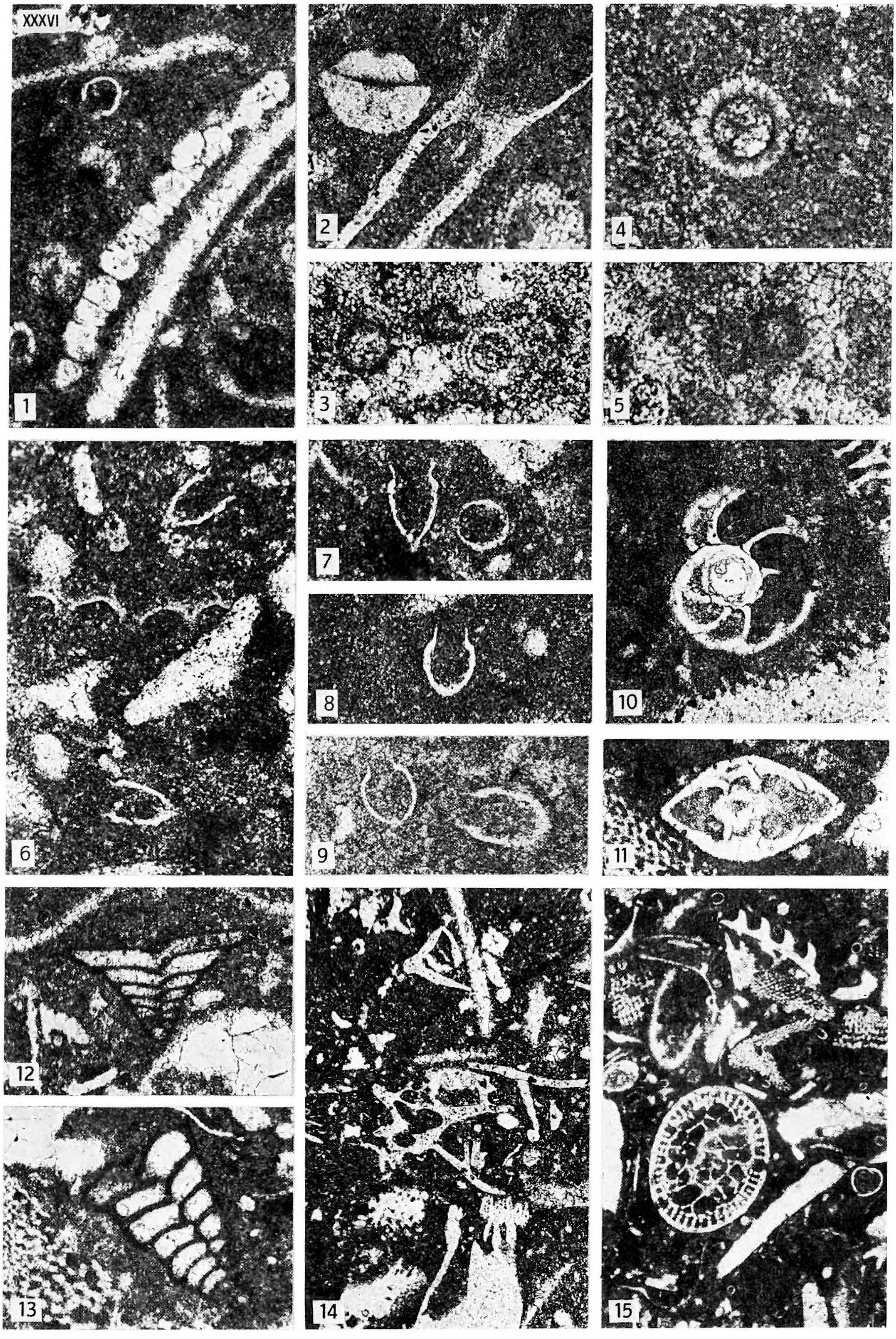
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PLATE XXXVII

Variants of Tithonian microfauna

1. Calpionella, *Globochaete alpina*, Radiolaria, Foraminifera (?) 87×
   Borehole TVG-50, 30.0 m.
2. *Calpionella alpina*, *Crassicollaria parvula*. 68×
   Borehole TVG-50, 28.75 m.
3. *Calpionella alpina*, *Crassicollaria parvula*, *Spirillina* sp., Radiolaria, Ostracoda. 68×
   Borehole TVG-50, 30.0 m.
4. Lombardia, detritus of Echinoidea, Calpionella, Aptychus. 27×
   Borehole TVG-50, 30.75 m.
5. Microbrachiopods, microgastropods, *Lenticulina* sp., Calpionella, Radiolaria, detritus of molluscs, Globochaete. 27×
   Borehole TVG-44, 32.30 m.
6. Crinoidea, Calpionella, Aptychus. 43×
   Borehole TVG-50, 29.75 m.
7. Microgastropods, Calpionella, Lenticulina, Globochaete, detritus of molluscs and echinoids. 43×
   Borehole TVG-44, 32.30 m.
8. Shell detritus of molluscs, ammonite embryons, Calpionella, Ostracoda. 27×
   Borehole TVG-59, 147 m.
9. *Calpionella alpina*, *Globochaete alpina*, microbrachiopods, mollusc shell detritus, fragments of echinoderms. 68×
   Borehole TVG-56, 8.25 m.

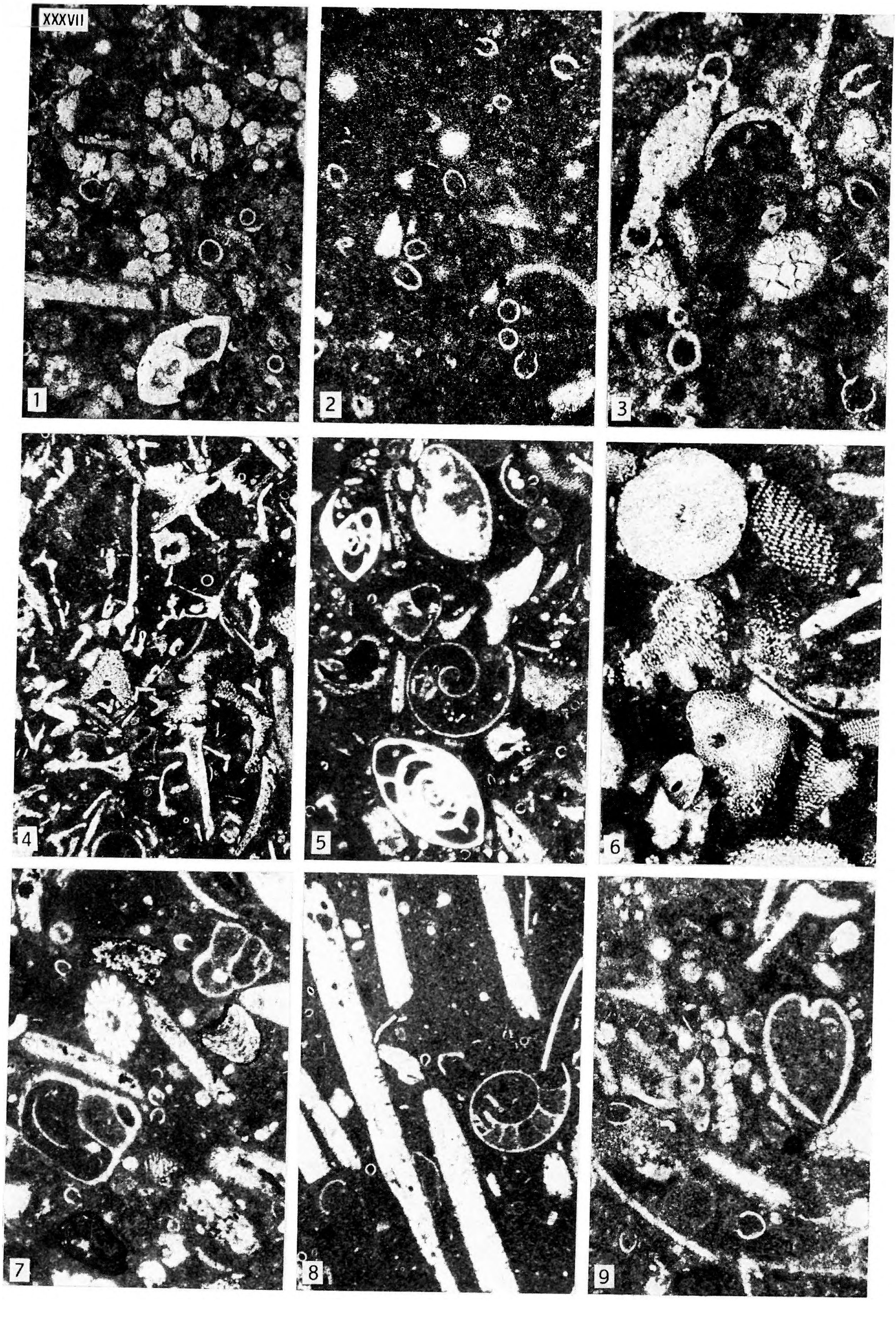
XXXVII
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PLATE XXXVIII

KÁLVÁRIA HILL

Tithonian microfacies

1. Micrite with Calpionellidae. *Calpionella alpina*, *Crassicolaria parvula*, skeletal elements of echinoderms, mollusc shell detritus, Globochaete, Radiolaria. 70×
2. Biomicrite with Calpionellida *(Calpionella alpina)*, skeletal elements of echinoderms, Lombardia, Radiolaria. 70×
3. Protoglobigerina biomicrite, *Calpionella alpina*, Radiolaria and mollusc shell fragments. 20×
4. Biomicrite with *Calpionella alpina*, benthonic foraminifera, Globochaete, mollusc shell fragments and skeletal elements of echinoderms. 15×

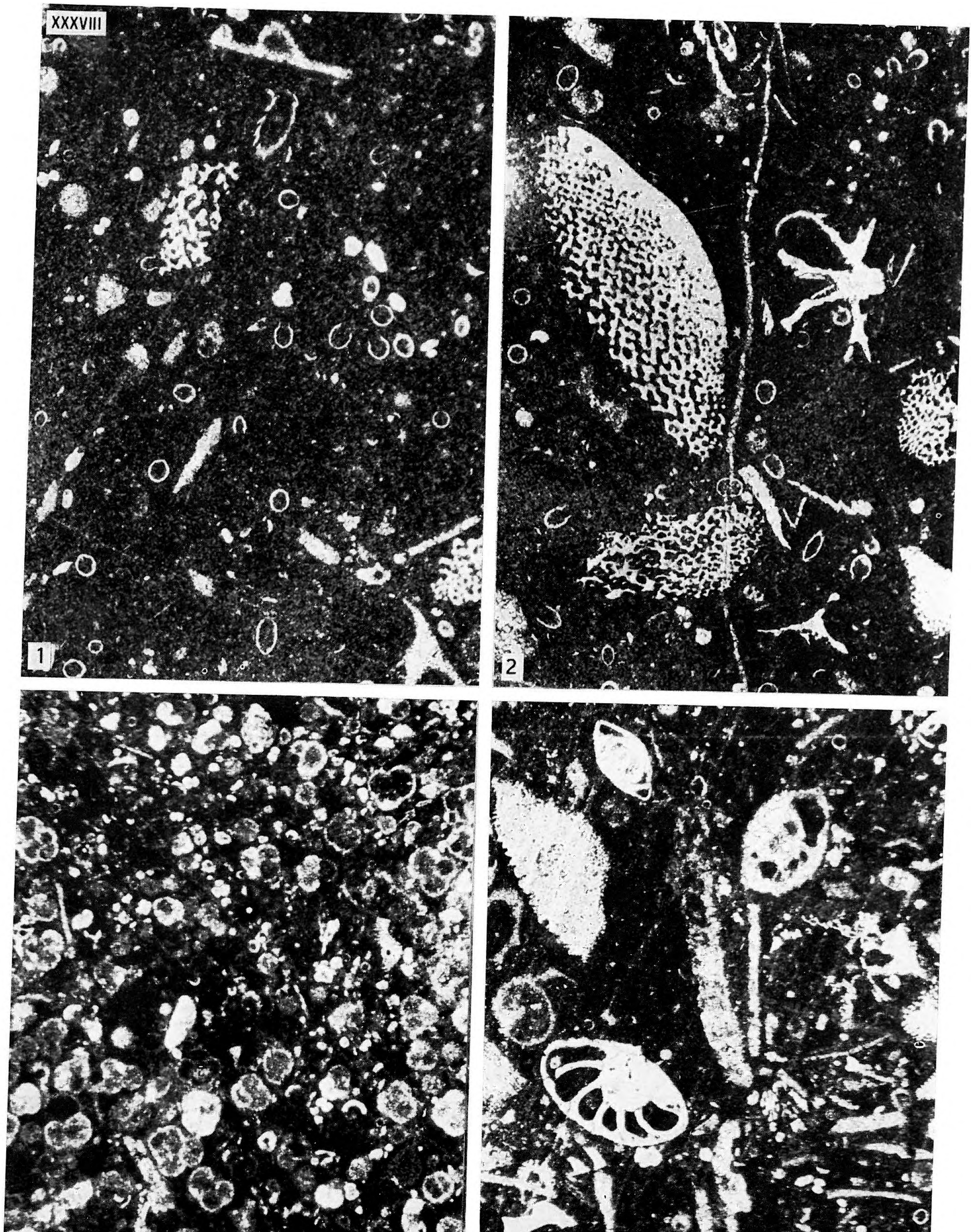
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PLATE XXXIX

KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA

Berriasian macrofauna

1. *Tirnovella* cf. *subalpina* (Mazen.) 1/1
2. *Jabronella paquieri* sp. 1/1
3. *Berriasella (Berriasella) privasensis* (Pict.) 1/1
4. *Fauriella gallica* (Mazen.) 1/1
5. *Berriasella (Picteticeras) picteti* (Jac.) in Kil. 1.5×
6. *Malbosiceras* sp. (ex gr. *M. chaperi-malbosi*) 1/1
7. *Pygope sima* (Zeuschn.) 1/1

8—9. *Pygope triangulus* (Lam.) 1/1

XXXIX

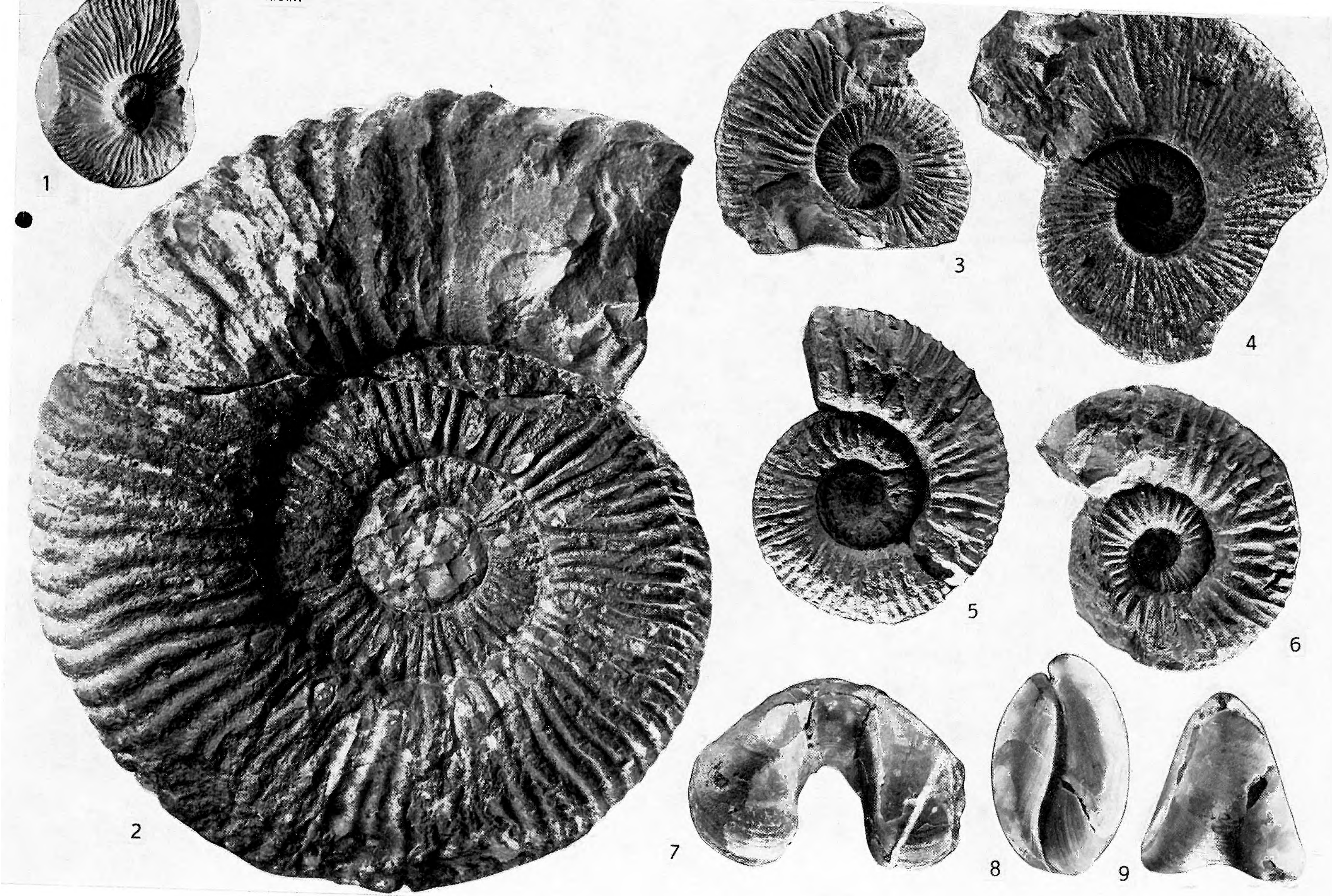

PLATE XL

Berriasian (Valanginian?)

Tintinnina and Foraminifera

1. *Markalius circumradiatus* (STOZEK) 2500×; +Nik.
   Borehole TVG-44, 31.1 m.
2. *Nannoconus steinmanni* CAMPTNER. 2500×; +Nik.
   Borehole TVG-44, 31.1 m.
3. *Calpionellites darderi* (COLOM) 105×
   Borehole TVG-50, 21.2 m.
4. *Calpionellites darderi* (COLOM) 105×
   Borehole TVG-50, 24.5 m.
5. *Calpionellites dadayi* (KNAUER) 170×
   Borehole TVG-44, 31.2 m.
6. *Calpionellites dadayi* (KNAUER) 105×
   Borehole TVG-44, 31.2 m.
7. *Stenosemellopsis hispanica* (COLOM) 170×
   Borehole TVG-44, 31.6 m.
8. *Remaniella cadischiana* (COLOM) 105×
   Borehole TVG-50, 22.6 m.
9. *Calpionellopsis oblonga* (CADISCH) 170×
   Borehole TVG-44, 31.2 m.
10. *Calpionellopsis oblonga* (CADISCH) 170×
    Borehole TVG-50, 20.5 m.
11. *Tintinnopsella longa* (COLOM) 170×
    Borehole TVG-33, 31.5 m.
12. *Tintinnopsella longa* (COLOM) 105×
    Borehole TVG-50, 21.4 m.
13. *Calpionellopsis simplex* (COLOM) 170×
    Borehole TVG-44, 31.4 m.
14. *Calpionella undelloides* (COLOM) 170×
    Borehole TVG-44, 31.1 m.
15. *Calpionella undelloides* (COLOM) 170×
    Kálvária Hill, profile at the northern corner.
16. *Calpionella undelloides* (COLOM) 170×
    Borehole TVG-44, 31.3 m.
17. Foraminifera. 68×
    Borehole TVG-59, 128.0 m.
18. Foraminifera. 68×
    Borehole TVG-50, 21.6 m.
19. Foraminifera. 43×
    Borehole TVG-50, 23.5 m.

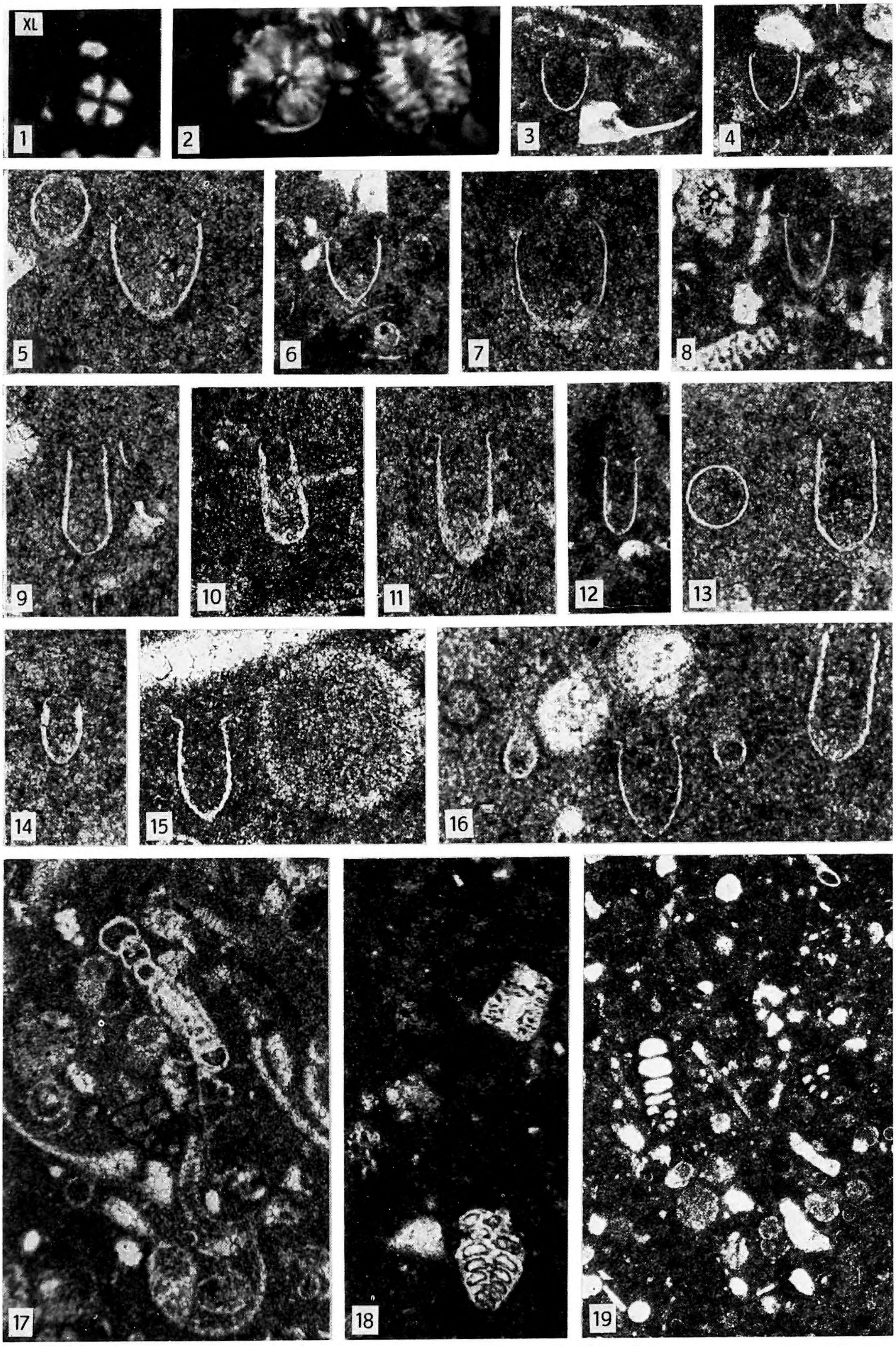
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PLATE XLI

Berriasian microfauna

1. *Cadosina fusca* WANNER. 262 ×
   Borehole TVG-50, 23.25 m.
2. *Cadosina fusca* WANNER. 170 ×
   Borehole TVG-50, 23.75 m.
3. *Cadosina carpathica* (BORZA) 262 ×
   Borehole TVG-50, 24.75 m.
4. *Calpionella alpina* LORENZ, *Calpionella undelloides* COLOM. 105 ×
   Borehole TVG-50, 24.50 m.
5. Radiolarians in biomicrite. 43 ×
   Borehole TVG-50, 20.0 m.
6. Protoglobigerina biomicrite. 27 ×
   Borehole TVG-50, 21.4 m.
7. *Spirilina* sp. in micrite. 87 ×
8. Ammonite embryons in biomicrite. 55 ×
   Borehole TVG-55, 60.4 m.
9. Biomicrite with microbrachiopods, Tintinnina, Radiolaria and mollusc shell detritus. 27 ×
   Borehole TVG-50, 24.0 m.
10. Aptychus in biomicrite. 27 ×
    Borehole TVG-50, 25.0 m.

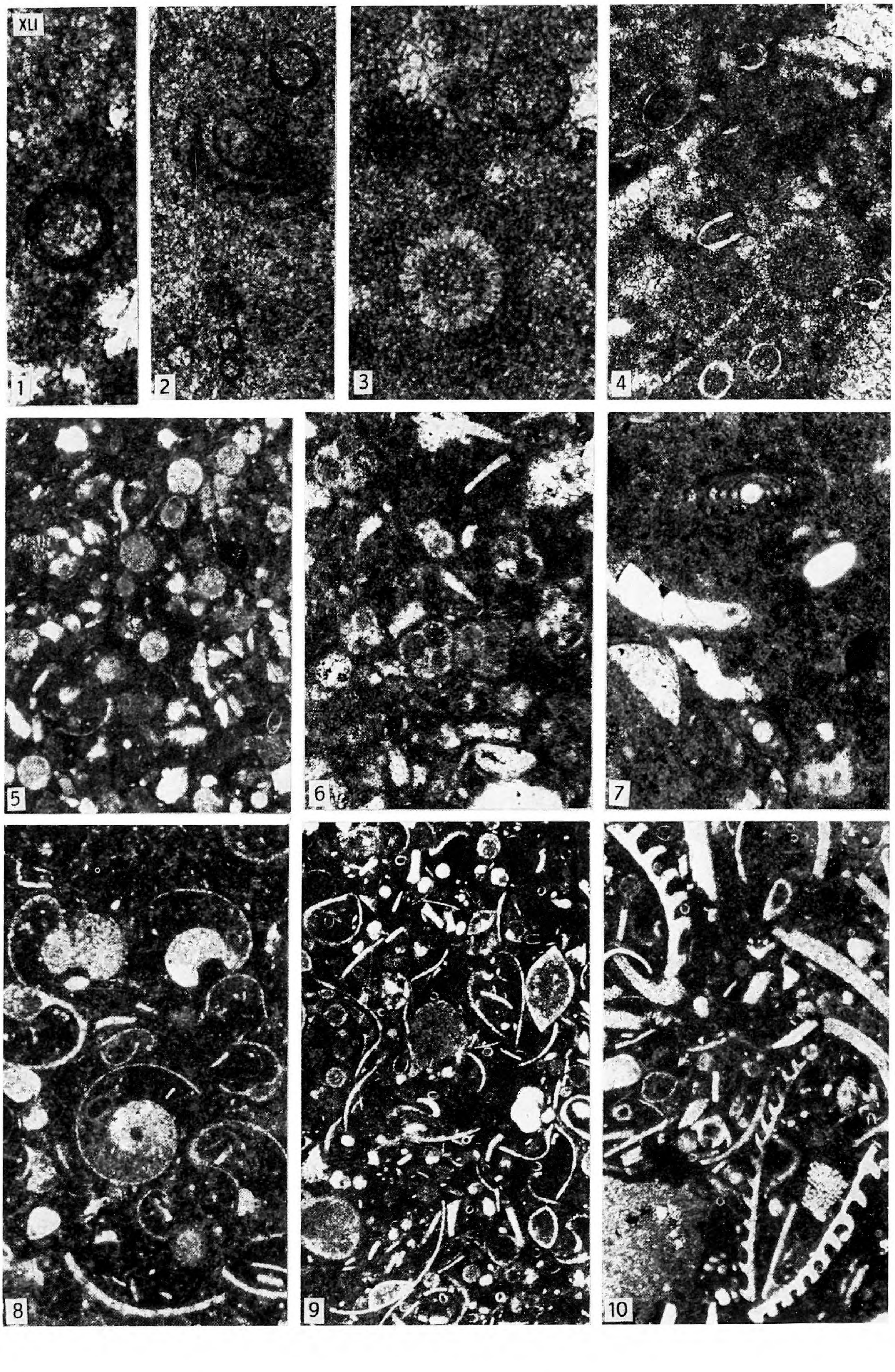
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PLATE XLII

KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA

Mode of occurrence of the Upper Aptian (Clansayan) Tata Limestone

1. Detail of the one-time rocky coast. Upper Aptian grey crinoidal limestones overlying a Tithono-Berriasian limestone cliff.
2. Mode of occurrence of the Tata Limestone overlying Upper Jurassic to Lower Cretaceous limestone beds. Geological Conservation Area, northern corner.

XLII


BERRIASIAN
APTIAN
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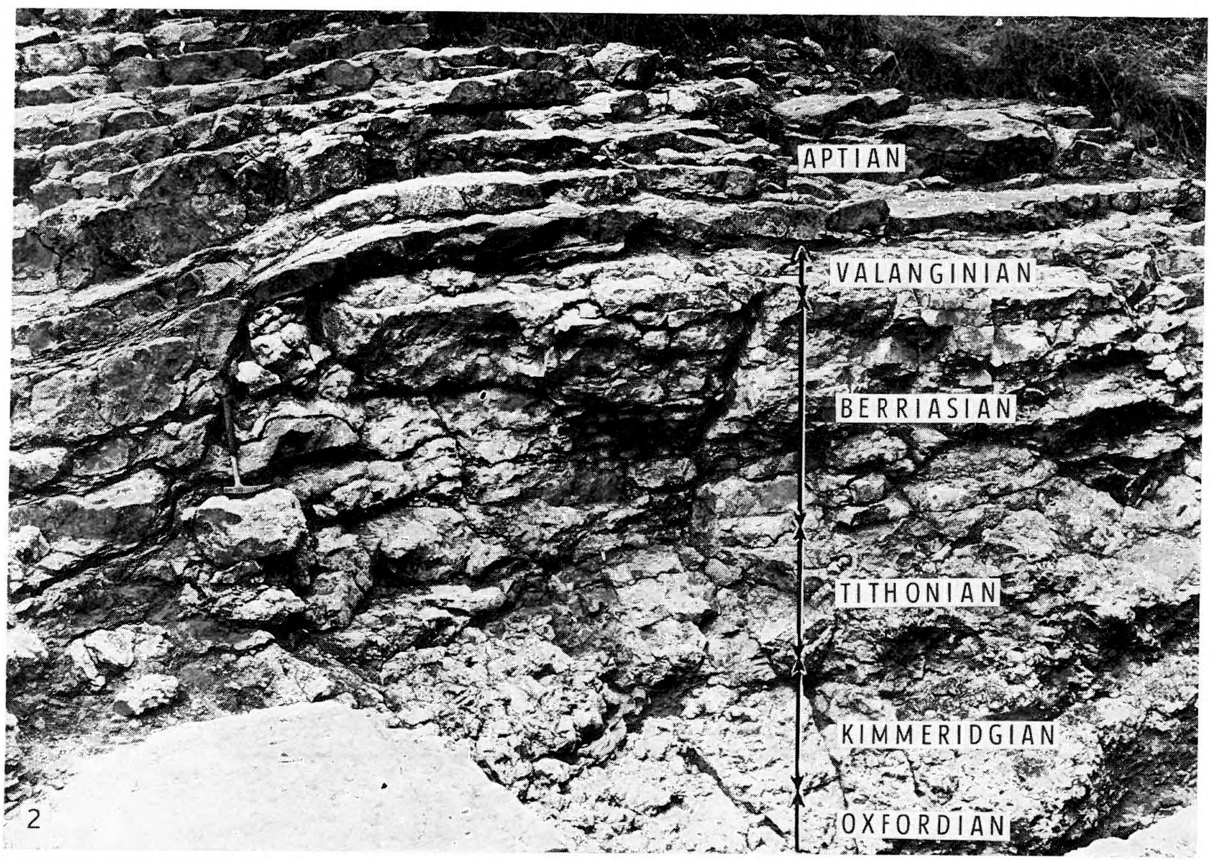
APTIAN
VALANGINIAN
BERRIASIAN
TITHONIAN
KIMMERIDGIAN
OXFORDIAN
2

PLATE XLIII

KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA

Upper Aptian (Clansayan) Tata Limestone

1a—d. *Torynocrinus (Collarocrinus) phialaeformis* SZÖRÉNYI.

2. Serpula remnants at the base of the grey crinoidal limestone.
3. Upper Aptian (Clansayan) grey crinoidal limestone (K_2) pinching out above the Upper Jurassic-Berriasian sequence (J_3).
4. Upper Aptian (Clansayan) grey crinoidal limestone layers below the cemetery wall.

XLIII

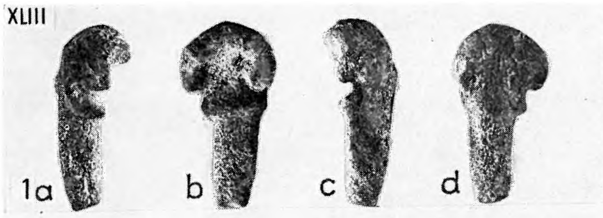

PLATE XLIV

Upper Aptian (Clansayan) Tata Limestone

1. Contact of Berriasian limestone and Upper Aptian grey crinoidal limestone with stromatolite-coated limestone debris at the base of the Tata Limestone.
   Borehole TVG-5, 58.8—58.95 m.
2. Fossils accumulated at the base of the Tata Limestone.
   Exposure in front of the property 21, Fazekes Street, Tata.

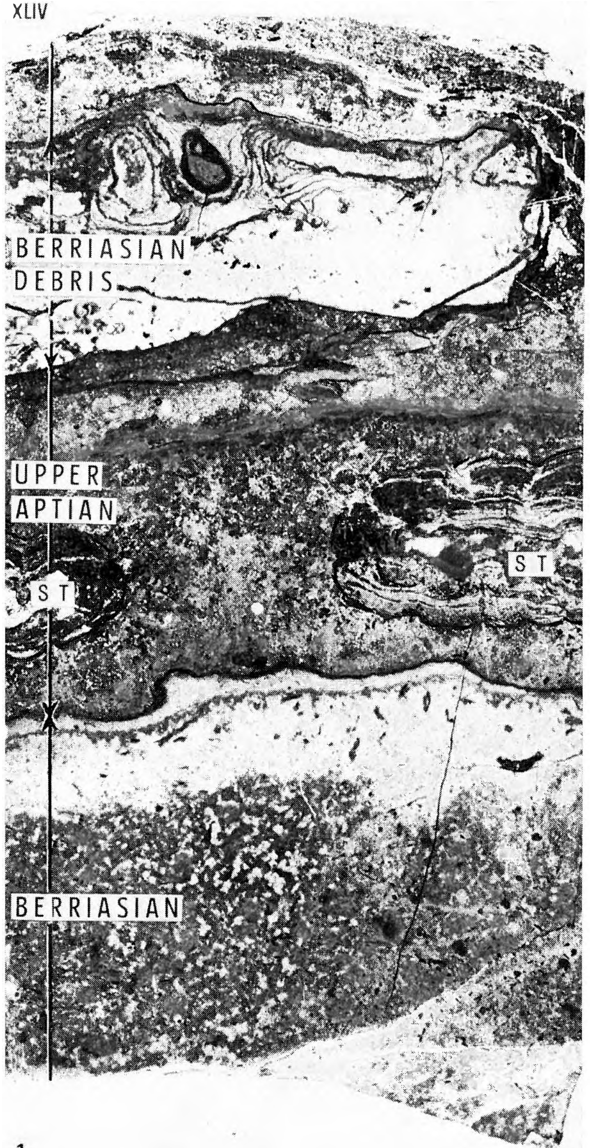

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PLATE XLV

KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA

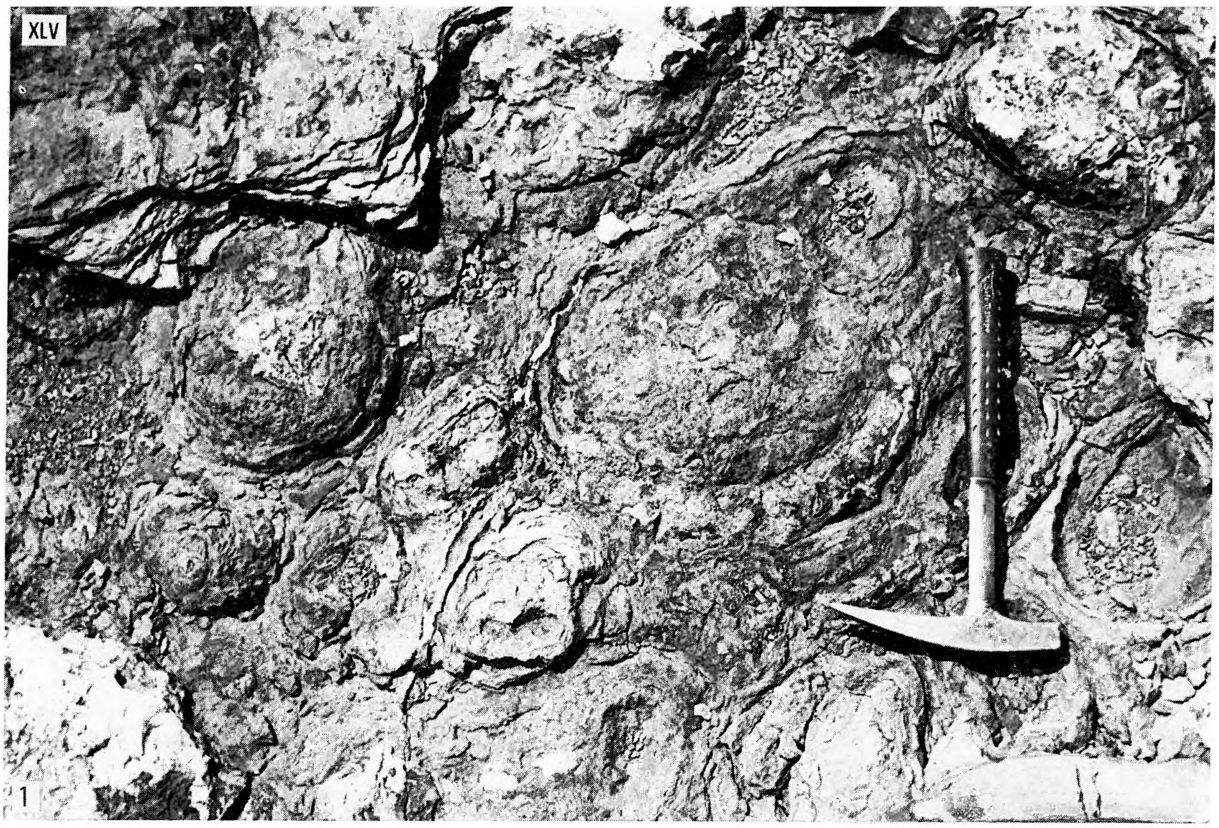
Upper Aptian (Clansayan) Tata Limestone

1. Stromatolitic coating at the base of the Upper Aptian grey crinoidal limestone, on the surface of the underlying Tithono-Berriasian limestone.

2—3. Stromatolite-coated Jurassic limestone debris. Section. 1/1.

4. Stromatolite-coated Jurassic limestone debris. 1/1.

XLV



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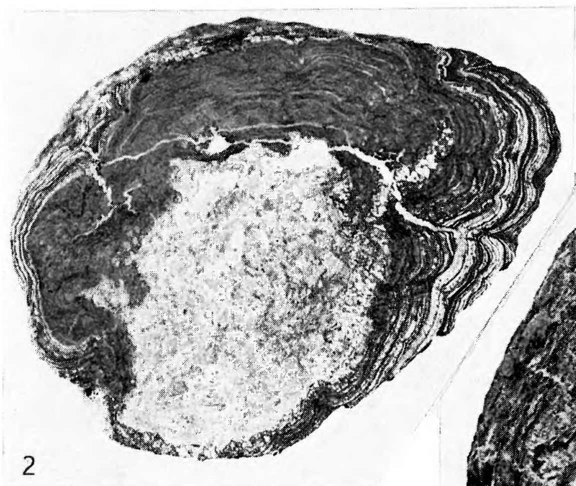

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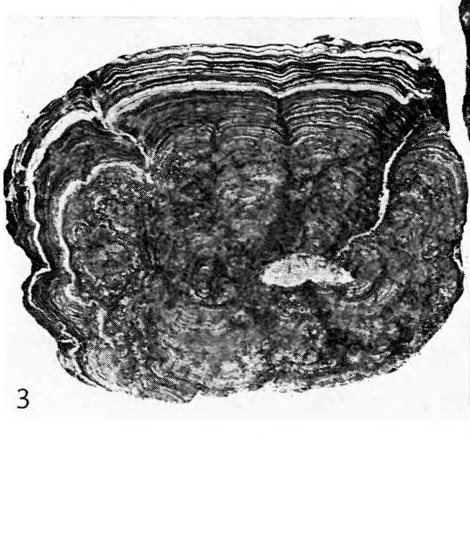

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Upper Aptian (Clansayan) Tata Limestone

Thin sections from the basal layers exposed in front of the Grammar School

1—7. Characteristic microscopic image of glauconite in the Tata Limestone.
   1. Glauconite grain with dia- or epigenetic cracking. 40 ×
   2. Glauconite-filled skeletal fragment of Crinoidea. 40 ×
   3. Glauconite grain in the process of limonitization with minute quartz inclusions. 40 ×
   4. Glauconite-filled skeletal fragments of echinoderms. 40 ×
   5. Limonitized glauconite grain. 40 ×
   6. Fresh glauconite grain. 40 ×
   7. Glauconite-filled sponge skeleton. 80 ×

8. Detrital grain of oöidic Dachstein Limestone from the Tata Limestone. 40 ×

9—10. Detrital grains of diabase from the Tata Limestone. 40 ×

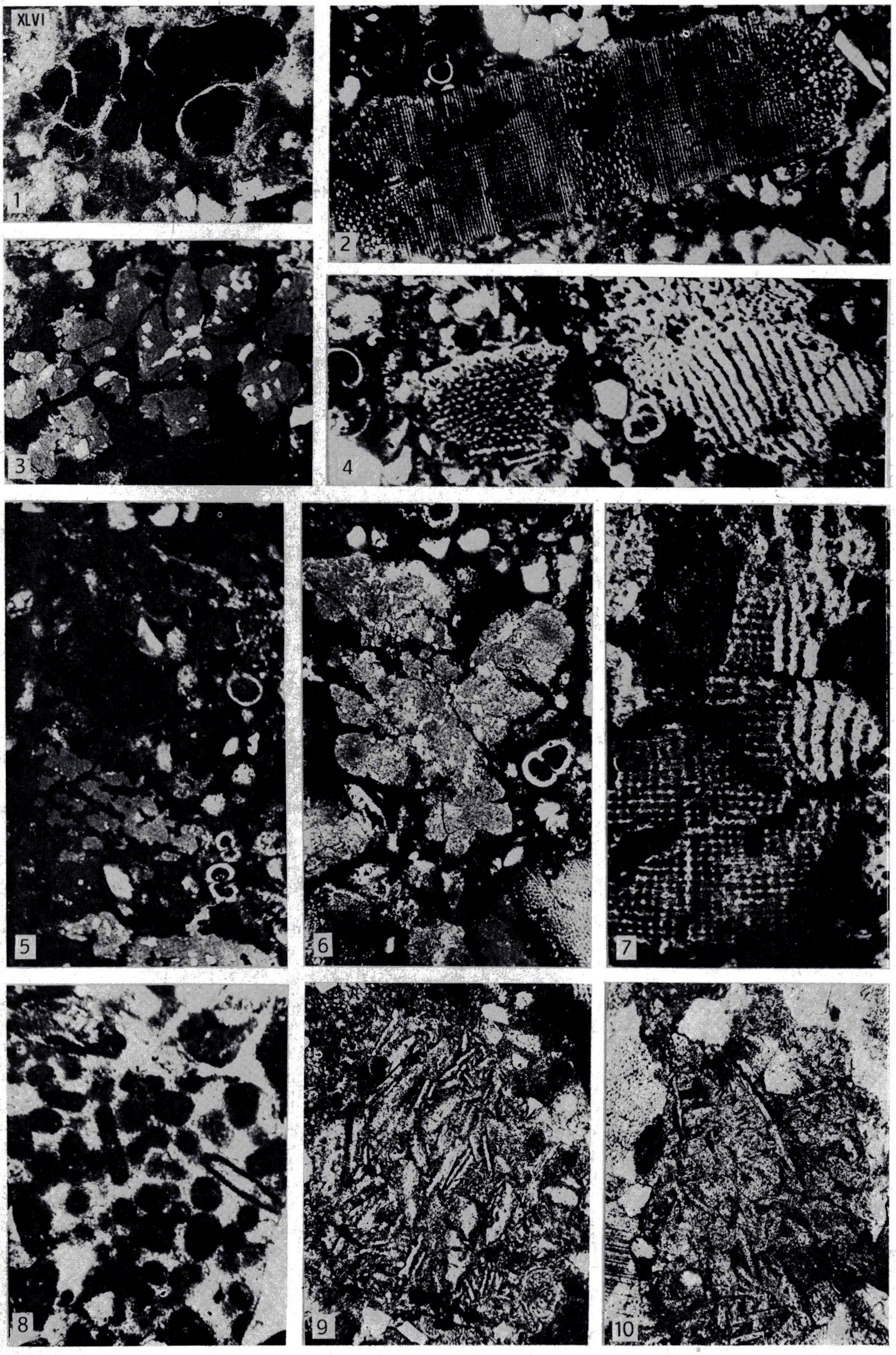
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PLATE XLVII

Upper Aptian (Clansayan) Tata Limestone

Characteristic microfacies types as photographed in thin sections

1. Sandy biosparite. 35.7 ×
   Borehole TVG-45, 101.5 m.
2. Fine-grained, fairly sorted foraminiferal biosparite. 35.7 ×
   Borehole TVG-45, 110.5 m.
3. Coarse-grained sandstone with bio- and extraclasts in a micrite matrix. 27.5 ×
   Borehole TVG-16, 12.0 m.
4. Bioclastic sandstone with a micrite matrix. 35.7 ×
   Borehole TVG-59, 122.7 m.
5. Sandstone with bio- and extraclasts in a micrite matrix. 68 ×
   Borehole TVG-45, 109.5 m.
6. Sandy bioextramicrosparite. 27.5 ×
   Borehole TVG-55, 50.0—52.5 m.
7. Biomicrite. 27.5 ×
   Borehole Ta-1047, 1.0—1.45 m.
8. Bioextrasparite. 27.5 ×
   Borehole TVG-59, 125.0 m.
9. Extrabiomicrosparite. 27.5 ×
   Borehole TVG-17, 11.0 m.

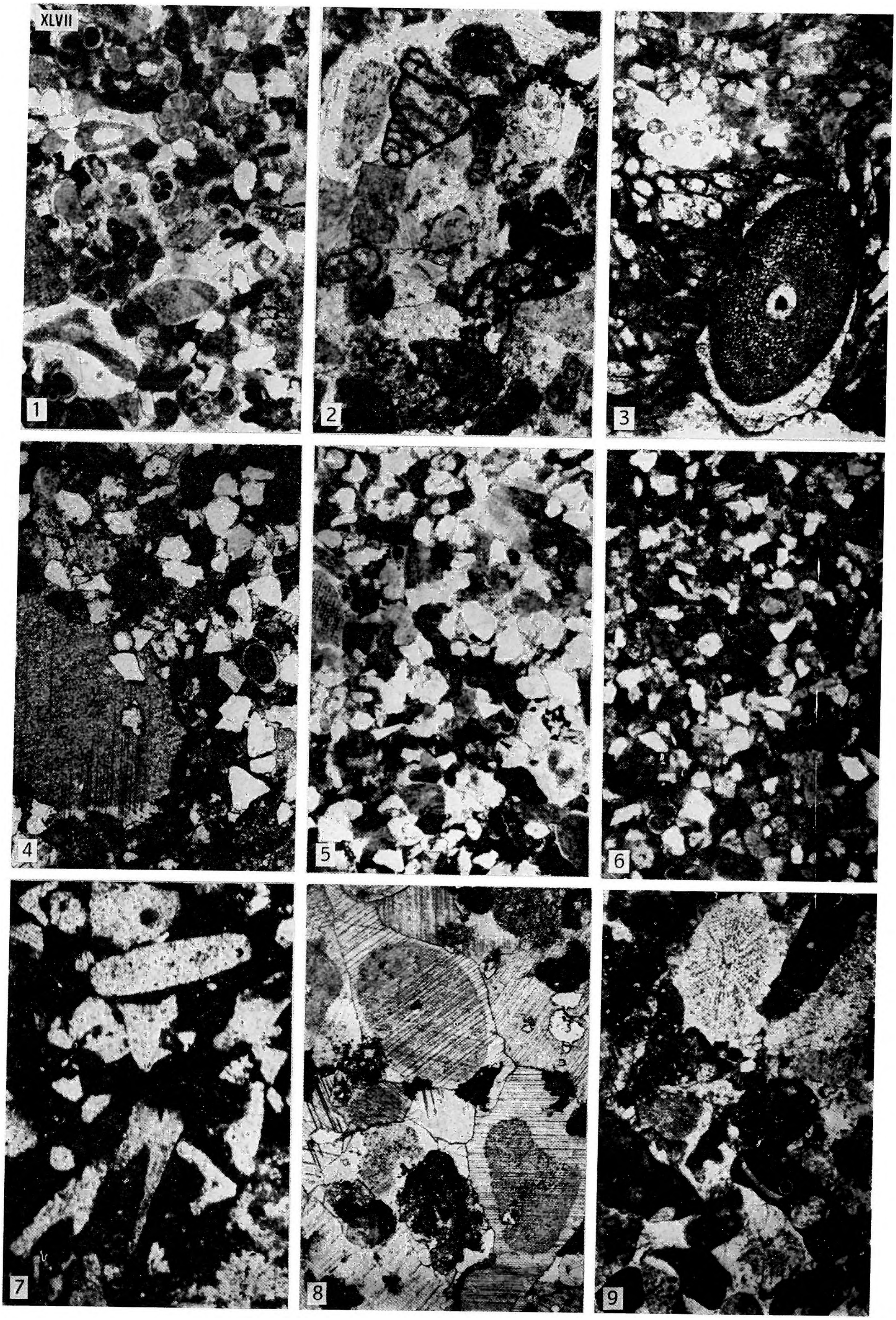
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PLATE XLVIII

Upper Aptian (Clansayan) Tata Limestone

Characteristic microfossils

1. *Lenticulina* sp. 68×
2. *Dorothia* sp. 68×
3. *Bigenerina* sp. 87×
4. *Dorothia (Marssonella)* sp., *Holothurioidea* sp. 68×
5. *Globigerinelloides algerianus* CUSHMAN et TEN DAM. 68×
6. *Cornuspira* sp. 105×
7. *Bryozoa* sp. 43×
8. *Bryozoa* sp. 27.5×
9. *Ticinella* sp. 43×


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PLATE XLIX

KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA

Upper Aptian (Clansayan) Tata Limestone

Fossils from the base of the grey crinoidal limestone

1. *Serpula filiformis* Sow. 2×
2—3. *Holcophylloceras (Salfeldiella) guettardi* (Rasp.) 1/1
4—8., 12—13. *Tetragonites duvalianus* (Orb.) 1/1
14—15. *Tetragonites heterosulcatus* (Anth.) 1/1
10, 16. *Ptychoceras* sp. 1/1
9, 11. *Hamites* sp. 1/1

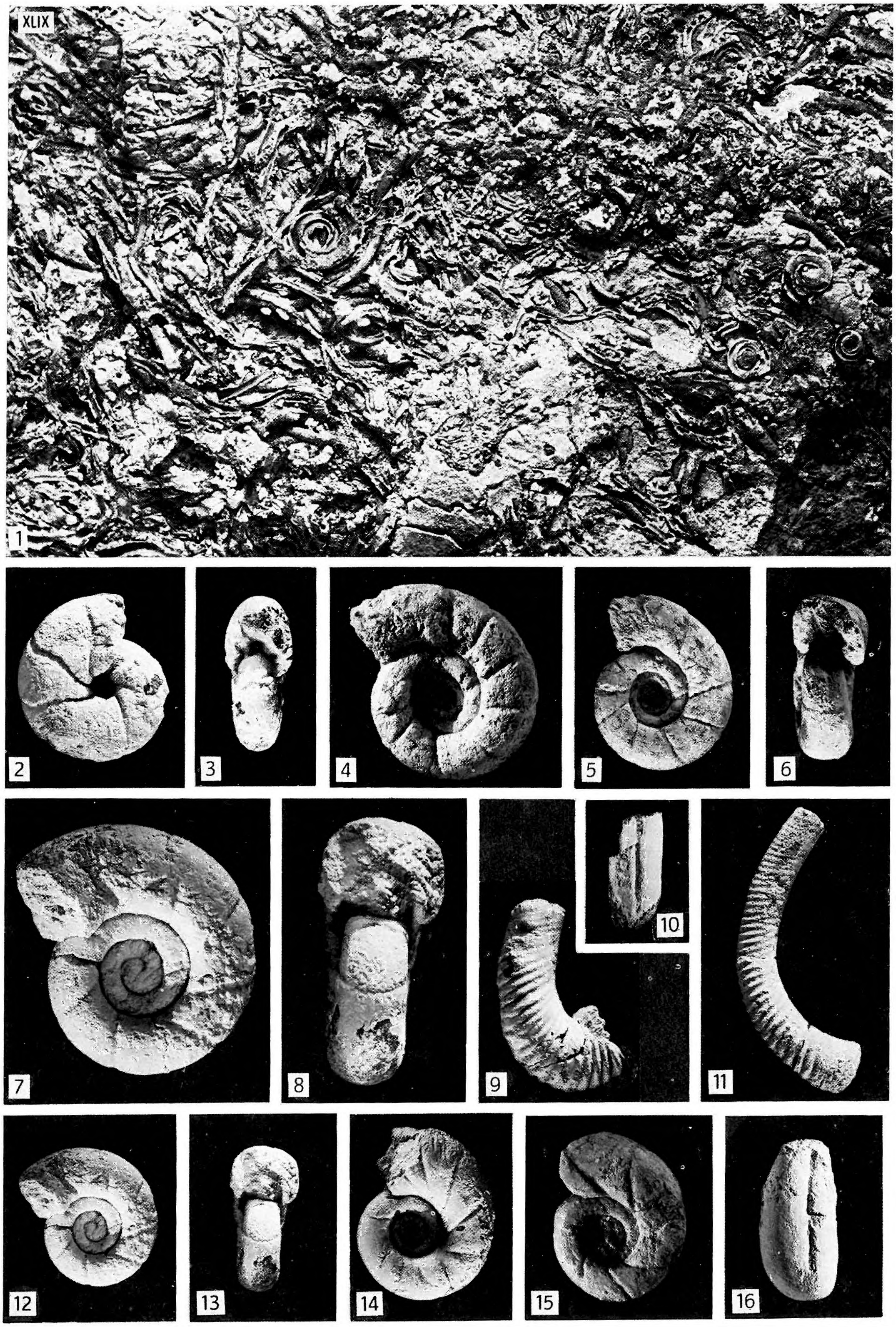
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PLATE L

KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA

Upper Aptian (Clansayan) Tata Limestone

Ammonoidea from the base of the grey crinoidal limestone

1— 5. *Valdedorsella getulina* (Coq.) 1/1
6— 7. *Valdedorsella* sp. 1/1
8. *Puzosiella minuta* Jegojan. 1/1
9—11. *Puzosiella* (div. sp.) 1/1
12, 14. *Uhligella* sp. 1/1
13. *Melchiorites* sp. 1/1
15. *Acanthohoplites bigoureti* Seunes. 1/1
16. *?Dufrenoyia* sp. 1/1
17. *Colombiceras* sp. 1/1
18. *Diadochoceras nodosocostatum* (Orb.) 1/1
19. *Acanthohoplites nolani* (Seunes)
20. *Parahoplites uhligi* Anth.

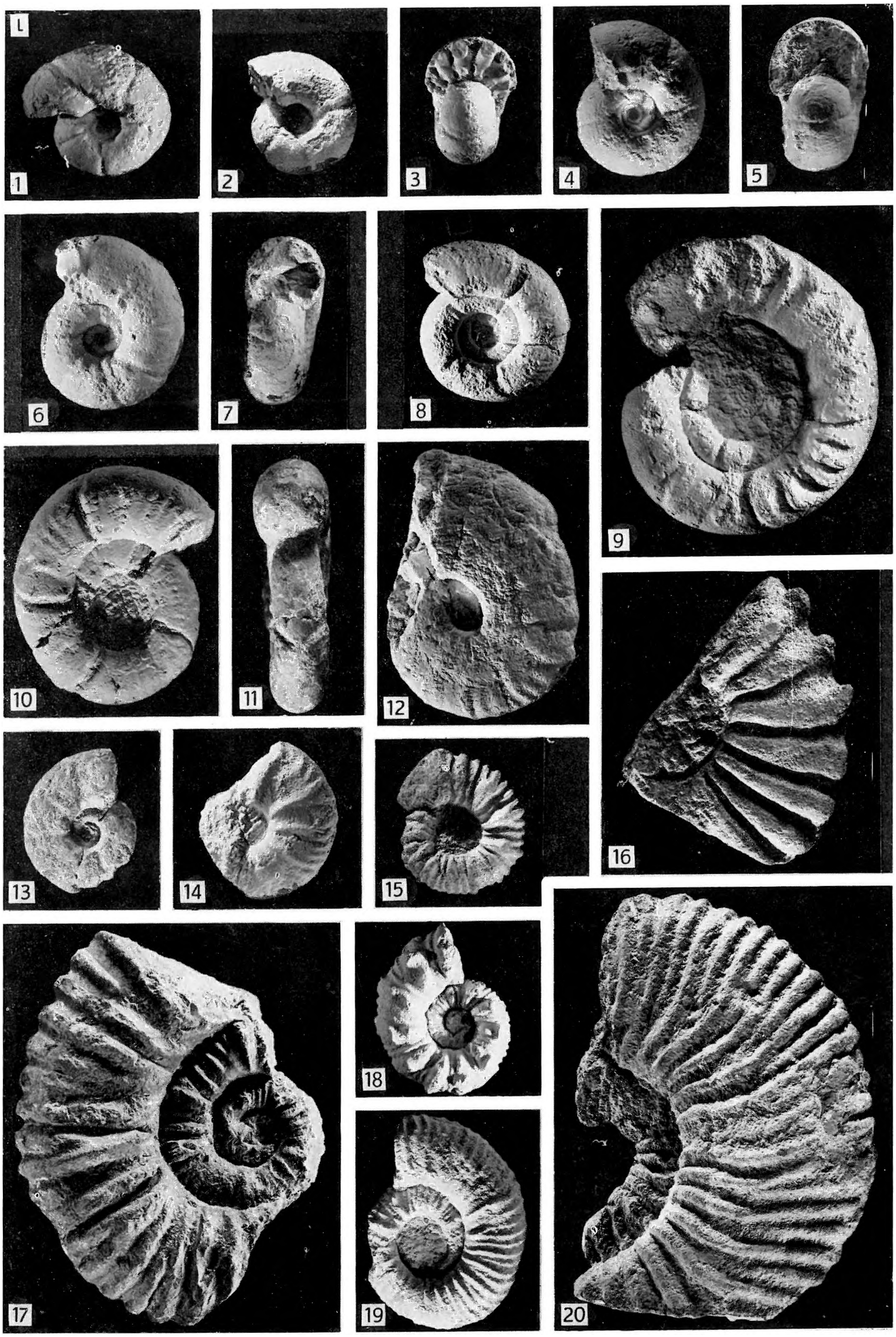
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PLATE LI

Lower Albian dark grey siltstone

Spore-pollen and microplankton remnants

1. *Cicatricosisporites furcatus* DEÁK 1963
   Borehole TVG-59, 89 m.
2. *Cicatricosisporites hughesi* DETTMANN 1963
   Borehole TVG-40, 37 m.
3. *Cicatricosisporites potomacensis* BRENNER 1963
   Borehole TVG-59, 89 m.
4. *Cicatricosisporites pseudotripartitus* (BOLCH. 1961) DETTMANN 1963
   Borehole TVG-59, 79 m.
5. *Cicatricosisporites* sp.
   Borehole TVG-59, 89 m.

6—7. *Appendicisporites crenimurus* SRIVASTAVA 1972
   Borehole TVG-59, 89 m.

8. *Appendicisporites* sp.
   Borehole TVG-59, 96 m.
9. *Trilites (Trilites) triangulatus* KDS. 1964
   Borehole TVG-45, 68 m.
10. *Trilites (Bikolisporites) toratus* (WEYL. et GR. 1953) JUHÁSZ 1972
    Borehole TVG-45, 68 m.
11. *Ischyosporites pseudoreticulatus* (COUPER 1958) DÖR. 1966
    Borehole TVG-22, 59 m.
12. *Ischyosporites* sp.
    Borehole TVG-45, 68 m.
13. *Corniculatisporites* sp.
    Borehole TVG-45, 62.2 m.
14. *Leiosphaeridia* sp. 750×
    Borehole TVG-22, 56.2—57 m.
15. Air-sacked coniferous pollen (*Podocarpidites* sp.)
    Borehole TVG-45, 62.2 m.
16. *Classopollis torosus* (REISS.) COUPER 1958
    Borehole TVG-22, 54.8—55.5 m.
17. *Inaperturopollenites hiatus* (R. POT. 1931) TH. et PF. 1953
    Borehole TVG-59, 96 m.
18. *Neoraistrickia* sp.
    Borehole TVG-59, 89 m.
19. *Hystrichosporis* sp. Tetrad
    Borehole TVG-59, 77 m.

1—13. and 15—19: 1000×

Photo by J. BÓNA

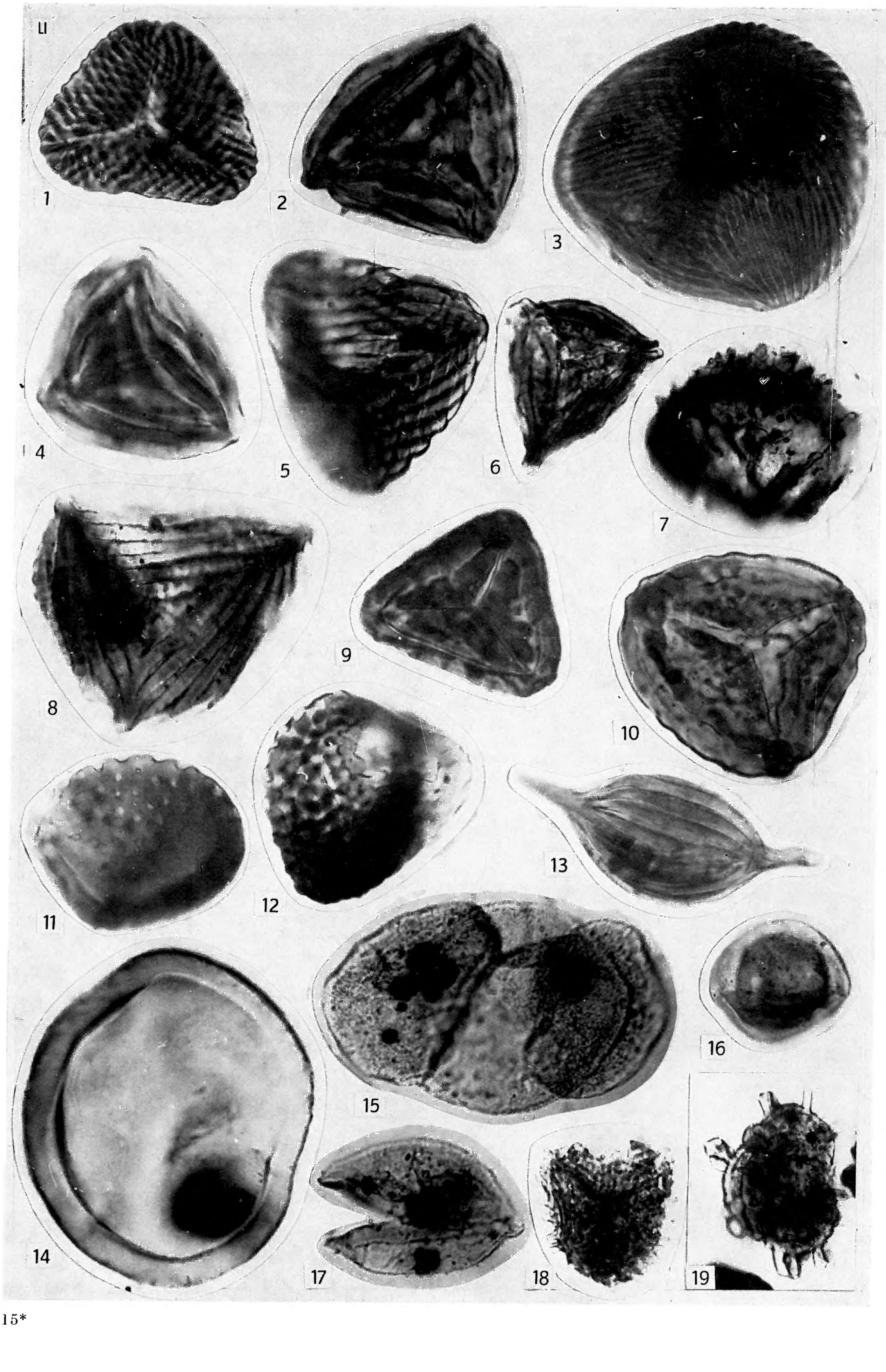
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PLATE LII

Lower Albian dark grey siltstone

Foraminiferal fauna

1—1a. *Ticinella* sp. 52 ×
Borehole T-150, 274.50—275.50 m.

2—2a. *Ticinella roberti* (GAND.) 52 ×
Borehole T-150, 274.50—275.50 m.

3—3a. *Hedbergella planispira* (TAPPAN) 80 ×
Borehole T-150, 275.50—276.50 m.

4—4a. *Gavelinella rudis* (RSS.) 52 ×
Borehole T-150, 292.00 m.

5. *Lenticulina sulcifera* (RSS.) 52 ×
Borehole TVG-22, 54.80—55.50 m.

6. *Globulina prisca* RSS. 80 ×
Borehole TVG-22, 54.00—54.80 m.

7. *Tritaxia tricarinata* RSS. 33.3 ×
Borehole T-150, 303.00 m.

8. *Dorothia gradata* (BERTH.) 40 ×
Borehole T-150, 275.50—276.50 m.

9. *Lenticulina gaultina* (BERTH.) 40 ×
Borehole T-150, 292.00 m.

10. *Dorothia gradata* (BERTH.) 40 ×
Borehole T-150, 292.00 m.

11. *Lenticulina gaultina* (BERTH.) 40 ×
Borehole TVG-22, 58.00—58.50 m.

12. *Proteonina* sp. 40 ×
Borehole T-150, 275.50—276.50 m.

13. *Lingulina lamellata* TAPPAN. 52 ×
Borehole T-150, 292.00 m.

14. *Frondicularia* sp. 40 ×
Borehole TVG-22, 55.50—56.20 m.

15. *Planulina schloenbachi* (RSS.) 52 ×
Borehole TVG-22, 55.60—56.20 m.

16—16a. *Gavelinella intermedia* (BERTH.) 40 ×
Borehole TVG-22, 54.00—54.80 m.

17. *Tristix excavata* (RSS.) 40 ×
Borehole T-150, 292.00 m.

18. *Eoguttulina anglica* CUSHM. et OZAWA. 80 ×
Borehole T-150, 292.00 m.

19. *Eoguttulina anglica* CUSHM. et OZAWA. 80 ×
Borehole TVG-22, 55.50—56.20 m.

20. *Ammobaculites* sp. 33.3 ×
Borehole TVG-22, 58.00—58.50 m.

21. *Marginulina* sp. 33.3 ×
Borehole TVG-22, 58.00—58.50 m.

22—22a. *Epistomina* sp., pyritized. 40 ×
Borehole T-150, 292.00 m.

23. *Dentalina* sp., fragment. 52 ×
Borehole TVG-59, 69.00 m.

24. *Vaginulina recta* RSS. 52 ×
Borehole T-150, 287.00 m.

25. *Reophax* sp., fragment. 52 ×
Borehole T-150, 292.00 m.

26. *Spiroplectinata annectens* (JONES et PARKER) 52 ×
Borehole T-150, 275.50—276.50 m.

27. *Spiroplectammina* sp. 52 ×
Borehole TVG-45, 62.80 m.

28—28a. *Planulina schloenbachi* (RSS.) 52 ×
Borehole T-150, 303.00 m.

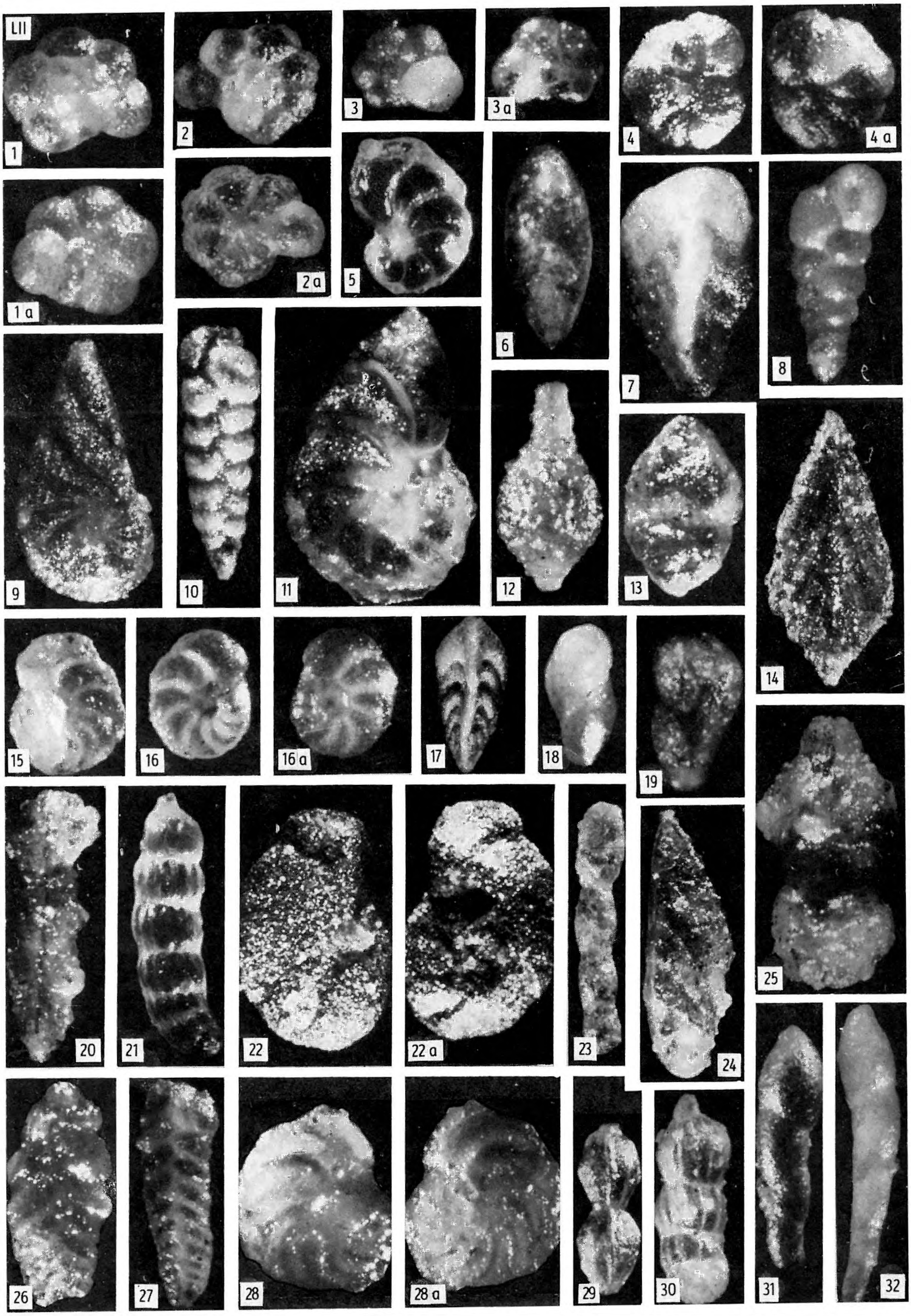
29. *Nodosaria* sp., fragment. 52 ×
Borehole TVG-22, 58.00—58.50 m.

30. *Marginulina jonesi* RSS. 52 ×
Borehole T-150, 303.00 m.

31. *Pleurostomella* cf. *obtusa* BERTH. 52 ×
Borehole T-150, 292.00 m.

32. *Pleurostomella obtusa* BERTH. 52 ×
Borehole T-150, 292.00 m.

Photo by I. BODROGI


LII
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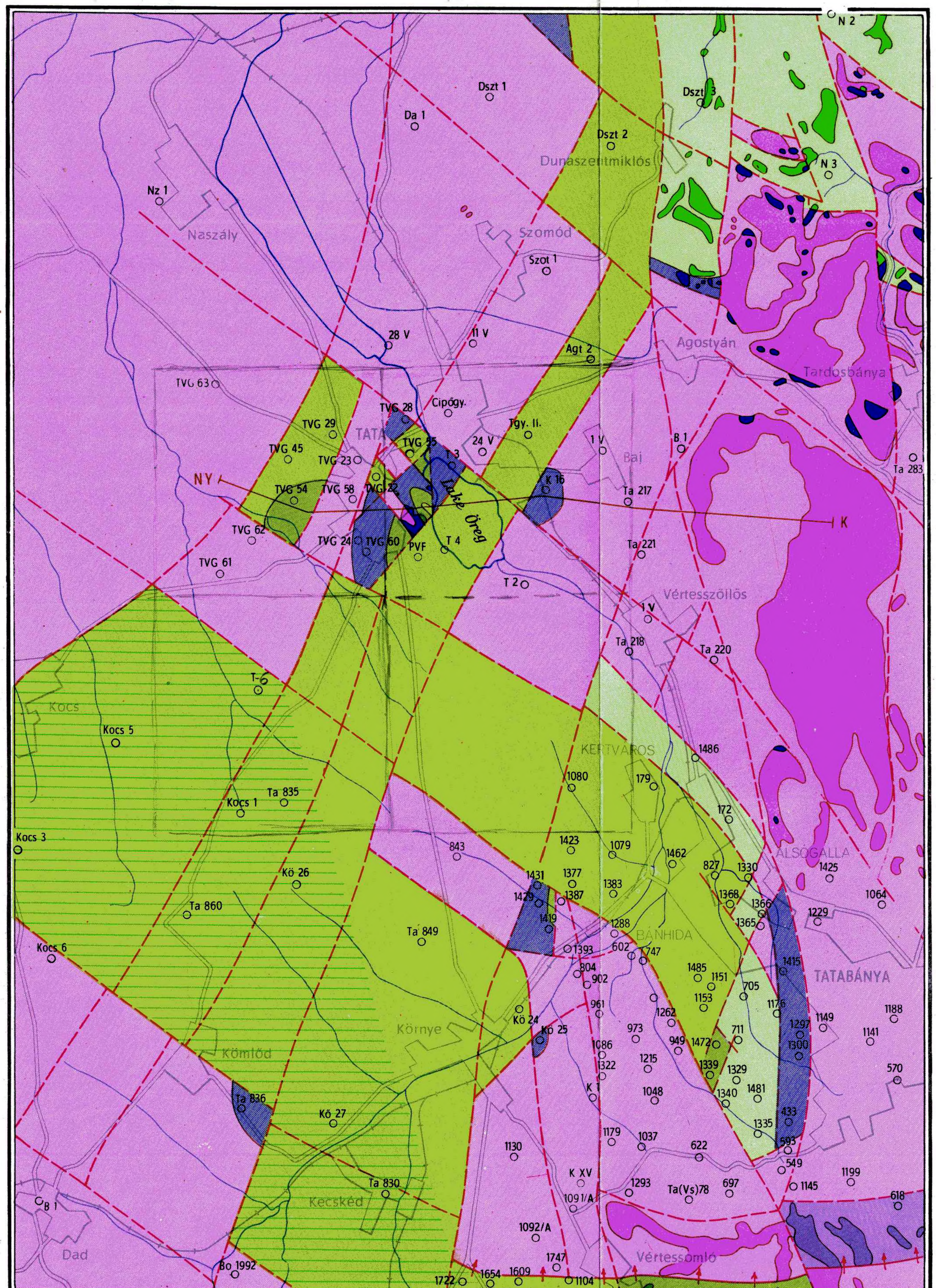


Textfig. 1. MESOZOIC BASEMENT MAP OF THE NW FORELAND OF THE GERECSE MOUNTAINS

PLOTTED by J. FÜLÖP and G. CSÁSZÁR

0 1 2 3 4 km

LEGEND:

Fault line

Reverse fault

LOWER ALBIAN siltstone

LOWER ALBIAN reef limestone

U. APTIAN /CLANSAYASIAN/ grey crinoidal limestone

NEOCOMIAN sandstone

JURASSIC limestone

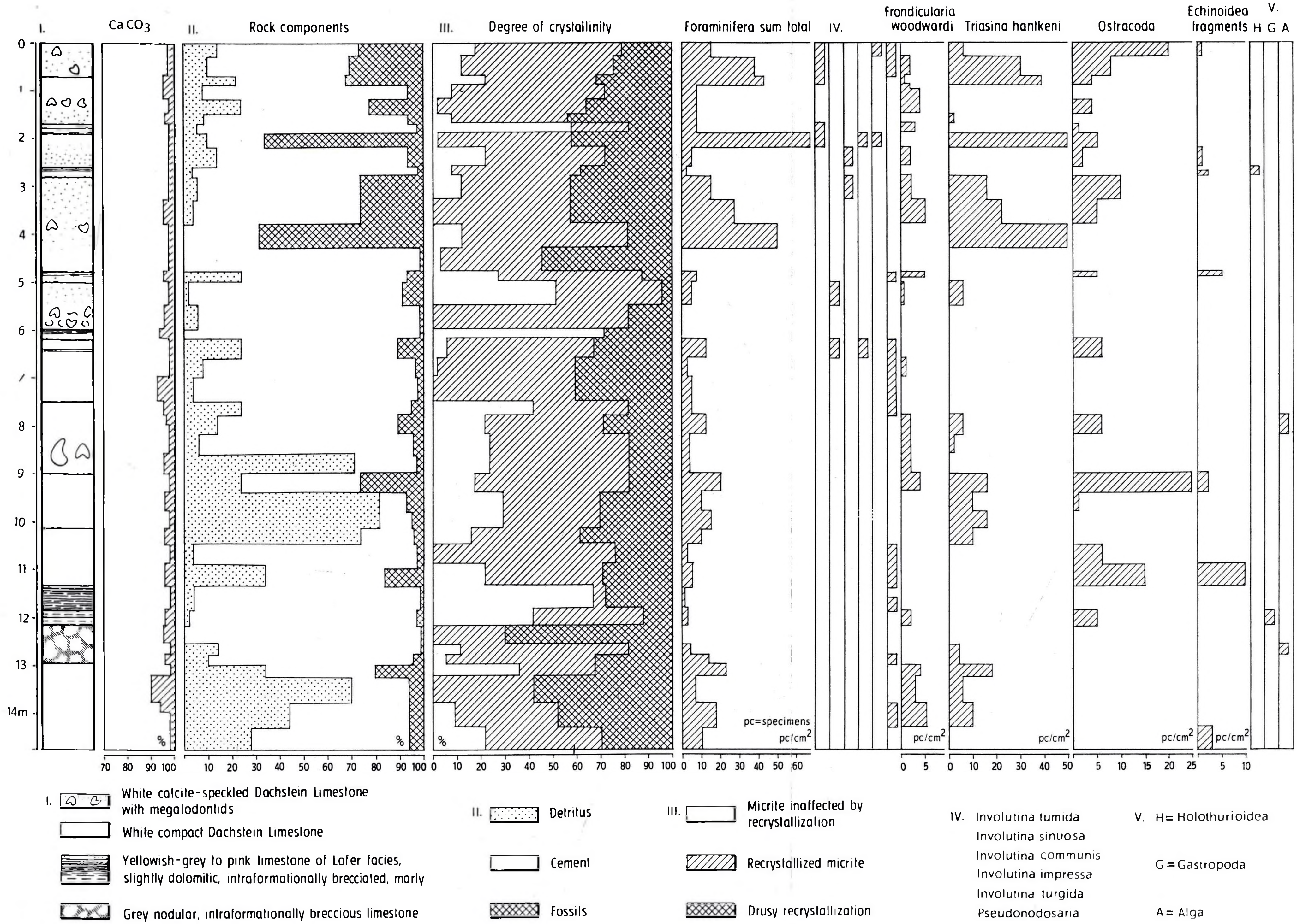
NORIAN-RHAETIAN Dachstein Limestone

NORIAN Hauptdolomit

The darker spots are outcrops

o Ta 1026 Exploratory drill penetrated into Mesozoic

W — E Section line of Textfig. 2



Textfig. 8: KÁLVÁRIA HILL'S SOUTHWESTERN QUARRY YARD. RESULTS OF INVESTIGATIONS OF THE EXPOSED DACHSTEIN LIMESTONE BEDS

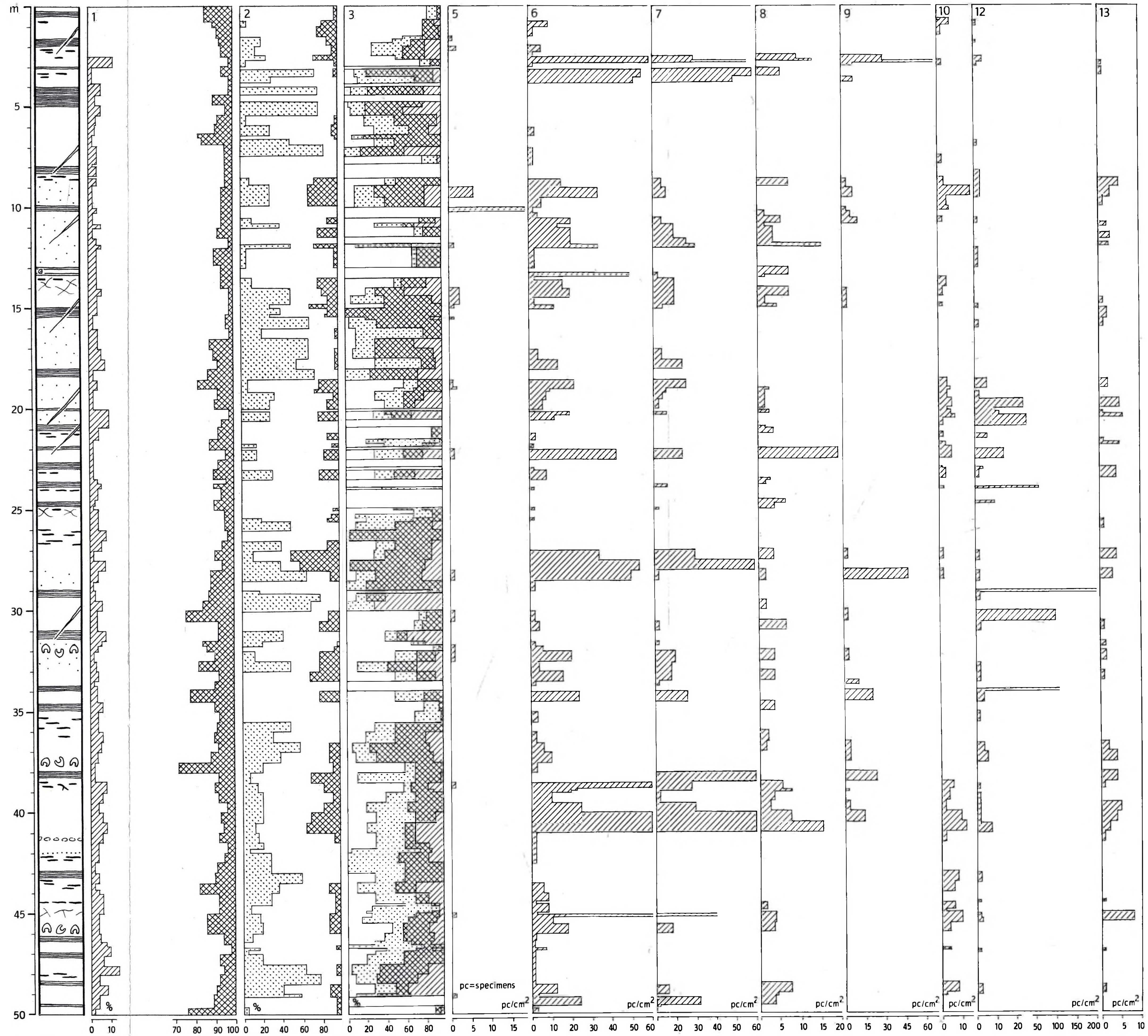
LEGEND TO TEXTFIG. 11-14

COLUMNAR SECTION

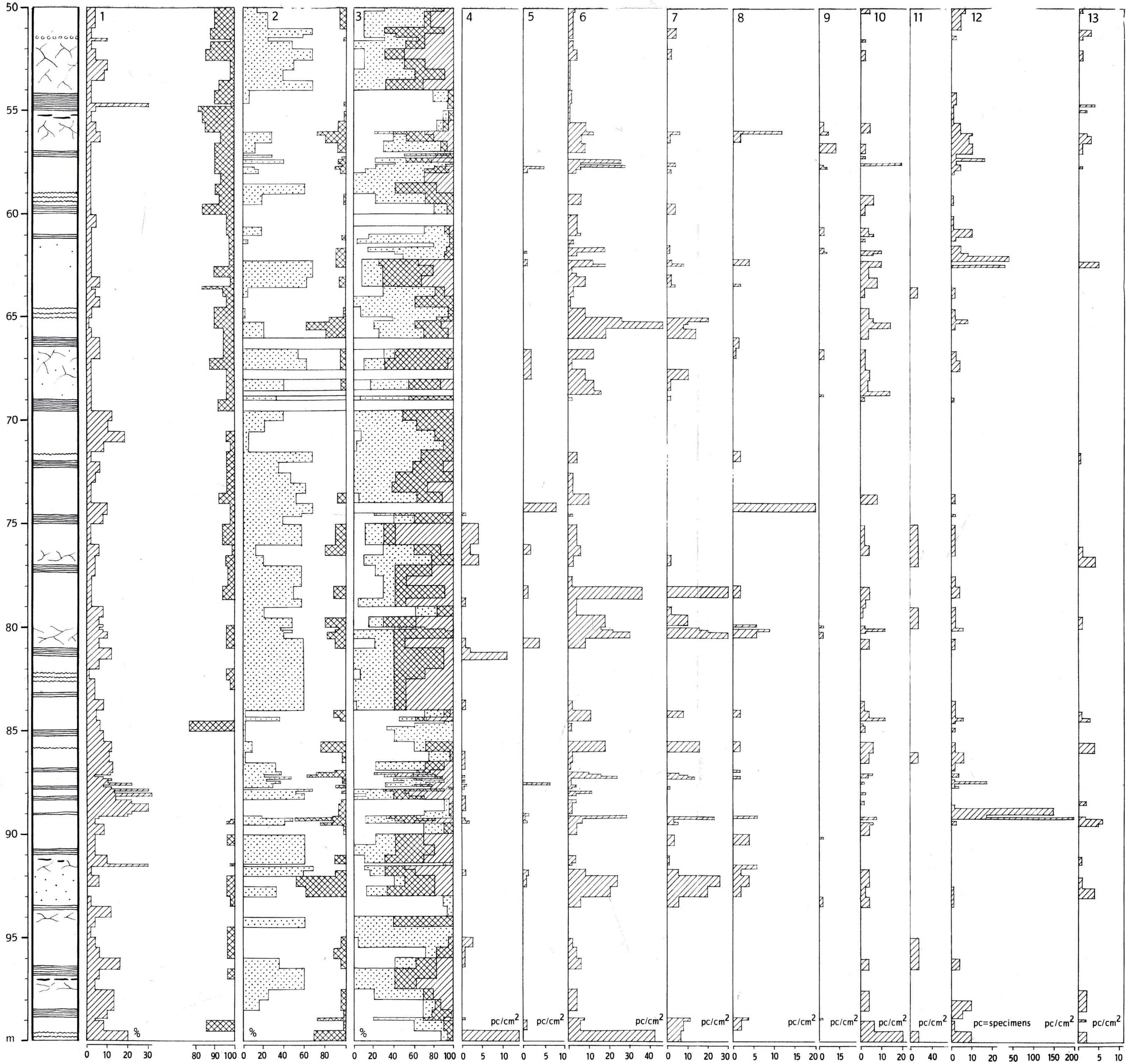
- Subtidal, compact Dachstein Limestone
- Subtidal, calcite-speckled Dachstein Limestone
- Intertidal layers
- Dachstein Limestone stained in a grid pattern
- Intraformational breccia
- Dark grey mottles and speckles
- Calcite-filled druses
- Stylolite
- Jurassic fissure-fill
- Megalodus remnants
- Coral sections
- Hydrozoan colonies

TEST DATA

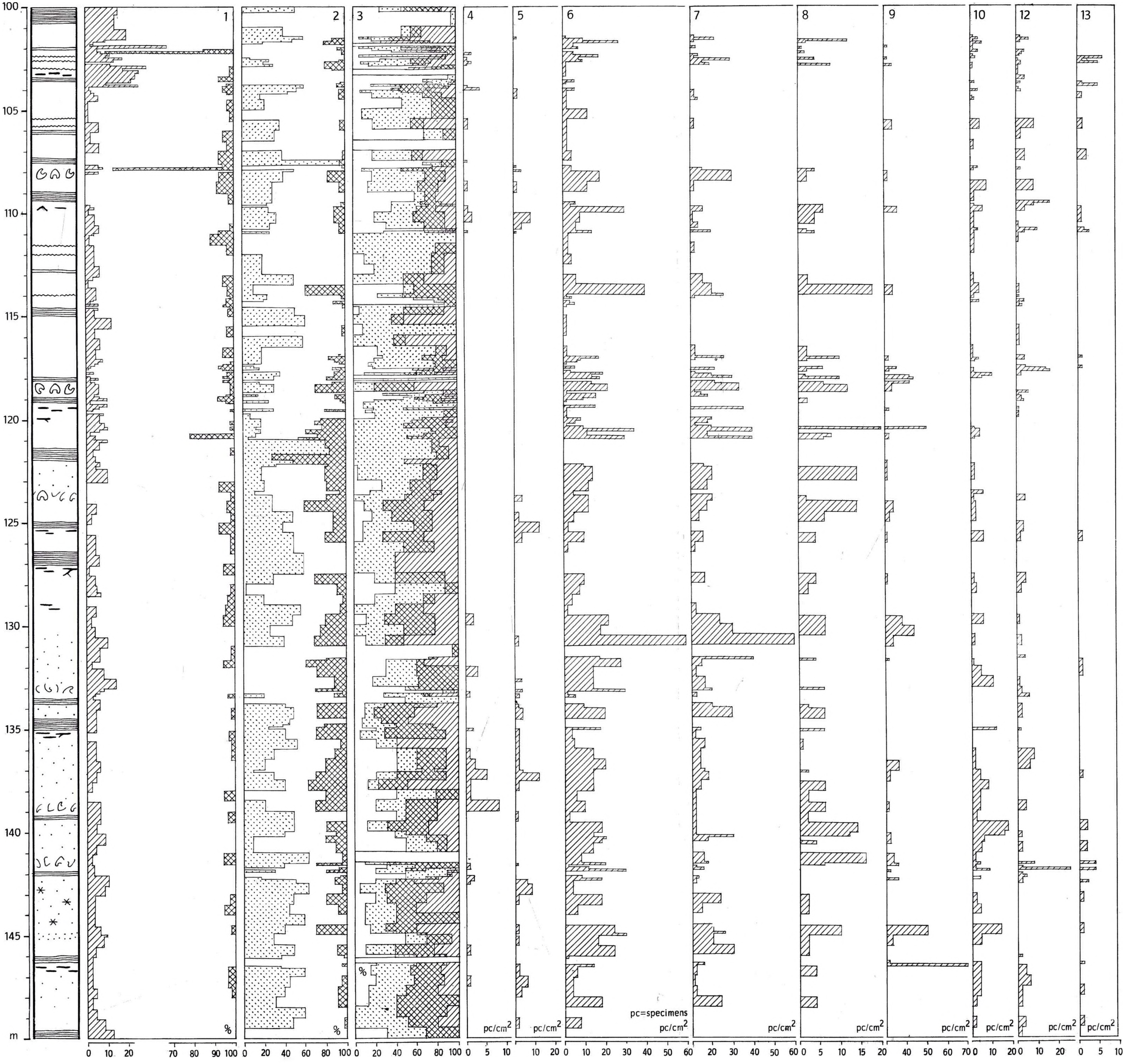
1. $MgCO_3$
   $CaCO_3$
   Insoluble residue
2. Cement
   Detritus of inorganic origin
   Organic detritus
3. Micrite
   Crystalline micrite
   Calcitic druses
   Detritus
4. Globochaete
5. Calcareous algae
6. Foramnifera sum total
7. Triasina
8. Involutina
9. Glomospirella
10. Frondicularia
11. Radiolaria
12. Ostracoda
13. Echinodermata



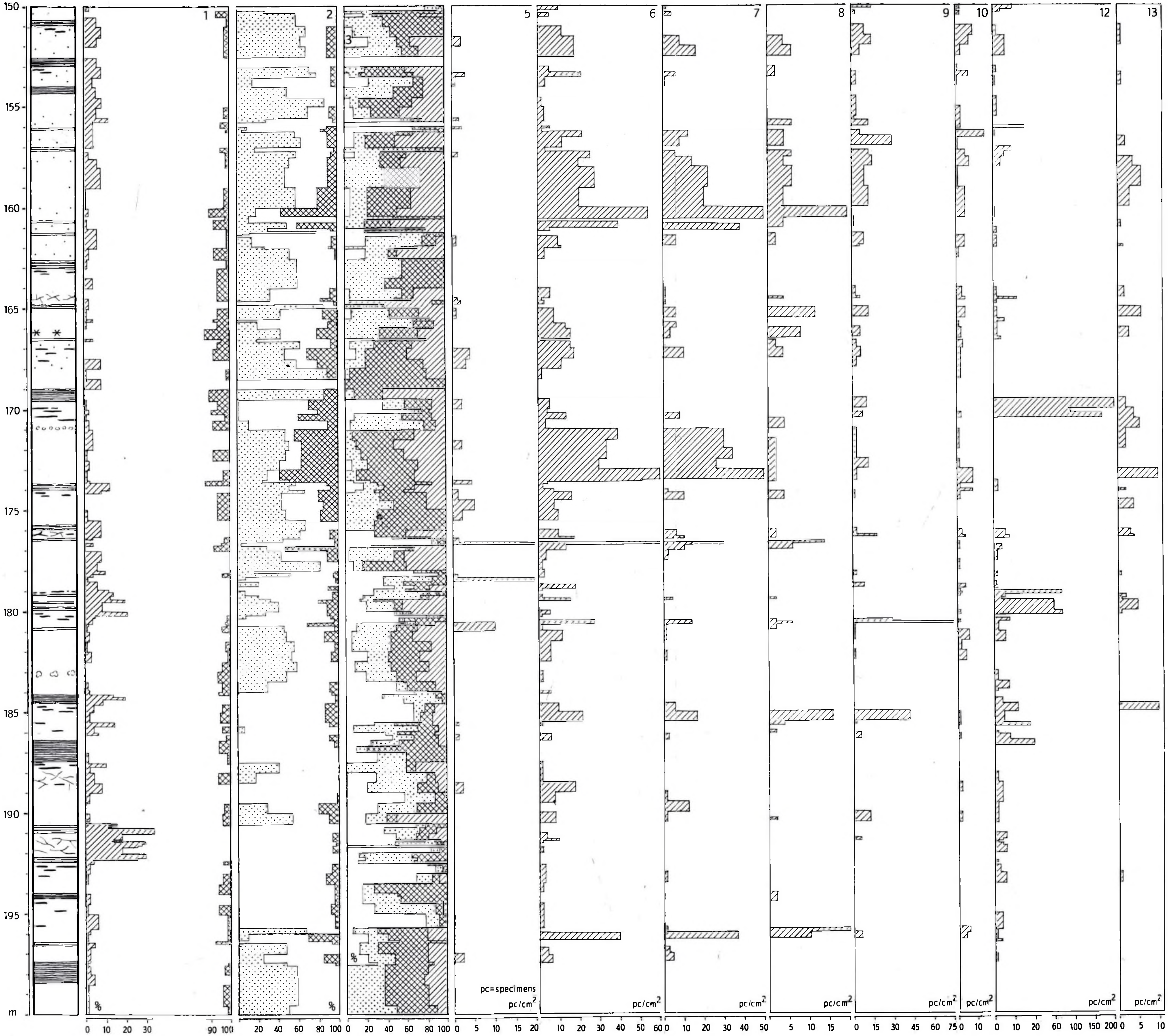
Textfig. 11: LITHOLOGIC LOG OF THE 0 TO 50m interval of BOREHOLE T-5



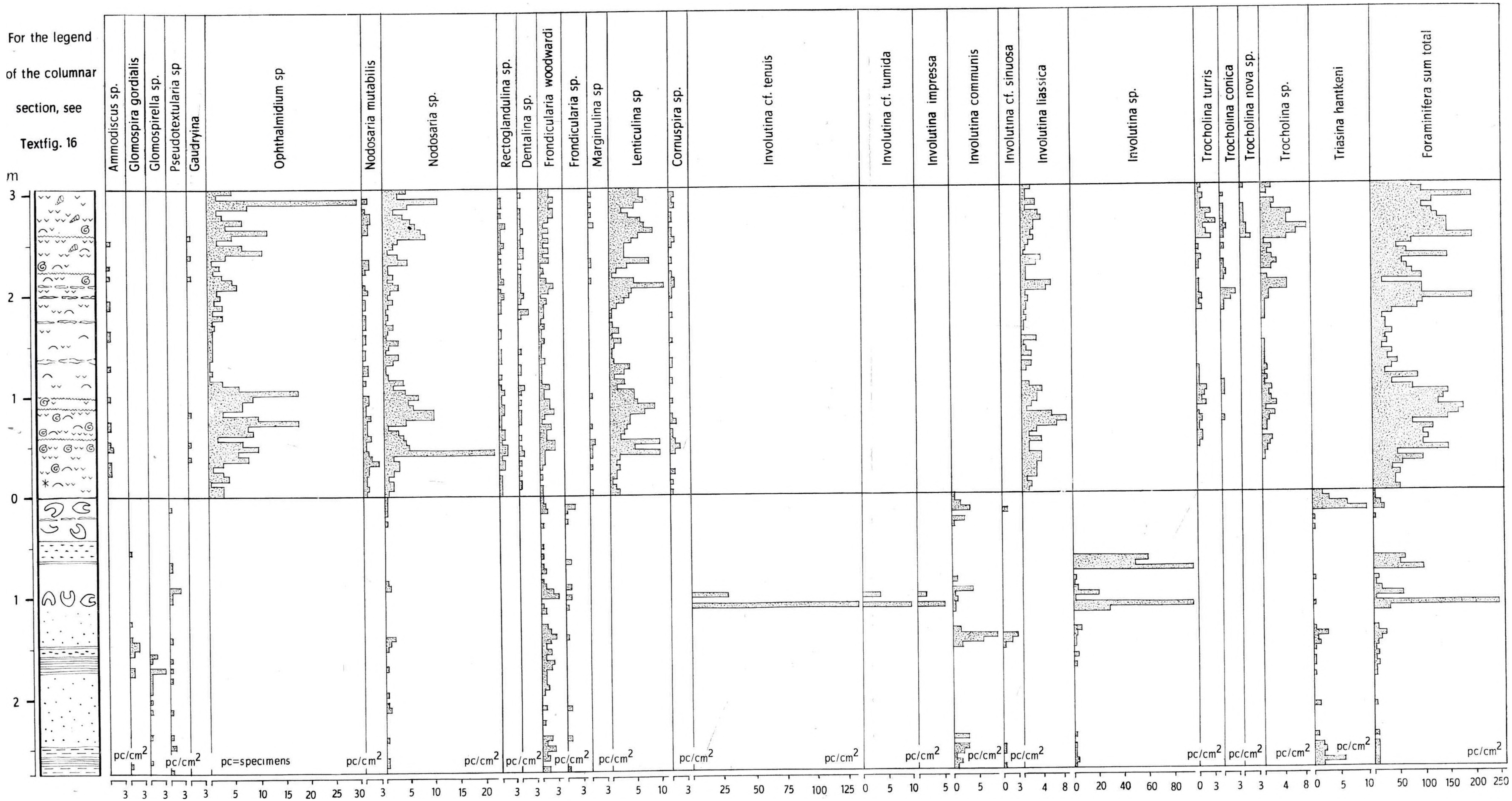
Textfig. 12: LITHOLOGIC LOG OF THE 50 TO 100 m INTERVAL OF BOREHOLE T.5



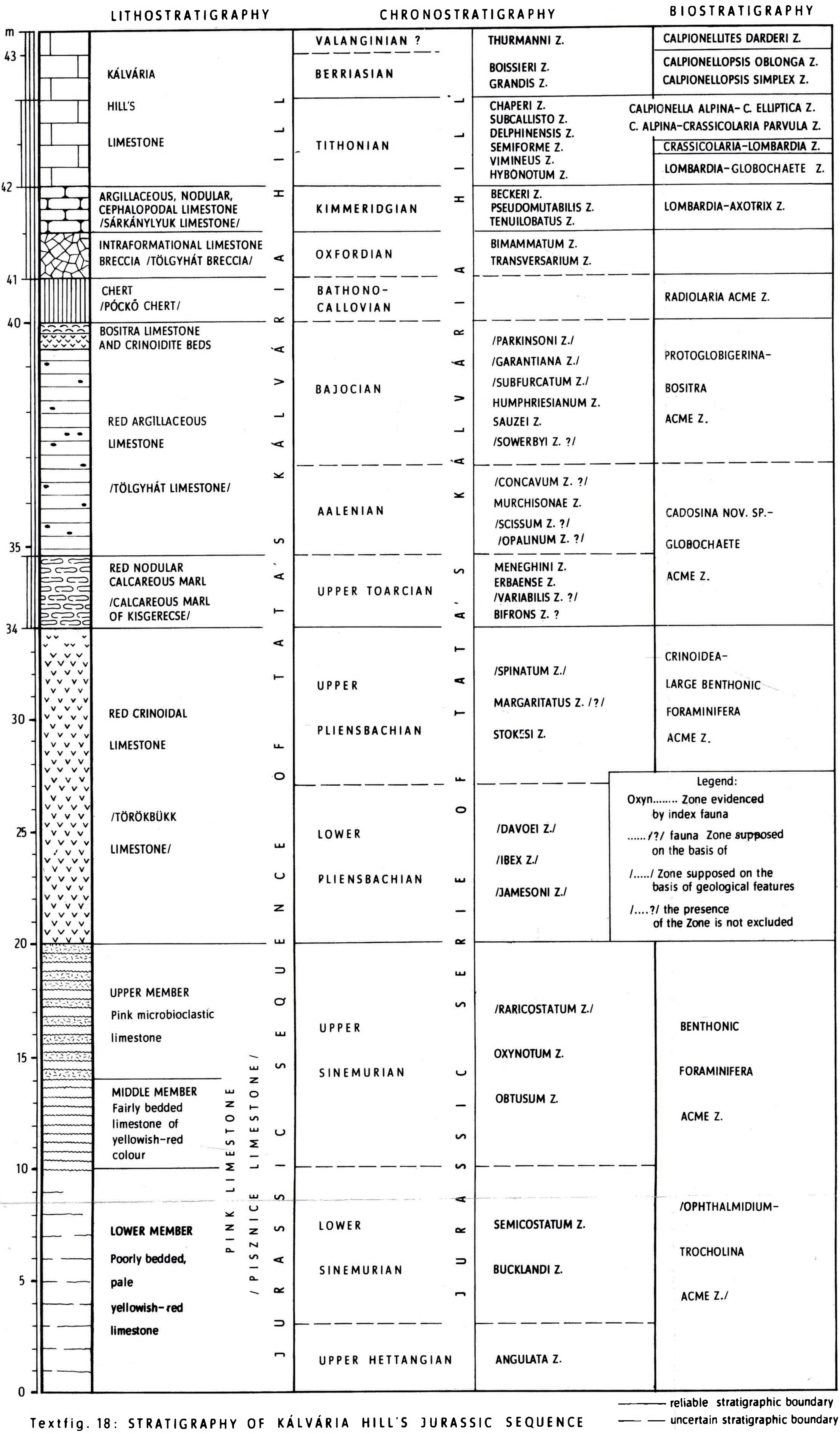
Textfig. 13: LITHOLOGIC LOG OF THE 100 TO 150 m INTERVAL OF BOREHOLE T.5



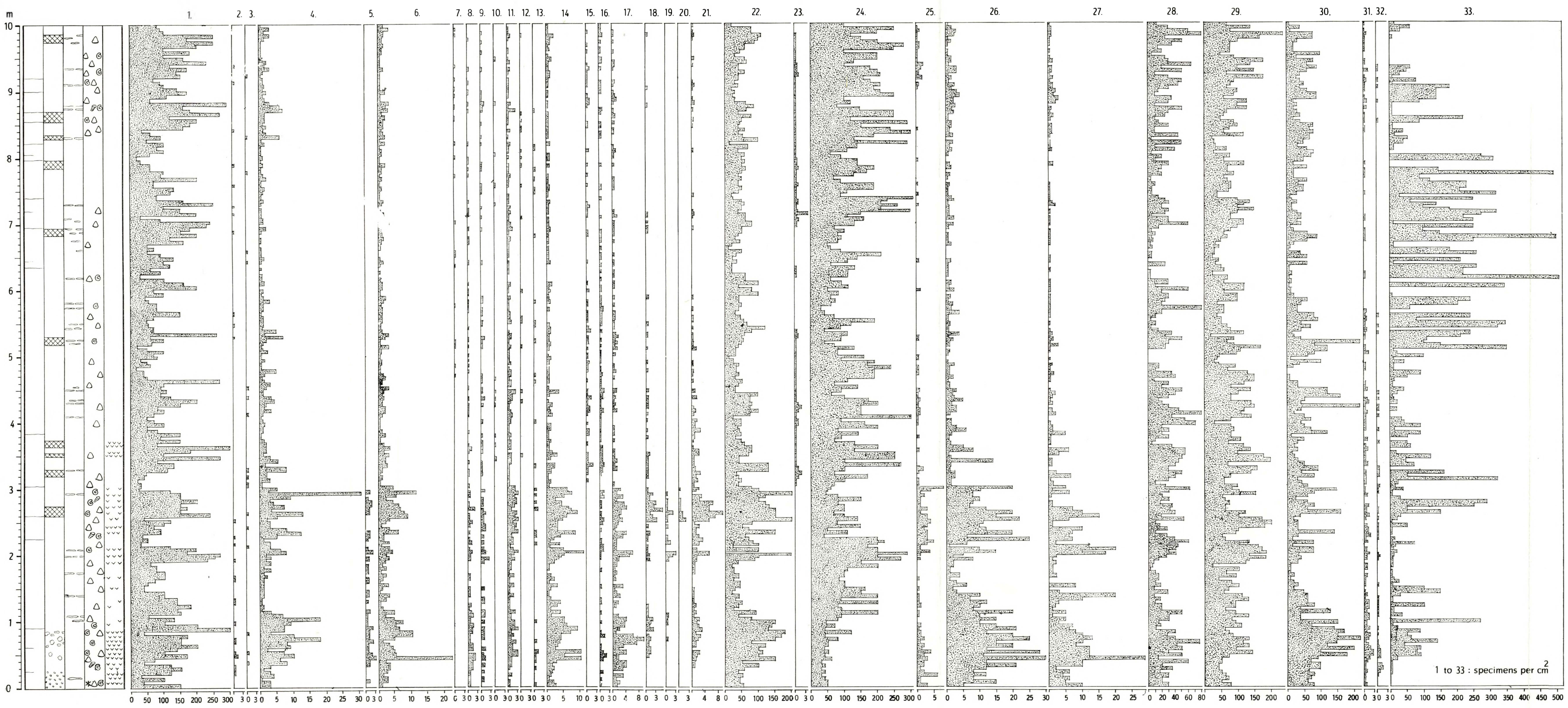
Textfig. 14: LITHOLOGIC LOG OF THE 150 TO 200m INTERVAL OF BOREHOLE T.5



Textfig. 17: FORAMINIFERA FROM THE TOP OF THE RHAETIAN DACHSTEIN LIMESTONE AND THE BASE OF THE UPPER HETTANGIAN PINK LIMESTONE: ANALYTICAL RESULTS. TATA, KÁLVÁRIA HILL



Textfig. 18: STRATIGRAPHY OF KÁLVÁRIA HILL'S JURASSIC SEQUENCE

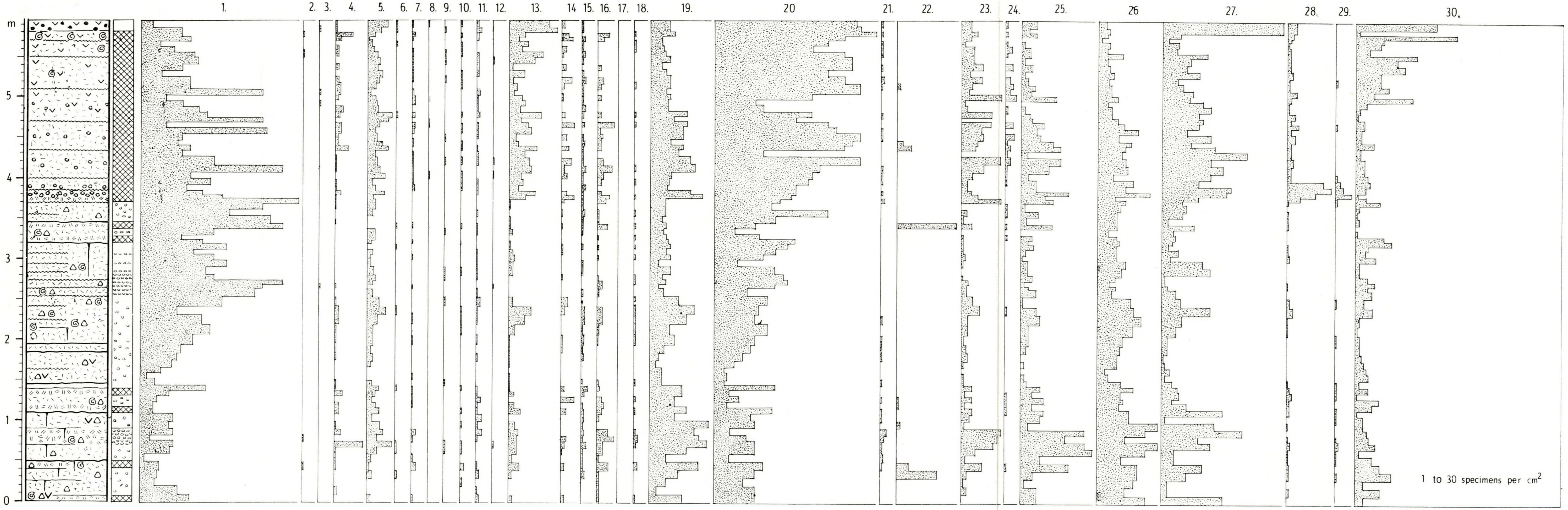


Contact
Oncolite
Lumpy and intraformationally breccious texture
Brachiopoda
Gastropoda
Pseudo-oöid
Sheet crack
Cephalopoda
Solitary coral
Crinoidea

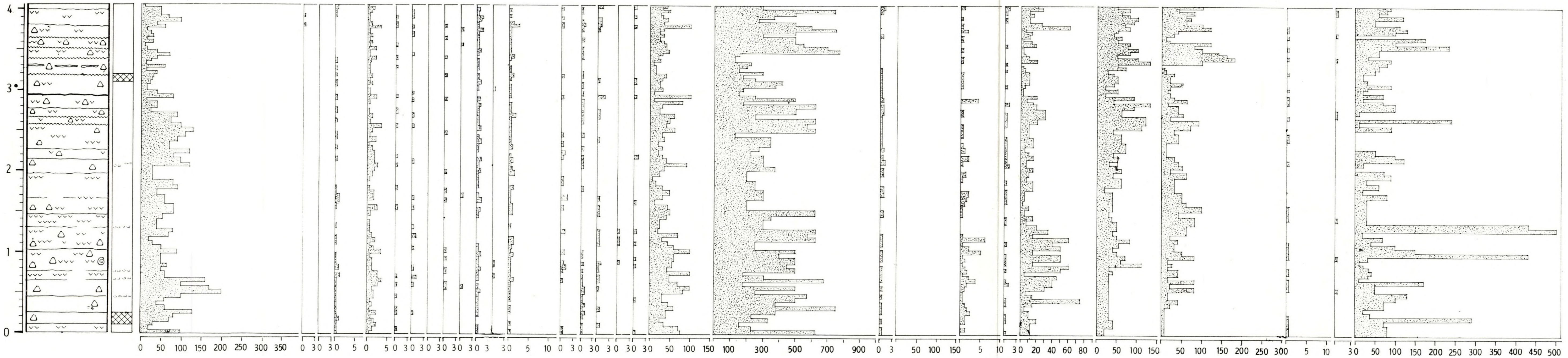
Textfig. 20: LOWER MEMBER /POORLY STRATIFIED, VERY LIGHT PINK/ OF THE LOWER LIASSIC /SINEMURIAN/ PINK LIMESTONE KÁLVÁRIA HILL, TYPE SECTION OF THE LIASSIC

LEGEND to Textfig. 20

1. Globochaete alpina
2. Ammodiscus
3. Gaudryina
4. Ophthalmidium
5. Nodosaria mutabilis
6. Nodosaria sp.
7. Pseudonodosaria
8. Rectoglandulina
9. Dentalina
10. Frondicularia brizaeformis
11. Frondicularia
12. Astacolus
13. Marginulina
14. Lenticulina 1
15. Lenticulina 2
16. Cornuspira
17. Involutina liassica
18. Trocholina turris
19. Trocholina conica
20. Trocholina nova sp.
21. Trocholina sp.
22. Foraminifera sum total
23. Radiolaria
24. Spongia
25. Brachiopoda
26. Gastropoda
27. Ammonites
28. Mollusc shell fragments
29. Ostracoda
30. Crinoidea
31. Echinoidea
32. Holothuricidea
33. Pyrite



Textfig. 22: RED MICROBIOCLASTIC LIMESTONE WITH TINY MANGANESE NODULES /UPPER MEMBER/ KÁLVÁRIA HILL, TYPE SECTION OF THE LIASSIC



Textfig. 21: FAIRLY STRATIFIED PINK LIMESTONE /MIDDLE MEMBER/

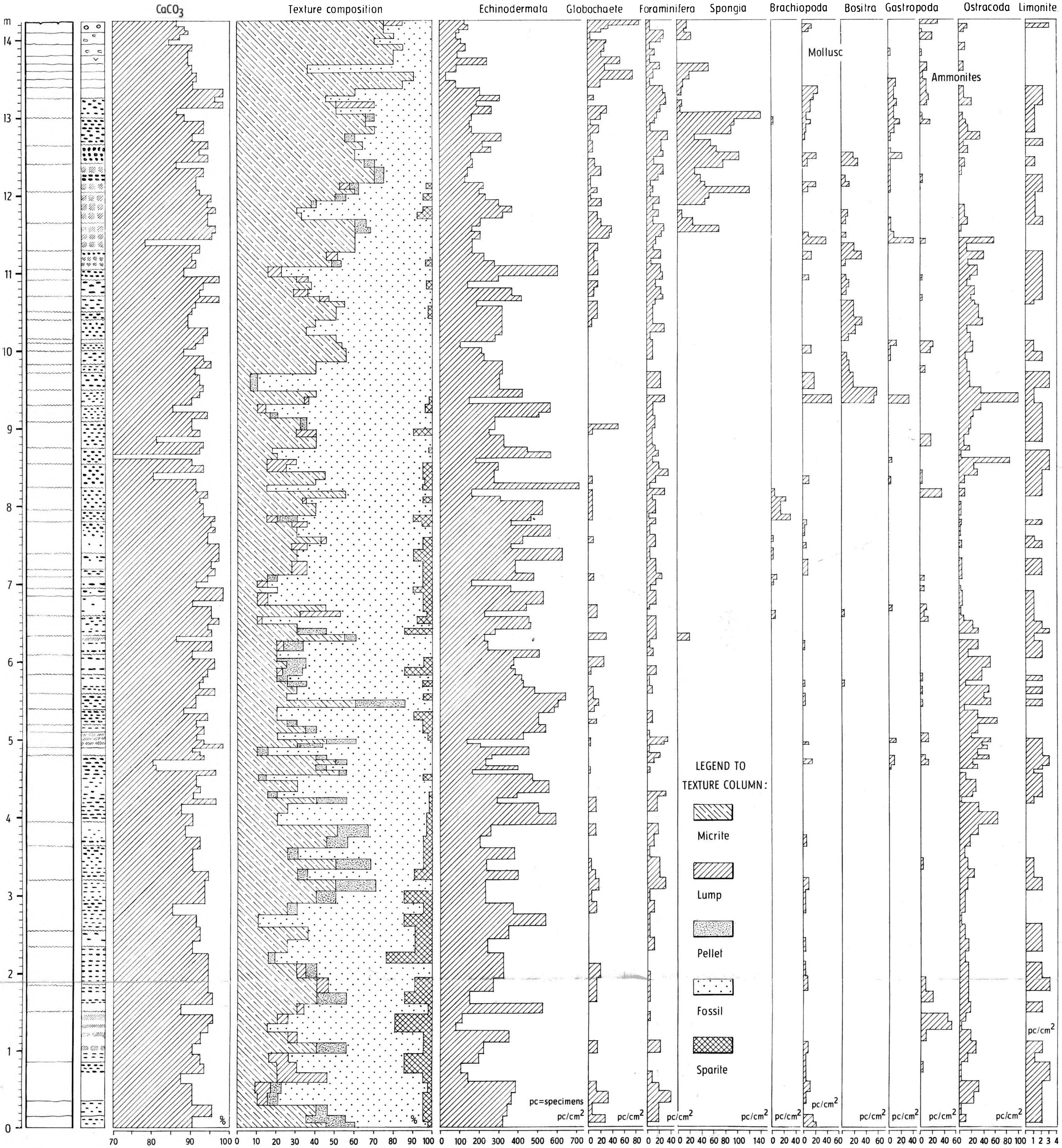
Bedding plane
Stylolite
Sheet cracks
Transversal fissures
Intraformational breccia
Lumpy texture
Mn – noduls
Microbioclastite
Microbioclastite /more densely packed/
Skeletal fragments of Crinoidea
Cephalopoda
Brachiopoda

Textfig. 21-22:

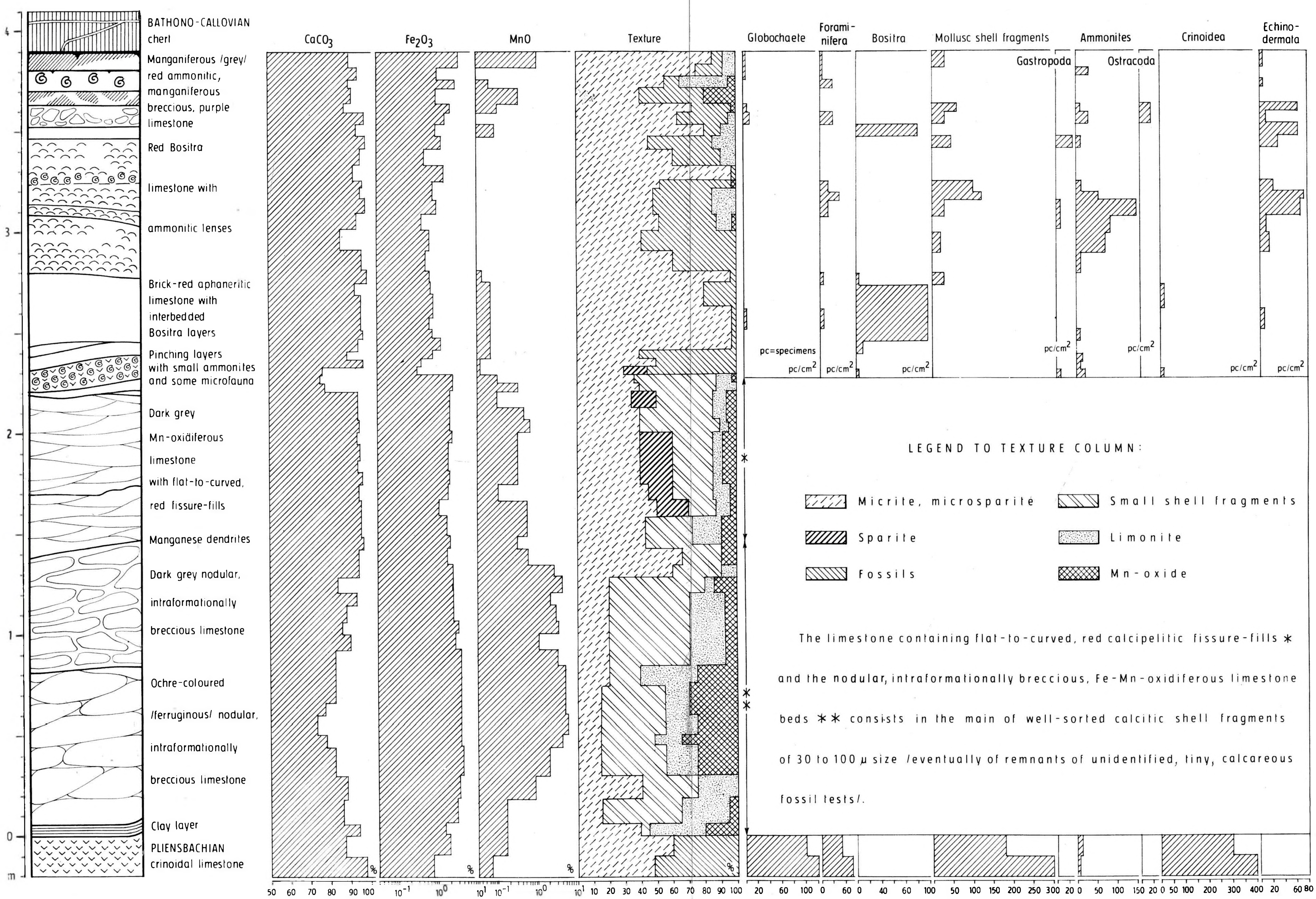
MIDDLE AND UPPER MEMBERS OF THE LOWER LIASSIC /SINEMURIAN/ PINK LIMESTONE

LEGEND to Textfig. 21-22

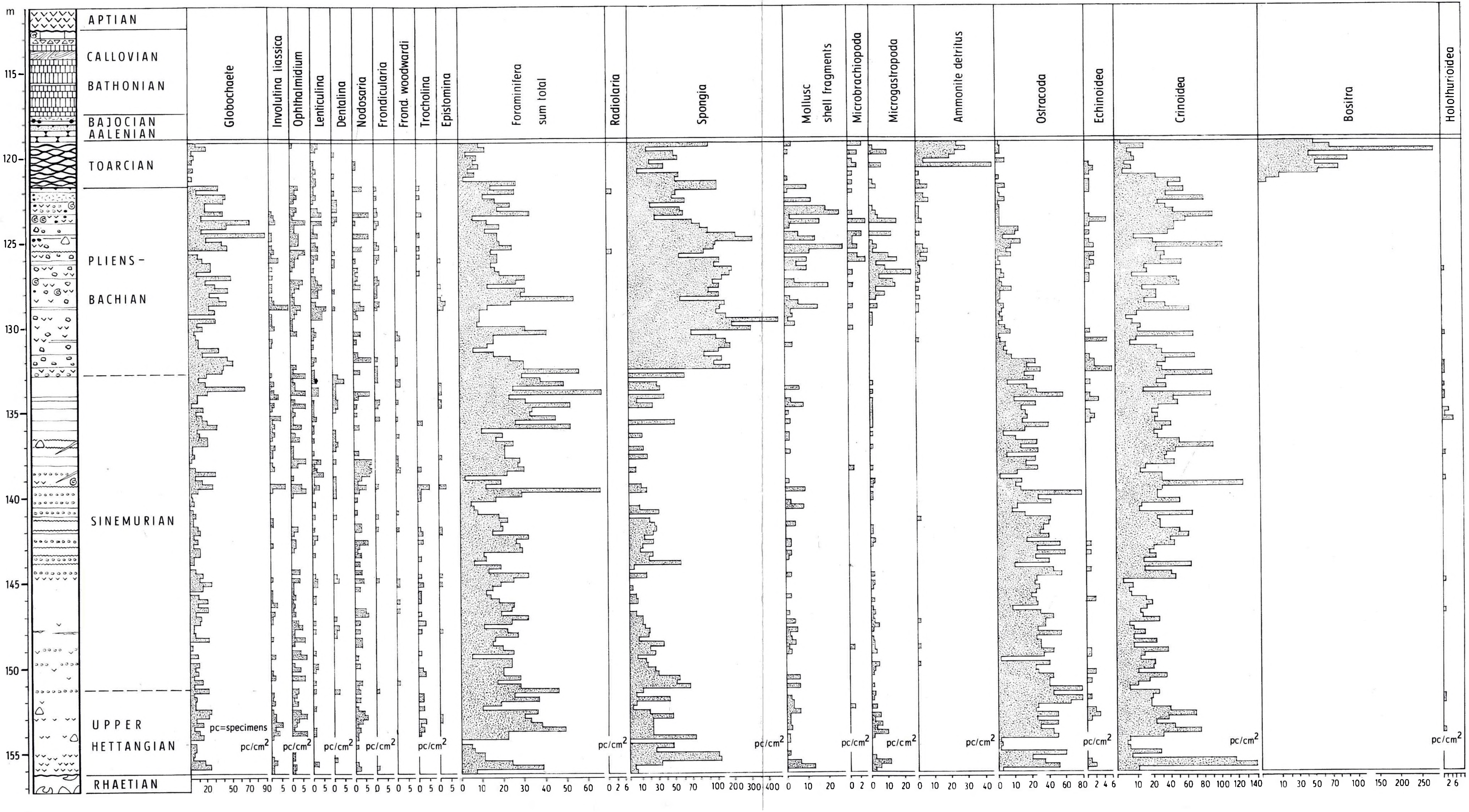
1. Globochaete alpina
2. Ammodiscus
3. Gaudryina
4. Ophthalmidium
5. Nodosaria
6. Pseudonodosaria
7. Rectoglandulina
8. Lingulina
9. Dentalina
10. Frondicularia brizaeformis
11. Frondicularia sp.
12. Lagena globosa
13. Lenticulina 1
14. Lenticulina 2
15. Cornuspira
16. Involutina liassica
17. Trocholina turris
18. Trocholina
19. Foraminifera sum total
20. Spongia
21. Brachiopoda
22. Posidonia
23. Gastropoda
24. Ammonites
25. Mollusc shell fragments
26. Ostracoda
27. Crinoidea
28. Echinoidea
29. Holothurioidea
30. Pyrite



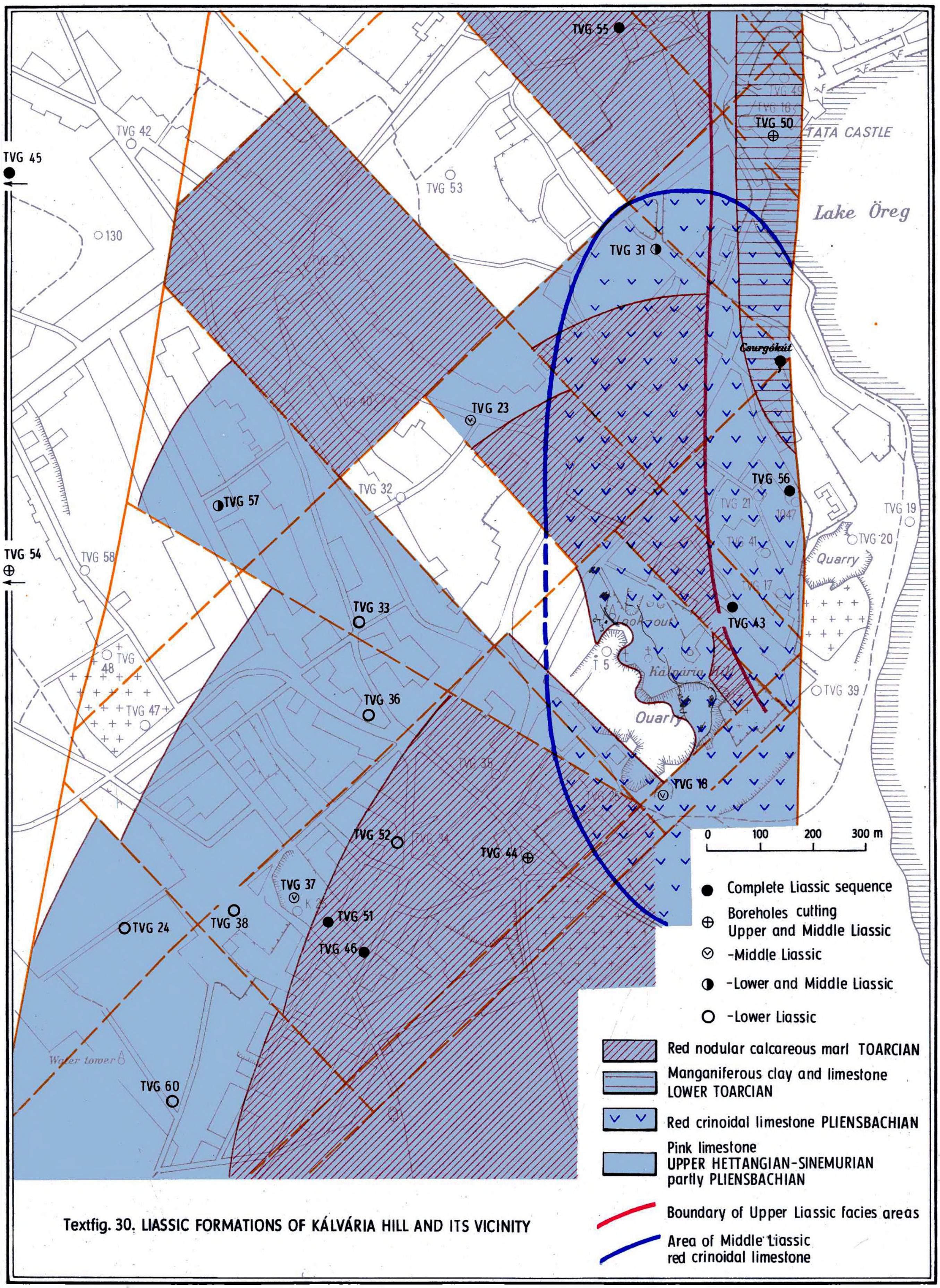
Textfig. 25: KÁLVÁRIA HILL S TEST DATA ON LIASSIC /PLIENSBACHIAN/ RED CRINOIDAL LIMESTONE FORMATION



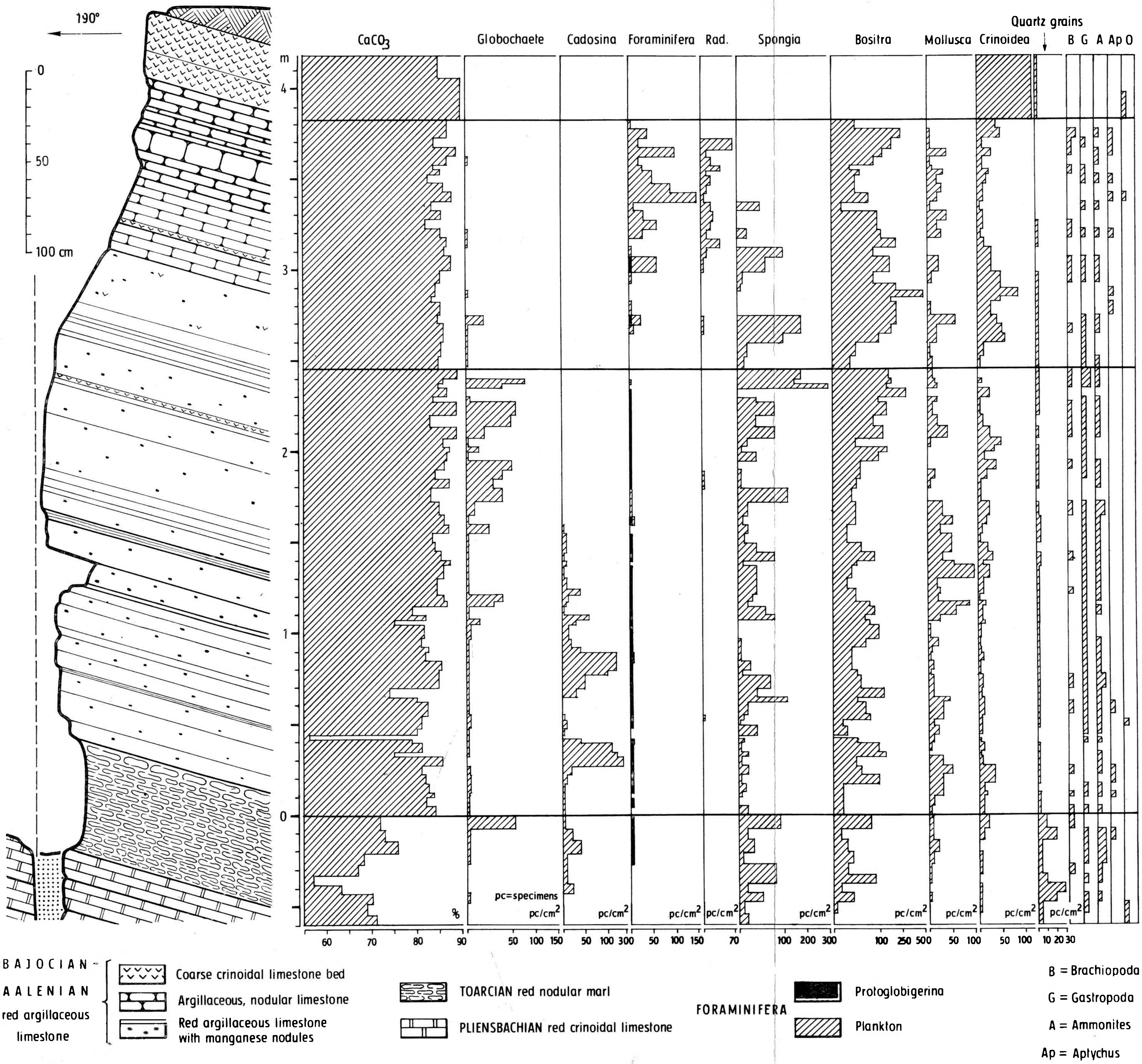
Textfig. 26: UPPER LIASSIC /TOARCIAN/ LIMESTONE SEQUENCE AT CSURGÓKÚT



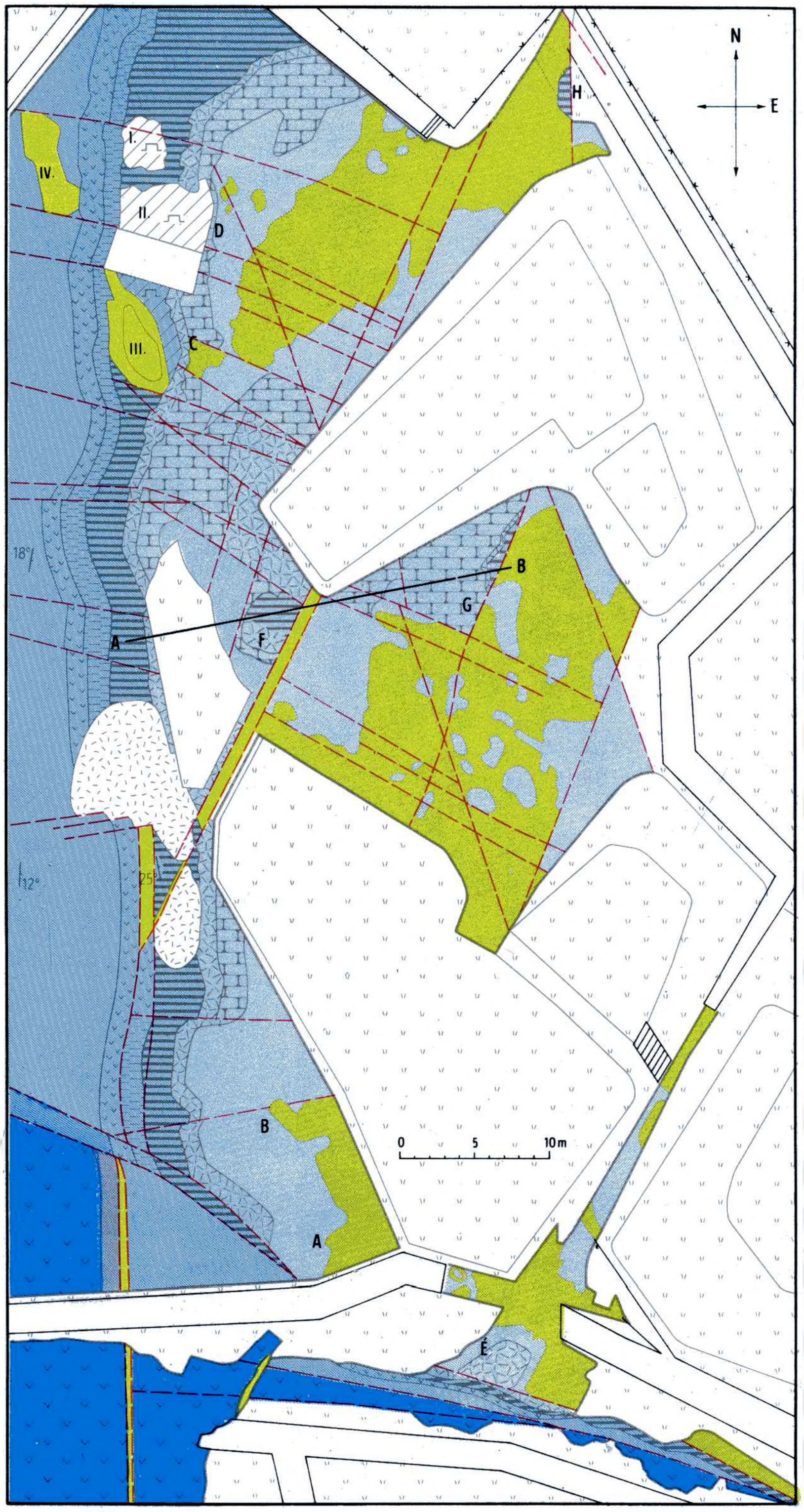
Textfig. 28: TEST DATA ON THE JURASSIC SEQUENCE OF BOREHOLE TVG 45



Textfig. 30. LIASSIC FORMATIONS OF KÁLVÁRIA HILL AND ITS VICINITY



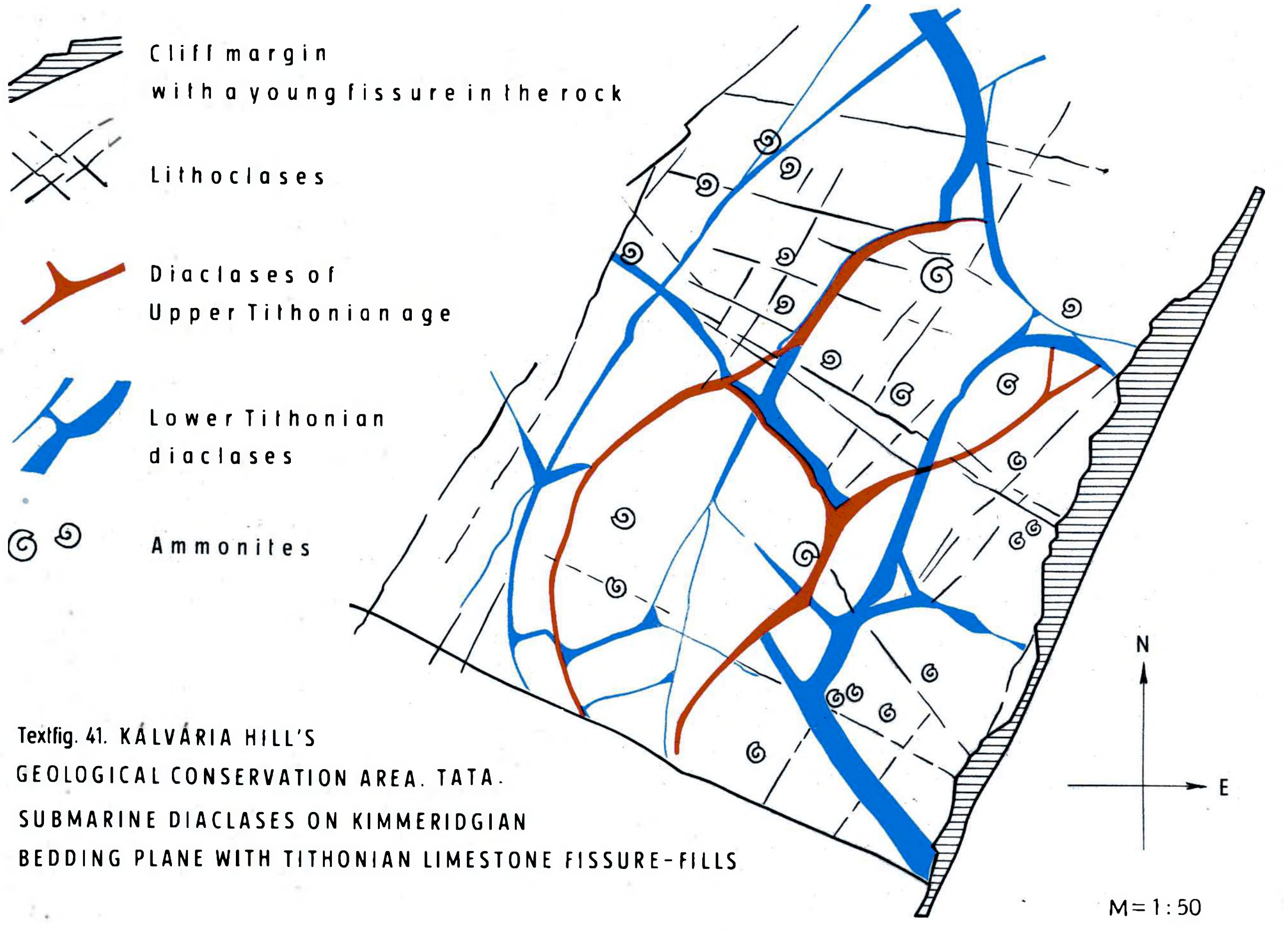
Textfig. 32: UPPER LIASSIC /TOARCIAN/ AND LOWER DOGGER /AALENIAN-BAJOCIAN/ SEQUENCE, KÁLVÁRIA HILL, GEOLOGICAL CONSERVATION AREA. ROCK WALL OF THE BIG FAULT



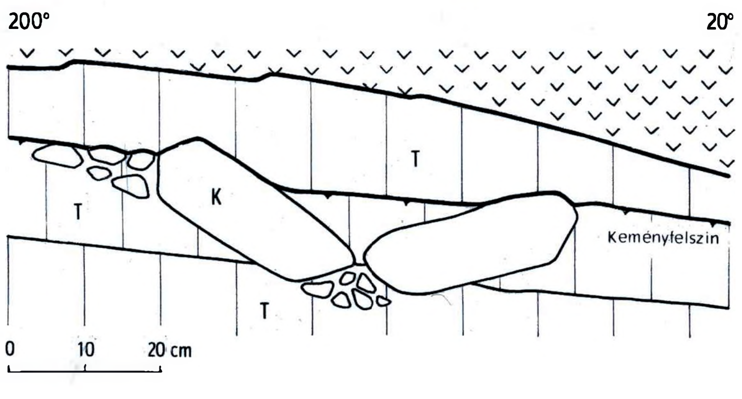
Textfig. 34. MALM-BERRIASIAN FORMATIONS UNCOVERED IN KÁLVÁRIA HILL' GEOLOGICAL CONSERVATION AREA

LEGEND:

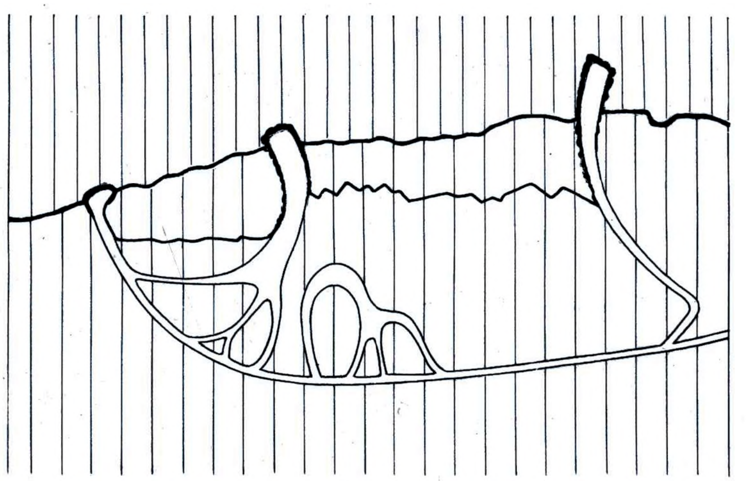
- Wire fence of the Geological Conservation Area
- Road and stairs
- A — B Orientation of the section shown in the Textfig. 40
- A – H Location of Eigures 35 to 40
- 25° Dip of strata
- Fault lines
- HOLOCENE soil cover and scree
- I.-II. PREHISTORIC chert pits
- Unrecovered chert pits
- III.-IV. PLEISTOCENE lithoclases, sand and clay fissure-fills
- APTIAN grey crionoidal limestone
- Break in sedimentation several stratigraphic stages between the Aptian crinoidal limestone and the Upper Jurassic-Berriasian limestone
- TITONIAN, partly BERRIASIAN, purple to grey cephalopodal limestone
- KIMMERIDGIAN red, argillaceous, nodular, cephalopodal limestone
- OXFORDIAN light grey intraformational limestone breccia
- BATHONO-CALLOVIAN chert
- BAJOCIAN brownish-red Bositra limestone
- BAJOCIAN dark red coarse-grained crinoidite
- AALENIAN-BAJOCIAN red, argillaceous limestone
- TOARCIAN red, nodular, calcareous marl
- PLIENSBACHIAN red crinoidal limestone



Textfig. 41. KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA. TATA. SUBMARINE DIACLASES ON KIMMERIDGIAN BEDDING PLANE WITH TITHONIAN LIMESTONE FISSURE-FILLS

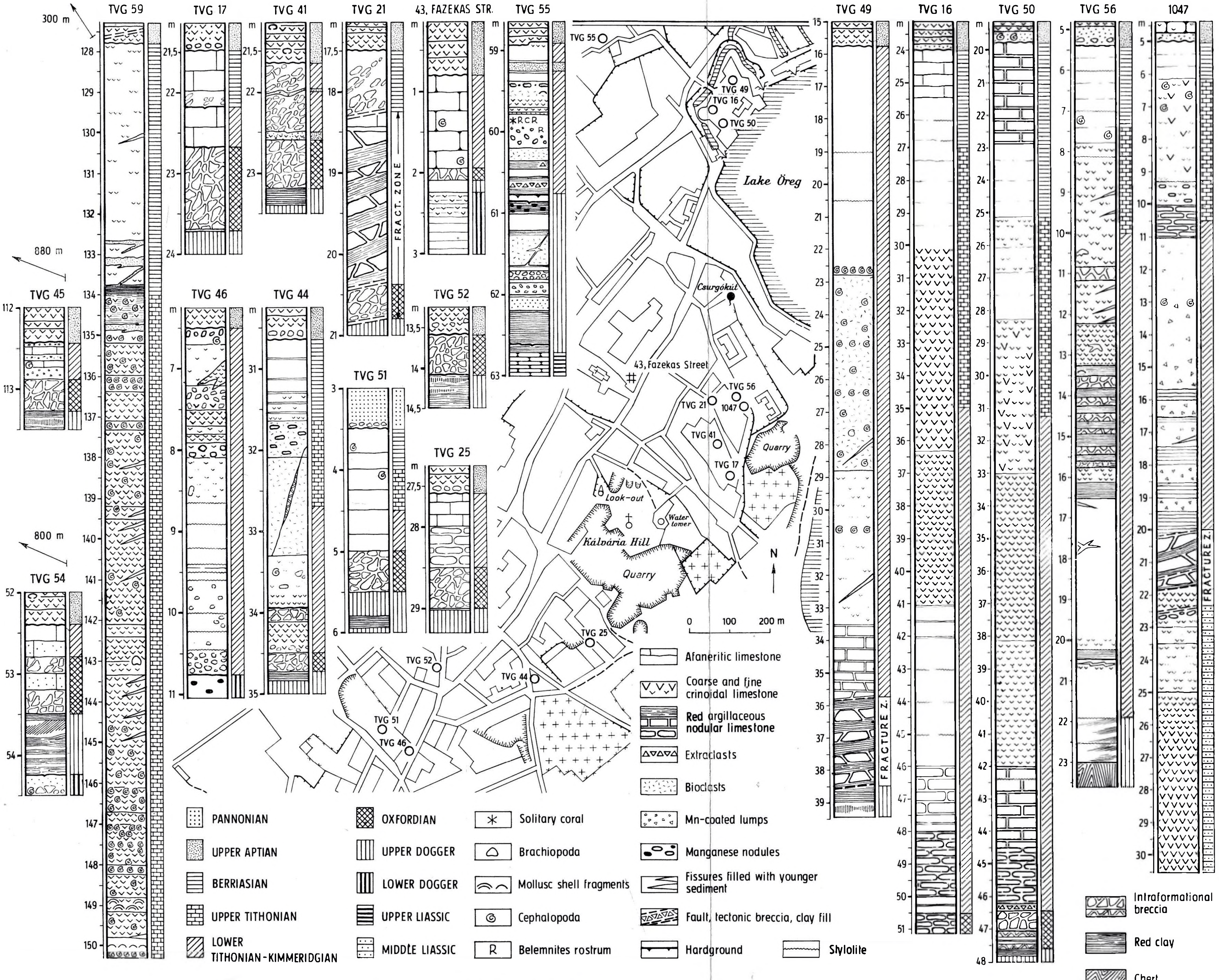


Textfig. 42. KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA. TATA. KIMMERIDGIAN SUBMARINE SCREE /K/ WITHIN TITHONIAN LIMESTONE /T/

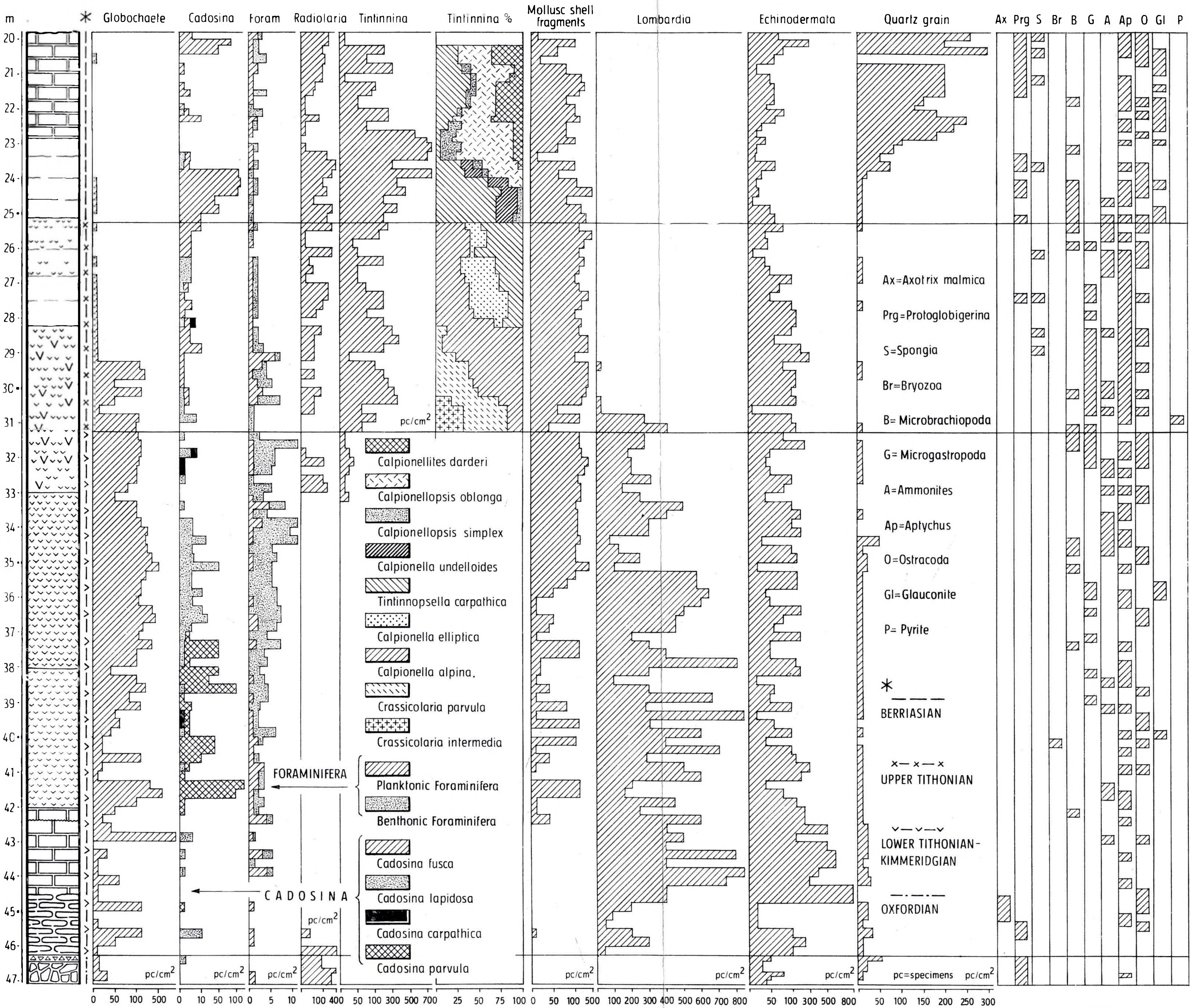


Textfig. 43. AMMONITE HALVED /BY SUBSOLUTION/ ON A HARDGROUND IN KIMMERIDGIAN-LOWER TITHONIAN LIMESTONE FROM THE 6.7 th m OF BOREHOLE TVG-46

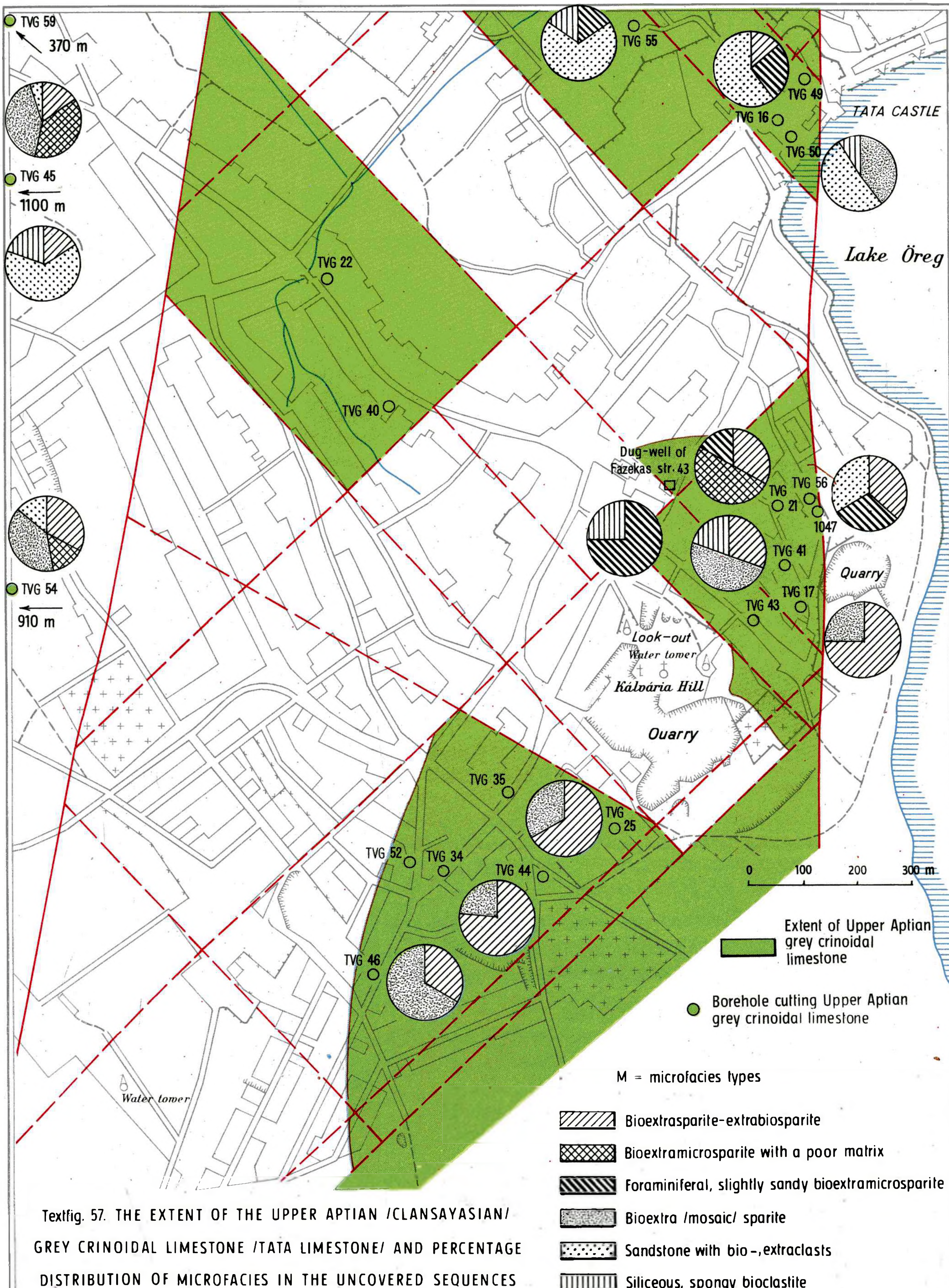
/NATURAL SIZE/



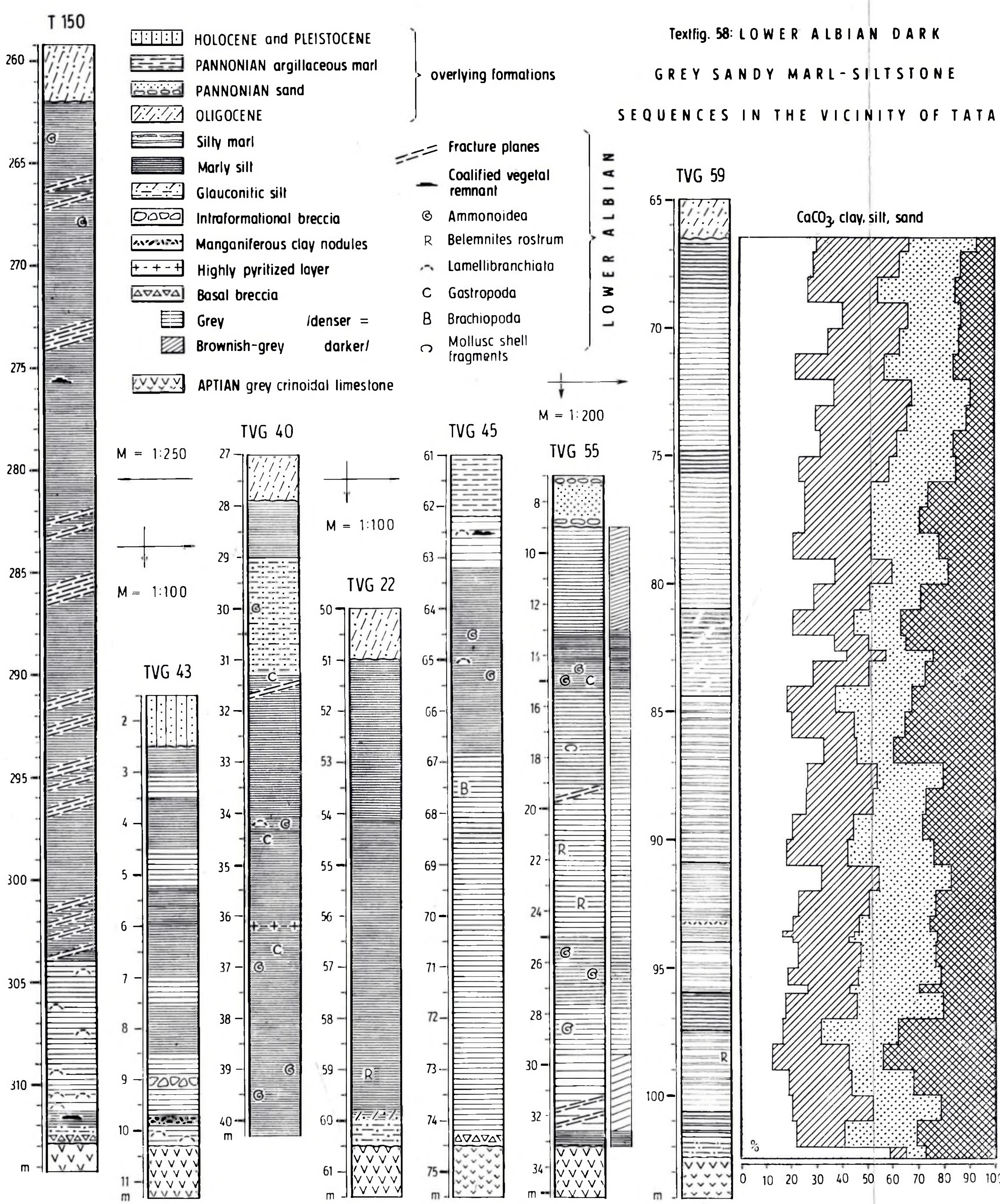
Textfig. 44: MALM SEQUENCES UNCOVERED BY SURVEY DRILLING AT TATA



Textfig. 46: MALM SEQUENCE "OF MARGINAL FACIES" OF BOREHOLE TVG 50



Textfig. 57. THE EXTENT OF THE UPPER APTIAN /CLANSAYASIAN/ GREY CRINOIDAL LIMESTONE /TATA LIMESTONE/ AND PERCENTAGE DISTRIBUTION OF MICROFACIES IN THE UNCOVERED SEQUENCES

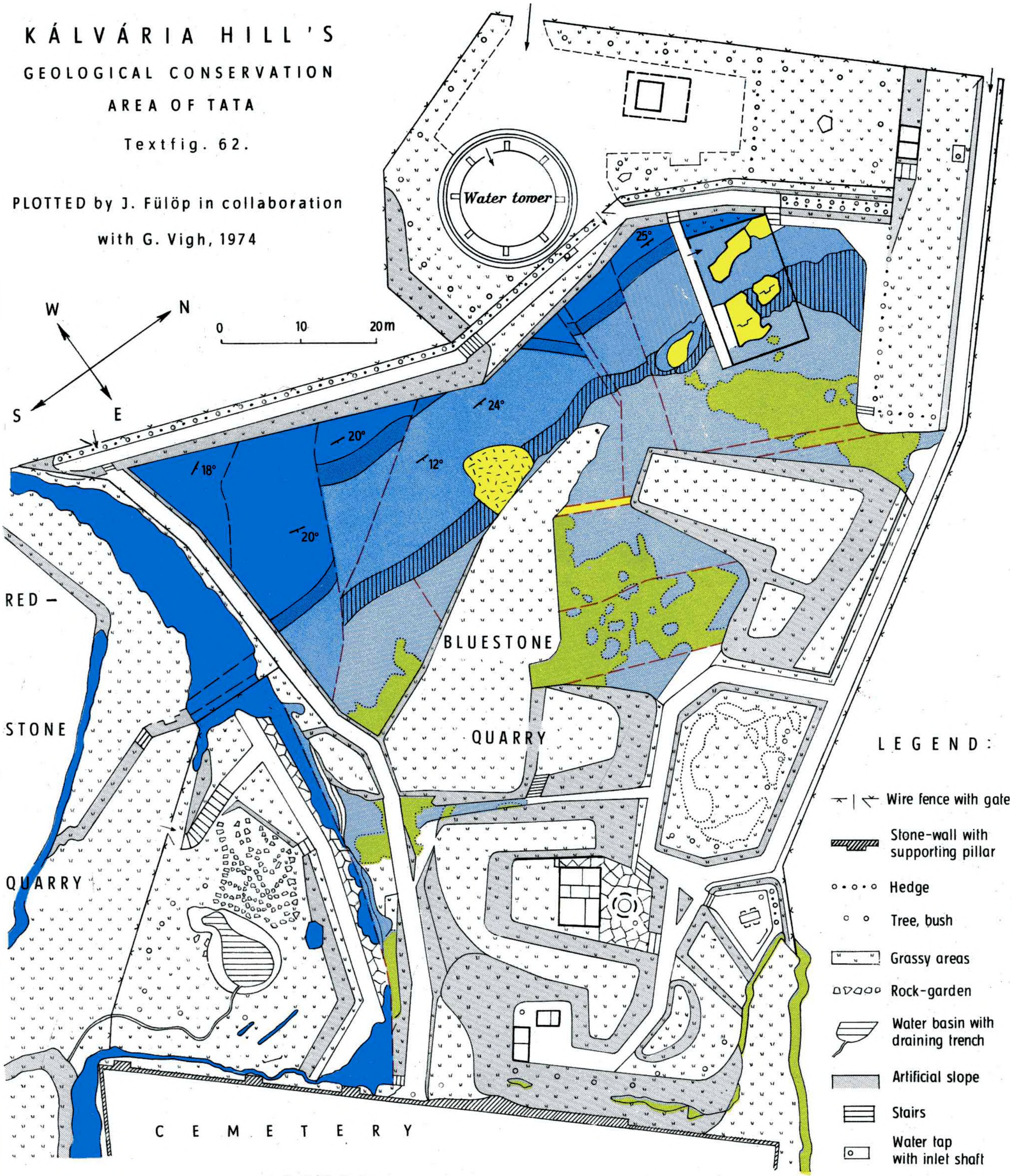


Textfig. 58: LOWER ALBIAN DARK GREY SANDY MARL-SILTSTONE SEQUENCES IN THE VICINITY OF TATA

KÁLVÁRIA HILL'S GEOLOGICAL CONSERVATION AREA OF TATA

Textfig. 62.

PLOTTED by J. Fülöp in collaboration with G. Vigh, 1974



LEGEND:

- RECENT quarry waste and redeposited sand cover
- Excavated prehistoric chert pit
- Area covered by chert detritus /above a supposed chert pit/
- PLEISTOCENE sand and clay filling fissures
- APTIAN grey crinoidal limestone
- UPPER JURASSIC-BERRIASIAN limestone
- BATHONO-CALLOVIAN chert
- AALENIAN-BAJOCIAN red limestone
- TOARCIAN red marl with limestone nodules
- PLIENSBACHIAN red crinoidal limestone
- Stone plates
- Table with chairs and long seat
- Building
- 24° Dip of strata
- Formation boudary /in case of conformity/
- Formation boudary /in case of unconformity/
- Fault line
- Karst water ducts
- Thermal karst cave